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For: Harold Moon
[illegible] Associates Inc.
Caracas, Venezuela

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Memorandum

TO : O/LAB, Mr. John F. McGonagle

DATE: July 21, 1970

FROM : LAB/PED, Robert H. Wilson

SUBJECT: Resource Training Manual "A Systems Approach to Training"

Attached is a copy of a Manual that has been used as resource material in training courses for teaching materials programmers.

The Manual explains how training systems analysts and programmed instruction writers develop their materials. It presents a basic model of the systems approach as well as the fundamentals of systems, job and task analysis.

The Manual was prepared and copyrighted by Mr. Harold Moon who used it when training systems analysts and programmers for training agencies in fifteen Latin American countries. Mr. Moon has authorized translations in Spanish and French, duplication and distribution for training purposes sponsored under A.I.D. directly or in collaboration with an International Technical Assistance Agency.

Attachment

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M818 Systems Approach to Training and
Programmed Instruction. 1964.
30 p.
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1.Programmed instruction. 2. Training manuals. 3.
Instructional materials. I. Title.

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THE SYSTEMS APPROACH TO TRAINING

AND PROGRAMMED INSTRUCTION

BY

Harold L. Moon

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PREFACE

This booklet tells how we work as training systems analysts and writers of programmed instruction materials. It presents a basic model of the systems approach to training that we employ. It also presents the fundamentals of system, job and task analysis, and describes programmed instruction in relation to these broader disciplines.

An impressive body of literature exists in these areas, but most of it is written in technical language and addressed to other specialists in the field. This booklet, however, is intended for those who are trying to ferret out the fundamentals of the systems approach to training and education. We have avoided discussing details of interest only to workers in the field. Readers will find that the complications and detail they will encounter in other literature are subsumed (although not made explicit) in our models. We have tried to make the meanings of technical terms clear, either by specific definition or by unambiguous use in meaningful contexts. We believe that the technical terms used are necessary to help the reader bridge the gap between this relatively elementary presentation and advanced treatises he may wish to read later.

We are indebted to the many people who have influenced what we have said and how we have said it. It would be impossible to name all who contributed to the development of our ideas, but we must surely acknowledge debt to our former mentors and colleagues of the Human Resources Research Office (HumRRO) of The George Washington University: Robert D. Baldwin, Edgar M. Haverland, Robert F. Mager and Robert G. Smith, Jr. They greatly influenced development of the ideas expressed in Chapter I, "The Systems Approach to Training: A Model." We also wish to thank H. O. Holt, Director of Training Research, American Telephone and Telegraph Company, for his criticism of Chapter I, and Lawrence M. Matthews, Principle Associate of Stevenson, Jordan and Harrison Management Consultants, Inc., for his review of the entire manuscript. The shortcomings that remain in the booklet are, of course, solely our own responsibility.

Portions of Chapter II appeared as a "Progress Report on Programed* Instruction: I. The Basic Concept," in The Personnel Job in a Changing World, edited by Jerome W. Blood and published, 1964, by the American Management Association, New York, N. Y.

Some of the examples used in Chapter III to illustrate the purpose and products of task analysis, and the examples in the appendices, are based on various working papers prepared by staff members of the U.S. Army Air Defense Human Research Unit, HumRRO, Fort Bliss.

H. L. M.

(*) Some publishers, as in this case, prefer one "m" in the spelling of this word.

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CHAPTER I

THE SYSTEMS APPROACH TO TRAINING: A MODEL

BACKGROUND

The Evolution of Systems and the Systems Approach

We all know about systems as groups of things which function together: irrigation systems, the solar system, the nervous system, and so on. Such terms have been current in Western culture for centuries. We also know that numerous systems for achieving various purposes have evolved since the Industrial Revolution. Most of these were combinations of existing machines and of men and machines, often put together rather haphazardly. The systems approach, however, is significantly different and is a great and far-reaching development of our age. It is a set of principles which emphasize clear definition of objectives and specific design and refinement of the means of achieving the objectives. The resulting system usually is maximally effective and efficient.

The systems approach has been developed to its highest art in the defense industry (the highly complex man-machine weapon systems developed since World War II are products of the method), but it has been adapted to meet the needs of other business and industry and has been widely accepted as a part of scientific management (Neuschel, 1960). The systems approach to training is a further extension of the method to help management achieve major goals.

The Purpose of Training and Origin of the Systems Approach to Training

Training has only one legitimate purpose: to assist in achieving organizational goals by obtaining maximum job performance at the lowest possible cost.

Those who do not keep the purpose of training clearly in mind tend to indulge in fads and other activities which have no clearly defined objectives. Even when the goals are fairly clear, partially ineffective or inefficient training methods are often chosen. In all such cases, time and money are wasted.

The systems approach to training has proved to be a valuable means of determining valid training objectives and subject matter and an aid in selecting or devising the means of effective instruction. It minimizes failure and maximizes success.

The military was the first to apply the systems approach to the solution of training problems. Modern man-machine weapon systems had become so complex that improved methods of training operator and maintenance personnel were needed to assure that the systems would become reliably operational in record time. Now the process is being used in business, industry and civilian government establishments to produce effective training at lower cost.

EFFECTS OF APPLYING THE SYSTEMS APPROACH

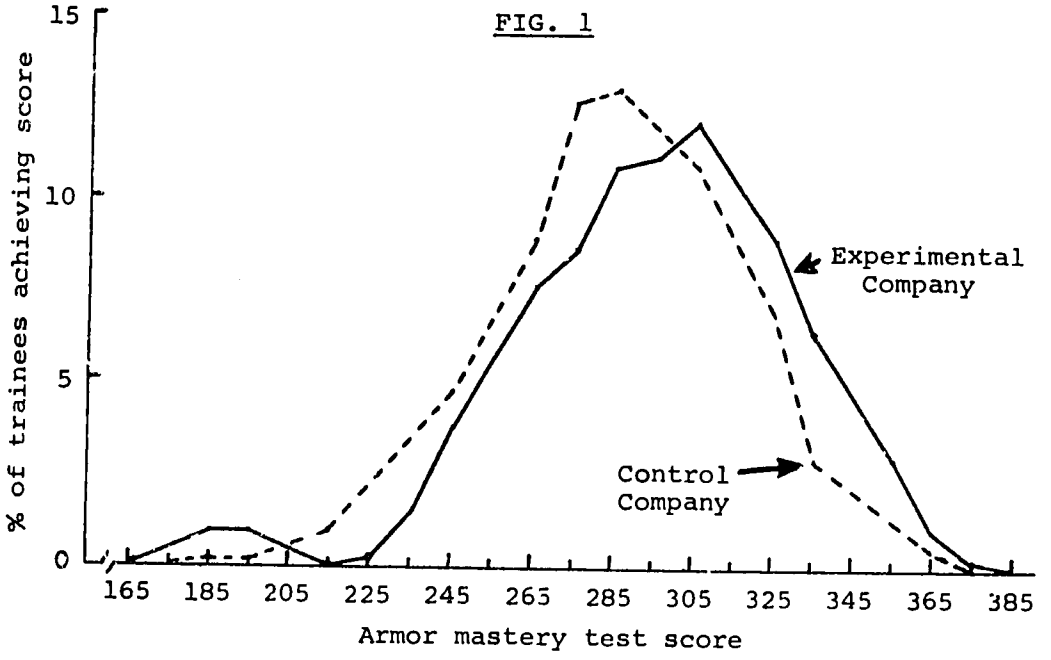
A representative example of the effects of applying the systems approach to training is an experiment performed for the Army by the Human Resources Research Office (HumRRO) of The George Washington University.

A better method of training tank gunners, drivers, and loaders was needed to remove deficiencies of armor crewmen. HumRRO researchers engineered a training system called SHOCKACTION (MacCaslin, et al., 1959). The training objectives and criterion tests were based on detailed task descriptions prepared by the researchers. Relevant subject matter was derived by task analysis.

