AD-A039 800 NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN D--ETC F/G 5/9
INSTRUCTIONAL DECISION MAKING IN THE DESIGN OF OPERATOR TRAININ--ETC(U)
MAY 77 J F BROCK

UNCLASSIFIED NPRDC-TR-77-31 NL

1 OF 1
AD
A039800

END
DATE
FILMED
6-77

NPRDC TR 77-31

May 1977

INSTRUCTIONAL DECISION MAKING IN THE DESIGN OF OPERATOR TRAINING: AN ECLECTIC MODEL

John F. Brock

Reviewed by
F. A. Muckler

Approved by
James J. Regan
Technical Director

Navy Personnel Research and Development Center
San Diego, California 92152

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NPRDC-TR-77-31	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): INSTRUCTIONAL DECISION MAKING IN THE DESIGN OF OPERATOR TRAINING: AN ECLECTIC MODEL	5. TYPE OF REPORT & PERIOD COVERED: Final Report, FY75 - FY76
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): John F. Brock	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Navy Personnel Research and Development Center, San Diego, California 92152	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: N0001976WR68719
11. CONTROLLING OFFICE NAME AND ADDRESS: Navy Personnel Research and Development Center, San Diego, California 92152	12. REPORT DATE: May 1977
	13. NUMBER OF PAGES: 40
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

(14) (6) (9) (10) (11) (12) 44p.

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

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

18. SUPPLEMENTARY NOTES

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

Instructional decision making
Task analysis
Learning hierarchies
Behavior taxonomies
Media selection
Instructional system design

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

A review of an instructional design process for the F-14 aircrew is given. The process emphasized job-relevant learning objectives, hierarchies of learning, and prescriptions for determining instructional strategies.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

390 772

FOREWORD

This project was conducted in support of a Commander, Naval Air Systems Command (AIR-413) request to furnish instructional technology consulting support to the F-14 Aircrew Task Analysis and Training Integration Program.

The entire staff of VF-124, Miramar NAS, should be recognized for their support of this effort. Within that organization, LCDR C. Flack Logan, LCDR Jim Lang, LCDR Joel Grafman, and LT Hoot Gibson deserve special mention for their cooperation. Mr. Mike Plunkett of COMNAVAIRSYSCOM (AIR-4132D) has been consistently helpful and supportive. The San Diego staff of Veda, Incorporated, particularly Mr. George Viglotti, Mr. Thel Hookes, and Ms. Nancy Marcuse, have contributed significantly to the success of the program. Mr. John Moore, also of Veda, has made unique and significant inputs to both the project itself and to the present document.

J. J. CLARKIN
Commanding Officer

SUMMARY

Problem

Current Navy training in the flight and operation of state-of-the-art weapons systems, although adequate, falls short of what is possible through modern instructional technology.

Objective

The purposes of this effort were (1) to develop a systematic approach to the design of instruction for operators of sophisticated weapons systems and (2) to produce effective training syllabi for the aircrew of the F-14 fighter aircraft.

Approach

Specific instructional techniques and models were applied to the design of a revised F-14 aircrew training program. No particular school of thought or technique was favored. In the cace of categorizing operator tasks, selecting training media, and sequencing of instruction, innovative and original models and techniques were developed specifically for the program.

Findings

This process is not the long-sought-after, fully proceduralized instructional design system. Many of the techniques developed came strictly out of necessity, and many have been validated only to the extent that they allowed the process to continue. An extensive review of the state-of-the-art of instructional technology has produced few hard findings, but rather a number of significant guidelines for the designer of instruction.

Conclusions

1. Early results of the current program indicate that the described process is producing an effective, job-relevant training system.

2. The documentation produced by the ISD contractor will allow rapid integration of the new syllabi and a new system for computer-managed instruction.

Recommendations

1. The F-14 aircrew training syllabi should be implemented with minimum disruption of ongoing training.

2. The algorithms and decision aids developed through this program should become part of the Navy's available instructional technology resources.

3. The possibility of using part-task trainers in the F-14 training program should be thoroughly investigated.

4. The CAI options resulting from the media selection algorithms should be carefully investigated.

5. The R&D community should further study the hierarchial nature of learning.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Problem

Current Navy training in the flight and operation of state-of-the-art weapons systems, although adequate, falls short of what is possible through modern instructional technology.

Purpose

The purposes of this research were (1) to develop a systematic approach to the design of instruction for operators of sophisticated weapons systems and (2) to produce effective training syllabi for the aircrew of the F-14 fighter aircraft. This report presents one way to design job-relevant training and describes the process by which F-14 training syllabi have been revised. Specific prescriptions for instructional sequencing and categorizing behavior represent innovations (actually instructional aids) that are quantum jumps forward in instructional technology.

Background

Instructional Systems Design

The Navy is committed to the systematic design of training courses (Chief of Naval Education and Training, 1975; Scanland, 1974). The approach, which is called variously course design procedure (CDP), systems approach to training (SAT), and instructional systems design (ISD), essentially takes the training course developer from a set of job tasks through the development of behavioral objectives to the conduct of a job-relevant training program. Montemerlo and Tennyson (1976) have traced the history of what is now called ISD from its beginnings in the systems analysis technology in the 1940s (Kershaw & McKean, 1958; Hoehn, 1960) to its current status as <u>the</u> way to design training (Butler, 1967; Rundquist, 1970; Chief of Naval Education and Training, 1975). Readers interested in a complete history and bibliography of SAT are referred to Montemerlo and Tennyson (1976).

That history describes the current research and development issues in ISD:

> The fundamental issue requiring resolution is the nature of SAT (Systems Approach to Training). The original concept holds that program development cannot be proceduralized, and that it is therefore the proper domain of the expert training program designer. The second SAT concept is that training program design is proceduralized, and that manuals can be developed which are used by personnel less competent and less costly than the expert to produce equally effective training programs. The resolution of this issue created by these two conflicting concepts probably lies in their synthesis. The fully proceduralized SAT concept has no basis in existing psychological

> theory and research. Yet experience with it has shown that laymen can be productive in some aspects of training program design. The original SAT concept, which relies on the expert, provides no information on the particular skills necessary to qualify one as an expert. Hard data are needed to determine what skills are necessary and the degree of proficiency to which each is required for the accomplishment of the various steps of training program development. (Montemerlo & Tennyson, 1976, p. 13)

The question of whether or not an ISD cookbook for the training novice is a reasonable goal is unresolved. However, the requirement for efficient and effective training programs remains. To the operational fleet, the R&D issue is secondary to the critical demand for good training right now. This real-world constraint is undoubtedly a major cause of the lack of hard data supporting either an ISD cookbook for the "job expert but training novice" or a set of ISD guidelines for the "instructional design expert."

The Navy Personnel Research and Development Center (NAVPERSRANDCEN) and its predecessors have been involved in ISD-related research for more than a decade (Curran, 1966; Rundquist, 1970; Brock, DeLong, & McMichael, 1975) and aircrew training design for the last 5 years (e.g., Brock, 1976; McLachlan & Crawford, 1975). This research has primarily been the result of targets of opportunity rather than the result of a cohesive, long-term R&D program. In addition, as NAVPERSRANDCEN has conducted general training research, serendipitous inputs to an ISD model have occurred.

What has evolved is a flexible, dynamic model for the design of job-relevant training. This report will document the current status of that model.

F-14 Aircrew Training

Fighter Squadron 124 (VF-124) is the Pacific Fleet training squadron for the F-14 Tomcat fighter aircraft. The F-14 is the Navy's newest fighter aircraft and is generally conceded to represent the state-of-the-art in airborne weapons systems. Its aircrew consists of a pilot and a naval flight offier (NFO). In a gross (but explanatory) oversimplification, the pilot flies the plane and the NFO operates the weapons systems. The NFO has no flight control instrumentation in his cockpit, and the pilot has few weapon system data displays in his. There is a minimum overlap of inflight tasks. (For a general description of the F-14, see Stevenson, 1975).

Before the initiation of the work reported herein, the history of the VF-124 training program was fairly typical: Initial training design was performed by the weapons system prime contractor with assistance from the Navy test pilot/NFO community. Before the F-14 was operational, a cadre of Navy figher aircrew personnel was trained in F-14 operation by the prime contractor. This cadre then designed the VF-124 aircrew training syllabi, which have continued to evolve under the guidance of an ISD department within the training squadron.

The design process for the initial syllabi began with the functions and characteristics of the F-14 weapons system. The emphasis of the current program is to train about the F-14 rather than how to operate it.

