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ABSTRACT

A program was conducted to prepare a plan for research toward empirical determination of critical and procedures for optimal selection of cost-effective methods and media. The procedure followed was a review of pertinent literature, analysis of the findings, identification of problems for further research, and formulation of new approaches to resolution of the problems. Results fell into two categories: (1) those pertaining to methods-media definition and classification, and methods-media selection criteria and procedures, and (2) those pertaining to training cost-effectiveness and analytical procedures. The literature review yielded little of immediate value. The empirical data on the relative cost-effectiveness of methods and media are insufficient as a basis for reliable selection of methods and media for specific training tasks. (Author/CK)

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HumRRO

The State of Knowledge Pertaining to Selection of Cost-Effective Training Methods and Media

Ronald W. Spangenberg, Yair Riback, and Harold L. Moon

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Fort Knox, Kentucky
HUMAN RESOURCES RESEARCH ORGANIZATION

Work Unit SMMART

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The Human Resources Research Organization (HumRRO) is a nonprofit corporation established in 1969 to conduct research in the field of training and education. It is a continuation of The George Washington University Human Resources Research Office. HumRRO's general purpose is to improve human performance, particularly in organizational settings, through behavioral and social science research, development, and consultation. HumRRO's mission in work performed under contract with the Department of the Army is to conduct research in the fields of training, motivation, and leadership.

The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

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FOREWORD

The research done for this report by the Human Resources Research Organization is part of an overall effort under Work Unit SMMART to provide a manual for Army trainers to use in selecting the most cost-effective training methods and media for specific training tasks. This report concludes Work Sub-Unit SMMART I, the purpose of which was to prepare a research plan for other SMMART work sub-units; the research plan was prepared separately.

Research under Work Unit SMMART is being conducted by HumRRO Division No. 2 at Fort Knox, Kentucky. The Division Director is Dr. Donald F. Haggard.

Military support for the research is being provided by the U.S. Army Armor Human Research Unit. The Unit Chief is LTC Willard G. Pratt.

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Meredith P. Crawford
President
Human Resources Research Organization

SUMMARY AND CONCLUSIONS

MILITARY PROBLEM

Systems engineering of Army training programs, as defined in CONARC Reg. 350-100-1,[1] provides for systematic consideration of critical factors in developing a program. When skillfully followed, these procedures replace most of the intuitive processes previously used. Still, training systems engineering retains the rules-of-thumb usually applied for selecting cost-effective training methods and media, and Army schools have found these to be unsatisfactory. The need, as expressed by the U.S. Continental Army Command (CONARC), is for empirically based criteria and procedures for selecting the most cost-effective methods and media for specific training tasks.

RESEARCH OBJECTIVE

The objective of Work Sub-Unit SMMART I was to prepare a plan for research toward empirical determination of criteria and procedures for optimal selection of cost-effective methods and media. To determine a realistic basis for the plan, research into existing pertinent knowledge was required.

APPROACH

The procedure followed for preparation of this report was a review of pertinent literature,[2] analysis of the findings in search of useful information, identification of problems to be resolved in further research, and formulation of new approaches (where appropriate) to resolution of the problems.

RESULTS

The research results fell into two major categories: (a) those pertaining to methods-media definition and classification, and methods-media selection criteria and procedures, and (b) those pertaining to training cost-effectiveness and analytical procedures.

The literature review yielded little of immediate value. The empirical data found on the relative cost-effectiveness of methods and media are insufficient as a basis for reliable selection of methods and media for specific training tasks. Also, the existing methods-media selection procedures, training cost-analysis procedures, and suggested approaches for developing such procedures are inadequate for Army needs, although portions of some of these may be useful in developing procedures for Army use. Possible approaches for removing these inadequacies are included in the report.

[1] U.S. Continental Army Command. *Training: Systems Engineering of Training (Course Design).*
[2] See Appendices F and G.

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The State of Knowledge Pertaining to Selection of Cost-Effective Training Methods and Media

INTRODUCTION

BACKGROUND

Systems engineering of Army training programs, as defined in CONARC Reg. 350-100-1,[1] provides for systematic consideration of critical factors in developing a program. When skillfully followed, these procedures replace most of the intuitive processes previously used. Even so, training systems engineering still retains the rule-of-thumb means usually applied for selecting cost-effective training methods and media, and Army schools have found these to be unsatisfactory.

The Human Resources Research Organization proposed that research be undertaken to ultimately correct these deficiencies through development of empirically based selection criteria and procedures. This resulted in two CONARC-sponsored Work Units—MEDIA and COST—at HumRRO Division No. 2.

The primary objective of Work Unit MEDIA was to develop a method for improving media implementation to meet specific training objectives in Army training programs. Part of this work was also concerned with a procedure for selecting the most satisfactory training methods.

The primary objective of Work Unit COST was to evaluate the feasibility of a preliminary model for comparing the cost-effectiveness of training media.

Exploratory research as part of Work Unit MEDIA, which included an extensive review of the literature, showed that neither suitable guidelines nor sufficient empirical data were available from which to derive adequate criteria and procedures for the most satisfactory selection and use of methods and media. Therefore, in December 1971, after a HumRRO-CONARC conference on Work Units MEDIA and COST, the efforts of these units were combined into an expanded program of research known as Work Unit SMMART—Developing Criteria for the Selection of Methods and Media by Army Trainers.

PURPOSE AND SCOPE OF REPORT

The purpose of this report is to fulfill the first requirement of Work Unit SMMART, that is, to summarize the state-of-knowledge pertaining to the selection of cost-effective training methods and media. Relevant findings in the literature are described and problems are discussed that must be resolved in the development of reliable procedures for selecting the most cost-effective methods-media combinations and training programs. Since the report reveals many deficiencies that may be alleviated through further research, it must not be considered as a manual for use in selecting training methods and media.

The report is divided into two parts: Part I concerns methods and media selection procedures, while Part II has to do with analyses of training cost factors.

Because of the topical nature of the chapter discussions and the extensive use of the literature, the relevant references are listed at the end of each chapter. The full literature review lists, for Parts I and II respectively, are presented in the final two appendices of the report.

[1] U.S. Continental Army Command. *Training: Systems Engineering of Training (Course Design)*, CONARC Regulation 350-100-1, Fort Monroe, Virginia, February 1968.

Part I

METHODS AND MEDIA SELECTION PROCEDURES

Chapter 1

EXISTING METHODS-MEDIA SELECTION PROCEDURES

Reliable procedures for selecting the most satisfactory instructional methods and media for specific purposes seem to constitute an ultimate goal for most educational research, but the research results have yielded only meager guidelines for use in educational planning.

Despite the lack of adequate empirical data on which to base developmental efforts, several methods-media selection procedures have been devised in and out of the Army. Those procedures devised outside are summarized in Appendix A, except for one procedure that is discussed in this chapter.

Each of the procedures presented in Appendix A is for the selection of both methods and media, as any such procedure must be in order to be meaningful. Neither methods nor media, when considered apart, have any *practical* meaning, even though educators and trainers often talk and write about the two separately. No model can be used without some medium or media to implement it. Likewise, no medium can be used without some method being implemented. Therefore, if a procedure in Appendix A does not specifically indicate methods, they are always implied.

None of the several methods-media selection procedures already in existence satisfies Army requirements for the following reasons:

(1) Most selection procedures developed outside the Army were designed for use in civilian schools, and the others were based upon specific restrictive assumptions and theories that do not sufficiently apply to Army conditions. The selection procedures developed within the Army were based entirely upon the procedures intended for use in civilian schools, and they have proved to be unsatisfactory for Army situations. The reasons for the deficiencies are that many Army training requirements, such as trouble-shooting and leadership, have no counterparts in civilian education, and Army training deals with numerous other factors that differ from those in civilian education, such as time restrictions, student ages, course content, and training environments.