The conventional course consumed 380 hours. Since the systems approach eliminated irrelevant subject matter and introduced more efficient instructional methods and administrative procedures, the experimental course required only 278 hours, a saving in time of 27 per cent.

In the experiment, one company of 160 men went through the experimental training system, and another company of 160 men -- comparable in aptitude, education, and other characteristics -- was trained by the conventional method. Both companies completed the training at the same time and were tested at the same time. The experimental company, although trained in two weeks less time, proved to be somewhat superior in over-all proficiency (See Fig. 1).

FIG. 1



(After MacCaslin, et al., 1959)

A comparison of the gains and costs of the two programs justified a recommendation that the experimental program be adopted for operational use.

Another example comes from industry (Holt, 1963). The American Telephone and Telegraph Company had the American Institute of Research study the problem of training outward telephone operators. Development of a new training system was recommended. The project began with an analysis of the operator's job, and the new courses and performance appraisals were based on this job information.

The training methods chosen included learning discussions, learning guides (programmed instruction), and applied practice. Since programmed instruction was used in about 50 per cent of the training and the instructor was "programmed" by a tight outline, the system was called a programmed training course.

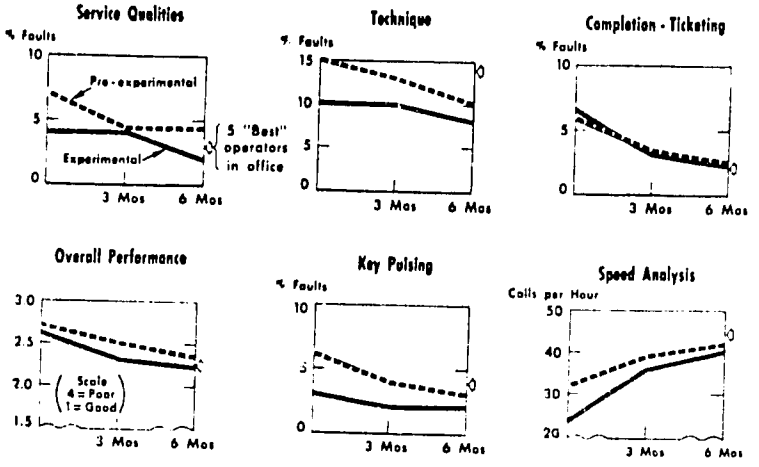
In order to compare the results of this new system with the results of conventional training, a trial was conducted in 10 different offices of operating companies in the Bell System. Before the programmed training course was begun, new operators who had just completed conventional training were evaluated by performance appraisal. Also appraised were five of the best regular operators in each of the 10 offices. The experimental trainees were appraised immediately after training. The trainees of both groups were appraised again after three months and after six months. Also, data were collected from both courses on the over-all time consumed and the amount of instructor time required.

Conventional training required an average of 13.5 days. The new system

required an average of 9.8 days, a reduction in training time of 27 per cent.

Instructor time also was greatly reduced. In the conventional course, an instructor was involved 100 per cent of the time, but only 60 per cent in the programmed training course, leaving 40 per cent free for other activities. Moreover, as Holt points out, "Average number of call conditions taught in the conventional course was 144. In the programmed training course, 160 call conditions were taught. Thus we could say that not only was the training accomplished in less time at less cost, but it also was more complete."

FIG. 2



(From Holt, 1963)

Comparisons of the performance appraisals are shown in Fig. 2. The components of performance represented by the graphs are indicated by the graph headings: Service Qualities, Technique, Completion-Ticketing, Overall Performance, Key Pulsing, and Speed Analysis.

In Holt's words, "...the dashed line indicates the P (conventionally taught) group and the solid line indicates the E (programmed training) group. An arrow marks the average performance of the 'five best' operators in the 10 offices (a total of 50 operators). Improved performance over time is indicated if the line slants down, except for speed analysis, which is the opposite."

Holt explains: "All but one of these ratings have to do with accuracy and show that the E group is consistently more accurate than the P group -- and, in fact, generally more accurate than the 'five best.' The E group was not as fast as either the P group or the 'five best,' although the difference between the groups narrows at three months and almost completely disappears at six months. (After the trial, the programmed course was strengthened in an attempt to bring up speed without losing accuracy....)"

THE SYSTEMS APPROACH AS A PROCESS

The basic process of the general systems approach consists of four major phases: analysis, design, development, and evaluation; but the specific procedures vary in each phase with the kind of system to be established.

As adapted for the solution of training problems, this model of the systems approach consists of five major phases:

1. Definition of the Input, Output, and Subject Matter.

2. Identification of the Operating Conditions and Constraints.

3. Design and Production of the Components.

4. Evaluation and Refinement of the System.

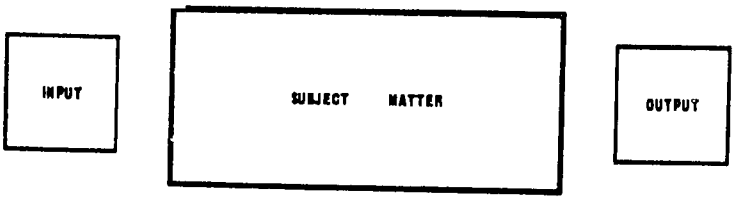
5. Operational Monitoring of the Output for Quality Control.

Following is a brief, general description of the process and product of each phase.

Definition of the Input, Output, and Subject Matter

The INPUT of a training system is the untrained person. The OUTPUT is the trained person. SUBJECT MATTER is everything the trainee must learn. These are represented in Fig. 2.

FIG. 2



The INPUT is defined by stating the characteristics of the trainees, such as sex, age, basic skills, aptitudes, level of education, motivation, attitudes toward training and toward using what they learn, and knowledge of the subject matter. If this information is not readily available, it is obtained by testing and interviewing, or it is specified as the criteria for the selection of trainees.

The OUTPUT is defined by stating precisely what the trainees must be able to do upon completion of training, the levels of proficiency desired, and the conditions under which the trained behavior must be demonstrated. These specifications are derived from the job requirements.

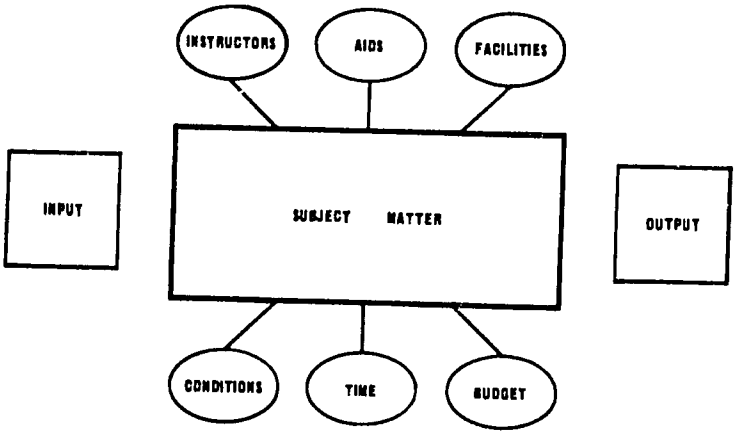
Job requirements include not only the behavior necessary to complete tasks but the job standards (the required job-competent proficiencies). If this information is not already available, it is obtained by task analysis (See "Task Description and Analysis," page 23).

The OUTPUT of a training system, as defined above, comprises the training objectives. These training objectives, in addition to being directly job-relevant, provide the advantages of allowing precise determination of course subject matter and the development of valid (job-relevant) tests. The value of such tests is discussed in the sections on "Evaluation and Refinement of the System" and "Operational Monitoring of the Output for Quality Control."

Identification of the Operating Conditions and Constraints

Before the components of a feasible training system can be designed, the conditions under which the system must operate and the constraints (limitations) on the designs must be known. These factors are illustrated in Fig. 3.

