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CURRENT STATUS OF THE TECHNOLOGY OF TRAINING

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ABSTRACT

This report presents a brief overview of the current status of the technology of training. The processes involved in designing a training system are arbitrarily analyzed into the following three areas: (1) determining training requirements, (2) developing the training environment, and (3) measuring the results of training. In each of these areas, an attempt is made to summarize and evaluate the adequacy of our technology. In a final section of the report, certain areas of research which appear to be especially promising are discussed.

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FOREWORD

This report was prepared by Dr. Gordon A. Eckstrand of the Aerospace Medical Research Laboratories. The report was prepared under Project 1710, "Training, Personnel and Psychological Stress Aspects of Bioastronautics." The paper was read by Dr. Eckstrand at the Seventy-Second Annual Convention of the American Psychological Association held at Los Angeles, California 4-9 September 1964.

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This technical report has been reviewed and is approved.

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CURRENT STATUS OF THE TECHNOLOGY OF TRAINING

INTRODUCTION

Purpose - The purposes of this paper are to present a brief overview of the current status of the technology of training and to indicate some areas where further improvements would make major contributions to training efficiency. The technology of training refers to a body of systematic knowledge and techniques which supports the design of training systems. It is the technology which bears on the things a training institution characteristically does in setting up and managing a training program to produce men capable of "performing effectively."

General Status of Training Technology - Let me begin by simply stating that a substantial technology of training does exist. The past decade has seen the development of a body of knowledge and technique which is rather directly applicable to the practical problems involved in designing training systems. It is by no means as well developed yet as the technology of aptitude testing; nevertheless, it is still substantial and it is growing.

Both research on training and actual experience in training development contribute to this gradually developing technology. In fact, it might be said that something like a psychology of training is developing which is separate and distinct from a psychology of learning; separate and distinct in terms of the goals, hypotheses, methods of investigation, and criteria by which its development is measured. Certainly, it is true that through the years there has been a hiatus between learning research and training practice. It appears that this gap is beginning to be filled, and that a psychology of training is providing the active research and development needed to bridge the gap between basic science and practical technology.

Let me now briefly mention two aspects of training technology which characterize its state of maturity in a rather general way. One of the most noteworthy things is the current emphasis on a systems approach to training. In this approach, the development of a training program is likened to the development of a weapon system. Here the systems engineer begins with an operational requirement: a precise statement of the objective to be achieved by the system. The systems designer then works backward from these objectives to produce an arrangement of subsystems which, when operated according to some operational plan, will fulfill the objectives. The process ends with a series of tests to assure that the design achieved does in fact fulfill the requirement. The design of a training system can proceed in the same manner. The behavior which some particular class of military men must exhibit on the job becomes the objective which must be achieved by the training system. The job of the training designer, then, is to select and sequence a series of learning experiences which will produce the required behavior. A testing phase is required to assure that the training program designed succeeds in producing men capable of performing as specified. Figure 1 (adapted from Hoehn and McClure, 22) shows the processes involved. The first process is the definition of the training objectives or desired performance outcomes. These objectives not only provide the critical input to the derivation of training content but are basic to the development of the criterion measures required to test the training system. The selection of training content, in turn, provides inputs to the design of training methods and materials. The training methods and materials, when implemented according to some administrative training plan, become the training program. At the completion of the training program, criterion measures are applied to obtain indications of the adequacy of the program outputs. The dotted lines show the various feedback loops that are used to modify the training system if the desired output has not been achieved. This general systems approach to training is having an increasing impact on the development of our understanding and control of the training process.

A second aspect of current training technology which characterizes its maturity is the rather considerable literature which has been produced describing this technology. Many books and reports have been published since 1960 which provide excellent summaries of the status of our knowledge in the various areas relevant to a technology of training. This, I feel, is indicative not only of the growing body of applicable knowledge which exists but of the growing number of psychologists who are actively engaged in training research and development. The availability of this literature has