(2) Existing selection procedures used in civilian schools have proved to be unsuccessful even for their intended purposes. One reason for the failure is that the selection criteria used were too general, too gross for use in identifying specific media for specific purposes. As Pryluck and Snow (1) stated, instructional media are most effectively used when unique media attributes are associated with specific subject matter (teaching points) and student learning activities. None of the existing selection procedures have provided for this.

In addition to being inadequate, most existing selection procedures are too complicated, and efforts to simplify them have resulted in over-simplification, which created even greater inadequacies. A practical selection procedure should avoid both pitfalls: over-simplification, which is inadequate, and over-complication, which is too laborious.

An approach different from those in Appendix A was introduced by Walker (2). Although he is not consistent in distinguishing between methods and media, and although his list of "techniques" is incomplete and includes some of doubtful value, Walker's approach can be useful if it is thoroughly and carefully developed.

Walker first prepared a list of techniques, which included lecture, job-experience training, on-the-job training, discussion sessions, texts, television (TV), programed instruction (PI), laboratory work, audiovisual (AV) equipment, simulation, trainers, tests, hypnosis, drugs, and sleep teaching. He then listed the criteria (Table 1) to be used for methods-media selection and prepared a matrix.

Table 1

Selection Criteria for Training[a]

Selection Criteria	Percentage of Technical Training Personnel Who Mentioned These Criteria
1. TIME TO PRODUCE	100
2. NO. OF STUDENTS TAUGHT	83
3. EFFECTIVENESS OF TEACHING MOTOR SKILLS	75
4. EFFECTIVENESS OF TEACHING THEORY	75
5. AMOUNT OF DATA NEEDED TO PREPARE	75
6. COST TO TEACH	75
7. COST TO DEVELOP	75
8. FACILITIES NEEDED TO PRESENT	67
9. SPECIFIC OBJECTIVES	67
10. LEVEL OF STUDENT INTELLIGENCE	58
11. STUDENT KNOWLEDGE	58
12. Student Motivation	33
13. QUALITY OF SPECIALISTS TO DEVELOP MATERIAL	33
14. EASE OF EVALUATING STUDENTS	25
15. FACILITIES NEEDED TO PREPARE	25
16. EASE OF ADMINISTRATION	17
17. COMPLEXITY OF THE TRAINING MATERIAL	17
18. FLEXIBILITY	17
19. NO. OF INSTRUCTORS TO INSTRUCT	17
20. NO. OF INSTRUCTORS TO DEVELOP	17
21. Student Reinforcement	17
22. Student Participation	17
*23. Realism	8
*24. Transfer of Training	8
25. MANEUVERABILITY	8
26. Variety of psychological/learning processes	8
27. Student feedback	0
28. Retention	0
29. Student-paced	0
30. No. of senses stimulated	0
31. LENGTH OF COURSE	0
*32. Stimulation of the operational environment	0
33. EASE OF PRESENTATION	0
34. Competition	0

CAPITALS = management-centered items

Lower case = student-centered items

* = equally student- and management-centered items

[a]R.W. Walker, "An Evaluation of Training Methods and Their Characteristics," *Human Factors*, (2)

To determine the value of each technique in relation to each selection criterion, he asked a group of training experts to rate each technique on a scale of 1 to 5 (1 being the lowest value, and 5 the highest). All selection criteria were assumed to have the same weight (to be of equal importance). When the experts completed their ratings, Walker calculated the mean values for each technique, shown in Table 2. The result is a technique-preference index based upon the judgments of training experts.

Table 2

Selection Criteria Matrix: Mean Evaluation Ratings[a]

	TRAINING TECHNIQUES															
SELECTION CRITERIA	Lecture	Job Experience Training	On-the-Job Training	Discussion Sessions	Closed Circuit TV	Programmed Instruction	Radio, Tape or Record	Film Strip and Audio	Slides and Audio	Telephone Instruction	Sleep Teaching	Sound Films	Laboratory	Simulators	Texts	Tests
Cost to develop	3.8	3.7	4.5	4.4	1.3	2.0	2.8	2.2	2.2	2.8	2.2	1.4	2.3	1.0	2.3	3.7
Cost to teach	3.5	2.9	3.6	4.4	2.4	4.5	4.2	4.1	4.1	2.8	3.0	4.2	2.1	1.9	4.3	4.2
Realism	1.8	4.5	4.9	1.7	3.2	2.4	1.6	3.2	3.1	1.6	1.8	3.4	4.4	4.7	2.1	1.9
Student participation	2.0	4.4	4.9	3.2	1.7	4.3	1.4	1.8	1.8	2.4	2.3	1.7	4.5	4.6	3.0	3.7
Student reinforcement	2.2	4.2	4.7	3.4	1.8	4.1	1.5	1.9	1.9	2.5	2.5	1.8	4.1	4.5	2.4	3.0
Effectiveness of teaching theory	3.4	2.8	2.9	3.7	3.5	4.3	2.6	3.2	3.0	3.0	2.7	3.4	3.2	3.0	3.4	2.4
Student feedback	2.2	3.9	4.3	4.2	1.3	4.1	1.3	1.3	1.4	3.1	1.7	1.2	4.0	3.9	2.0	4.4
No. of instructors to develop	4.3	3.8	3.6	3.9	1.6	2.2	3.0	2.7	2.8	3.6	3.0	1.9	3.5	1.4	2.4	3.9
No. of instructors to instruct	3.4	3.4	3.4	3.0	3.7	4.5	4.3	4.4	4.4	3.2	4.4	4.2	3.0	2.4	4.4	3.7
Transfer of training	2.2	4.4	4.4	2.7	2.8	2.8	1.9	2.7	2.6	2.3	2.3	3.2	4.3	4.6	2.4	2.2
Maneuverability	4.5	2.1	1.8	4.3	1.7	4.7	4.0	3.9	4.0	3.2	2.9	3.9	1.5	1.7	4.7	4.6
Student motivation	2.5	4.5	4.7	3.5	3.4	3.5	2.4	3.1	2.8	2.7	2.8	3.5	4.5	4.5	1.9	2.7
Retention	2.3	4.2	4.7	3.5	2.9	3.7	1.9	2.8	2.7	2.3	2.8	3.0	4.4	4.4	2.6	2.9
Flexibility (adaptability)	4.9	3.8	4.1	4.6	2.0	1.6	1.9	1.7	2.0	4.6	2.5	1.2	2.4	1.2	1.5	3.0
Student knowledge level	3.9	2.6	3.0	3.4	3.3	4.2	2.9	3.1	3.0	3.4	3.4	3.4	2.9	2.8	3.2	2.4
Student-paced	1.6	3.2	3.8	2.8	1.2	4.7	1.6	1.9	1.9	2.6	2.1	1.2	3.8	3.6	4.5	3.4
Quality of specialists to develop material	3.1	2.7	2.8	2.9	1.5	1.9	2.6	2.4	2.4	2.5	1.7	1.7	1.9	1.3	1.8	2.8
No. of students taught	4.4	2.0	1.5	2.6	4.4	4.9	4.4	3.5	3.7	3.2	2.8	4.3	1.7	1.7	4.7	4.3
Facilities needed for preparation	4.7	3.3	3.9	4.5	1.2	3.9	2.5	2.4	2.6	3.4	2.6	1.3	2.4	1.3	3.3	4.4
Facilities needed to present	4.5	2.4	3.0	4.3	1.5	4.7	2.7	2.8	2.8	2.8	2.9	2.3	1.7	1.7	4.6	4.6
Complexity of the training material	2.4	4.2	4.3	2.8	3.0	3.5	1.7	2.8	2.8	2.3	2.4	3.0	4.1	4.3	3.2	2.1
Specific objectives needed	1.8	4.0	3.9	2.7	3.3	4.1	2.9	3.1	3.1	3.2	3.6	3.1	3.2	3.8	3.7	3.7
No. of senses stimulated	2.3	3.8	4.2	2.4	2.9	2.5	2.0	2.9	2.8	2.3	1.9	2.8	4.0	3.8	2.1	2.1
Length of course	4.4	1.7	3.0	4.3	2.3	3.9	3.8	3.7	3.5	3.6	3.1	3.5	2.7	1.2	3.4	3.6
Amount of data needed to prepare	3.8	2.9	3.4	3.8	2.5	2.0	2.7	2.5	2.5	2.8	2.7	2.0	2.5	1.5	1.7	2.8
Variety of psychological learning processes	1.6	4.3	4.8	2.7	2.1	3.3	1.5	2.3	2.3	2.0	1.6	2.3	4.3	4.2	2.1	2.7
Simulation of operational environment	1.4	4.3	5.0	1.9	3.1	1.9	1.7	2.9	2.8	1.4	1.7	3.3	4.3	4.5	1.7	1.6
Ease of presentation	3.4	2.4	2.7	3.6	2.4	4.8	3.7	2.4	3.4	2.7	3.4	3.3	2.0	1.7	4.5	4.4
Ease of administration	3.5	2.7	2.8	3.5	3.3	3.4	3.3	3.5	3.5	2.4	3.3	3.6	2.4	2.5	3.5	2.8
Time to produce	3.9	3.4	3.9	3.9	1.7	1.8	2.7	2.3	2.4	2.9	2.5	1.8	2.4	1.0	1.7	3.3
Ease of evaluating students	2.0	3.3	4.1	2.6	1.7	4.0	1.8	1.9	1.9	2.1	2.3	1.9	3.6	4.2	2.4	4.7
Student competition	1.9	3.2	3.6	4.0	1.5	2.7	1.6	1.7	1.7	2.1	1.5	1.6	3.8	4.4	1.9	4.0
Level of student intelligence	2.1	4.2	4.7	2.3	2.7	3.7	2.3	2.8	2.8	1.8	2.8	3.4	3.7	4.2	1.8	1.9
Effectiveness of teaching motor skills	1.3	4.5	4.9	1.5	2.5	1.8	1.5	2.3	2.3	1.5	1.6	2.7	4.6	4.7	1.7	1.4
Total	101	118	129	113	81	116	85	93	93	91	87	90	110	102	97	109