FIG. 3



To identify the OPERATING CONDITIONS, answers are sought to questions such as these:

1. How much time is available for study each day?

2. Will study be:

   - at scattered geographic locations?
   - at a central location?
   - in a supervised group?
   - with instructors available?
   - at work stations?
   - at home?
   - on idle time between job tasks?
   - on released time?
   - on over-time?
   - on their own time?

3. Will the training be mandatory or optional?

4. Will the trainees buy or be given the materials?

CONSTRAINTS on the design of the system are identified by seeking answers to questions such as these:

1. What training facilities are available?

2. What kinds and number of instructors are available?

3. What training aids are available?

4. What is the over-all training time limitation?

5. What are the administrative conditions?

6. What is the training budget?

Design and Production of the Components

A training system must receive the untrained person (INPUT) and modify his behavior to match that specified in the training objectives (OUTPUT). This must be done under the operating conditions and within the constraints on design. Consequently, the system designer must consider operating conditions and constraints along with psychological facts and theories when designing the course and lesson components of the system. He must take all these factors into account when deciding:

1. Order of the subject matter within the total system, within courses, and within lessons.

2. Method(s) of instruction; e.g., lecture, laboratory, correspondence, programmed instruction, conference, seminar, demonstration, role playing.

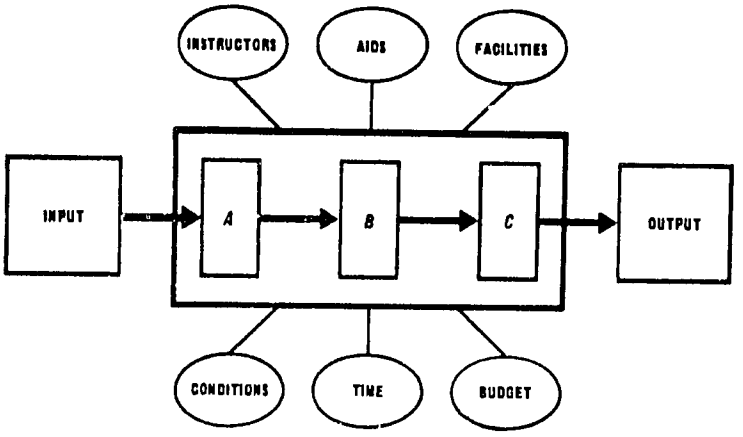
3. Format(s); e.g., texts, workbooks, manuals, audio and/or visuals, instructor guides.

4. Training aids; e.g., audio and/or visual devices, job simulators, laboratory kits.

If an instructor is to function as part of the system he may be considered a component. Instructor components are "designed" by specifying precisely how they will behave in the system. These specifications can be used for the selection of instructors or as objectives for their production through training.

When the system has been designed, the components are produced to specifications. In Fig. 4, boxes "A", "B", and "C" represent lesson components. They could, of course, represent course components.

FIG. 4



Each lesson has its own INPUT and OUTPUT specifications and its own "blueprint" (by design) to guide production.

Evaluation and refinement of the system

To evaluate a system, three kinds of tests are prepared:

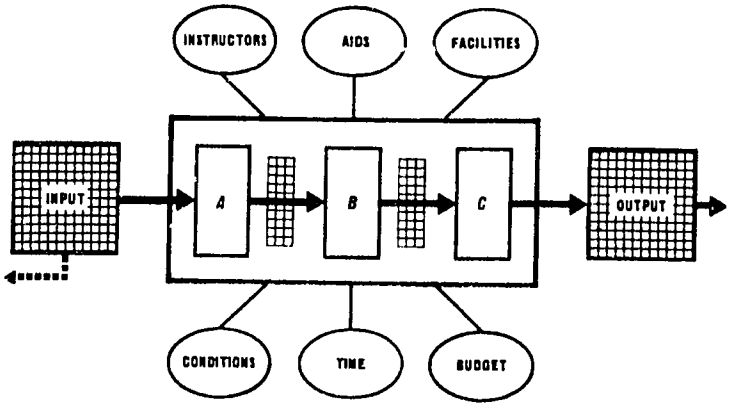
1. A prerequisite (trainee selection) test.

2. A diagnostic test for each lesson.

3. A final criterion test.

The prerequisite test is used during development of the system to assure that the trainees selected as developmental test students have the critical input characteristics for which the system was designed. In Fig. 5, this test is represented by the cross-hatching in the INPUT box. If a person does not pass this test, he is rejected, as indicated by the reverse arrow at the bottom of the box.

FIG. 5



The diagnostic tests, based on the objectives of each lesson, are used to evaluate the effectiveness of the lessons as they are developed. If a developmental student does not achieve the objectives of a lesson, the lesson is refined

6

by revision until it is effective. In Fig. 5, these tests are represented by the cross-hatched areas between lesson components "A"-"B" and "B"-"C".

The final criterion test is based on the objectives (OUTPUT) of the complete system. Each section of this test is keyed to appropriate lessons so that if the developmental students do not achieve the over-all objectives, faults can be detected in the lessons which can be corrected by further revision. In Fig. 5, the final criterion test is represented by the cross-hatching in the OUTPUT box.

Operational Monitoring of the Output for Quality Control

Quality control usually can be maintained economically in a training system by using the same tests employed in evaluating and refining the system, but in some cases it may be desirable to shorten the diagnostic tests to facilitate administration.

As much actual or simulated job performance as is feasible should be included in the final criterion test to assure validity for the purpose of monitoring the output for quality control. As an on-going check on the effectiveness of the system, the results of frequent job performance evaluations should be fed back to those responsible for training. This information is valuable for use in making possible further refinements in the system. Also, changes in job tasks or standards should be reported quickly so that the training system can be kept up to date.

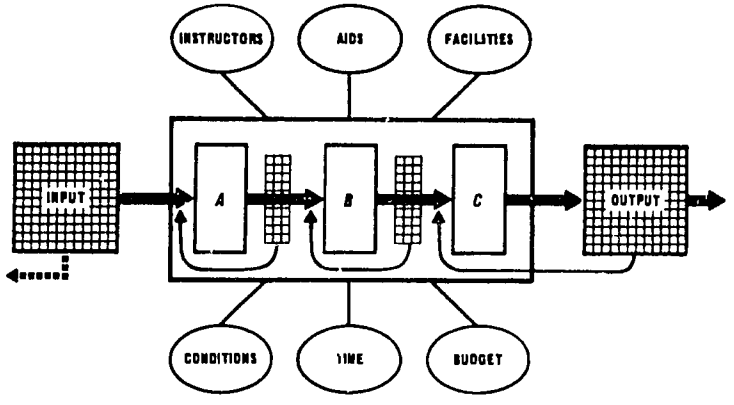
The prerequisite test is used to assure that qualified trainees are selected as the input.

The diagnostic tests are used to check the achievement of each trainee after each lesson.

The final criterion test is used to check each trainee for achievement of the over-all objectives.

If trainees fail to achieve the objectives at any point, they can be recycled, as shown in Fig. 6 by the reverse arrows extending backward from the test blocks, or be given remedial instruction or practice before they proceed in the system or are placed on the job.

FIG. 6



Failure on any test, however, indicates trouble. Perhaps the quality of the instruction has dropped. Perhaps the trainees are not applying themselves. Perhaps errors were made in trainee selection. Whatever the cause, investigation can be made and corrective measures taken to restore effectiveness and efficiency in the system.

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CHAPTER II

PROGRAMMED INSTRUCTION AND TEACHING MACHINES

THE METHOD

Some have called programmed instruction the greatest innovation in education since the invention of movable type. Others have said it will revolutionize education and training. These views may be extreme, but the method holds great promise as an educational and training tool.

Sometimes it is called programmed training, programmed learning, automated instruction, or teaching by machine (although a machine usually is not necessary), but all these terms refer to the same basic concept.