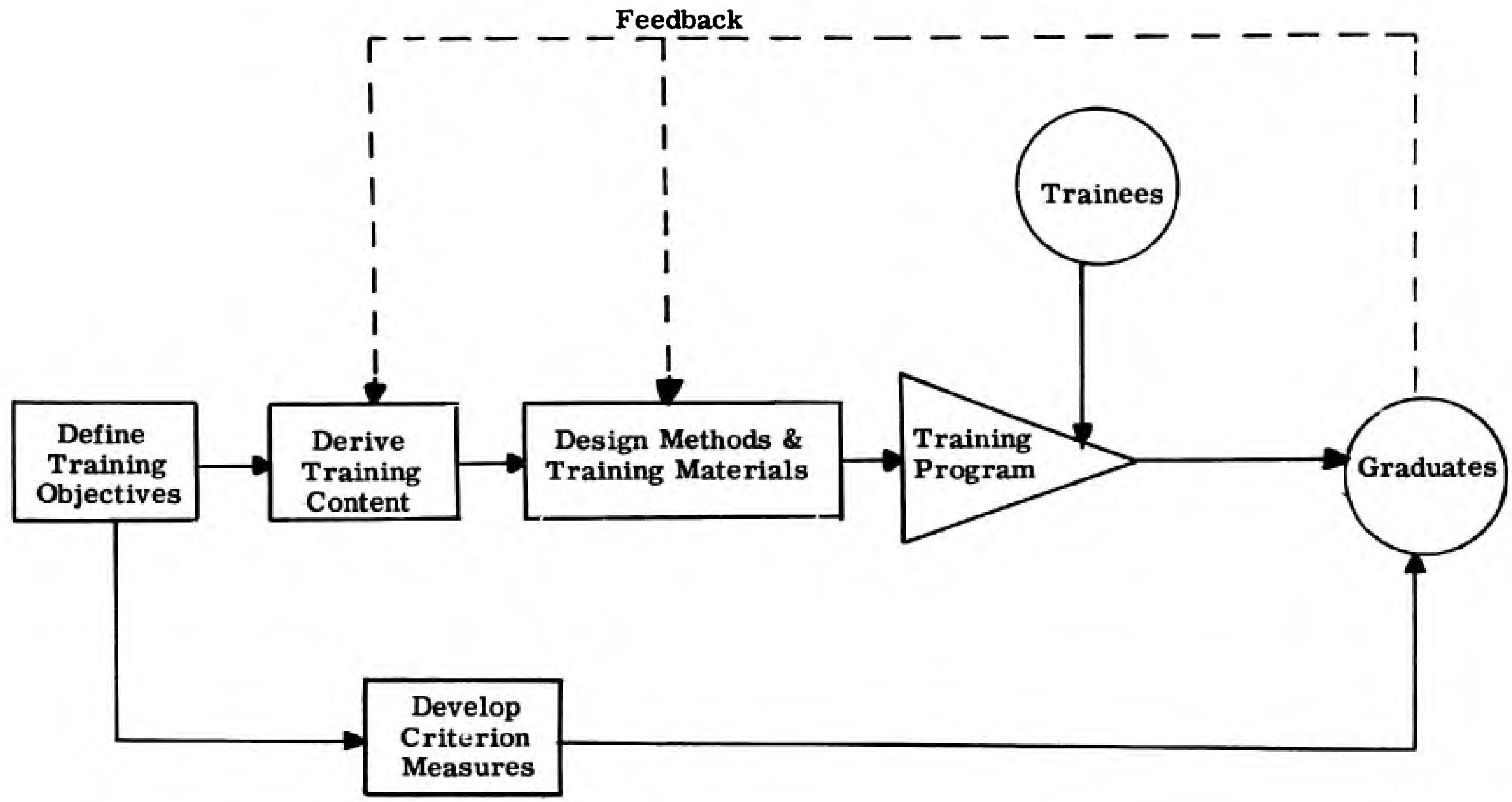

Figure 1. A Systems Approach to Training

also made my job somewhat easier. In preparing this paper, I have depended heavily upon these authoritative sources, rather than upon a detailed review of all relevant literature.

Elements of a Technology of Training - In describing the current status of the technology of training, one needs some rubrics under which to organize the discussion. The next sections of this paper are organized around a general conception of the training system, following the basic idea presented in Figure 1. For purposes of this discussion, the processes involved in designing a training system are arbitrarily analyzed into the following three areas:

1. Determining Training Requirements

2. Developing the Training Environment

3. Measuring the Results of Training

In each area, an attempt will be made to summarize and evaluate the adequacy of our technology. This is not to imply that this technology is being applied to the development of all military training programs. This is definitely not the case. My purpose is to sketch out the status of the technology that is available for application, and I will not attempt to evaluate the extent to which it is being applied.

DETERMINING TRAINING REQUIREMENTS

Emphasis on Training Objectives:

Fundamental to the design of a training program and supporting materials is the determination of what behaviors are to be trained. The behaviors to be trained, of course, are those that are determined to be required for successful performance on the job. It is this determination which provides the starting point for the design of the training system and for the design of the criterion measures which will be used to evaluate the training system. Certainly, one of the most significant recent developments in training technology is the emphasis which has been placed on the precise statement of training objectives and on the development of methods for accomplishing this task. In fact, Crawford has suggested that this may constitute the single most important contribution which has been made to the design of training systems (6).