[a]R.W. Walker, "An Evaluation of Training Methods and Their Characteristics," *Human Factors* (2), © Human Factors Society, Reprinted by permission.

To use the index for selecting preferred techniques, Walker prepared the following three-step selection procedure:

(1) Select those criteria that are relevant to an instructional task. For example, from Table 2 one might select the criteria—realism, student reinforcement, transfer of training, and student motivation.
(2) Sum the mean rating values for each technique on the criteria selected in Step 1.
(3) Choose the technique that has the highest total rating (the largest sum of mean ratings as determined in Step 2).

Although Walker's procedure is not based upon empirical data, his approach might be used to develop a procedure for use by the Army until an empirically based procedure can be derived. For Army purposes, better lists of methods and media would have to be provided. Also, the methods and media ratings assigned by training experts would have to be according to selection criteria meaningful to Army trainers.

The U.S. Army Southeastern Signal School (3) took an approach somewhat similar to Walker's in an attempt to determine how methods and media are selected for Army courses. They sent a list of eight questions to 24 Army schools, and received 18 responses (one in each of 18 schools). On the basis of those responses and information gleaned from the literature, the Southeastern Signal School prepared 18 principles to guide trainers in selecting methods and media.

Besides not meeting Army requirements for an empirically-based procedure, the results of this approach can be questioned on at least two counts:

(1) The eight questions were too few and too broad to yield enough precise information on which to base reliable conclusions.

(2) An analysis was not made across the various levels of training-system planning or across the various course types.

In summary, the Army needs a new methods-media selection procedure to meet its particular requirements, not because there is a lack of existing procedures, but because none of them can be used or be adapted for use in selecting the most effective methods and media for Army courses.

References for Chapter 1

1. Pryluck, C. and Snow, R.E. "Toward a Psycholinguistics of Cinema," *Audio-Visual Communication Review*, vol. XV, Spring 1967, pp. 54-75.
2. Walker, R.W. "An Evaluation of Training Methods and Their Characteristics," *Human Factors*, vol. 7, 1965, pp. 347-354.
3. U.S. Army Southeastern Signal School. *A Guide to Planning Instructional Methods and Media Application in Army Training*, USASESS-PAM-350-1, Fort Gordon, Georgia, August 1971.

Chapter 2

A NEW APPROACH TO METHODS SELECTION

Since existing procedures for selecting instructional methods and former approaches to the development of such procedures have proved inadequate, a new approach is needed as the basis for further research.

The following approach, consisting of four major tasks, might be fruitful:

(1) Identify teaching-point (a knowledge or skill to be learned) characteristics that can be used in selecting training methods.
(2) Functionally define and classify training methods and techniques.
(3) Derive a means for relating teaching-point characteristics to appropriate training methods.
(4) Identify student individual differences that can be used in selecting the most satisfactory training methods and techniques.

Information pertaining to each of these tasks is presented and discussed in this chapter.

CHARACTERISTICS OF TEACHING POINTS

A teaching point is a knowledge or skill to be learned. In Army training systems engineering, essential knowledges and skills to be learned in a course are stated in the training objectives and subject matter that are specified in the Training Analysis Information Sheets. Thus, information on knowledges and skills is readily available so that the characteristics they have that can be used for selecting training methods can be determined.

CHARACTERISTICS USEFUL FOR SELECTION

The characteristics of teaching points that probably can be most useful for selecting methods (and media) are those that indicate the processes within the nervous system of the student that are required for learning. These processes, discussed at length by Glaser (1), Gagne (2), and DeCecco (3), are *relating* (associating), *discriminating*, and *generalizing*:

Relating is establishing an association between particular stimuli and particular responses.

Discriminating is distinguishing between appropriate and inappropriate stimuli.

Generalizing is associating the correct response with appropriate but somewhat different stimuli.

All teaching points require the process of relating if they are to be learned. In addition, some require discrimination learning to prevent confusion of stimuli so that the learner can discern differences, such as differences in makes and models of wheeled vehicles. Others require generalization learning so that the student can recognize common characteristics of classes, such as machine guns, aircraft, technical manuals, and other classes of military objects.

These teaching-point learning requirements cannot be used alone in selecting training methods, but they can be very useful when a particular kind of relating, discriminating, or generalizing is identified; that is, one must note whether the relating, discriminating, or generalizing must be visual, aural, tactile, olfactory, gustatory, or kinesthetic/proprioceptive. These sensory requirements imply, of course, that the student-learning activities must be seeing, hearing, touching/feeling, smelling, tasting, or muscular coordinating (as in motor-skill learning).

For use in selecting training methods, these student activities must be translated into terms that more commonly denote student activities in a learning situation, terms that can be used to relate student activities to training methods. Thus, *seeing* should be represented by either *observing* or *reading*; *hearing* should be represented by *listening*; and touching/feeling, smelling, tasting, and muscular coordinating should be represented by *doing*. These four categories of student activities—observing, reading, listening, doing—best describe student learning activities for the purpose of selecting training methods. These activities are called the means by which teaching points can be learned.

RULES FOR RELATING TEACHING POINTS TO MEANS OF LEARNING

Since learning-by-doing is an essential Army training principle, it should be applied in practical exercises as a part of every instructional program; and since doing is always indicated as a means of learning both mental and motor skills, the practical exercise as a training method is always indicated for these purposes. Thus, identification of this method as one to be used is not difficult.

The major problem in developing an adequate method selection procedure is to provide a reliable means of identifying those methods by which students can acquire the knowledge that they must apply in a practical exercise, or the knowledge that will prepare them to practice in a practical exercise.