Commander, Navy Air Systems Command (COMNAVAIRSYSCOM) therefore authorized a training program redesign effort directed at the VF-124 syllabi. Veda, Incorporated, at San Diego, California, was selected as the contractor for this effort. NAVPERSRANDCEN was requested to serve as instructional advisor to the program. One of the factors in COMNAVAIRSYSCOM's decision was that one of the weapons system subcontractors was developing a computer-managed training (CMT) system for VF-124; it was hoped that the CMT and the ISD efforts would dovetail into an efficient and effective training program.

VF-124 trains its aircrew in modern classrooms, learning carrels equipped with both tape/slide and video tape playback capabilities, three operational flight trainers (OFT), three mission trainers, a cockpit procedures trainer, one AWG-9 operational maintainance trainer,[1] and an F-14 cockpit/ejection seat trainer.

---

[1]The AWG-9 is the heart of the F-14 weapons system. It is made up of a radar, computer, and interface system with weapons and their associated displays (NATOPS, Note 1).

ANALYSIS PROCEDURES

ISD Model

The model developed and applied by Veda and NAVPERSRANDCEN in the F-14 ISD effort stems from that developed by Rundquist (1970), as modified by Brock and DeLong (1975). The model has also been influenced by Gagne (1970), Merrill (1971a), and Markel and Tiemann (1973). The model consists of the following steps in training course design:

1. Develop course mission (overall training goal).
2. Identify job tasks.
3. Establish job-entry standards.
4. Group tasks for instructional planning.
5. Develop training tasks (job task and school conditions).
6. Specify the test (add standards to training tasks).
7. Complete the objectives.
8. Organize the training by objectives (strategy).
9. Develop media, job aids, criterion tests, and other course material.
10. Conduct the course for validation.

The model also flows from a synthesis of NAVPERSRANDCEN's expertise in instructional technology and the contractor's expertise in both systems analysis and fighter aircraft weapons systems. Since the model draws on such a variety of resources without advocating any specific school, it may be termed eclectic.

Course Mission

The mission of VF-124 is:

> To provide the knowledge and skills necessary for preparing the Category I replacement pilot (RP) and the replacement Naval Flight Officer (RN) for an F-14 fleet assignment where he will be able to perform proficiently in all aspects of aircraft operation, weapons utilization, and mission accomplishment (Fighter Squadron 124, 1974).

Task Analysis[2]

Montemerlo and Tennyson (1976) state: "There is universal agreement in the SAT [systems approach to training] literature that task analysis is necessary. However, there is little agreement as to what a task analysis is" (p. 15).

No attempt is made in this report to develop the ultimate definition of task analysis. The task analysis method used in this work was a systematic

---

[2]Much of the description of the F-14 task analytic process is taken from the F-14 Pilot and NFO task inventories prepared and published for the Navy by Veda, Inc. (Note 2).

process that resulted in precise specifications for all tasks, whether cognitive or psychomotor, required by the operators to direct the weapon system to the completion of its mission.

A review of F-14 weapons system documentation was the first step in analyzing each task. Considerable data on aircrew tasking exist in the form of operating manuals, training manuals, system descriptions, engineering reports, test and evaluation reports, and fleet operational reports.

After these data were collected and organized, individual and group interviews became a key source of information and task validation. Job experts (i.e., F-14 pilots and NFOs) were interviewed in 1-hour sessions by researchers responsible for developing the task analyses. During the interviews, Veda analysts explored specific task areas with the interviewees. These job experts described the tasks they performed on varying missions and with varying aircraft configurations, and summarized their experiences (Table 1). The analysts interviewed at least three experts for each job. Additionally, analysts witnessed a limited number of actual tasks such as an aircrew performing a preflight inspection.

Table 1

Average F-14 Aircrew Interviewee Experience

Item	Average Response
Years of military service	10
Years of flight service	9
Total flight hours	2068
F-14 flight hours	175
Number of carrier deployments	2.4
Number of combat deployments	2.2
Number of carrier landings	343
Number of F-14 carrier landings	5
Months of instructor experience	29
Months of F-14 instructor experience	10.4

Note: These data are taken from Veda, Note 3.

From these procedures (data organization, interviews, observations), the F-14 aircrew task analyses were developed. What follows is a description of the end products of these analyses and their underlying assumptions.

The basic mission of the F-14 was broken down into a hierarchy of mission phases, mission elements, and first-order tasks (Figure 1).

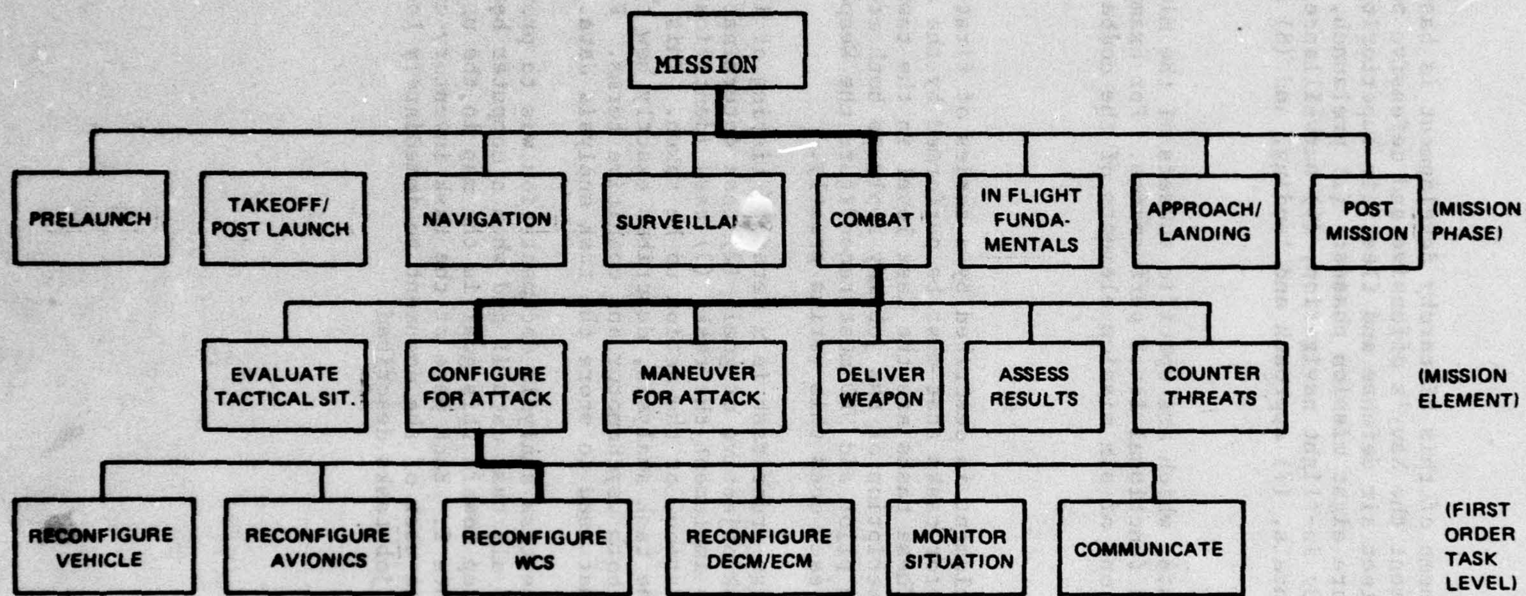


Figure 1. First-order tasks--configure for attack (Veda, Note 2).

Mission Phases

The central theme of this hierarchy development is based on the F-14's mission to augment the Navy's offensive and defensive posture, with special emphasis on fleet air defense and fleet air superiority. Within this overall mission are eight mission phases: (1) prelaunch, (2) take-off and postlaunch, (3) in-flight navigation, (4) surveillance, (5) combat, (6) in-flight fundamentals, (7) approach and landing, and (8) post-mission.