Perhaps the above sounds like a statement of the obvious. If so, one should recall that the description of job requirements in behavioral terms is certainly not the starting point for all efforts to develop training programs. Many such efforts still begin with consideration of what is known in a general area rather than what the trainees must know in order to do their job.

Steps in Deriving Training Objectives:

Current knowledge is not yet at the point where the concepts and techniques for determining objective training requirements can be precisely specified. Nevertheless, principles and procedures have been developed and tested which provide a systematic approach to this aspect of training design. Several recent summaries of this material are available (22, 32, 33, 49). While some differences in nomenclature and detail exist among the various approaches available, the major steps involved in determining training requirements can be summarized as follows:

Analysis of the job - An analysis of a job for purposes of training must begin with a listing of all of the tasks which comprise the job. A task may be defined as any group of activities performed at about the same time or in close sequence, and having a common work objective. A position or job, of course, is the sum total of tasks a single person may be responsible for.

Once tasks have been identified, task descriptions must be prepared. Task descriptions specify the essential activities involved in the performance of a task. They describe the activities of the human in operational terms, i. e., terms which are characteristic of, and appropriate to, the system. Usually included in task descriptions are the purpose of the activity, the equipment involved, the conditions under which the activities are performed, and criteria which define adequate performance in terms of time, errors, probability, etc. These task descriptions form the basis for job descriptions which are essentially a specification of job performance requirements. They specify what a man must be able to do to be considered satisfactory on his job. Miller has defined a good task description as "one which specifies what criterion responses should be made to what task stimuli and under what range of conditions" (32).

Specification of knowledge and skills - The next step is to select the concepts, skills, information, etc. which trainees must be taught to enable them to meet the performance requirements specified in the job description. This is the process of determining the means by which the job performance requirements can be achieved. This process of determining knowledge and skill requirements is a complex and difficult one, and we are far from being able to specify an optimum procedure to accomplish it (20). We do know, however, that the process is aided by looking at job performance requirements in behavioral rather than operational terms. The techniques of task analysis have been developed and refined over the past decade for this purpose. Task analysis is a systematic method for determining the behavioral requirements in task performance, and a number of procedures and formats for this purpose have been developed and used. The training designer must use the task analysis to determine what the trainee should be taught in order to perform effectively on the job. There are many criteria which will assist him in making these decisions, but it essentially remains a process that is highly subjective and based considerably upon experience. Any major improvements in this area are dependent upon the development of a taxonomy which will provide the task analyst with terms and concepts useful in looking at tasks in terms of their behavioral ingredients.

Determination of training objectives - Based upon the specification of knowledges and skills which are required to meet job performance standards, the objectives of training are formulated. Referring back to our systems model, these objectives are essentially specifications which define the output which is expected from the training system. The clarity and adequacy with which this can be accomplished is primarily dependent upon the completeness and accuracy of the determination of knowledge and skill requirements. A well formulated set of training objectives must meet at least the following general criteria:

1. Relevance - Is each training objective defensible in terms of the knowledge and skill required for adequate job performance?

2. Completeness - Do the objectives account for all of the required performance outputs?

3. Measurability - Are the objectives stated in a way which suggests an operation for determining that the objective has been achieved?

The previous paragraphs have been written as if the particular training system being designed was the sole means for developing the required performance output. This is an obvious oversimplification. Training objectives are not necessarily the same as job performance requirements. In fact, they rarely are. Training is almost always divided into certain stages (basic, individual, team, etc.). The objectives of any one course or stage of training are, consequently, usually something less than the complete job performance requirements. Likewise, some training is almost always left to be completed in the actual job context. The achievement of certain performance capabilities may be assigned to various types of job aids. Therefore, even the final stage of training may have training objectives that differ from the job performance standards. Thus, the overall training objectives which are to be accomplished by any particular training system must be broken down into a series of sub-objectives. The important thing, however, in terms of a technology of training, is that the process starts with an analysis of what the trainee will be expected to do on the job. However far the process of fractionation is carried, the process remains rooted in job performance.

Summary:

In summary, what can be said about the status of our knowledge on determining training requirements? Briefly this.

We can specify a series of steps that one should follow, and there is reason to believe that these steps have considerable generality. A number of tested formats and procedures are available which are useful in carrying out these steps, and criteria are available for evaluating the results. Nevertheless, the gathering, classifying and organizing of information about training requirements is still a judgmental process depending to a considerable extent upon the experience of the training analyst. The current state-of-the-art does, however, serve to make this judgmental process explicit and systematic.