In formulating the rules for relating teaching points to their means of learning, we considered whether:

(1) The teaching points are in a practical exercise.
For example, a practical exercise to teach map reading would require a map for presenting the teaching points; therefore, a map would be at least part of the material in a practical exercise.

(2) The teaching points are not in a practical exercise.
For example, an illustration to aid learning of a concept, such as a picture of a fly beside the Empire State Building to convey the concept of the relationship of a micron to an inch. Once the concept is learned, such an illustration would not be useful in performing either the practical exercise or the job task to which the concept is related.

(3) The teaching points require relating, discriminating, or generalizing, as discussed previously.

Following are the rules we formulated for relating teaching points to their appropriate means of learning:

Observing. Teaching points are learned by observing if the practical exercise or teaching point requires:

(1) Associating visual stimuli with actions.
(2) Discriminating between visual stimuli before or during the practical exercise.
(3) Generalizing to different stimuli before or during the practical exercise.

(4) Visual Action (e.g., to visually select, match, recognize, identify; to assist motor action, such as drawing, painting, carving, calibrating an ohmmeter, tuning a radio receiver).

Reading. Teaching points are learned by reading if the practical exercise or teaching point requires:

(1) Associating printed verbal materials with actions.
(2) Discriminating between printed verbal materials.
(3) Generalizing to different printed verbal materials (e.g., recognizing that various kinds of printed materials belong to a given class, such as Field Manuals).
(4) Action in relation to printed verbal materials (e.g., writing a staff study or preparing written orders).

Listening. Teaching points are learned by listening if the practical exercise or teaching point requires:

(1) Associating verbal or nonverbal sounds with action (e.g., spoken commands, reveille).
(2) Discriminating between verbal or nonverbal sounds.
(3) Generalizing to different verbal or nonverbal sounds (e.g., perceiving an essential meaning when expressed in different words, recognizing that actual night surveillance radar sounds are the same as heard on tape recorders in the classroom).
(4) Action in relation to verbal or nonverbal sounds (e.g., giving a briefing, playing a bugle).

These means of learning—the student activities of observing, reading, listening, and doing—are used in the following section for selecting appropriate training methods.

DEFINITION AND CLASSIFICATION OF TRAINING METHODS

Most research results that were intended to indicate the relative effectiveness of instructional methods have been confounded because the researchers failed to isolate the elements of methods that governed learning activities. In other words, the methods used were not carefully defined and controlled so that specific results could be attributed to the effects of specific elements or to different interaction effects of the elements. To avoid these errors in future research, it is necessary to carefully define and classify the elements of methods according to their basic function.

DEFINITIONS OF METHODS AND TECHNIQUES BY FUNCTIONS

The definitions in this section are classified according to three major categories:

(1) Pure presentation methods and techniques
(2) Student verbal interaction methods and techniques
(3) Knowledge application methods

The term "technique" applies to those instructional functions that cannot stand alone as methods, but when used in conjunction with some methods may increase method effectiveness. These techniques are identified as such in their definitions.

The names given to the methods and techniques are not necessarily intended for Army use. For example, "lecture" is a term excluded from the lexicon of Army training, so it would not be used in methods-media selection materials for use by Army trainers. For the purposes of further research, "lecture" is merely a label for the function that is defined.

Pure Presentation Methods and Techniques

Lecture. A formal or semiformal presentation of oral information by a single individual; facts, concepts, problems, relationships, rules or principles presented orally either directly (as by a classroom instructor) or indirectly (as by tape recorder, film, or TV); basically a means of telling students information they need to know to attain a training objective.

Demonstration. Portrayal of a sequence of events to show a procedure, technique, or operation; may be oral (as in teaching radio procedures) or visual (as in teaching operation or handling of equipment or materials); may be presented directly (as by a classroom instructor) or indirectly (as by film or TV if visual, or by tape recorder if oral).

Exhibit. A visual display used to present information essential or helpful to the student in attaining a training objective; may be, for example, actual equipment, models, mockups, graphic materials, displays (by venetian blind or chalkboard), projected images, or sand table; may be presented directly in the classroom or indirectly by film or TV.

Indirect Discourse. Verbal interaction among two or more individuals which is heard by the student; may be a dramatization, such as a play or a skit, or a dialogue between panel members following their lecture presentations.

Assigned Reading. Printed verbal materials such as books, periodicals, manuals, or handouts from which the student is required to obtain information essential or helpful to him in attaining training objectives.

Rhetorical Questioning. A presenter technique of using questions, not to evoke student verbal responses but to emphasize a point, stimulate student thinking, keep students alert, or direct student attention, with the presenter providing his own answers; may be used directly (as by a classroom instructor) or indirectly (as by film or TV).

Student Verbal Interaction Methods

Evocative Questioning. A presenter-controlled technique in which questions are used to evoke objective-related information from the student to aid his learning and to provide feedback to the presenter as to the degree and quality of student learning.

Programed Questioning. A presenter-controlled technique used to systematically demand a sequence of appropriate student responses; may be used directly (as by an instructor in a classroom) or indirectly (as by film, TV, programed booklets or teaching machines, including computers).

Student Query. A technique by which students can search for information by questioning a classroom instructor, tutor, coach, or an appropriately programed computer.

Discussion. Interactive sharing of information and experiences by a group of students; includes statements of ideas and comments related to achieving a training objective; an instructor may or may not be present to monitor the exchange.

Knowledge Application Methods

Practical Exercises. Student interactions with things, data, or persons, as is necessary to attain training objectives; all forms of simulation (e.g., games and interaction with hardware simulators) and interaction with actual equipment or job materials (e.g., forms).

DEFINITIONS OF TRADITIONAL TERMS BY FUNCTIONS

The foregoing statements, proposed as mutually exclusive definitions of training methods and techniques, are sufficient to include all training processes. This does not mean that the terms used must be substituted for other terms that have traditionally denoted "methods" of training or instruction. It is helpful to note, however, that traditional terms can now be more clearly defined by stating the mutually exclusive functions, as defined earlier, which are included in traditional methods.

A *conference*, as the term is understood in Army training, may be defined as a training process that includes lecture, exhibits, evocative questioning, rhetorical questioning, and student query (or whatever function that may be included).

Guest Speaker (used by the Army to denote a method of instruction) can be defined as a lecture and whatever other function or functions are used during the presentation.

A *seminar* (depending upon the specific processes each seminar may include) may be defined as a discussion following instructor or peer lecture or demonstration.

A *case study* may be defined as a discussion following a presentation by reading assignment, lecture, or demonstration.

Role playing may be defined as a practical exercise and may include indirect discourse, evocative questioning, and discussion.

Programed instruction may be defined as including programed questioning and exhibits (as in Skinner and Crowder techniques) or, as in the case of adjunctive programed instruction, assigned reading.

Tutoring or *coaching* may be defined (depending upon the function of the tutor or coach) as questioning, lecture, demonstration, and student query.

Peer instruction—instruction by a fellow student or students—is not sufficiently defined unless the peer-instruction function is designated, such as, demonstrating, questioning.

Correspondence instruction may be defined as assigned reading and possibly practical exercises and, perhaps, programed questioning.

This list of terms which traditionally designate training methods, but which actually denote one or more of the mutually exclusive functions as defined above, is not intended to be exhaustive.

RELATING MEANS OF LEARNING TO TRAINING METHODS

Teaching points can be classified according to their means of learning, which are observing, reading, listening, and doing. To use the means of learning to select training methods, a device is needed for identifying the methods by which each means of learning can be implemented. Table 3 is such a device.

In Table 3, two methods—demonstration and exhibit—are subdivided to distinguish between two kinds of demonstrations (visual/oral) and two kinds of exhibits (visual/print). Also, it can be seen that the learning requirements of observing, listening, reading, and doing can be implemented by various methods, ranging from one for doing (but of many types) to four for listening.