Definition

Programmed instruction is an effective means of applying the principles of efficient learning by which students and trainees learn thoroughly and rapidly. Whether the means of presenting the materials is a book, a machine, or some other device, programmed instruction incorporates these principles:

1. The subject matter is presented in small bits, or steps, arranged in psychological teaching order, and each step builds deliberately on preceding ones.

2. The trainee actively participates in the teaching-learning process by completing a sentence, answering a question, working a problem, or doing whatever is appropriate.

3. The trainee is informed immediately in each step as to whether his response was appropriate. "Right" responses are confirmed and "wrong" responses are corrected before he proceeds in the sequence.

4. The material is carefully prepared to lead the trainee into making appropriate responses.

5. Each trainee progresses at his own rate. The rapid learner is not held back and the slower learner is not left behind in confusion. All learners thoroughly comprehend the subject matter as they proceed.

These principles are not new. They have been used by master teachers at least since the time of Socrates. However, it was the work of psychologists that clearly identified the principles, and until the invention of programmed instruction there was no effective means of applying them on a large scale.

THE NOVELTY AND ADVANTAGES OF THE METHOD

The novelty of programmed instruction is in the structure of the series of steps (items or frames) called a "program," which simulates the one-to-one student-teacher interaction of the tutorial process. When a program is completed, tested, and known to be effective with a given trainee population, the instructor who prepared the materials is able, without being present, to teach all who use the program.

A program may have only a few steps or several thousand, depending on the training objectives. It may be the major instructional unit or be only a part of a unit of instruction, such as portions of a course that are difficult to teach by ordinary methods.

COMPARISONS OF TRAINING TIMES
AND TYPICAL AVERAGED PERFORMANCE SCORES
OBTAINED BY CONVENTIONAL AND PROGRAMMED INSTRUCTION

(*) Final test scores, unless otherwise indicated
(**) In weeks, days or hours, as indicated
(----) Not given, or no basis for comparison

(Sources of information are available upon request)

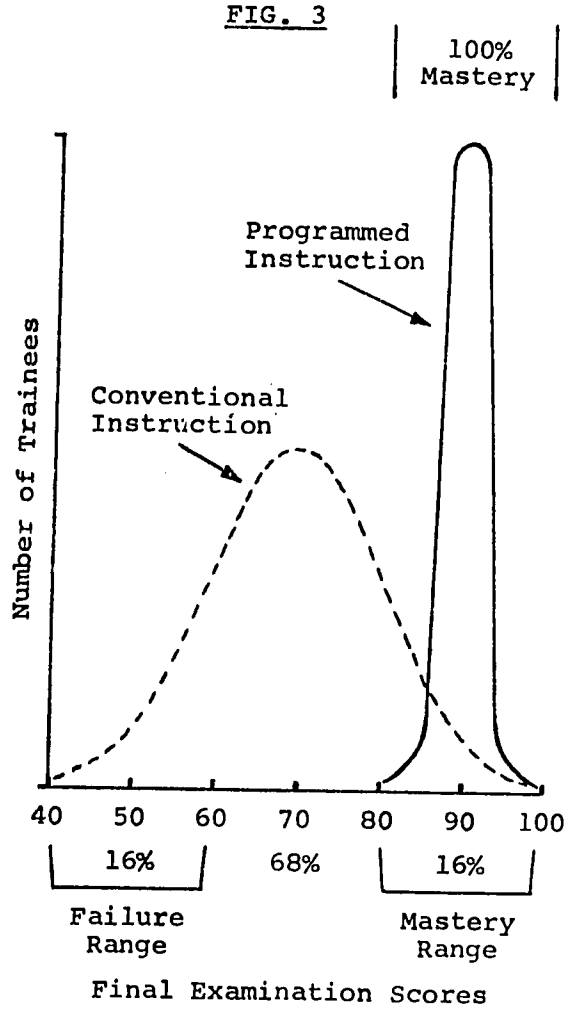
ORGANIZATION	COURSE	TRAINEES	FIG. 1 PERFORMANCE* Conventional Instruction	Programmed Instruction	Performance Gained	FIG. 2 TRAINING TIME** Conventional Instruction	Programmed Instruction	Time Saved
CHASE MANHATTAN BANK	IBM Proof Machine Operation	High School Graduates	OK for work	OK for work	----	6 days	3 days	50 %
	IBM Keypunch Machine Operation	High School Graduates	OK for work	OK for work	----	15 days	10 days	33 %
IBM	Introduction to 7070 Programming	High School Graduates	86.2 %	95.1 %	8.9 %	15 hrs	11 hrs	27 %
DU PONT	Reading Engineering Drawings	Maintenance Mechanics	81.0 %	91.0 %	10.0 %	17 hrs	12 hrs	30 %
SCHERING	Fulvecin (Product Information)	Drug Detailers	60.1 %	91.9 %	31.8 %	28 hrs	10 hrs	64 %
FEDERATED DEPT. STORES	Customer Relations & Sales Procedures	Sales Clerks	79.0 %	92.0 %	13.0 %	5 hrs	4 hrs	20 %
FIRST NATION-CITY BANK	Teller Tasks	Bank Tellers	82.9 %	86.2 %	3.3 %	3 wks	1 wk	67 %
SPIEGEL	Package Billing	High School Graduates	OK for work	OK for work	----	40 hrs	26 hrs	35 %
U.S. AIR FORCE	Department of Personnel Training	Airmen	80.0 %	86.0 %	6.0 %	420 min	200 min	52 %
CONVAIR	KIFIS-Jet Training	Experienced Flight Engineers	92.0 %	92.0 %	0.0 %	180 min	135 min	25 %

Following are the basic advantages of the method:

1. The instruction is uniform and consistent. All instructors are not equal in teaching ability. Even the best instructors have their "off days." Instructors also differ greatly in the way they present subject matter or even in the subject matter they present. With programmed instruction, all trainees learn the same thing in the same way, and management knows exactly what they are learning.

2. The quality of training is high. All trainees usually master the subject matter, although they vary in the amount of time they spend studying. Fig. 1 (opposite page) shows some typical average scores on final examinations obtained by companies using programmed instruction. Notice that most of the average scores are above 90%.

FIG. 3



What this high level of achievement means when compared with typical results obtained by conventional methods is shown graphically in Fig. 3. With conventional instruction, the range of scores is relatively great. Some fall in the failure range, most in the middle 68%, and a few in the mastery range. With programmed instruction, virtually all scores fall in the mastery range. This means that all trainees know essentially the same thing and are uniformly qualified for their jobs.

It is interesting to note that in conventional classroom methods all students study about the same amount of time. Some may miss one or more class periods because of illness, and different amounts of time may be spent on homework, but in general the amount of study time is held somewhat constant. It is the amount of learning that varies. However, in programmed instruction, when students progress at their own rate, it is the amount of study time that varies. The degree of learn- is held much more constant.

3. Training time is saved. People learn faster with programmed instruction. In general, savings in time vary from 25 to 50 per cent over conventional instruction. Savings from 20 to 75 per cent have been reported. Typical examples are shown in Fig. 2.

   - The experience of a large photo-chemical firm provides a striking though atypical example of both increased quality and time saved. Technicians were to learn to use a new data collection system which employed IBM cards. One group was trained by conventional methods and performed at the 15-per-cent error level at the end of training. At this error level the system could not operate. This group required about seven months to reach the two-per-cent error level. Those trained by programmed instruction reached the one-per-cent error level after one week.

4. Individuals can be trained. This means that those responsible for training do not have to wait until a group accumulates, fast learners can be placed

on the job sooner, and those who would ordinarily miss classroom sessions because of illness do not miss anything -- they pick up where they left off and go on to master the subject matter.

5. Training can be decentralized. In many instances, self-sufficient programs can be used effectively at widely scattered locations without instructors. This not only reduces or eliminates the cost of bringing trainees to and maintaining them in a centralized training situation, it makes it possible to accomplish training that otherwise could not be done.