DEVELOPING THE TRAINING ENVIRONMENT

After the objectives of training have been specified, the next step is to determine how these objectives can best be attained. This involves developing a training environment which will transform inputs to the training system (trainees) into graduates who can perform at specified levels on the job. Here again, the systems design analogy is appropriate. The goals of the training system designer are the required human performance outputs. His task is to design and assemble methods, materials and media which will provide the learning experiences required to achieve the training goals. This can be looked upon as a procedure of selecting or designing training tasks and of establishing the procedures for practice on these tasks. We see here the two factors that are involved in optimizing training efficiency - transfer of training and learning efficiency. Training tasks are designed to produce transfer, and procedures are selected to assure that these tasks will be learned efficiently. What does the technology of training have to offer in carrying out this process?

Applicability of General Principles:

An impressive body of information on human learning has been accumulated. One might expect that this body of information would provide systematic and practical guidelines for the training systems designer. As most of you know, I am sure, this is not the case. Attempts to derive from this information principles useful in designing training tasks and procedures have proved to be disappointing. Gagne and Bolles have suggested several reasons why this is true (16).

Despite this state of affairs, there are some general principles regarding the design of training tasks and procedures of practice which appear to have rather wide applicability across different types of training functions. Although such principles are generally only qualitative in nature, they are of considerable assistance in developing efficient training environments, and many existing training programs could be improved by their application. Several recent publications provide useful summaries of these principles (16, 21, 28, 43).

One of the major results of the past decade of military training research has been the recognition of the importance of task characteristics for the effectiveness of different training variables. For example, the training activity appropriate for learning a fixed procedure differs from that appropriate for a problem solving task. Any very precise and specific guidance for designing the training environment will require that principles be differentially related to tasks on which training is required. Hoehn has made a preliminary attempt to do this with respect to electronics maintenance positions (21). It is difficult, however, to organize existing information in this manner. What is lacking is a reliable system for classifying tasks into a set of categories which are homogenous with respect to the conditions fostering learning. Such a classification should readily encompass both the tasks which are used in the laboratory and those found in military jobs. The availability of such a task taxonomy would be valuable to the technology of training in two major ways. First, it would immediately provide a system for organizing existing information in a way which would facilitate its application to particular training problems. Second, it would provide a most useful tool in determining deficiencies in our knowledge and thereby serve to guide future research. Until such a task classification scheme is available, the differential application of principles in the design of training environments will be difficult and imprecise, having more of the characteristics of an art than a technology. A general discussion of this problem has been provided by Cotterman (5).

One of the major problems in developing an efficient training program is how to divide the total knowledge and skill requirements of a job into segments of training content and how to sequence these segments. This is a problem which is never faced by learning research involving only simple tasks. It is also a problem on which it is difficult to do good applied research due to the sheer magnitude of experimentally comparing alternative ways of organizing a lengthy training program. Consequently, little is available in the way of experimental data. Miller, however, has developed a general approach for dividing total performance requirements into training segments (31) and Jones has pointed out how molar correlational analysis can be used to determine the best order for a series of training program elements (23).

Training Media:

The term training media has come to refer to a class of instructional aids and devices that vary from training films through complex simulators. Military training psychologists have devoted a great deal of their effort to studies of various kinds of training media as opposed to training methods. There are perhaps two reasons for this.

First, training aids and devices are being used to a considerable extent in military training. The complexity of the jobs involved and the requirement for training efficiency has led to an increasing emphasis on technological aids for training. In the development of any particular training program, one of the most important decisions that must be made concerns the media through which instruction is to be presented.

Second, military psychologists have perhaps realized that it is easier to implement principles of effective training when they are embodied in devices and other media that provide reproducible blocks of instruction than when an attempt is made to influence the behavior of instructors. Travers has used this argument in suggesting that behavioral scientists will have the greatest impact on training if they concentrate on equipment and devices (46). Likewise, the fact that media can be used over and over again is an important factor in allocating resources to their improvement.

A great deal of research has been devoted to the various kinds of instructional media. For most of the media, data are available concerning at least some of the factors which determine their effectiveness. Several recent treatments of this information are available (10, 26, 27). Likewise, a good start has been made on organizing information on the effectiveness of various training media in meeting specific training objectives. Here also, publications are available which provide guidance for determining when media are required in a training program and what media are most suitable (7, 37).

<u>Simulators</u>:

With the increased complexity of the weapon and supporting systems being developed for use by the military, greater dependence is being placed upon simulators for training the individuals and crews who must operate these systems in an extremely accurate and reliable manner. Because of their importance and expense, training psychologists have devoted considerable attention to the design of simulators, and several summaries of the available information have been published (1, 15, 35, 43). Nevertheless, engineering technology related to simulation has grown much more rapidly than has our ability to specify the characteristics which a simulator should have in order to be most effective. Consequently, most current simulators are designed against a criterion of physical fidelity rather than fidelity of the operations and tasks which are presented to the trainee. In many cases, of course, this is not a problem, since physical fidelity often does produce high transfer of training and costs no more than some conditions of lesser fidelity. In other cases, such as visual simulation and motion simulation, physical fidelity is difficult, costly or impossible. In these areas, we are badly in need of additional research. Needless to say, such research is costly, time consuming, and poses difficult methodological problems.