The techniques of rhetorical questioning, evocative questioning, programed questioning, and student query do not appear in the table since they cannot stand alone as methods, and because the means of learning are not sufficient criteria for their selection. Criteria that may be appropriate are discussed in the following section.

INDIVIDUAL DIFFERENCES AS CRITERIA FOR METHODS/TECHNIQUE SELECTION

Selection of the most satisfactory instructional methods and techniques may ultimately depend upon the requirements of student individual differences.

Table 3

Relating the Means of Learning to Training Methods

Methods	Means of Learning			
	Observing	Listening	Reading	Doing
Lecture		X		
Demonstration (Visual)	X			
Demonstration (Oral)		X		
Exhibit (Visual)	X			
Exhibit (Print)			X	
Indirect Discourse		X		
Assigned Reading			X	
Discussion		X		
Practical Exercises (Many Types)				X

Certainly, every person is different, and some authorities, such as Cronbach and Snow (4) and Bracht (5), have suggested that no single instructional process will provide the most effective learning experience for all students. They note that some students will be more successful with one instructional program, others with another, in achieving a common set of objectives. But research dealing with individual differences has failed to yield sufficient data to provide an empirical basis for selecting the most effective methods-media combinations. For example, Bracht reviewed 90 research studies and found only five that showed methods to be differentially effective with different groups of students, and these differences were all associated with verbal interactive methods.

Hoban and Van Ormer (6), in a summary of film research, found some evidence to suggest that learning from films is dependent upon student intelligence, training, or previous knowledge of the subject. They further suggested that higher ability students gain more from verbal presentations. Meierhenry (7) and Smith (8), however, asserted that evidence for the superiority of films for low IQ students was not warranted. But more recently, Snow and Salomon (9) concluded that film and television presentation characteristics are likely to interact differently with students of varying aptitudes.

Numerous researchers, such as Allen and Daehling (10), Eattu (11), and Baker (12), have been unsuccessful in using the Guilford (13) structure-of-intellect ability factors to find differences in ability that predict the effectiveness of different methods and techniques with students who differ in ability. The results of these carefully controlled experiments are well summarized by Bunderson and Dunham (14), who expressed doubt about the practical values of using different abilities to differentiate between methods. They give four reasons for their skepticism:

> (1) Individual differences useful in predicting differences in method are very uncommon.
> (2) The differences which are found are not large enough to be useful, because slight changes in the learning tasks eliminate the differences.
> (3) The criterion-based tests used to evaluate performance do not enable them to be used in diagnosing possible differences.
> (4) The payoff gained by providing alternate methods may be less than the payoff gained by revising the single best learning task. In instructional design

> there is probably no factor that produces more improvement for more students than the careful revision of a program based on an analysis of student performances.

Other researchers have not been as pessimistic as Bunderson and Dunham. For example, Allen (15), after reviewing the literature in teaching methods and media, concluded that study of the three-way interaction between stimulus, task, and the individual learner, while extremely complex, may lead to a more precise understanding of the instructional roles of methods and media. The potential fruitfulness of such research has been suggested by Gagne (2), Briggs *et al.* (16), Salomon and Snow (17), Briggs (18), Allen (15), Salomon (19), and Campeau (20). Although no adequate empirical evidence has been generated to date, there is reason to assume that further research should provide the criteria necessary for selecting the most satisfactory methods and techniques for given purposes.

In HumRRO's Project IMPACT, for example, the significant differential performance predictors in the introductory part of the course were different from those that were useful for prediction of performance in the later, more complex stages (Seidel, 21). In the introductory part of the course, five factors proved to be significant predictors; these included associative or primitive memory, general reasoning, a general quantitative skill, and student expectancy just prior to the criterion test. In the later, more complex portion of the course, 11 factors were shown. Figural adaptive flexibility (the main factor), perceptual speed, and ability to make comparisons rapidly and accurately appeared especially useful. Student expectancy (self-assessment) appeared important at an *earlier* point in this portion at the pre-test. Finally, a higher level memory factor, chunking memory, was shown.

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Chapter 3

MEDIA

MEDIA SELECTION AND MEDIA DESIGN

Media selection has two related, but very different, aspects: (a) media selection per se, which is choosing between the physical (material structure) characteristics of devices that can be used to convey messages; and (b) media design, which is selecting the particular attributes of media (such as capabilities of presenting color or of depicting motion) that can most effectively present different kinds of teaching points and assist student learning.

Media design is far more important than merely selecting the physical media that have or can be made to have certain attributes. In other words, as Tosti and Ball (1) suggested, selection of media equipment and devices should depend upon the attributes that are *necessary for effective instruction.*

INSTRUCTIONAL MEDIA REQUIREMENTS

Some instructional medium or combination of instructional media (whether persons, hardware, or software) is essential for presenting knowledge that the student must learn. In addition, instructional media must guide and otherwise assist the student in learning, if learning is to be efficient.

Gagne's (2) analysis of learning and media functions greatly aids understanding of specific media requirements. He tentatively identified eight types of learning and pointed out that the basic function of instructional media is to *create the external learning conditions* that are necessary for each type of learning to occur efficiently. More specifically, he noted that to create the external conditions required for learning, media must do seven things:

(1) Present stimuli. Even the simplest type of learning requires a stimulus, and as the types of learning become more complex, various kinds of stimuli are necessary to make learning both possible and efficient.

(2) Direct student activities. Various kinds of stimuli must direct student attention and otherwise indicate to the student what he must do in the learning situation.

(3) Provide models for terminal performance. Such models orient the student to the nature of the behavior he must learn.

(4) Provide prompts. For most kinds of learning, prompts should be available to the student. For example, learning of verbal and motor chains is made easier if demonstrations or models provide prompts to help learning of proper sequences. Then, too, multiple discrimination learning is made easier if prompts or cues make differences in words or things more distinctive.

(5) Guide thinking. Efficient learning of mental skills requires hints or suggestions to guide student thinking. Such guidance helps the student to make connections between concepts which he can use to form principles, and to discern relationships between principles which he can use to solve problems.

(6) Induce transfer of knowledge. The process of learning to transfer knowledge to novel situations usually is begun by asking the student questions of the problem-solving variety. Demonstrations may also aid this kind of generalizing (transfer) to other things or situations that are similar to, but not the same as, those used to teach the concepts or principles or those used to demonstrate how the knowledge can be generalized. Visual exhibits also can induce transfer by illustrating the kinds of things or situations to which the knowledge applies.

(7) Provide feedback. An important condition for learning is to let the student know whether the consequences of his learning are correct so that the learning can be reinforced if correct or be restructured if incorrect.

Such instructional media requirements indicate how media can be used to create the external learning conditions which make learning possible and efficient. Obviously, media can be used in many ways, but to reliably provide the most satisfactory media for given purposes, one must have adequate evidence of the effectiveness of various media attributes for different purposes.

GUIDELINES IN THE LITERATURE FOR MEDIA SELECTION

Research results and theoretical conclusions by instructional-media authorities concerning the form and manner of presenting teaching points provide some (though incomplete) guidelines for media selection. The various considerations are discussed under the following groupings:

1. Words (reading/listening) or pictures
2. Words (reading/listening) and pictures
3. Pictures
4. Listening or reading
5. Listening and reading
6. Listening

WORDS (READING/LISTENING) OR PICTURES

The nature of the knowledge (teaching point) to be learned will, in large part, determine the form and manner of presentation, such as by telling or by showing.

A decision to use words or pictures usually is based upon whether the knowledge can be presented concretely (Taylor, 3). Allen *et al.* (4) demonstrated the ease of making this distinction when they found that subject matter could be identified by untrained persons as inherently concrete or non-crete. Allen *et al.* (5) report, however, that little specific direct study has been made of the effects of using words or pictures, although much attention has been given to different types of media that have words or pictures as elements.