Mission Elements

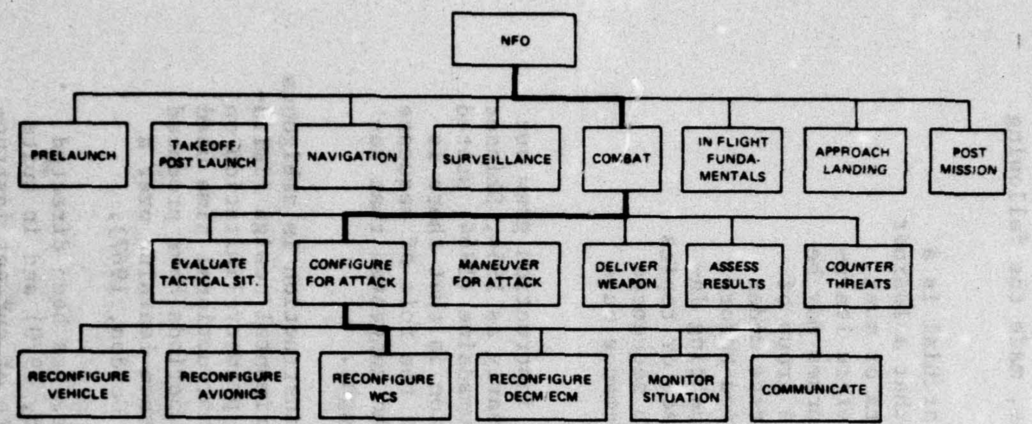
Mission elements, which are specific subsets of the mission phases, describe more detailed functional level performance. For example, "configure for attack" is one of six mission elements of the combat mission phase.

First-order Task

Each mission element is described by a series of first-order tasks--cognitive and psychomotor tasks that must be performed by the aircrew for mission completion. These tasks are the last level in the task hierarchy for which a simple description of the job may apply to both crew members. For instance, both the pilot and NFO must reconfigure the Weapons Control System (WCS), but how each does this varies greatly.

Under each first-order task is a detailed listing of its subtasks, broken down by (1) task objective or goal, (2) task determination, or the decisions necessary to implement the task, (3) task identification by code, and (4) task implementation, or the action to be taken. This last step, the lowest level in the task analysis, describes exactly how the task is to be accomplished in both psychomotor and cognitive terms. Figure 2 is an example of the format used to store the task analysis data.

One goal of the task analysis documentation was to provide for computer processing of all task data if and when a computer became available. An important step toward this goal is the map in the upper right of the example in Figure 2. Each page of the task inventory contains such a map, which allows the user of the document to immediately locate himself in the context of the job tasks described.



TASK IDENTIFICATION

NFO COMBAT CONFIGURE WCS	N NCO NCOC NCOC-3

TASK OBJECTIVE	TASK DETERMINATION	TASK I.D.	TASK IMPLEMENTATION	NOTES
Reconfigure AWG-15		NCOC-3.1.0.0		
	Determine requirements for reconfiguring AWG-15	3.1.1.0		
		3.1.1.1	Set MSL OPTIONS switch	
		3.1.1.2	Set MSL SPD GATE switch	
		3.1.1.3	Set jettison controls	
		3.1.1.4	Set NEXT LAUNCH	
Reconfigure AWG-9		NCOC-3.2.0.0		
	Determine requirements for reconfiguring AWG-9	3.2.1.0		
		3.2.1.1	Set WCS mode	
		3.2.1.2	Set collision steering switch as required	
		3.2.1.3	Set Altitude Difference Ranging (ADR) as required	
		3.2.1.4	Enter target altitude via CAP	

Figure 2. Task inventory format (Veda, Note 2).

Hierarchies and Sequences

Okey (1973), in his study of learning hierarchies, made the following observation:

> The idea that learning is cumulative or hierarchial is a common-sense notion. Intuitively one feels that a learner must master arithmetic before tackling algebra or must learn to distinguish certain letter sounds before learning to read. As a result, certain school courses may be listed as prerequisites for other courses. A group of topics may be ordered in sequence within courses under the assumption that one topic should be studied before another. Efforts have been made also at sequencing instruction on a level more detailed than courses or topics within a course. The aim has been to develop sequences of learning tasks at a level of single performance outcomes. (p. 87)

The earliest insights into optimum sequencing of instruction grew out of the postwar programmed instruction movement. As early as 1954, Skinner was suggesting the logical necessity of sequence. Lumsdaine (1964) stated that the basic assumption of any programmed instruction is that there is an ideal, or optimal, learning sequence. A review of the role of sequence in instruction can be found in Niedermeyer (1968), who suggested that sequence may not be as important as has been first thought.

Empirical support for the logical sequencing of instruction is ambiguous at best. Briggs (1968) attributed this more to experimental design limitations than to some kind of learning phenomenon. The primary limitation on instructional sequence research has been the brief instructional time used in most studies. The few studies of longer learning periods have produced positive results that show logical sequence does enhance learning over a reasonably long learning period (Payne, Krathwohl, & Gordon, 1967).

Most theoretical work in instructional hierarchies has been directed toward a taxonomy of hierarchical levels (Gagne, 1965, 1970) and in spite of ambiguous empirical support and the embryonic state of current instructional theory, most modern instructional technologists view hierarchies as necessary in the instructional design process (e.g., Gleiner & Lephene, 1975).

Researchers in the present effort determined that a hierarchical analysis of job tasks in the task inventory would (1) lead to an initial sequencing of the training course and (2) identify individual information bits that would have to be taught. This analysis basically worked backwards from the job task to a group of discrete prerequisite skill and knowledge elements. Figure 3 is an example of one such hierarchy.

Each discrete element of the hierarchy was transformed into a completely stated learning objective with specified behavior, conditions, and criteria. Each of these learning objectives, therefore, defined one test point of the yet-to-be-developed F-14 aircrew training curriculum.

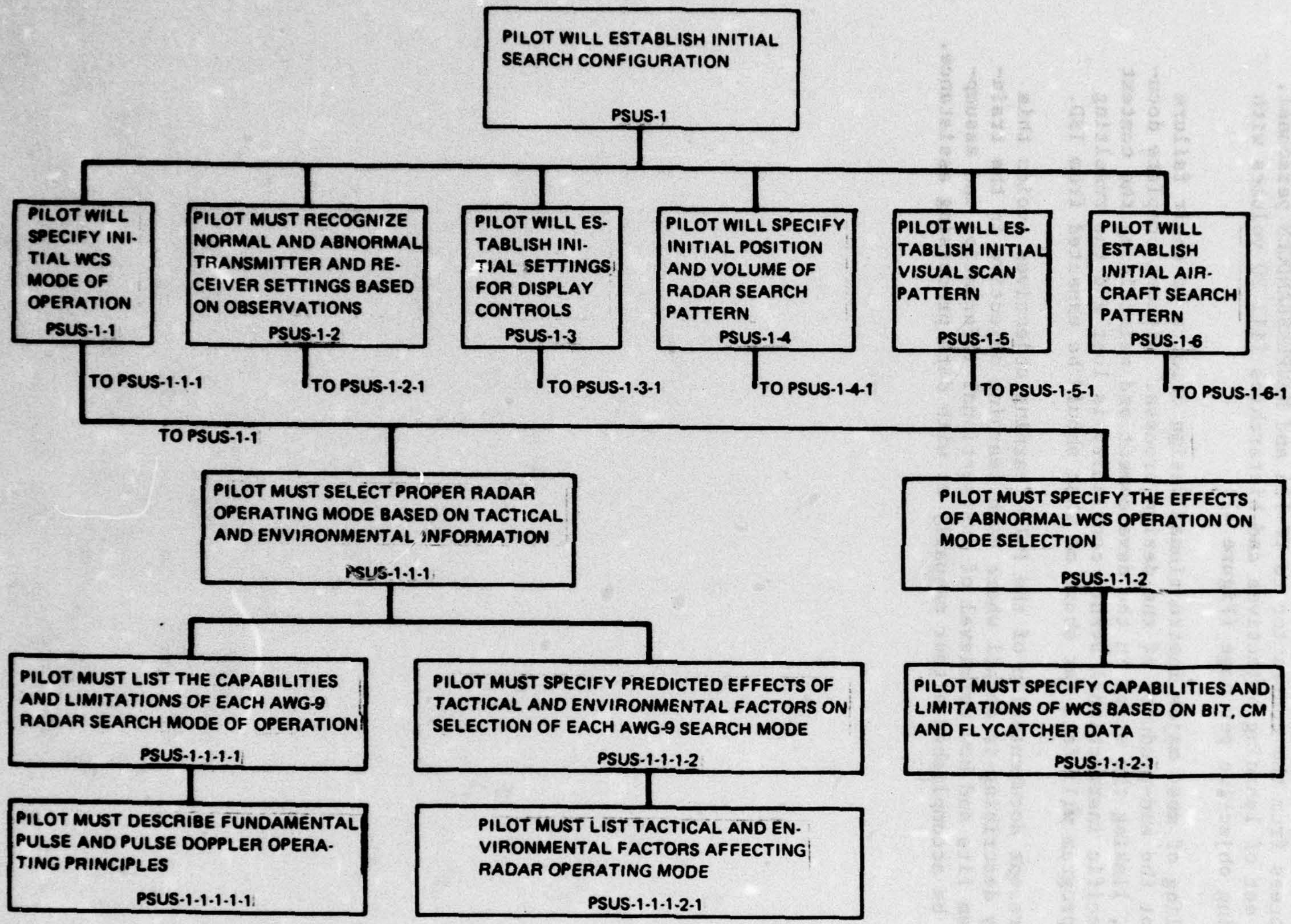


Figure 3. Example of task analysis hierarchy (Veda, Note 4).