<u>Automated Instruction and Programmed Learning</u>:

No current summary of the technology of developing training environments would be complete without some mention of automated instruction and programmed learning. These techniques have received a great amount of attention and have influenced many basic concepts of training. Basically, these are techniques to achieve greater control of learning with minimum use of an instructor. Usually, automated instruction and programmed learning involve the presentation of a relatively small amount of instruction, either an overt or an implicit response by the trainee, and some indication of the adequacy of the trainee' s response. The techniques represent an application of the principles of reinforcement and learning by practicing relevant behaviors. Although most devices and programs are based on similar principles, a wide variety of devices and programs have been developed. Publications are available which provide practical summaries of the types of devices and programs that are available (19, 25, 38), how to prepare such instructional materials (29)*, and the potential uses of such instruction (17).

Military research and applications have contributed very extensively to the technology of automated instruction and programmed learning. Military organizations conducted much of the applied research that led to these techniques and have actively promoted their use (36). Hopefully, these techniques will ease some of the military training problems associated with individual differences among trainees, inadequate number or quality of instructors, need for personnel trained above a minimum level and preferably quite uniform in performance capability, and training programs of fluctuating magnitude (9).

Evaluations of automated instruction and programmed learning have revealed a wide range of findings. Perhaps the safest conclusion is that the techniques can be applied to a wide range of training problems with a substantial improvement of one type or another (36, 39).

Future training systems undoubtedly will involve greater use of automated instruction and programmed learning. These techniques may well be mixed with more conventional media. Judging from the bulk of many self-instructional programs, and the exploding engineering technology, we can expect future self-instructional systems to involve super-reduced film and/or computers. Such systems offer a necessary potential for the storage and retrieval of instructional information.

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*Walther, R. E. and Crowder, N. A. Preparation of Intrinsically Programmed Instructional Materials, AMRL-TR (In publication), Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio.

The general concept of self-instruction has extensive implications for the technology of developing the training environment. Impressive results have been obtained by allowing trainees to select their training environment from a variety of offered materials. In an early study on this concept, trainees were given the training objectives and allowed to select the media to reach the objectives. The trainees offered this opportunity reached the training objective more rapidly than those trained in any other way. This concept of learner controlled instruction has great potential and should receive increasing research attention.

<u>Summary:</u>

In summary, it can be said that much of the research on human learning provides little guidance on practical training problems. Still, a number of useful principles are available. Some of these have wide generality while others appear to apply only to training for specific kinds of tasks. A major advance in the development of efficient training environments would be possible if a classification of training tasks could be developed which would relate task characteristics to principles of effective training.

A substantial body of knowledge is available about the effectiveness characteristics of various training media, and guidance is available for selecting media for various training functions. Simulators are being used increasingly to provide high level training for complex man-machine systems. Our ability to specify the characteristics which such devices should have has not kept pace with engineering technology.

Automated instruction and programmed learning appear to be effective means of meeting many training objectives. These techniques are here to stay and are having considerable impact on both older and new training techniques. Although the printing press is far from being outmoded, film and computer techniques may promise economical and efficient learner controlled instruction in the near future.

MEASURING THE RESULTS OF TRAINING

Proficiency measures during training can serve a number of different purposes. This paper is primarily concerned with proficiency measures whose major purpose is that of quality control; i.e., evaluating the training program in terms of the goals which have been set for it. In assessing the current status of technology in this area, two major trends should be mentioned.

Emphasis on Evaluation:

In recent years, there has been an increasing awareness of the need to evaluate training programs. Trainees have always been tested, of course, but the purpose has frequently been to assign grades rather than to evaluate the training program. Several factors have contributed to this change in emphasis. One is simply the greater urgency for training efficiency in the modern military organization faced with limited manpower resources and equipment of increasing complexity. Another is the use of the systems approach to the development of training systems. Application of the systems approach is dependent upon various feedback loops which can be implemented only by measuring the output of the training system.

The high level of current interest in proficiency tests for training evaluation is indicated in several recent treatments of this problem in the literature (14, 18, 42, 48).

Criterion-Referenced Measures:

The second major trend concerns the manner in which the training system is to be evaluated. Increasing emphasis is being placed on evaluating training systems in terms of objectives which have been carefully derived from an analysis of the job for which training is being provided. Such proficiency tests are based on the statement of training objectives and should be prepared quite independently from the design of the training program (see Figure 1). If the training objectives have been carefully derived and state what the graduate should be able to do, under what conditions, and to what standard of proficiency, they provide a useful criterion for evaluating the training program.