   - For example, oil companies in the service station business have not been able to effectively help their dealers train station personnel. Now, Humble Oil & Refining Company has provided a programmed instruction basic training course that dealer Driveway Salesmen can take in about 10 hours by a teaching machine. Additional film strips for use in the machine are being supplied on how to sell tires, motor oil, and gasoline, and how to service positive crankcase ventilation valves, etc.

6. Less instructor time is needed. Since most programmed materials are studied individually, even when trainees are grouped in a classroom, instructor attention is required only a small portion of the time. This means that instructors can do more creative work with individuals or be free for other important work. It also means that more people can be trained without enlarging the training staff.

7. Most trainees like it. They usually enjoy studying at their own rate and knowing at all times "how they are doing," and are surprised and pleased as information quickly "sinks in."

THE HISTORY OF PROGRAMMED INSTRUCTION

As one might expect, programmed instruction did not suddenly burst full-blown from the head of Zeus. It evolved over the past 35 years in two main channels: university and military research and development.

In the early 1920's, Sidney L. Pressey at Ohio State University designed and built a machine for automatically testing and scoring. The device presented multiple-choice questions and would not advance until the student pressed the appropriate button. Pressey found that students tested by his machine learned significantly more than those who did not use the device. Pleased with the results, Pressey predicted that machines of his sort would revolutionize education. There probably are several reasons why little interest was aroused: Sputnik had not been launched; there was little concern about a teacher shortage; research in the psychology of learning was not as advanced as it is today; and Pressey's emphasis was on testing, not teaching.

In the military, training demands of World War II sparked the development of several devices which were quite similar to some current teaching machines, but the programs were not as well developed because the emphasis was still on testing. However, in the early 1950's Norman Crowder, who was doing training research for the Air Force, and B. F. Skinner, a Harvard psychologist, began working independently on the methods which underlie programmed instruction as it is known today. Crowder developed the branching (intrinsic) method, and Skinner developed the linear (extrinsic) method.

The Crowder method employs multiple-choice questions to test the students frequently. If a correct choice is always made, the student progresses through the program in the shortest sequence. If a wrong choice is made, he is branched to remedial instruction and given another chance. Crowder-type programming is called intrinsic because the sequence followed by the student is determined by his responses. In the Skinner linear method, the student constructs each response instead of making a choice from a set of plausible answers. The programming is

called extrinsic because all students go through the same sequence which is provided by the programmer. Steps in a Skinner linear program are much smaller than in the Crowder branching type.

Although the classical Skinner and Crowder methods seem equally effective in some areas of instruction, strict adherence to either for all purposes is awkward. Sophisticated programmers now mix the two to obtain greater flexibility and to give the students a change of pace. Modifications of the Skinner method have become so numerous that it is no longer definitive of the field to describe only the classical linear and branching models. For example, linear and branching programs now employ both constructed and choice responses or only choice responses, and there are several kinds of linear-branching techniques.

When Skinner described his method in Science in 1958, the time was right. The teacher shortages and demands for more scientists and engineers had created a favorable climate for the teaching machine. Interest spread rapidly in the military, the colleges and universities, the schools, industry and government agencies. The U.S. Office of Education, the Carnegie Corporation, the Ford Foundation and other agencies made large sums of money available for continuing research.

Within five years after Skinner's article appeared, almost every major publisher either had published or was planning to publish programs, and about 1,000 programs, ranging in quality from poor to excellent, were available from various sources (Hendershot, 1964).

APPLICATIONS OF PROGRAMMED INSTRUCTION

Use in Schools, Industry, and the Government

Many schools and colleges have adopted one or more programs and numerous others are experimenting with programmed instruction. Use in the schools, however, is lagging behind applications in industry and in government establishments.

According to a survey conducted in 1963 by AT&T training research personnel, about one third of the large companies were using the method on a regular or experimental basis and in the following manners: in formal training, 30 per cent; on-the-job training, 60 per cent; home study, 33 per cent. Such companies are AT&T, Du Pont, Eastman Kodak, IBM, National Cash Register, Quaker Oats, RCA, United Air Lines, Univac, many insurance companies, and several drug and oil companies. About 10 per cent of the large companies not using it said that they plan to do so, and most companies which have had experience with the method are expanding its use.

In the military, the Air Force is continuing to produce and use a large number of programs, and the other branches of the armed forces have followed suit to a lesser degree. Among the government agencies using the method are the Agency for International Development, the Bureau of the Census, the Bureau of Indian Affairs, the Central Intelligence Agency, the Department of Health, Education and Welfare, the Department of Labor, the Federal Aviation Agency, the General Services Administration, and others. Probably the largest single custom-tailored programmed instruction project within government is the one for training the 30,000 workers who will take the 1964 agricultural census.

Subject Areas

Some think that the effectiveness of programmed instruction is limited to subjects that usually are learned by rote. This is not true. There is nothing in the principles of the method to restrict its use, and there is no sound reason to believe that it will not prove to be flexible enough to encompass most well defined subject matters if employed with ingenuity and imagination. The question to ask is not, "Can this be programmed?" but "Should this be programmed for the

purpose of achieving our objectives?"

Primitive as programmed instruction now is, it has been notably successful in teaching subject matters as diverse as grade-school spelling, chess, appreciation of poetry, contract law, computer programming, the principles of logical trouble-shooting, many levels of mathematics, some foreign languages, and dozens of other subjects.

THE ROLE OF TEACHING MACHINES

Until 1962 the number of teaching machines being developed outnumbered the programs available to go in them. This rather odd state of affairs apparently resulted from lack of understanding by many machine developers that a program is the heart of programmed instruction. In most instances a machine is not necessary and can often be a hindrance. Since it has been demonstrated that simple book materials are as effective or, in some cases, more effective than machines as presentation devices, announcements of new machines have dropped off, and since the expected market for machines has not yet developed, only a few have actually gone into production.

One should not conclude, however, that there is no role for teaching machines, now or in the future. In some instances a machine is necessary to administer programmed instruction effectively and economically. For example, Humble Oil & Refining Company ordered development of a low-cost device using color film strips after an analysis of the training problem showed that such a device was advisable; service station trainees would not deal well with books but would interact with a machine, and use of film in cartridges avoided soiling of the programs and simplified their distribution.

If programmed instruction is to be used for developing complex motor skills, appropriate machines must be designed. An example is the SAKI Keypunch Trainer, developed by Solartron in England for Califone-Roberts Electronics Division of Rheem Manufacturing Company. There is a wide range of possibilities for special purpose devices of this sort. Many now engaged in programmed instruction also are alert to the possibilities of communicating with trainees by sensory channels other than the visual and auditory. For certain purposes, training can be maximized by providing tactile, olfactory, proprioceptive, and perhaps gustatory stimuli in devices of various sorts. Much of this has already been done in both simple and complex equipment simulators.

One of the most significant applications of programmed instruction will be by machines designed as an integral part of large man-machine systems. There are at least two such developments. One is in the Teleregister Instamatic system used by United Air Lines for reservation and flight information. Ticket agents are trained in various aspects of their job on 900 sets around the country which are linked by high-speed telephone lines to a computer in Denver.

Hughes Aircraft has designed teaching machines into airborne anti-submarine warfare equipment for the U. S. Navy. Leonard Silvern, who assisted in the design, states the advantages: "Teaching machines and performance aids can be integrated together into a system (which will) really return training to the actual job environment where it can be measured, calibrated and controlled with relation to actual job performance standards and criteria." (Silvern, 1962). Development of this kind of capability can be expected to accelerate.

It is fairly well known that experiments with computer-based teaching machine systems are being conducted -- at IBM, System Development Corporation, University of Illinois and elsewhere (Coulson, 1962). Not so well known is that the Russians are conducting similar experiments and have concluded that the use of computerized systems is feasible in U.S.S.R. training and education (Krasnaya Svezda, Dec. 1962, and Sovetskaya Kirgiziya, Jan. 1963). In this country, however, it is doubtful if these kinds of arrangements can ever be made to do enough to justify their cost.