The final learning objective hierarchies resulted from an iterative review process from the contractor to VF-124 and NAVPERSRANDCEN personnel. The final set of learning objectives and hierarchies fill 20 volumes with one learning objective per page (Figure 4).

A failing of most major instructional design efforts is their failure to document the end-products of the design process. Without complete documentation, linking the steps in the development and maintaining the context of any specific instructional event, continuity is lost and the resulting training program will fall far short of what should be expected from ISD.

The present documentation of the F-14 learning objectives avoids this pitfall by describing in detail where each learning objective in the training program fits and how retrieval of instructional information and assumptions can be accomplished either manually or with data processing assistance.

TOPIC	Optimize initial WCS search configuration	I.D.	PSUS 2.0.0.0
TASK	Optimize display configuration	I.D.	PSUS 2.1.0.0
LEARNING OBJECTIVE STATEMENT Optimize display control settings	Learning Objective Code PSUS-2-1	Task Behavioral Classification 4	Learning Type Kn. Rpt.
BEHAVIOR Pilot will optimize settings for display controls	CONDITIONS Given a dynamic F-14 display and control system and a series of problem situations, each with varied system, tactical and environmental factors		STANDARD To criterion
HIGHER ORDERED LEARNING OBJECTIVES Optimize search configuration	CODES PSUS-2	LOWER ORDERED LEARNING OBJECTIVES Display control - functions	CODES PSUS-2-1-1
TRAINING EVENT(S)			

Figure 4. Learning objective analysis worksheet (Veda, Note 4).

INSTRUCTIONAL DECISION MAKING

Job Entry Standards

As the task analysis effort was being completed and the objectives and their hierarchies were being developed, fighter squadrons (VF-1 and VF-2) returned from the F-14's first deployment. A sample of the pilots and NFOs was given the task inventories and asked to rate the importance of each task on the following seven-point scale:

1. Course graduate should be able to perform this task as rapidly and accurately as an experienced F-14 pilot/NFO.

2. Course graduate should be able to perform this task as accurately but not as rapidly as an experienced F-14 pilot/NFO.

3. Course graduate should be able to perform this task as rapidly but not as accurately as an experienced F-14 pilot/NFO.

4. Course graduate should be able to perform this task but with neither the speed nor the accuracy of an experienced F-14 pilot/NFO.

5. Course graduate should have in-depth knowledge about this task but not be able to perform it.

6. Course graduate should know about this task but not be able to perform it.

7. Course graduate should neither know about nor be able to perform this task.

Table 2 presents the distribution of ratings by four raters for the tasks in the surveillance and combat mission phases of the task inventory.

Five major findings that influenced later instructional decisions were:

1. Learning objective standards should emphasize accuracy rather than speed.

2. Approximately 15 percent of the tasks contained within the surveillance and combat mission phases require the highest level of attention (i.e., were consistently rated number one).

3. Graduating aircrews are expected to perform nearly 99 percent of the tasks in the inventory. However, slightly less than half of these tasks were rated 1, 2, or 3.

4. The surveillance mission phase is the most critical tactical area for the NFO.

5. The combat mission phase is the most critical tactical area for the pilot.

Table 2

Ratings of the Relative Importance of F-14 Combat and Surveillance Tasks

Scale Category	Percentage of Tasks per Scale Category: Surveillance Phase	Combat Phase
Pilot Tasks	N = 298	N = 888
1	15	15
2	9	24
3	1	0
4	70	59
5	0	1
6	5	1
7	0	0
TOTAL	100	100
NFO Tasks	N = 1204	N = 1024
1	14	17
2	50	39
3	0	1
4	36	43
5	0	0
6	0	0
7	0	0
TOTAL	100	100

Note. Data taken from Veda, Note 3.

These data were invaluable in prescribing the initial limits of the ISD. Although very few tasks were dropped from training consideration, initial planning could (1) designate tasks that needed intensive training and (2) prescribe the criteria dimensions of the others (i.e., time, accuracy, or number of correct responses). These data gave the instructional designers the real-world requirements base from which they could construct their training program.

Learning Types

The problem of defining types of learning is a subset of the larger problem of deriving usable behavioral taxonomies, which will be discussed in some detail in the following section. However, if there is a finite, manageable number of learning types and we can discover how best to accomplish each type, instructional theory can progress.

Early learning research and theory were centered on reducing all learning to some single phenomenon. Thorndike was interested in associations and Pavlov, in reflexes. Ebbinghaus did his major work on verbal learning, Kohler concentrated on problem solving, and Hull hypothesized complex stimulus-response chains. Although fascinating, their work has been of minimal help to the classroom instructor or the designer of instructional programs.

Gagne (1965, 1970) defined eight kinds of learning that are related hierarchically: problem solving, rule learning, concept learning, discrimination learning, verbal association, chaining, stimulus-response learning, and signal learning. (For a succinct discussion of them, see Gagne, 1971.) Although Gagne was not the first theoretician to identify different types of learning, he was the first to bridge the gap between learning theory and instructional theory. He does not postulate completely different learning mechanisms, but "merely observed that learning which occurs under different conditions has different characteristics and can consequently be considered different as far as instruction is concerned" (Merrill, 1971b, p. 34).

Merrill and Tennyson (1971), after comparing Bloom (1956), Gagne (1965), and Merrill (1971b), concluded that the 10 categories of learned behavior described by Merrill comprise a superior learning taxonomic model (i.e., comes closest to describing distinct and observable learning types). Figure 5 shows Merrill's (1971a) 10 categories of learned behavior.

Emotional	**Emotional (Signal Learning)**		
Psychomotor	**Topographic**	**Chaining**	**Complex Skill**
Memorization	**Naming**	**Serial Memory**	**Discrete Memory**
Complex Cognitive	**Classification**	**Analysis**	**Problem Solving**

Figure 5. Merrill's learning types.

Gagne's original eight learning types required a strict hierarchy of types--stimulus-response preceded chaining, chaining preceded discrimination, etc. Merrill's paradigm defines four learning constructs--emotional, psychomotor, memorization, and complex cognitive--the latter three of which have self-contained hierarchies. In other words, there is an order to learning psychophysical tasks--from topographic (stimulus-response) to complex skill. However, these are not, in turn, necessarily prerequisite to memorization or complex cognitive skills.

In an interesting progression, Markle and Tiemann (1973) have further developed Merrill's model. Essentially, the Markle and Tiemann model (Figure 6) adds a third dimension to the Merrill model and employs a more useful vocabulary. For example, the idea of algorithmic sequences is immediately understandable to the operator of a state-of-the-art weapon control system. Likewise, the concept of kinesthetic repertory is quickly grasped by the pilot of a high-performance aircraft.

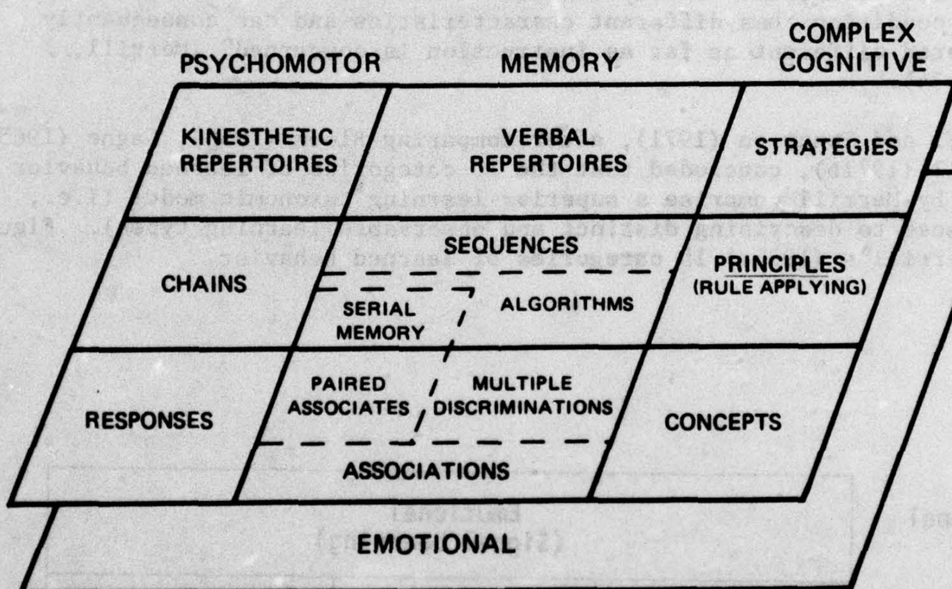


Figure 6. Markle's and Tiemann's learning types.