Proficiency measures which rank individuals with respect to such an absolute standard of quality are called criterion-referenced measures. They permit assessment of performance and provide information on degree of competence which is independent of the performance of others. Such measures are useful in quality control, in that they permit one to determine whether an individual has reached or surpassed performance standards that have been established.

Many of the proficiency measures currently used in training systems are norm-referenced. With such measures, a particular individual's proficiency is evaluated in terms of a comparison between his performance and the performance of other members of the group. Norm-referenced measures tell us only that one individual is more or less proficient than another, but tell us nothing about how proficient either of them is with respect to the performance standards. For this reason, such measures are of limited value in proficiency measurement intended for quality control.

This is unfortunate, because most of the research which has been done on psychological testing has been concerned with norm-referenced measures. However, the two types of tests are quite different, and it is important that the technology appropriate to one is clearly distinguished from the technology appropriate to the other. An excellent discussion of the important differences between criterion-referenced and norm-referenced measures is provided by Glaser and Klaus (18).

Developing Proficiency Measures:

One of the major problems in the development of proficiency measures is the specification of the behavior to be measured. If the approach to training system design which has been described here has been followed, this will already have been accomplished with the development of the training objectives. For most military jobs, these training objectives will be stated in terms of job performance standards. Proficiency measurement then becomes the task of measuring how well the trainees can meet these job performance standards. Unfortunately, relatively little attention has been paid to the problem of measuring how well an individual can perform the tasks for which he has been trained. In contrast, the literature on written tests is quite substantial. There is, however, an increasing recognition of the need for proficiency tests which measure the individual's ability to perform specified tasks at criterion levels, and it is expected that this is one problem which will receive increased attention in the future.

There are three important classes of problems that must be faced in developing proficiency measures. These will be discussed briefly below in terms of the current state-of-the-art.

Measurement problems - Any proficiency test is an attempt to measure human behavior. As such, a number of basic problems in psychological measurement are involved; problems such as reliability, testing conditions, test formats, etc. Much has been written on these aspects of the measurement problem, and in general, the technology is well developed. Adequate treatments of this technology are available and no further discussion is required in this paper.

Relevance - The most basic problem in developing proficiency measures for training is relevance. The problem of relevance is one of establishing the degree of behavioral equivalence between the test situation and some other situation, usually performance on the job. Developing proficiency measures, then, consists of developing test situations which will elicit behavior from the trainee which is closely related to that required for successful performance on the job. In accomplishing this, a variety of measurement approaches are available.

The most direct measure of proficiency, of course, would be to test the trainee's ability to perform on the job. Such measures are, in fact, often used both in industry and in the military. Wilson has listed five categories of on the job measures which have been used (48):

1. Tangible product measures
2. Measures of specific behavior elements

3. Gross performance measures
4. Inferred positive performance
5. Malperformance measures

Tangible product measures are not very useful in military operations because a product in this sense is seldom involved. Methods 3, 4, and 5 all have serious disadvantages for use in evaluating training. The most serious is that they are really measures of systems performance rather than human performance. Thus, it is impossible to obtain a measure of trainee performance independent of other factors which also influence system output. Examples of such factors are equipment variability, adequacy of supervision, adequacy of logistic support, etc. Measures of specific behavior elements on the job, however, have often proved to be both feasible and useful. With this method, jobs or tasks are broken down into individual, quite specific activities. The performance of these activities is then observed on the job. When this method is used with carefully prepared checklists and objective standards of performance, it can be quite reliable and useful in evaluating training. A recent example of the use of this method to evaluate training has been reported by Siegel, Schultz and Federman (40). It would appear that this type of on-the-job measure deserves considerably more attention.

A second approach to the problem is the use of <u>simulators</u> or other types of <u>work sample</u> situations. Increasing sophistication and ingenuity in techniques for simulation are providing new ways to elicit criterion behavior for proficiency measurement. Tests using simulation of the work environment offer many of the advantages of on-the-job measures. At the same time, the greater control which simulation allows makes it possible to rule out many extraneous factors which exist on the job. With the growing need for more intensive and specific measures of job performance, simulators will become increasingly important in the proficiency measurement field. Considerable attention has already been given to the use of electronic simulators in providing improved opportunities for measuring human performance in complex man-machine systems. Such simulators reproduce all of the major sources of stimulus input and also allow for realistic response output. In addition, the computer portions of such simulators can often be used not only to provide the dynamics required for system simulation but to automatically monitor and score the performance of the trainee. The status of the technology involved in using simulators to measure the proficiency of flight crews has recently been documented by Smode, Gruber, and Ely (42). This treatment would apply, in general, to any complex man-machine system. Some jobs do not involve extensive interactions between man and machine, of course, and in such cases, it is often possible to elicit criterion behavior without the use of complex equipment. Two recent examples of such job simulations are the in-basket test for school principals (13) and a classroom simulation for teachers (24).