It seems likely that more versatile computer programs will have to be developed to take advantage of computer versatility.

A feasible computerized system would have to do much more than store information, receive student responses, and control output devices. It would have to be self-organizing, learn from experience with students, and sense and respond to ever-changing subject matter and to a host of student variables. Such a system can be developed now on the basis of what we know about programmed instruction and the limitations of computers (Roe, Lyman, and Moon, 1962). Something like this must be developed soon if some of our school systems are not to break down or if the quality of education is not to suffer seriously under the burgeoning weight of students in relation to the shortage of teachers. Conventional teaching methods and programmed texts alone cannot be expected to carry the burden.

PROBLEMS CREATED BY PROGRAMMED INSTRUCTION

Despite its many advantages, programmed instruction is not a panacea for all training problems.

The over-all purpose of any training effort should be to obtain maximum job performance at the lowest possible cost. In most cases, the initial cost of programmed instruction is high. For this reason alone it should not be used indiscriminately. Other less expensive methods of instruction may be as effective, perhaps even more effective for a given purpose. Nevertheless, programmed instruction has proved that it can pay handsome returns on its investment when used appropriately. Decision as to which training tools to use should await careful analysis of the training problem, as is done in the systems approach to training.

The problems of administering programmed instruction should be considered carefully. For example, the advantage of students progressing at their own rate can become an administrative disadvantage. What will be done with those who finish early? Can they continue in other portions of training or be placed on the job without delay or without disrupting work schedules? Also, the advantage of individual training can become a disadvantage if planning does not include decisions as to where and when the trainees will study. These factors may seem minor, but they have proved to be major for some companies.

Another problem has caused much disappointment to companies that were too eager to jump on the band wagon -- the difficulty of programming. An expertly designed program appears deceptively simple, so much so that many have assumed that good programs can be produced with little training. In most cases the opposite is true. Effective programming is largely an art. It requires a high level of skill and a great amount of time, energy, and tenacity. It also requires a willingness to test the materials and to revise them again and again until desired results are obtained. Moreover, many errors can be made in the conduct of a programming project that will result in excessive production costs before the novice knows that trouble is near.

These pitfalls and others that have caused varying degrees of disappointment in applying the method have been summarized by Industrial Relations News (Feb. 1964):

- Over-reliance on teaching machines. Some companies bet on "Model-T teaching machines" and lost because the heart of programmed instruction is not the machine.

- Choice of programmers. In the early days of the technique many "self-appointed experts" entered the field in an attempt to accumulate a quick profit. Selection of a programmer on straight competetive bidding can be dangerous because the low bidder may not be a quality programmer. On the other hand, lack of purchasing know-how has, in some cases, led to an inflated value of services.

- Insufficient investment. A major programming project can go on for more than a year. This raises financial problems for the small company.

- Too much reliance on "off the shelf" programs without modification to company needs. Often these programs are not suited to the training objective.

- Failure to survey, diagnose, and distinguish training volume and needs. Programmed instruction may not have been the most economic tool with which to accomplish training.

- Over-reaction against using teaching machines. Still, some people will not respond well to the pencil and paper training. And, in many on-the-job situations physical factors in the work environment make machines advisable.

Most of these hazards can be avoided if the systems approach to training and programmed instruction is employed.

THE SYSTEMS APPROACH TO PROGRAMMED INSTRUCTION

To be effective and efficient, programming must proceed in two distinct phases: the Preparation Phase and the Construction Phase.

The process actually is the systems approach to programming, and reference will be made at appropriate points to the correspondence of steps in these two phases to the steps discussed in "The Systems Approach to Training: A Model."

In the preparation phase the problem is analyzed and the "blueprints" and specifications are prepared for use in the construction phase. In the construction phase the frames which make up the program are written and refined.

Steps in the Preparation Phase

1. The characteristics of the trainees and related factors are stated by seeking answers to questions like these:

   - Are they experienced personnel or novices?

   - What is their

     - sex?
     - range of age?
     - reading level?
     - educational level?
     - vocational or professional level?
     - aptitude?
     - attitude toward study?
     - attitude toward using what they learn?
     - self-image in relation to their jobs?

   - What do they know about the subject matter?

   - What factors can be employed in training to enhance their motivation for study and good job performance, to impress them with the value of their work, and to help them gain greater job satisfaction?

     (Stating the characteristics of the trainees and related factors constitutes definition of the INPUT of a training system.)

2. The training objectives are specified by answering these questions, with the

cooperation of a job expert:

- Precisely what must the trainees be able to do upon completion of the program?

- Under what conditions must they demonstrate the trained behavior?

- What proficiency must they have?

When job procedures are involved, these statements of terminal behavior are often reviewed by a panel of job experts in order to detect discrepancies and to standardize procedures. In many cases, standardization of procedures results in great savings in the cost of training and in continuing administration of the job.

(Stating the objectives constitutes definition of the OUTPUT of a training system.)

3. The program contents are determined by:

- Analyzing the training objectives to determine the exact subject matter (everything, both behavioral and conceptual, the trainee must learn in order to achieve the objectives)

- Specifying the subsoil or prerequisites (the knowledge and skills the trainee will bring with him to the program).

- Identifying pedagogical content (examples, illustrations, devices, and other means which will make the program most effective).

Appendix II is an example of a training objective, related subject matter and other program content, and of the form in which statements are made.

4. The study and administrative conditions are stated by answering questions such as these:

- How much time is available for study each day?

- Will study be

  - in a supervised group?
  - with an instructor available?
  - at work stations?
  - in a quiet place on company premises?
  - at home?
  - on idle time between job tasks?
  - on released time?
  - on overtime?
  - on their own time?

- Is the course mandatory or optional?

- Will the trainee buy or be given the materials?

- Who will administer the programs and give tests?

(This information constitutes identification of the operating conditions and constraints on the design of components in a training system.)

5. Lesson plans are prepared by answering these questions:

- How long should each lesson be?

- Which subject-matter sequence will be most effective within the program

and within each lesson?

- Which programming method or technique will be most effective in each lesson or in the various units of the lesson?

  (Better programmers are not committed to or biased in the direction of a particular programming method or technique. They choose or create that which they believe will be most effective in meeting each objective.)

6. The format(s) and means of presentation are chosen.

   Criteria include the training objectives, trainee characteristics, kinds of frames, kind of subject matter, length of the program, location of training, and the study and administrative conditions.

   (Lesson planning and choice of format(s) and means of presentation constitute the design of the components of a training system.)

7. Recommended procedures for administering the completed program are prepared.

   (Following these procedures constitutes operational monitoring for quality control in a training system.)

8. The results of the preparation phase are reviewed and approved by client management before the construction phase begins.

Steps in the Construction Phase

1. A diagnostic test is constructed for each lesson, and a criterion (final) examination is prepared for the entire program.

2. The frames are written for each lesson.

3. As each draft of a lesson is completed, it is reviewed by a programming editor.

4. Each lesson draft is reviewed by a subject-matter expert to be sure that the subject matter has not become distorted.

5. Each lesson and the tests are given to several trainees, one at a time.

6. After each testing experience, the lessons are revised as seems necessary to make them more effective.

7. To be sure that revisions are fully effective, each lesson and test are given to more trainees.

8. If necessary, the process of checking, testing and revision is repeated until the program is fully effective in meeting its objectives.

9. Usually a field test is appropriate to determine if the program is effective and if the administrative procedures are adequate under conditions of actual use.

   (Completion of the construction phase constitutes production of the components and the evaluation and refinement of a training system.)

Chapter III

SYSTEM, JOB, AND TASK ANALYSIS

System, job, and task analyses are performed to obtain necessary information for the design of an economical training system, for provision of appropriate job aids, and for valid job performance evaluation.