Given the present state of knowledge in this area, Gagne and Rohwer (6) concluded that:

> (1) When given the choice between words and pictures (if deemed equivalent) pictorial materials are superior to verbal materials.
>
> (2) The conditions that might dictate choices between using words and pictures are almost entirely undermined at the empirical level. (They were not aware, however, of the Allen *et al.* (4) study.)

Levie and Dickie (7) have summarized some theoretically generated guidelines for selecting words or pictures:

(1) Pictures usually are superior to words for eliciting recall and recognition.
(2) Pictures usually are superior to words when the student lacks the verbal equivalent (when the student knows no word or words to represent a thing or concept).
(3) Pictures usually are superior to words for teaching concrete subject matter.
(4) When learning involves understanding a large number of relationships, a visual exhibit which presents all the relationships simultaneously in a structure (such as a map or schematic diagram) can be helpful.
(5) Learning of behaviors such as creative thinking may be assisted by visual displays.
(6) When the order of ideas or knowledges is critical, words are preferred.
(7) When graphic materials are not readily interpreted by the student, spoken words are preferred. (If graphics are to be useful, the student must be skilled in interpreting them.)

One must keep in mind that these guidelines were theoretically, not empirically, derived.

WORDS (READING/LISTENING) AND PICTURES

Levie and Dickie (7) concluded that more learning may result from audiovisual presentation under certain conditions, but they were unable to define or understand these conditions, usually because the research from which they drew their conclusion was not well designed and controlled.

PICTURES

To determine when pictorial or graphic materials should be used to present teaching points, one must consider whether the following media attributes are necessary: color, motion, realistic detail, multi-image, and size of illustration. Studies related to each of these variables are summarized in the following paragraphs.

Color. Exton (8) noted that color is used to distinguish between or to identify elements in graphic displays, to highlight significant features, to serve as a basis for codes, and to clarify the entire presentation by providing visual contrast. The effectiveness of using color to differentiate between items in displays to reduce search time has also been documented by many researchers, most recently Shontz *et al.* (9).

Use of color as potential aids in learning is indicated in study reports by Peterson and Peterson (10), Saltz (11), and Weiss and Margolius (12). One must be careful, however, to use color appropriately in training. For example, Underwood (13), Mechanic (14), and Bahrick (15) found that performance suffered when color was used in training but not in the task to which the training was to transfer, because the students learned and responded to color distinctions (cues) in training that were not in the task situation.

Motion. An excellent study of the relations of motion to learning was made by Allen and Weintraub (16). They examined learning of facts, sequences, and concepts, and found that motion was best used for learning procedural sequences. They also found that motion portrayal aided learning only when motion was an integral part of what had to be learned. The implications of their study are that motion should be used when (a) the content to be learned consists of the motion itself; (b) characteristics of the movement must be learned; and (c) the content is enhanced and clarified by the motion.

Spangenberg (17) examined the effects of motion in learning a weapon-disassembly procedure. He concluded that motion helps learning of procedures when (a) the activity requires simultaneous motion in different directions; (b) the activity is unfamiliar to the student; and (c) the activity is not easily described in words.

Degree of Realistic Detail. Dwyer (18) summarized an extensive series of studies on degree of realistic detail in illustrations. He found in pace studies (when all students received equal viewing time) that illustrations showing relatively small amounts of realistic detail were most effective. However, in self-paced studies (as much time as the student wanted), he found that the more realistic illustrations were most effective. Dwyer concluded, therefore, that effectiveness of the degree of detail in pictorials depended upon whether study time was limited by the instructor or unlimited according to the student's choice.

Dwyer also concluded that effectiveness of an illustration in helping the student depends upon the type of information he needs; for example, if he must learn to sketch an object, he should have a line drawing instead of a photograph. In other words, as Denenberg (19) also showed, the illustration should provide only that degree of realistic detail that is required for transfer of training to job performance; unnecessary detail reduces the efficiency of learning.

In studies of training men to perform procedural tasks, Cox *et al.* (20) and Grimsley (21, 22, 23) found that fidelity (realistic detail) of training devices can be low with no adverse effect on training time, level of proficiency, amount remembered over time, or time to retrain.

Cox *et al.* also found no differences in learning a procedural task on a full-sized panel, a half-sized panel, or a panel only one-nineteenth the area (5x7 inches) of the full-sized panel, if the parts of the device remained clearly visible.

Size of Illustration. Moore and Sasse (24), in a study comparing the size effects of projected illustrations, found that recall of detail was best when a medium-sized screen area of 35 x 70 inches was used. (The large-sized area was 70 x 70 inches, and the small size was 35 x 35 inches.)

Other studies have *not* shown that reliable differences in effect are attributable to the size of screen area (Greenhill, *et al.* 25; Reede and Reede, 26). The illustration must be large enough, however, to show the detail required for learning.

Multi-Image Displays. Millard (27) suggests that for instructional purposes the projected multi-image is particularly adapted for making comparisons, for illustrating the development of related concepts, and for showing relationships. Although logical, his suggestions are not based upon empirical evidence. Lawson (28) reported that multi-image displays affect attitude and meaning. He based his conclusions on his observation of student reactions.

LISTENING OR READING

Sticht (29) found that a large number of men of poorer reading ability said they preferred to learn by listening rather than by reading. He also found indications that poor readers might learn certain prose materials as well by listening as by reading, and he concluded that listening as a skill has special meaning for inept readers. In a later Army study, Sticht *et al.* (30) found no difference in learning by listening and by reading.

After reviewing the research, Hartman (31) concluded that reading is more effective than listening when the information is difficult or complex. He also found several specific instances with less difficult material when listening was best.

LISTENING AND READING

Simultaneously reading and listening to the same words (total redundancy) does not facilitate learning of verbal materials—probably, as Carroll (32) suggests, because oral presentation tends to be much slower than normal reading speeds, and the reading and listening interfere with each other.

Allen *et al.* (4) found that directive audio in conjunction with printed materials can aid learning if it is used to discuss and emphasize parts of a message or of a printed exhibit.

LISTENING

Chu and Schramm (33) cite several studies that compare indirect discourse with lecture. They concluded that there are no reliable differences between these two methods.

Sticht *et al.* (30) found that with Army students as much as 36% savings in listening time can be attained with only moderate loss in comprehension by using rate-controlled recordings (compressed speech).

Carroll (32) cites studies of many other variables involved in learning by listening that should be considered in the design of listening experiences, but that are not useful in differentiating between either methods or media.

Although some of the data mentioned in the Guidelines section can be useful in the selection of media, further research is needed on the effectiveness of media attributes for specific instructional purposes before an empirical basis for selection of the most satisfactory media can be derived.

DEFINITION AND CLASSIFICATION FOR ADEQUATE MEDIA SELECTION

Many researchers have expressed the need for clear definitions of instructional media to aid unambiguous communication. Such definitions are also essential for development of an adequate media selection procedure. In addition to unambiguous definitions, a viable media classification system is urgently needed as a basis for further fruitful research and for a feasible media selection procedure. Neither of these needs is met in the literature.

MEDIA DEFINITIONS

Several lists of media definitions are in the literature, such as those provided by Gerlach and Ely (34), Brown *et al.* (35), and Bretz (36), but all have the following faults: (a) Only a few of the same media and media-related terms are defined in each list; (b) the terms common to all lists are defined differently in each list; (c) no clear criteria are given for listing or excluding terms.

To be adequate for selection of media for specific instructional purposes, the list of media definitions must be prepared according to the following rules:

(1) The list of terms must be exhaustive.
(2) Media definitions must be based upon meaningful media attributes (capabilities).

(3) The definitions must be easily understood.
(4) The definitions must relate directly to user-identified media requirements.

MEDIA CLASSIFICATION

For a media classification system to be viable, it must satisfy the following requirements:

(1) The number of categories must be large enough to include all media, but small enough to make the selection procedure easy to use.
(2) The categories must be defined in terms that clearly relate to user requirements, and thus:
  (a) Appropriately order user thinking about media
  (b) Provide the means for unambiguous communication between systems engineers and others involved in designing and developing training programs.