Situations do exist and will continue to arise where it is difficult or impossible to obtain objective measures of performance. In such cases, one must be content to use tests which measure correlated behaviors. Such tests elicit and evaluate behavior which is different than that which is required on the job, but which is expected to be correlated with job performance. The most common type of correlated behavior measures is the use of verbal tests to assess performance which is essentially non-verbal. The many job knowledge tests used by the military services are examples of this approach. Such tests have the advantage of being easily constructed and economically administered when compared with on-the-job or simulated proficiency measures. However, whereas proficiency measures made on the job or in simulated situations can be said to be relevant by definition, this is not the case with correlated-behavior measures. With such measures, relevance must be established empirically by demonstrating a correlation with performance-derived scores. Once this has been done, however, their use is perfectly defensible. Techniques for developing and validating written tests are, of course, well developed. It is quite likely that the optimum proficiency measurement test for many situations lies somewhere between complete simulation and written tests. At the present time, however, there are few principles for deciding what features of the job environment must be simulated for proficiency test purposes. This is a most important problem area and requires additional research.

Sampling - A third important problem area in developing proficiency measures is that of sampling. The content of a proficiency test used to evaluate training must accurately reflect the objectives of training, and the extent to which it does is a measure of its content validity. There are some highly repetitive jobs where it is possible to obtain proficiency measures on the total universe of job behaviors. In most military jobs, however, the variety of component tasks involved and the range of conditions under which they must be performed make this approach impossible. In these cases, it is necessary to sample in some way, and this is usually done by selecting for measurement those behaviors which are judged to be most important in successful performance on the job. Techniques in the area of sampling and the closely related problem of weighting are not well developed, and the most commonly employed method is that depending upon the judgment of experts. An excellent discussion of sampling and weighting in the development of proficiency tests is provided by Glaser and Klaus (18).

Even with the concept of sampling, however, proficiency tests which are based upon measuring performance either on the job or in simulated situations often involve excessive amounts of time. In measuring the performance of maintenance personnel, for example, a single troubleshooting problem may involve several hours. This has been one of the major reasons why written tests have been so much more popular than performance tests. It would appear that there is a need for the development of new concepts in this area. The present dilemma of excessive testing time is closely tied to the concept of grading students for the purpose of ranking them. If one accepts the fact, however, that proficiency measures at the end of training are for the purpose of evaluating the training system rather than for ranking students, other strategies may be possible which will permit adequate evaluation in much less time.

Summary:

In summary, it can be said that greater attention is being given to the evaluation of training systems in terms of proficiency tests which are criterion-referenced. Developing such proficiency tests involves problems in three areas -- measurement, relevance, and sampling. A rather well developed technology is available to support the development of tests which satisfy basic measurement criteria. Relevance can be assured by measuring proficiency on the job or in simulated job situations or by measuring behavior which has been shown to correlate with proficiency on the job. It would appear that proficiency measures taken of simulated job performance offer the most promise, but more information is needed on how to specify the degree of simulation required to assure relevance. Techniques for sampling behavior to include in proficiency tests are not well developed. New concepts are required to reduce the time which performance tests require.

PROMISING RESEARCH AREAS

The previous sections of this paper have discussed the status of the technology which bears on training the military man to perform effectively. It has been seen that a considerable body of systematic knowledge and techniques does exist, and that it is growing rapidly. We have by no means reached the decelerating portion of the curve, however, and future research and development may be expected to produce substantial gains in training efficiency. What are some of the areas in which further improvements would make major contributions to the training of military personnel? A general discussion of new ideas, techniques, and procedures in the field of training and training research has been provided by Smode (41). My purpose here is to single out for brief discussion several areas which appear to be especially promising. Before doing this, however, it would be well to mention again that information which is available is not being applied in many areas of military training. Significant, and in some cases, large, improvements in training efficiency could be achieved by using what we already know. Therefore, it would appear that a study of the problems and processes of applying the currently available technology would have high potential payoff.

Task Classification:

The earlier portions of this paper have made clear the basic importance of a task taxonomy to the development of training systems.