SYSTEM ANALYSIS

Definition of "System"

A system of the sort under discussion consists of men, hardware and software components which interact to accomplish a purpose through specified procedures.

Purpose of System Analysis

A system is analyzed to determine the roles of humans in the system and to identify the things and conditions with which they must be concerned.

The results provide the framework necessary for the conduct of job analyses, and information for inclusion in operation and maintenance manuals.

Performance of System Analysis

System analysis is accomplished by:

1. Identifying the kinds of jobs (positions) required by the system and the number of incumbents required in each job.
2. Determining or specifying the characteristics of persons qualified as trainees for each job (as described in "Definition of the Input..." of a training system, page 4).
3. Determining the relationships of man-machine components and man-man components.
4. Preparing system function (work flow) charts.
5. Stating administrative procedures.
6. Identifying the functions the equipments have in common.
7. Identifying normal preventive maintenance schedules, or specifying recommended schedules, such as lubrication, cleaning, tightening, checking, adjusting, and periodical parts replacement.
8. Identifying the normal maintenance requirements (scheduled and unscheduled) the equipments have in common.
9. Identifying the names and locations of equipment units and parts, and listing the catalogue numbers of parts.
10. Identifying the tools, test equipment, spares and other supplies necessary for normal equipment maintenance.
11. Evaluating the adequacy of existing manuals or designing and specifying the contents of new manuals.

JOB ANALYSIS

Purpose of Job Analysis

Job analyses are performed to:

1. Break each job into its duties and tasks.
2. Identify the working conditions for each duty and task.
3. Identify the required job standards.

The results of job analyses, together with the products of task analyses, allow the derivation of valid (job-relevant) training objectives and the preparation of criterion measures for job performance evaluation. They also provide the best bases for merit ratings, job incentives, and union arbitration.

Definitions

Duty -- a distinct major activity required of a job incumbent. A job is made up of one or more duties: e.g., the job of an auto mechanic is composed of duties such as "Tune up the engine," "Grind the valves," etc.

Task -- a work operation that constitutes a logical and necessary step in the performance of a duty:

- discrete task -- routine procedural steps.
- continuous task -- activities such as steering a car, observing equipment indicators, etc.

Working conditions -- physical and environmental conditions, such as weight loads to be lifted, vibration, noise, temperature, protective gear that must be worn, etc.

Job standards -- the required amount and quality/accuracy of work, and the acceptable time limit on performance.

Performance of Job Analysis

Job analyses and task descriptions are accomplished by interviewing one or more job experts or by observing job performance or both.

Job analyses are performed by:

1. Stating the job duties and tasks in terms of what the job incumbent does. (Appendix I is a brief example.)
2. Stating the working conditions.
3. Stating alternate tasks (other than standard procedures) which can or must be performed in case of accident, breakdown, or other predictable emergencies.
4. Stating the kinds of possible human error and how they can be avoided.
5. Identifying tasks common to two or more jobs.
6. Identifying job standards common to two or more jobs.
7. Developing task flow charts along a time baseline, to identify tasks which must be performed at or almost at the same time (time-shared tasks).

TASK DESCRIPTION AND ANALYSIS

When job analysis has identified the job duties and tasks, it is possible to break each task into its parts or elements.

Purpose of Task Description and Analysis

Tasks are described and analyzed to determine the precise subject matter -- everything behavioral and conceptual the trainee must learn in order to perform his job. The results also provide the bases for specification of job aids and for design of the training system.

Definitions

Task description -- a detailed statement of the behavioral steps required to perform a task. These behavioral steps are called task elements.

Task Analysis -- the systematic study of task behaviors (elements) to determine what physical, mental, and other psychological characteristics are required of trainees in order for them to achieve the job behaviors.

Some people consider task description and task analysis as synonymous and apply the latter term to the process of task description. However, in the process we employ, task analysis refers to the activity that is necessary to obtain accurate, detailed information for use in effective, efficient training which is not readily apparent in the task descriptions. Thus, we differentiate between the two processes even though they are often performed simultaneously.

Performance of Task Description

Task description is accomplished by:

1. Identifying the cue or cues (action determinants) which indicate (signal) that a task must be performed.

   - A cue may be a signal light or a buzzer, a spoken or written command, or a condition or time which requires the performance of an operating procedure. Cues may be of great variety and may be easy or very difficult to detect: e.g., high temperature, whether it is indicated by a guage or is felt; grinding noises which may be heard; abnormal vibrations which may be felt, etc.

2. Identifying in each task element the control or object to be activated.

   - This may be a lever, switch, knob, wheel, screw, another human, a technical manual, a job aid, etc.

3. Describing the required action upon the control or work object.

   - This may be physical, as in throwing a switch; mental-vocal, as in composing and giving an order to another person; or a combination of physical and mental activity, as in trouble-shooting.

4. Describing the condition that will exist when the correct action has been performed (that which will indicate to the job incumbent that everything is all right or that something went wrong).

   - Also described are the indications of malfunction and the alternate tasks or task elements which these cues indicate as appropriate.

5. Specifying the time allowed for performance of the elements of time-limited tasks or of tasks where time may be used as a measure of proficiency.

   - For maintenance tasks, two time standards are specified: one for the time required to perform the task itself; the other for the time required to perform the total maintenance operation, including any other necessary tasks, such as removing other equipment or components to get at the desired item.

Performance of Task Analysis

Task analysis is performed by identifying:

1. Important knowledge content in the form of an idea, statement, or self-instruction.

   - Such knowledge might be, "Never ground a hot electric conductor," or "To measure electrical resistance, the circuit must be open."

2. Perceptual requirements.

   - For example, the trainee must perceive bare wires, terminals, prongs and other objects as potential "hot electric conductors." He must also learn what a "grounding condition" is, and so on.

3. When the names and locations of objects must be known.

   - If the trainee is to relate symbols to ideas, or symbols to action, he must have a vocabulary of terms, and he must name and locate objects or stimuli.

4. When the trainee must know what to search for.

   - He must learn what classes of indicators, controls, and stimulus characteristics to look for under varying conditions in the work environment.

5. When precautions are necessary to ensure accuracy or to avoid danger to personnel, equipment, or the product.

6. When interpretation of symbols or signals is necessary.

7. When procedures must be over-learned for emergency situations not feasible to simulate.

8. When calculations must be performed.

9. When problem solving, diagnosis and trouble-shooting are required.

   - The trainee must learn:

     - to recognize a problem of a given type calling for a given method of solution.
     - what constitutes an acceptable solution.
     - what alternatives are permissible.
     - what strategies can be used.
     - what errors should especially be guarded against.

10. When inventions and improvisations are required.

11. When ideas and knowledge will simplify training of skills.

12. When specific tools and equipment must be used in performing a task.

Task Description and Analysis Forms

Many forms have been used for task descriptions and analyses; they often vary to accomodate economically the information to be derived from various kinds of jobs. Those analyses which involve complex equipment and procedures usually require more elaborate forms to provide appropriate categories for information. The precise form usually is developed or selected after the system and job analyses have revealed the complexity of the task-equipment relationships.

When task analyses are completed, the form usually is changed in order to communicate readily with those who will use the information. For this purpose we use the form shown in Appendix II. Quite often, the complete job and task analyses are prepared in that form from the outset, which saves time.

STATEMENT OF TRAINING OBJECTIVES AND SUBJECT MATTER

Training Objectives

A complete and sufficiently detailed job-task analysis reveals what must be accomplished on the job under various conditions and the standards required for job-competent performance. From this information, training objectives are derived.

In the formal training situation it is rarely feasible (in terms of budget, time, facilities, etc.) to train people to the levels of proficiency required on the job. Consequently, those activities and subject matter appropriate for formal training are selected from the total job-performance objectives. Also specified are the levels of proficiency to be achieved in formal training.