In other words, adequate media classification must, as Meredith (37) stated, provide utility, convenience, and economy.

Although numerous attempts have been made to classify media (Appendix B), none has met the preceding requirements, and none can be adequately adapted for Army use.

A PROPOSED SCHEME FOR MEDIA DEFINITION, CLASSIFICATION, AND SELECTION

THE AGGREGATIVE DEFINITION

The lack of useful media definition and the analysis of definition requirements sparked the notion of the "aggregative definition." This term denotes that, for practical purposes, an instructional medium is nothing more nor less than the sum (or aggregate) of its functional capabilities in a training process. Thus, aggregative media definitions are precisely what is needed for use in selecting media.

To provide such definitions, note first that instructional media have two basic functions: (a) to implement training methods, and (b) to assist student learning of teaching points.

Therefore, to state a complete aggregative definition of any medium, one must identify its capabilities for presenting:

(1) Stimuli that can be observed, read, heard, touched/felt, tasted, or smelled (to implement training methods).
(2) Stimuli that can assist the learning processes of association, discrimination, and generalization.
(3) Stimuli that can assist students of different characteristics in learning different kinds of teaching points.

Identification of media capabilities that can implement training methods is a rather simple process that Army systems engineers and instructors can perform. But identification of media capabilities that can best assist learning has not been done with a satisfactory degree of confidence by even highly skilled instructional media specialists. One reason is that, as Saettler (38) pointed out, not enough experimental evidence exists to reliably show the different effects of various media stimuli on the learning of different kinds of teaching points by different kinds of students. By "media stimuli" we mean such things as color, shaded contrasts, symbols, graphs, regular motion, speeded motion, slow motion, photographs, montages, depictions of time and distance relationships, enlarged or reduced sizes, animation, tachistoscopic flashes, X-rays, and two and three dimensions.

This is not to say that nothing is known of the effects of media, but rather that the state of this knowledge is general rather than specific. As Salomon (39) noted, it is known that the effects of media attributes vary when the subject matter varies, and when the students vary in abilities, attitudes, and cultural background. In other words, only enough is known for us to realize that there are problems which further research must solve if enough specific media effects are to be identified for reliable selection of the most satisfactory media.

MEDIA CLASSIFICATION

To provide a basis for a media selection procedure, media attributes must be classified in a way that creates a media selection system. The media attributes useful for our purposes fall into three major categories—media which can be used to:

(1) Implement training methods.
(2) Assist the learning processes of association, discrimination, and generalization.
(3) Assist different kinds of students in learning.

These statements are easily translated into three major selection categories by which the media attributes must be classified:

(1) Training methods
(2) Learning processes
(3) Student differences

Each of these categories must, of course, be divided into subcategories so that media attributes can be classified according to specific methods, learning processes, and student differences.[1]

Tables 4, 5, and 6 show how media attributes (aggregative media definitions) can be used to relate media to the major selection categories. For illustrative purposes, each category is represented by only a few examples. The complete system would include all useful categories and subcategories.

SELECTION PROCEDURE

Having created a classification system that can be used for selecting media, the selection procedure can be derived by merely stating how the system would be used.

Although methods and media have been discussed separately and a methods-selection procedure apart from media has been proposed, it should be noted again that for all application purposes neither methods nor media can be considered separately. As mentioned in Chapter 1, methods have no reality until they are applied by the media that implement them. In other words, to ask "Which method is most effective?" and "Which media are most effective?" is to pose pseudo questions, for they cannot be answered separately. The only meaningful question is, "Which methods-media combinations are most effective for given instructional purposes?"

[1] Of interest are the findings of HumRRO Army studies in Work Unit SPECTRUM on the effectiveness of different training strategies in aiding different learning processes with men of different aptitude levels. They are reported by Showel (40), Fox *et al.* (41), Montague and Showel (42), Taylor and Fox (43), Taylor and Montague (44), and McFann (45).

Table 4

Media Classification According to Capabilities for Implementing Methods

Training Method	Media Stimuli[a]		
	To Be Observed	To Be Heard	To Be Read
Lecture		X	
Demonstration (visual)	X		
Demonstration (oral)		X	
Visual exhibit	X		
Print exhibit			X
Indirect discourse		X	
Assigned reading			X

[a]Each "X" represents the names of all media that have the capabilities for implementing the training methods.

Table 5

Media Classification According to Capabilities for Assisting Learning Processes

Learning Process	Media Stimuli[a]		
	Color	Motion	Sound
Association	X	X	X
Discrimination	X	X	X
Generalization	X	X	X

[a]Each "X" represents the names of all media that have the capabilities of presenting stimuli to assist the learning processes. The categories of color, motion, and sound are only examples. Further research must identify all stimuli that should be related to the learning processes. Also, each major learning-process category must be divided into subcategories for the kinds of relating, discriminating, and generalizing indicated by various kinds of teaching points.

Therefore, the methods-selection procedure proposed in Chapter 2 and the media-selection procedure proposed here must be combined as shown in Table 7.

The medium or media identified (together with their attributes) may consist of hardware, or software, or both. If hardware is involved, it may be on hand in the school that will use it; if not on hand, a decision of whether to buy it can be made. When software is involved (e.g., film, videotape, print), the training materials to be mediated by the software may be available; if not, a decision of whether to develop it can be made.

Table 6

Media Classification According to Capabilities for Assisting Different Kinds of Students in Learning

	Media Stimuli[a]		
Student Characteristic	Color	Motion	Sound
Age	X	X	X
Level of Education	X	X	X
Learning Ability	X	X	X
Other	X	X	X

[a]Each "X" represents the names of media. The major categories of student differences are only examples. Further research may extend the list, reduce it, or eliminate it, depending on whether certain stimuli actually increase the effectiveness of instruction with different kinds of students. Also, each student-difference category must be subdivided to provide categories for different age groups, levels of education, and learning abilities.

Thus, media selection consists of either identifying useful media that are available, or identifying media attributes that can be used to develop desired training materials. So, obviously, the selection procedure can be used for both media selection and media design.

As noted earlier, Tosti and Ball (1) suggested that one should specify the media capabilities necessary for the instructional requirements before selecting the media. This is a difficult task to do well, for it requires much knowledge of how specific media capabilities can be used best. When future research provides such knowledge, and when it is stored in the proposed media-selection system, the task of designing the most satisfactory media for given purposes will have been done. All the user would need to do would be to identify the kind of teaching points to be learned, the kind of students who must learn them, and the method to be used, and then follow the proposed media-selection procedure.

By completing this relatively simple process, the user would be able to identify both the appropriate media capabilities and media devices. When two or more media have the same capabilities (which probably would often be the case), an additional selection step would be necessary—that of choosing between the media on the basis of cost-effectiveness. This choice, however, as well as decisions to buy or to develop media, should be made only after cost-effectiveness studies and utility analyses (discussed in Part II) have been made.

THE AGGREGATIVE DEFINITION CARD

The numbers of media and media attributes that must be classified make the use of matrices (similar to classification Tables 4, 5, and 6) impractical, as the selection procedure would be too complicated and time-consuming.

If, however, edge-punched or IBM cards were used, the selection procedure would be quick and easy. Edge-punched cards have a row of holes along each border. The classification system would be established by assigning a specific card hole to each of the

Table 7

Combined Methods-Media Selection Procedure

Selection Procedure	Product
Methods	
1. Apply rules for relating teaching-point characteristics to means by which the teaching points can be learned.	A particular means of learning specific teaching points (observing, reading, or listening).
2. Use the particular means of learning to identify methods that can implement that means.	All training methods that can implement the means of learning.
3. Use student difference characteristics to identify method most effective for a specific kind of student.	The most effective method for presenting the teaching points to specific students.
Media	
1. Use most effective method identified above to identify media that can implement that method.	All media that can implement the method and assist learning.
2. Use the same teaching-point characteristics used to identify a particular means of learning to more specifically identify appropriate media.	All media that can implement the method and assist learning of the specific teaching points.
3. Use the same student-difference characteristics used to identify most effective method to also identify the most effective media.	The medium or media that can be used for both implementing the method and assisting a particular kind of student in learning the specific teaching points.

subcategories of the major categories we have identified as methods, learning processes, and student differences. Each medium would be represented by one card; if there are 65 media, for example, there would be a stack of 65 cards.