The next step, once the decision was made to use the Markle and Tiemann model, was to bridge the gulf between the pilot and NFO behaviors in the aircraft and the more abstract learning types.

Task Category System[3]

Ever since Bloom (1956) published his Taxonomy of Educational Objectives, instructional theoreticians and researchers have carried on the search for some way to classify human behavior into discrete categories. If a set of behaviors falls into a particular category, then research into training of that particular category can yield usable generalizations with real world applications. It has been 20 years since Bloom first published his cognitive domain taxonomy and the goal of a generalizable taxonomy remains as elusive as ever.

A taxonomy implies that man's behavior--at least the part that is of concern to the trainer--is discrete; that is, it can fit into some finite number of classifications. Invariably, however, taxonomies of behavior tend to be situationally specific (e.g., Miller, 1969) or directed toward a manageable domain, like psychomotor (e.g., West, 1957) or cognitive (e.g., Bloom, 1956). Looking for the ultimate behavior taxonomy is like looking for the ultimate hammer--it is better to let the task determine the tool.

In reducing the jobs of the F-14 aircrew into discrete tasks, a continuum of job task behavior was perceived. At one end is a group of tasks that are singular responses to specific system stimuli; and at the other end, tasks requiring unique responses to the aircraft's environment. The former have been designated "reactive behavior" and the latter, "decision behavior." The "reactive" end of the scale is very functional and emphasizes the machine system stimulus. The "decision" end of the scale is highly cognitive and emphasizes the performing human.

Table 3 shows the task behavior scale and its seven discrete categories; Figure 7, the continuous scale from which the categories are derived; and Figure 8, an algorithm that was developed to assign tasks into appropriate categories.

Although the influence of Gagne (1970) on the categories is apparent, it must be emphasized that these operator behavior categories are not analogous to Gagne's (or anyone else's) learning types. The categories describe system operator behavior. The type of learning that must occur to acquire the behavior follows from the categorization but there is not a one to one relationship.

The behavioral category scale is used twice in the instructional decision-making process. First, it can lead one from the operator's behavior--which is categorized first--to a designation of learning type. Table 4 shows the relationship of the behavioral categories to the models of Gagne, Merrill, and Markle and Tiemann. That of Markle and Tiemann was selected as the best decision aid to this instructional design effort because its language and organization most nearly relate to the operator repertoire of required skills. The point of getting to the learning types is to be able to draw upon whatever R&D data base may exist that would indicate how best to train a particular learning type. Since there is a hierarchical relationship to the learning types, instructional sequencing is also facilitated.

---

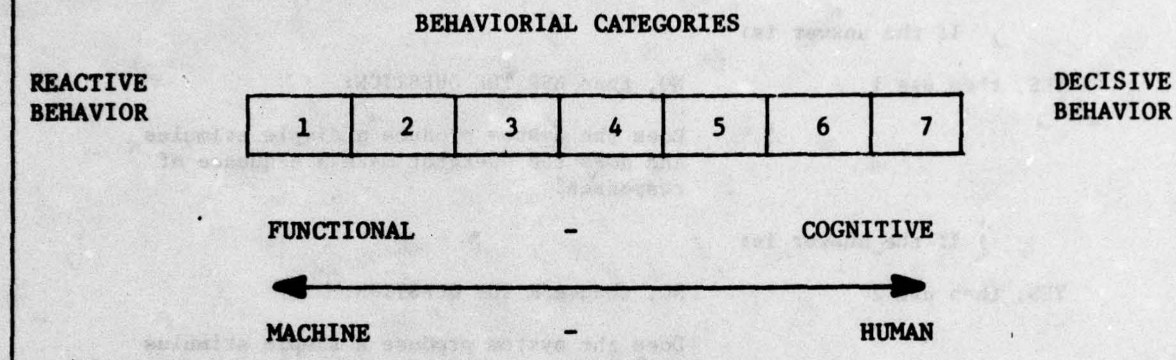
[3]Much of this section was presented in Brock (1976).

Table 3

Operator Task Behavior Categories

Type	Name	Description
1	**Stimulus Response**	**Specific operator response to a system-generated stimulus.**
2	**Sequenced Chaining**	**Specific set of operator responses initiated by a system stimulus.**
3	**Algorithmic Chaining**	**Set of operator responses initiated by a system's stimuli; each response may act as a stimulus for further responses in the chain**
4	**Interactive Chaining**	**Operator ferrets out system and environmental stimuli and makes set of responses.**
5	**Multiple Discrimination**	**Operator discriminates among system and environmental stimuli.**
6	**Concept and Rule Application**	**Operator applies concepts and rules to system and environmental stimuli.**
7	**Decision Making**	**Operator solves unique problems in the system and environment.**

***Note*. From Brock (1976).**



Each task may be described by the following behavior:

1. **A specific operator response to a system-generated stimulus.**
2. **A specific set of operator responses initiated by a system stimulus.**
3. **A set of operator responses initiated by a system's stimuli.**
4. **A situation in which the operator ferrets out system and environmental stimuli and makes sets of responses.**
5. **A situation in which the operator discriminates among system and environmental stimuli.**
6. **A situation in which the operator applies concepts and rules to system and environmental stimulus situations.**
7. **A situation in which the operator solves unique problems with system and environmental stimuli.**

Figure 7. Behavioral category for F-14 weapons system operation (Brock, 1976).

BEHAVIORAL CATEGORY	ASK THE QUESTION:
	Does the system produce a simple stimulus and does the operator make a single response?
If the answer is:	
YES, then use 1	NO, then ASK THE QUESTION:
	Does the system produce a simple stimulus and does the operator make a sequence of responses?
If the answer is:	
YES, then use 2	NO, then ASK THE QUESTION:
	Does the system produce a simple stimulus followed by an operator response (or responses) which produces a second stimulus which produces a second response, etc.?
If the answer is:	
YES, then use 3	NO, then ASK THE QUESTION:
	Does the operator actively interact with the *system and environment, attending to selected* stimuli and making appropriate responses?
If the answer is:	
YES, then use 4	NO, then ASK THE QUESTION:
	Is the operator presented with discrete sets of system and environmental stimuli and must he distinguish among them?
If the answer is:	
YES, then use 5	NO, then ASK THE QUESTION:
	Can the operator completely respond to the environmental and system stimuli by applying set rules and concepts?
If the answer is:	
YES, then use 6	NO, then ASK THE QUESTION:
	Must the operator make unique responses to an infinite combination of environmental and system stimuli?
If the answer is:	
YES, then use 7	NO, then REEVALUATE THE BEHAVIOR.

Figure 8. Behavioral category selection algorithm.

Table 4

Task Behavioral Category Relationships to Three Learning Type Models

If task behavioral category is:	Then the learning type will be: Gagne	Merrill	Markle & Tiemann
1. Stimulus-Response	Stimulus-Response	Stimulus-Response	Responses
2. Sequenced Chaining	Chaining or Verbal Association	Chaining or Serial Memory	Chains or Sequences (Serial Memory)
3. Algorithm Chaining	Same as 2	Same as 2 or Analysis	Chains or Sequences (Algorithms)
4. Interactive Chaining	Same as 2	Analysis	Kinesthetic Repertories or Verbal Repertories
5. Multiple Discriminations	Multiple Discriminations	Discrete Memory	Associations (Multiple Discriminations)
6. Concept and Rule Application	Concept Learning or Rule Learning	Classification or Analysis	Concepts or Principles (Rule Applying)
7. Decision Making	Problem Solving	Problem Solving	Strategies

The second use made of the task category scheme is in the assignment of practice and test characteristics. A high-fidelity simulator is not necessarily the best place--or even an adequate place--to practice or measure some kinds of task performance. Behavioral categories 6 and 7 appear to be best practiced and tested in a classroom or learning carrel which minimize irrelevant cues. For example, solving an intercept geometry problem is a highly cognitive skill that requires much practice. To have to develop finesse at this skill while "flying" a simulator (with all its attendant problems) is unreasonable. This type of classroom cognitive practice and test process has been successful with surface Navy officers (McCutcheon & Brock, 1971; Brock, 1972).