However, the objectives of formal training may be only a part of the over-all training goals. A complete training system may include many kinds of on-the-job training situations to develop the trainees to desired proficiency. If so, objectives are stated for each stage in the over-all training system. In each case the objectives are derived from the job requirements.

The Value of Valid Training Objectives

Some of the advantages of valid (job-relevant) training objectives were discussed in Chapter I, "The Systems Approach to Training: A Model." They also have great value when used for:

1. Communication with training officials and job experts;

   - for use in review, to be sure that job requirements and training objectives are exactly what is needed and wanted.

2. Communication with suppliers of training materials, job aids, and technical manuals;

   - for use as part of the precise specifications upon which suppliers will base their bids.

3. Communication with supervisors;

   - they need to know precisely what should be accomplished so that they can give both training support and administrative follow-up.

4. Communication with instructors;

   - they need to know precisely the results expected of them so that training objectives do not become twisted and the instruction does not move out of line.

5. Communication with trainees;

   - in situations where objectives are not clear, trainees spend much time in trying to find out exactly what is expected of them. Precise objectives remove uncertainty and confusion and enhance motivation to learn.

Subject Matter

Complete and detailed subject matter relevant to each task is abstracted from the task descriptions and analyses. Complete subject matter includes both the behavioral requirements and conceptual knowledge that the trainees must learn.

It is of major importance to note that all relevant subject matter is specified and that all irrelevant information is excluded. This contributes greatly to the effectiveness and efficiency of the training system.

In final form, both the objectives and subject matter are stated as in Appendix II. When the information is stated and coded in this form, it can be used for efficient communication for review in conferences (face-to-face or by telephone) or by correspondence. It also provides the exact basis on which the preparers of training materials can estimate costs; and the form constitutes the "blueprint" from which materials writers can work economically in relation to lesson-plan specifications.

CONSIDERATION OF JOB AIDS

When the training objectives and subject matter are stated in final form, consideration is given to job aids and various ways of making the information available which may reduce the amount of training required. For example, such job aids may be check lists, tables of data, nomograms, manuals, etc., which the trainees can easily be taught to use.

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APPENDIX I

EXAMPLE OF DUTY AND TASK STATEMENTS

(Electronics Technician using a TS-352 A/U Multimeter)

DUTY: 1. Measure any resistor (or between any two circuit points) and report whether it is within tolerance.

TASKS:

1.1. Attach leads to meter.

1.2. Set meter switches.

1.3. Adjust meter needle to zero.

1.4. Prepare the circuit.

1.5. Connect meter probes to the circuit or component.

1.6. Check the range for maximum accuracy.

1.7. If necessary, readjust the range selector switch and re-zero the needle.

1.8. Determine the exact value.

1.9. Interpret and report the finding.

1.10. Retire the meter.

DUTY: 2. Measure any AC voltage and report whether it is within tolerance.

TASKS:

2.1. Attach leads to meter.

2.2. Set meter switches.

2.3. Connect meter probes to the circuit.

2.4. Prepare the circuit.

2.5. Read the value.

2.6. Interpret and report the finding.

2.7. Retire the meter

(Although the task statements and sequences are similar for both duties, they are not exactly alike. Also, analysis of the tasks would reveal that most of them must be performed differently, even though at this level they are stated in the same way. For example, 1.2. and 2.2. both say the same thing, "Set meter switches," but the settings must be different in the performance of each duty.)

(Results of the analysis of tasks of Duty 1 are shown in Appendix II.)

APPENDIX II

OBJECTIVES AND SUBJECT MATTER FOR DETERMINING OHM VALUES WITH THE TS-352 A/U MULTIMETER

1. Measure any resistor (or between two circuit points) and report whether it is within tolerance (without aid or error within five minutes).

1.1. Attach leads to meter.

1.1.1. Select two leads -- one red and one black, each having a short tip on one end, and a probe or alligator clip on the other end.

1.1.2. Place the short tip of the black lead in the common jack (-DC ±AC OHMS).

1.1.3. Place the short tip of the red lead in the OHMS jack.

1.2. Set meter switches.

1.2.1. Set FUNCTION switch at OHMS.

1.2.2. If the expected value is known, turn the range selector switch (located at lower right on the meter) to the position that will place the anticipated reading in midscale on the OHMS (upper green) scale.

1.2.2.1. For a color-coded resistor, this may be done by using the color of the multiplier band to indicate the number of zeros desired in the selector switch position; e.g., if the multiplier band is yellow, this would indicate four zeros, or Rx 10000.

1.2.3. If the expected value is <u>not</u> known, turn the range selector switch to Rx 100, or to any Rx position.

1.3. Adjust meter needle to zero.

1.3.1. The meter needle must be zeroed for resistance measurements.

1.3.2. The needle must be rezeroed whenever the range selector switch is changed.

1.3.3. Short the probes by holding them securely together (or clamp the alligator clips together).

1.3.4. When the probes are shorted, the needle will deflect to the right, to or near zero on the upper row of numbers on the OHMS scale.

1.3.5. While standing directly in front of the meter scale and holding the probes together with one hand, slowly adjust the OHMS ZERO ADJ knob with the other hand until the meter needle is exactly at zero on the OHMS scale.

1.4. Prepare the circuit.

1.4.1. Turn the power off.

1.4.1.1. Recall that circuit power <u>must be off</u> when measuring resistance.

1.4.2. If necessary, open the circuit by disconnecting at least one end of the resistor.

1.4.2.1. Recall that the circuit <u>must be open</u> to measure resistance.

1.5. Connect meter probes to the resistor or the circuit.

1.5.1. Attach the black probe or clip to one wire lead of the resistor (or to one end of the circuit), scratching for contact if necessary.

1.5.1.1. Recall that polarity is <u>not</u> a factor when measuring resistance.

1.5.2. Touch the red probe to the other wire lead of the resistor (or to the other end of the circuit), scratching for contact if necessary.

1.5.3. <u>CAUTION</u>: for accuracy, not safety, do not let both hands touch the probes or resistor leads or circuit ends.

1.6. Check the range for maximum accuracy.

1.6.1. Read the needle deflection roughly on the row of numbers directly above the OHMS scale.

1.6.2. The row of numbers directly above the OHMS scale is used for <u>all</u> ranges.

1.6.3. If the reading is between 10 and 100, go to 1.8.

1.6.4. If the reading is <u>not</u> between 10 and 100, go to 1.7.

1.7. If necessary, readjust the range selector switch and rezero the needle.

1.7.1. If the reading is above 100 and the range selector switch is not at its largest value (Rx 10000), adjust the range selector switch to one or more <u>larger</u> values until the meter needle is between 10 and 100 or the largest position is reached on the selector switch.

1.7.2. If the reading is below 10, adjust the range selector switch to one or more <u>smaller</u> values until the needle is between 10 and 100 or the smallest position is reached on the selector switch.

1.7.3. Rezero the needle as in 1.3. above.

1.8. Determine the exact value.

1.8.1. While standing directly in front of the meter scale, read the value on the upper row of numbers on the OHMS scale.

1.8.2. Calculate the correct magnitude by multiplying the value shown on the OHMS scale by the multiplier indicated by the range selector switch position.

1.9. Interpret and report the finding.

1.9.1. Use the tolerance color band on the resistor as the acceptable deviation from the value indicated by the resistor color code, and report whether the determined value is within tolerance.

1.9.2. If the reading was zero, report the resistor (or circuit) as shorted.

1.9.3. If the reading was infinity, report the resistor (or circuit) as open.

1.10. Retire the meter.

1.10.1. If the meter is not to be used again soon, remove the red and black leads from the meter.

1.10.2. <u>CAUTION</u>: if the leads remain in the meter for use again soon (but not immediately), turn the FUNCTION switch away from OHMS to prevent unnecessary drain on the batteries if the probes or clips should become shorted.