No rigorous science of behavior in instructional situations will be possible until we have made much more headway on the problem of classifying the tasks on which instruction is given. What is needed is a task classification scheme such that membership in a class will be related to the applicability of principles of training. The availability of such a classification system would be a major advance in the technology of training. It seems likely that it will be a long time before such a system is available. A note of encouragement is seen, however, in the increased interest which has been demonstrated in this problem during the past few years. A number of tentative classifications applicable to limited areas have been proposed: Fitts (11) for perceptual-motor skills; Miller and Folley (34) and Hoehn (21) for electronic maintenance tasks; and Smode, Gruber, and Ely (43) for operator tasks in weapon systems. Likewise, Fleishman's studies of perceptual-motor learning in terms of the ability requirements of tasks provides a method for task classification (12). An early project directed specifically at this problem resulted in three general classification systems based upon different approaches to the problem. These were presented at the APA Convention in 1960, and two of them have been subsequently published (30, 44). Thus, it is apparent that some interesting progress is being made in this area. What is needed now is a vigorous effort to test and evaluate the available taxonomies in terms of their reliability, validity, and heuristic power. Only then will we know whether we are on the right track or whether entirely new concepts and approaches will be required.

Individualization of Training:

The extent to which there are individual differences in learning characteristics sets a limit on the efficiency with which a group of individuals can be trained using any single training procedure. Any further increases in efficiency must be obtained by matching training procedures to the characteristics of the trainees. This problem is the counterpart of the task classification problem. Here, however, we are interested in classifying students with respect to their training characteristics. It seems quite likely to me that one of the most significant ways in which the efficiency of military training can be increased is greater use of the various devices and techniques which allow instruction to be individualized. There is some evidence to support this position. In a promising basic research study, Allison found significant relationships between learning parameters and measures of human ability (2). A few other studies have shown a relationship between training methods and aptitude differences. Theoretically, of course, any measurable differences between individuals which affect the efficiency of learning can be used as a basis for the differential programming of instruction. The general implications of this concept for training and training research have been discussed by Eckstrand (8).

Recently, the development of automated teaching devices and techniques has provided a class of teaching and training media which are capable of adapting to individual differences. However, to date these devices and techniques have involved only the most limited type of adaptability. This is perhaps not surprising in view of our lack of knowledge about the relationship between individual differences and various methods of programming training. Stolurow has recently described a concept called idiomorphic programming in which the responsiveness of the teaching system is based upon a large amount of information about the individual student (45). The effective implementation of such a system will be impossible, however, until much more information is available. This is certainly an area of research which offers high potential payoff. The importance of this research is highlighted by the rapid advances being made in computer technology and adaptive programming techniques. Electronic computers are making possible training systems with almost unlimited possibilities for responsiveness to individual differences, but we do not yet know how to make use of this potential.

Factors Outside the Training System:

As the quantity, variety, and complexity of the equipment used by the military increases, there is an increasing need for methods to reduce the cost and time for developing technically qualified personnel to operate and maintain this equipment. One way to do this is to increase the efficiency of training, and this has been the primary subject of this paper. Another approach, however, is through factors outside the training system itself which have an impact on the nature and magnitude of the training which is required. It seems likely that major reductions in training costs and time can be achieved by exerting some kind of control over the training requirements which are generated. Two areas of importance will be mentioned.

Personnel system - The personnel system in the military services has an impact on the training system in several ways. To take just one example, consider the matter of assignment at the end of training. In a recent Navy survey of Electronic Technicians, it was found that approximately one-half of the ET's serving with the fleet and about one-fourth of those ashore were not working primarily within the area indicated by their service ratings (3). Similar findings have been reported in an Army study (4). If the personnel system cannot assure that a graduate will be assigned to the job for which he was trained, the training system is required to produce a generalist rather than a specialist. This greatly increases cost and time. Thus, one area which would warrant additional research is the relationship between assignment and rotation procedures and the cost and time required for training.

Equipment design - Training requirements are, to a considerable degree, implicit in the design of the equipment which the military services develop and use. Various techniques are used to predict what training requirements are generated by new equipment so that appropriate training systems can be developed and operated. At the present time, however, very little effort is made to control training requirements by influencing the design of equipment. There is no reason, however, why this should not and could not be done. Certain operational and engineering constraints have been placed on system designers for years, e.g., weight, power, reliability, compatibility with existing facilities, etc. Logically, the same approach could be taken with respect to personnel and training requirements. In order to make this possible, however, we must develop much more quantitative information about the trainability of various kinds of tasks. The availability of such data would make it possible for training requirements to be considered and traded off with other engineering factors in the design of systems. This capability would permit a great improvement in our ability to train military men to perform effectively.

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13 ABSTRACT

This report presents a brief overview of the current status of the technology of training. The processes involved in designing a training system are arbitrarily analyzed into the following three areas: (1) determining training requirements, (2) developing the training environment, and (3) measuring the results of training. In each of these areas, an attempt is made to summarize and evaluate the adequacy of our technology. In a final section of the report, certain areas of research which appear to be especially promising are discussed.

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