The tasks in categories 4 and 5 are those that require the high fidelity of a Weapon System Trainer for task practice and test (e.g., flight maneuvers for the pilot and complex search procedures for the NFO).

Categories 1, 2, and 3 will be best practiced in dynamic part-task trainers that only need to simulate key subsystem cues and responses. The kind of part-task training developed by Crawford (1976) for the S-3A Viking aircraft allows efficient practice of skills in these categories.

The behavioral category system, then, has served as a bridge between the operational system and the training system and has stimulated the development of training strategy decision aids.

Sequencing

The large-scale sequence of the training course is based on nothing more sophisticated than "fundamental before complex, single task before dual task." The Markle and Tiemann (1973) model becomes critical at the individual learning unit level for it is at this level that necessary psychological prerequisites to learning become critical.

The task analysis hierarchies described earlier (Figure 3) become the intraunit sequencing outline. The prescribed order of each hierarchy is the initial sequence of the course. However, many of the high-level F-14 aircrew learning objectives have common prerequisite skills. Finding these common prerequisites defined the low-level learning objectives that make up either pretest components or preliminary instructional modules. (The assumption that the skills that appear prerequisite are, in fact, prerequisite has not been tested; the consequences of a pilot or NFO not learning a critical skill are far too serious for such experimentation.) An algorithm developed and used by the ISD team for its intraunit sequencing decisions is shown in Figure 9.

To date, no other cases in which a learning type model such as Markle's and Tiemann's was used on a scale approaching that described herein have been found.

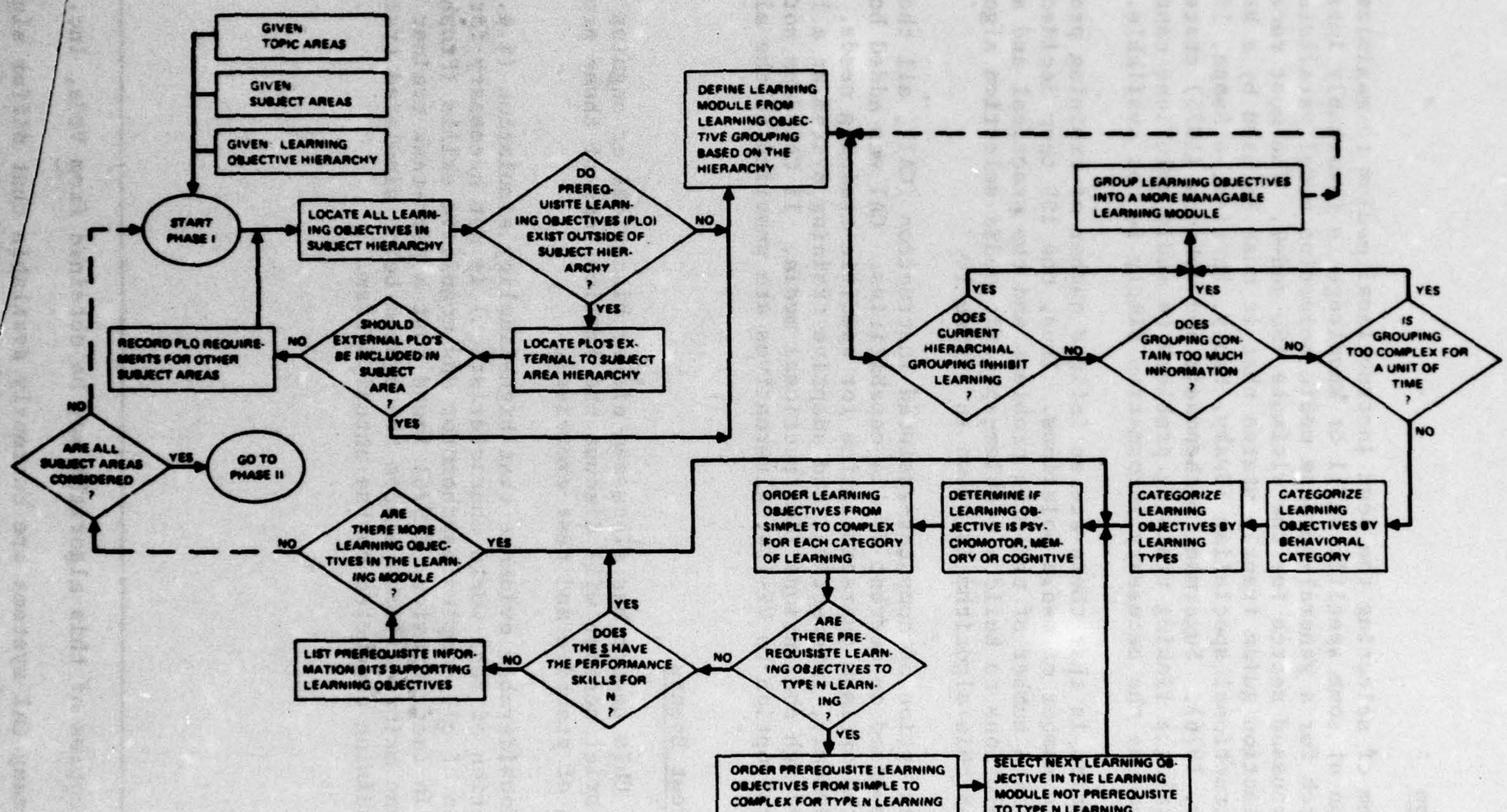


Figure 9. Instructional sequencing algorithm (Veda, Note 5).

Media Selection

The problem of selecting the best instructional medium to maximize the acquisition of some specific skill or knowledge is remarkably intractable; the search for a general-purpose media selection model parallels the previously discussed search for the ultimate ISD model. The most recent Navy media selection guide frankly states that it must be used by a knowledgeable instructional specialist (Braby, Henry, Parrish, & Swope, 1975; Aagard & Braby, 1976). Sugarman, Buckenmaeir and Johnson (1975) state that a complete catalogue linking training problems to media solutions cannot be workable because the necessary information simply is not available.

The suggestion is that there are an infinte number of training problems and an infinite number of media solutions. Thus, the ISD team decided to use its own finite number of training problems and the practical and accessible media solutions to build a problem-specific media selection algorithm. An example from this algorithm is shown in Figure 10.[4]

With the exception of computer-assisted instruction (CAI), all the media selections are based on current VF-124 capabilities. CAI was added because it describes the optimum characteristics for specific training needs. It allows for a dynamic, interactive, and adaptive training system at a level unavailable through conventional instructional media. If CAI does not become a practical option to VF-124, alternatives are provided in the algorithm.[5]

Practice and Test Events

Up to now, this report has discussed either historical or ongoing processes. This brief section will discuss the implications of these processes for the design of practice and test exercises.

There is considerable evidence that high-fidelity simulation (i.e., exact reproduction of real world characteristics) is not necessary for the acquisition of all complex psychomotor and cognitive skills (Prophet & Boyd, 1970). In fact, Crawford (1976) found that a part-task trainer that had at least one major difference from the system being simulated trained better than training conducted on the actual system.

---

[4]Complete copies of this algorithm may be obtained from Veda, Inc.

[5]Although many CAI systems are currently available that differ significantly from one another, the term is used here generically to describe an instructional delivery system with the characteristics described in the text.

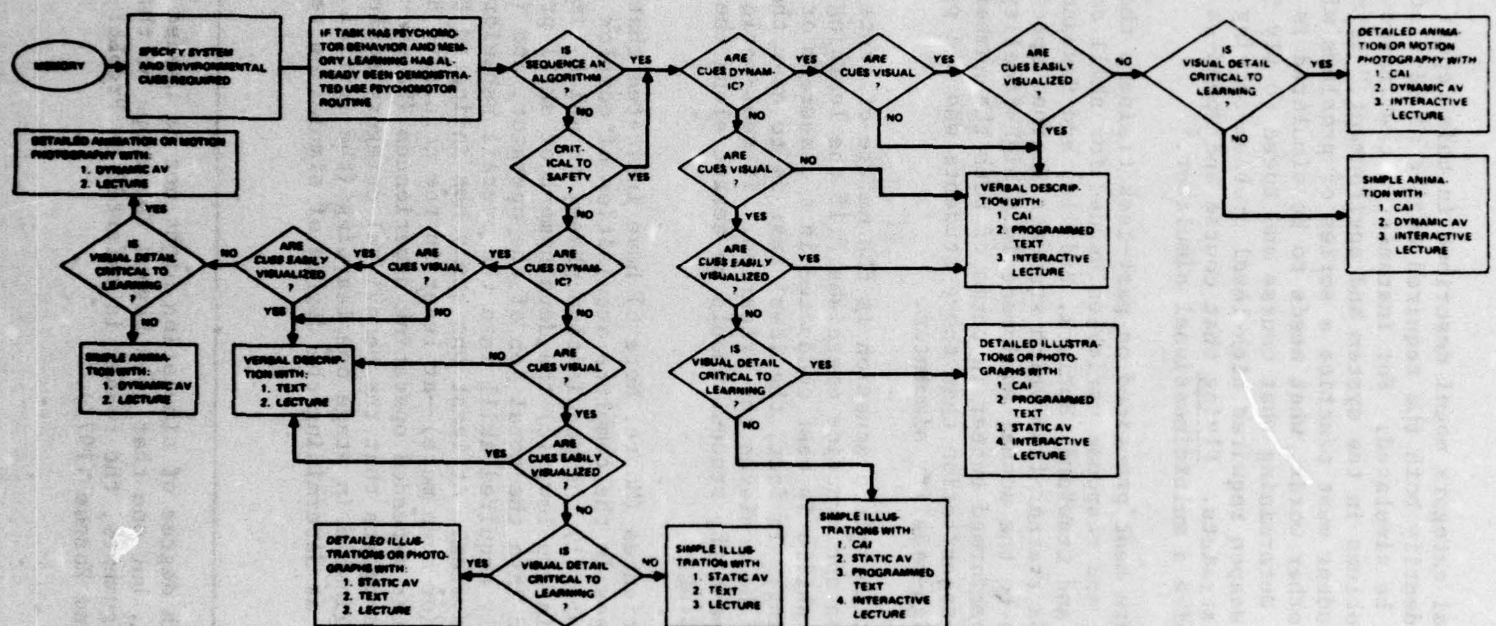


Figure 10. Example of media selection algorithms (Veda, Note 5; reprinted with permission).

The behavioral category model described in this report and in Brock (1976) can be used to identify both the required degree of simulation and the specific factors to be simulated. For instance, a task rated 7, "Operator solves unique problems in the system and environment," is the kind of task for which the student must practice a series of problems with infinite dimensions. In other words, what needs to be simulated is not hardware but situations. Determining what course and speed to fly to fire a particular kind of weapon requires high-level problem-solving under extremely limiting time restraints. Flying that course and speed--a 4 in the behavior scale--does require a multidimensional simulator.[6]

Some tasks are best practiced on part-task trainers that can simulate the specific cue and response variables needed for skill acquisition. Crawford (1976) and Crawford, Hurlock, Padilla, and Sassano (1976) have described an S-3A trainer from which students learned specific procedures and then went on to the actual equipment in a high-fidelity simulator. These students performed better in terms of both the number of problems solved and time-to-criterion than those students who had practiced exclusively in the high-fidelity simulator.

A key factor in this discussion is the nature of tests that evolve from these acquisition and practice exercises. If the learning and practice of problem-solving skills is best conducted in a classroom or learning carrel, then so is testing. In fact, the ideal test is to have the student practice each skill until he achieves the criterion. If real-world constraints prevent this, at least the student should be tested along the same dimensions he has been practicing.

Recent experiences (Moore, Note 6) have indicated that there are at least three stages in the complete acquisition of complex psychomotor and cognitive skills: (1) the acquisition phase, in which time and probably accuracy criteria are low, (2) the development of skill proficiency before it is integrated into the total job of the operator, and (3) the integration of the newly acquired skill into the overall behavioral pattern required to operate the system. At least one study has indicated that there may be a fourth level (or even more)--at least in the cognitive domain--that is reached only after extended operating experiences (Eddowes & Waters, 1976). Early evidence suggests that the behavioral category scale discussed earlier may only be applicable in stage one learning (the initial acquisition phase), at least as far as determining the degree of simulation required.

---

[6]That a high degree of simulation might not be needed even here is a very real issue, but one that goes beyond the scope of this paper. For the relevant arguments, the reader is referred to Prophet and Boyd (1970) or Provenmire and Roscoe (1971).

DISCUSSION

Much of this research was simply a review of instructional technology state-of-the-art. However, the specific algorithms and the behavioral category scale represent innovations that should have immediate application to various and dissimilar training programs. Some evidence for this conclusion has been indicated (DeLong, Note 7).

This process is not the idealized and elusive fully proceduralized instructional design system. Many of the techniques developed in this effort came of necessity, and have been validated only to the extent that they allowed the process to continue. An efficient job relevant training program is being designed, but whether or not it will ever be conducted remains to be seen.

The typical ISD team is composed of job experts and instructional specialists. In the military, the former role is taken by uniformed personnel and the latter by staff education specialists. However, in the reported effort, the contractor functioned initially as job expert and eventually as job expert, instructional designer, and documentation producer; NAVPERSRANDCEN personnel served as program consultants. The F-14 training community's time is completely dedicated to ongoing training requirements. An effort of this magnitude is simply beyond the manpower resources of an operational unit. VF-124 did have the authority to review and approve each step of the process; all steps reported herein have been so approved. Although command lines were occasionally fuzzy and some time was lost in the review process used in the present approach, it seems a reasonable approach to ongoing training programs requiring major ISD without a concurrent reduction in student load.

COMNAVAIRSYSCOM had planned that this ISD program would coincide with a computer-managed training (CMT) system being developed as a separate effort, but that CMT program failed and is no longer an available option. However, the Versatile Training System, which has previously proved successful in managing an aircraft maintenance training program is being installed at VF-124. Because of the documentation and coding system used in the ISD effort, full compatibility between the new system and the new syllabi is foreseen.

An extensive review of the current instructional technology state-of-the-art has produced few hard findings, but rather a number of significant guidelines for the designer of instruction, be he behavioral scientist or Navy Chief Petty Officer.

CONCLUSIONS

1. To stop designing training until a definitive ISD model is developed is out of the question; there may never be such a model.

2. The F-14 ISD team has proceeded from a task analysis to a syllabus outline and the evidence indicates that an effective and efficient training program is being developed.

3. The documentation produced by the ISD contractor will allow rapid integration of the new F-14 training syllabi into the Navy's Versatile Training System.

RECOMMENDATIONS

1. The F-14 aircrew training syllabi developed as described herein should be implemented with minimum interference with ongoing training.

2. The algorithms and decision aids developed on this project should become part of the Navy's available instructional technology resources.

3. The possibility of using part-task trainers in the F-14 training program should be thoroughly investigated. The potential cost savings are well worth committing seed money to such a program.

4. The CAI options resulting from the media selection algorithms should be carefully examined.

5. Begin an R&D program to study learning hierarchies. The assumption that the logically derived hierarchies are necessary to the learning process should be investigated under other than operational conditions, where the implications of a task not being learned are minimal.

REFERENCES

Aagard, J. A., & Braby, R. Learning guidelines and algorithms for types of training objectives (TAEG Report No. 23). Orlando: Training Analysis and Evaluation Group, March 1976.

Bloom, B. S. (Ed.). Taxonomy of educational objectives: The classification of educational goals, Handbook I: Cognitive domain. New York: David McKay Company, 1956.

Braby, R., Henry, J. M., Parrish, W. F., Jr., & Swope, W. M. A technique for choosing cost-effective instructional delivery systems (TAEG Report No. 16). Orlando: Training Analysis and Evaluation Group, April 1975.

Briggs, C. J. Sequencing of instruction in relation to hierarchies of competence. Pittsburgh: American Institute for Research, 1968.

Brock, J. F. Development of a task category system for the design of air crew training. Paper presented at the Fifth Psychology in the Air Force Symposium, United States Air Force Academy, Colorado, April 8-10, 1976.

Brock, J. F. Development of two models for improvement of a combat information center watch officer course: A proposal for implementation (Research Memorandum SRM 73-1). San Diego: Naval Personnel and Training Research Laboratory, 1972.

Brock, J. F., & DeLong, J. L. Design and conduct of a mechanical maintenance training program with an annual flow rate of 11,000 trainees: A review. In W. J. King & J. S. Duva (Eds.), New concepts in maintenance trainers and performance aids (NAVTRAEQUIPCEN IH-255). Orlando: Human Factors Laboratory, Naval Training Equipment Center, October 1975, 103-116.

Brock, J. F., DeLong, J. L., & McMichael, J. S. PSI + job-task analysis = effective Navy training. Educational Technology, 1975, 15(4), 28-31.

Butler, F. C., Jr. Job Corps instructional system development. Washington, D. C.: Office of Economic Opportunity, January 9, 1967.

Chief of Naval Education and Training. A plan for centralized management of instructional systems development within the Naval Education and Training Command, August 15, 1975.

Crawford, A. M. Low-cost training using interactive computer graphics. Paper presented at the Fifth Psychology in the Air Force Symposium, United States Air Force Academy, Colorado, April 8-10, 1976.

Crawford, A. M., Hurlock, R. E., Padilla, R., & Sassano, A. Low-cost part-task training using interactive computer graphics for simulation of operational equipment (NPRDC Tech. Rep. 76TQ-46). San Diego: Navy Personnel Research and Development Center, July 1976.

Curran, T. E. A task inventory for the CICWO on a combatant ship under normal steaming conditions for course design purposes (NPRA Res. Rep. 67-9). San Diego: Naval Personnel Research Activity, December 1966.

Eddowes, E. E., & Waters, B. K. Two evaluations of the effectiveness of cognitive pretraining in undergraduate pilot training (UPT): The cognitive model revisited. Paper presented at the Fifth Psychology in the Air Force Symposium, United States Air Force Academy, Colorado, April 8-10, 1976.

Fighter Squadron 124. F-14 combat readiness training syllabus, September 1974.

Gagne, R. M. The conditions of learning (2nd ed.). New York: Holt, Rinehart, and Winston, 1970.

Gagne, R. M. The conditions of learning. New York: Holt, Rinehart, and Winston, 1965.

Gagne, R. M. Learning hierarchies. In M. D. Merrill (Ed.), Instructional design: Readings. Englewood Cliffs, NJ: Prentice-Hall, 1971.

Gleiner, A., & Lephene, R. Learning is for everyone or the deline and fall of the bell-shaped curve. An interactive slide/tape presentation. Bunker Hill, PA: Bunker Hill Community College, 1975.

Hoehn, A. J. The development of training programs for first enlistment in electronic maintenance MOS's: III. How to design the handbook materials (HumRRO Research Memorandum). Fort Knox: Human Resources Research Organization, February 1960.

Kershaw, J. A., & McKean, R. N. Systems analysis and education (RM-2190-RC). Santa Monica, CA: The Rand Corporation, June 1958.

Lumsdaine, A. A. Educational technology, programmed learning and instructional science. Theories of learning and instruction. Chicago: National Society for the Study of Education, 1964, 371-402.

Markle, S. M., & Tiemann, P. W. The learning process. Chicago: Tiemann Association, 1973.

McCutcheon, R. E., & Brock, J. F. Effects of establishing a conceptualization context for learning, monitoring, and evaluating tasks (NPTRL Res. Rep. 72-4). San Diego: Naval Personnel and Training Research Laboratory, 1971.

McLachlan, J. C., & Crawford, A. M. Research and development activities and the S-3A aircrew training system. Campus, December 1975, 19-21.

Merrill, M. D. (Ed.). Instructional design: Readings. Englewood Cliffs, NJ: Prentice-Hall, 1971. (a)

Merrill, M. D. Necessary psychological conditions for defining instructional outcomes. Educational Technology, August 1971, pp. 34-39. (b)

Merrill, M. D., & Tennyson, R. D. Hierarchical models in the development of a theory of instruction: A comparison of Bloom, Gagne, and Merrill. Educational Technology, September 1971, pp. 27-31.

Miller, E. E. A taxonomy of response processes (HumRRO Tech. Rep. 69-16). Fort Knox: Human Resources Research Organization, September 1969.

Montemerlo, M. D., & Tennyson, M. E. Instructional systems development: Conceptual analysis and comprehensive bibliography (NTEC IH-257). Orlando: Naval Training Equipment Center, February 1976.

Niedermeyer, F. C. The relevance of frame sequence in programmed instruction: An addition to the dialogue. AV Communication Review, 1968, 3(16), 301-317.

Okey, J. R. Developing and validating learning hierarchies. AV Communications Review, 1973, 21(1), 87-107.

Payne, D. A., Krathwohl, D. R., & Gordon, J. The effect of sequence on programmed instruction. American Educational Research Journal, 1967, 4, 125-132.

Provenmire, H. K., & Roscoe, S. N. An evaluation of ground-based flight trainers in routine primary flight training. Human Factors, 1971, 13(2), 109-116.

Prophet, W. W., & Boyd, H. A. Device-task fidelity and transfer of training: Aircraft cockpit procedure training (HumRRO Tech. Rep. 70-10). Alexandria, VA: Human Resources Research Organization, July 1970.

Rundquist, E. A. Job training course design and improvement (2nd ed.) (NPTRL Res. Rep. 71-4). San Diego: Naval Personnel and Training Research Laboratory, 1970.

Scanland, W. Developing the instruction. Campus, April 1974, 14-16.

Skinner, B. F. The science of learning and the art of teaching. Harvard Educational Review, 1954, 24, 89-97.

Stevenson, J. P. Grumman F-14 "Tomcat". Fallbrook, CA: Aero Publishers, 1975.

Sugarman, R. C., Buckenmaier, C. C., & Johnson, S. L. SAT revisited: A critical post-examination of the systems approach to training. Proceedings of the Human Factors Society 19th Annual Meeting. Dallas: October 1975.

West, L. J. Review of research in typewriting learning with recommendations for training (AFPTRC Res. Rep. TN-57-69). Lackland AFB, TX: Air Force Personnel and Training Research Center, June 1957.

REFERENCE NOTES

1. NATOPS flight manual, Navy Model F-14A aircraft. NAVAIR 01-F14AAA-1, 1 November 1975.

2. Veda, Inc. F-14 task inventory (Pilot and NFO) VS 115U/4.582, 30 June 1975. (Available from Veda Incorporated, 7851 Mission Court, Suite 320, San Diego, California 92108)

3. Veda, Inc. F-14 aircrew task analysis methodology. VS 100U/4.582, 30 January 1975. (Available as in Note 2)

4. Veda, Inc. F-14 aircrew learning objectives (Pilot and NFO). 53033-76U/P4582, 30 April 1976. (Available as in Note 2)

5. Veda, Inc. (Available as in Note 2).

6. Moore, J. S. Personal communication, 27 July 1976.

7. DeLong, J. L. Personal communication, 30 June 1976.

DISTRIBUTION LIST

Chief of Naval Operations (OP-987H), (OP-914), (OP-964D)
Chief of Naval Personnel (Pers-10c)
Chief of Naval Research (Code 450) (4)
Chief of Naval Material (NMAT 035)
Chief of Naval Education and Training (N-4), (N-5)
Chief of Naval Technical Training (Code 016)
Chief of Naval Education and Training Support
Chief of Naval Education and Training Support (01A)
Chief of Information (OI-2252)
Commander, Naval Air Systems Command (AIR-413, PMA-241)
Commander Training Command, U. S. Atlantic Fleet (Code N3A)
Commander Naval Air Force, U. S. Pacific Fleet
Commander Naval Air Force, U. S. Atlantic Fleet
Commander, Armed Forces Vocational Test Group
Commanding Officer, Fleet Combat Training Center, Pacific (Code 00E)
Commanding Officer, Naval Aerospace Medical Insitute (Library Code 12) (2)
Commanding Officer, Naval Education and Training Program Development Center
Commanding Officer, Naval Development and Training Center (Code 0120)
Commanding Officer, Fleet Training Center, San Diego
Commanding Officer, Naval Damage Control Training Center
Commanding Officer, VF-124
Officer in Charge, Naval Education and Training Information Systems Activity, Memphis Detachment
Director, Defense Activity for Non-Traditional Education Support
Director, Training Analysis and Evaluation Group (TAEG)
Advanced Systems Division, Air Force Human Resources Laboratory, Wright-Patterson Air Force Base
Flying Training Division, Air Force Human Resources Laboratory, Williams Air Force Base
Occupational and Manpower Research Division, Air Force Human Resources Laboratory (AFSC), Lackland Air Force Base
Personnel Research Division, Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base
Program Manager, Life Sciences Directorate, Air Force Office of Scientific Research (AFSC)
Technical Library, Air Force Human Resources Laboratory (AFSC), Lackland Air Force Base
Technical Training Division, Air Force Human Resources Laboratory, Lowry Air Force Base
Army Research Institute for the Behavioral and Social Sciences
Coast Guard Headquarters (G-P-1/62)
Secretary Treasurer, U. S. Naval Institute
Military Assistant for Training and Personnel Technology, ODDR&E, OAD(E&LS)
Director of Acquisition Planning OASC(I&L)
Defense Documentation Center (12)