On the face of each card would be the following (and perhaps other) useful information concerning the medium:

(1) Generic name
(2) Attributes
(3) Special considerations for use
(4) Space and facility requirements
(5) Personnel requirements
(6) Cost factors
(7) Effectiveness factors

A medium card would be coded for selection purposes by the following process: When a medium attribute is related to one or more of the method, learning-process, and student-difference subcategories, the hole assigned to each of these subcategories would be notched out on the card. When all appropriate holes are notched out, the medium card will have been completely coded for selection.

To select the most effective media for given instructional purposes, one would use a card-sorting needle and perform the following three steps:

(1) To select all media that can implement a given method, the user would insert the needle in the card hole assigned to that method. He would then raise the needle, and all appropriate media cards would fall out of the deck. He would use only these cards for the next step.

(2) To select those media that can both implement the method and assist a particular learning process, the user would insert the needle in the hole assigned to that learning process, raise the needle, and the appropriate cards would fall out for use in the final step.

(3) To select those media that can implement the method, assist the learning process, and assist a particular kind of student in learning the teaching points, the user would insert the needle in the hole assigned to that particular kind of student, raise the needle, and the appropriate card or cards would fall out.

If only one card is obtained in the final step, the most satisfactory method-medium combination has been identified. If more than one card falls out, the most satisfactory method-medium combination could be selected on the basis of cost-effectiveness and utility analysis data.

NUMERICAL CLASSIFICATION METHODS

Several numerical methods for classifying large numbers of variables have been developed in various areas of science, especially in biology (Sokal and Sneath, 46), and these methods have proved to be powerful classification tools.

Silverman (47) examined the feasibility of such techniques for task classification and concluded that their use is warranted in solving problems related to Navy personnel.

McQuitty (48, 49, 50, 51, 52, 53) devised several numerical methods for classifying experimental subjects (persons) according to large numbers of experimental variables.

One or more of these methods may well be adapted for classifying and selecting media if further research proves the proposed approach to be inadequate.

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Part II

ANALYSES OF TRAINING COST-EFFECTIVENESS FACTORS

Chapter 4

DECISION-MAKING LEVELS AND UTILITY ANALYSIS

INTRODUCTION

Part I summarized findings in the literature related to selection of training methods and media and proposed a combined methods-media selection procedure based upon teaching-point characteristics and a new approach to media definition and classification.

Part II summarizes findings in the literature related to selection of cost-effective training systems, including—but not limited to—selection of the most cost-effective methods-media combinations. Part II also presents problems and proposes possible solutions pertaining to development of adequate procedures and techniques for utility analysis of Army training systems, which include analyses of training costs, training benefits, and training effectiveness.

To aid understanding of the basic costing requirements of adequate utility analyses, attention is concentrated on the two major training-cost categories: developmental costs and operational costs. Other cost factors that appropriately should be included in utility analyses to resolve specific problems, such as nonlinear depreciation schedules, opportunity costs, and changing dollar values, are discussed by Fisher (1).

ARMY DECISION-MAKING LEVELS

Complete utility analyses of Army systems must answer questions raised on four decision-making levels.

I. The One-Lesson or One-Subject-Matter Level

Questions to be answered include:

1. Which methods-media combinations can effectively present and assist the learning of teaching points?
2. Are the media available?
3. Can the instructor use the methods and media?
4. What differences in payoff and costs would result if one method-media combination is substituted for another?

II. The Course Level

Basic concerns are the same as in Level I, but broader in scope, and both available media and media that must be developed may be considered. Questions to be answered include:

1. What differences in overall course payoffs and costs would result from alternative methods-media combinations (including media that may be developed)?
2. How can on-hand and available media be allocated for the most cost-effective results?

III. The Army Subsystem Level (e.g., combat systems and ordnance)

Basic concerns are general short- and long-term training policies and investments in new training systems and facilities. Questions to be answered include:

1. Is it more cost-effective to provide formal or on-the-job training?
2. In certain manpower areas, would it be more cost-effective to develop job aids in lieu of training?
3. What cost-effective changes can be made in training in relation to the Volunteer Army?

IV. The Overall Army System Level

This is the broadest decision-making level where overall policies are generated to guide training decisions of all sorts on Level III. Training policies at this level would relate to the long-term readiness of the Army, and questions may include:

1. What new instructional systems will be required to meet the needs of advancing Army technology?
2. What investments in training are needed now to meet emergency manpower requirements without resorting to more costly crash-training programs?

DEFINITION OF TERMS

The following definitions of technical terms are designed to aid understanding of the remainder of this report.

Benefits of training	Attainment of an organization's objectives (benefits sought by organizational function) and reduction of the organization's operating cost which can be attributed to training; such benefits are not training (effectiveness) results per se, such as student achievement, but benefits gained from the existence and function of trained manpower.
Benefit analysis	A process for determining or estimating the dollar values of benefits gained from training.
Cost analysis	A process for determining or estimating the dollar cost of training.
Cost-benefit analysis	A process for evaluating the benefits gained from a training system in relation to the system's cost, and for comparing the cost-benefits of alternative systems or of variations of the same system.
Cost-effectiveness analysis	A process for evaluating the effectiveness of a training system (usually in terms of student achievement) in relation to the system's cost, and for comparing the cost-effectiveness of alternative systems or of variations of the same system.
Effectiveness of training	A measure of the usefulness (utility) of a training system in attaining the training objectives.
Outcomes of training	Results of training that cannot be measured or to which numerical values have not been assigned.
Payoffs of training	Training outcomes that are measured by some numerical scale, such as student grades or numbers of dollars.
System	A training system, unless otherwise stated.

Training system	Instructional methods and media, and non-media equipment, facilities, persons, and supplies used to evoke and control learning activities that are necessary for students to attain specific training objectives.
Utility analysis	A term which combines cost-benefit and cost-effectiveness analyses.
Utility of an organization	An organization's usefulness in gaining desired benefits.
Utility of a training system	A system's usefulness in providing manpower the organization can use to gain benefits.

UTILITY ANALYSIS: PURPOSE AND EXPANDED DEFINITION

All training systems are intended to produce desirable outcomes, and training officials usually are concerned with the effectiveness and costs of the systems. They should be concerned with identifying the system design among alternative designs that will yield the highest degree of payoff at the lowest possible cost.

Successful identification of the most cost-effective system depends on the quality of judgments on the four levels of decision making defined earlier. The quality of judgments largely depends on the validity and reliability of the information available to decision makers, and the validity and reliability of this information depends, in turn, on the adequacy of training-utility analyses.

Utility analysis includes cost, benefit, effectiveness, cost-benefit and cost-effectiveness analyses. Cost analysis is the subject of Chapter 5. Cost-benefit and cost-effectiveness analyses are related to the overall problem of utility analysis, and they are all discussed in Chapter 6.

UTILITY ANALYSIS ON THE FOUR DECISION-MAKING LEVELS

Use of the term "training system" in relation to utility analysis may suggest to some that the process is either too broad or too restrictive for use on all four levels of decision making, but its applicability on all levels can be readily seen when the term "training system" is appropriately interpreted.

On Level I, training system can correctly denote even one lesson within a unit of instruction, or a single unit of instruction within a course.

On Level II, a course, itself, can correctly be called a training system.

On Level III, all courses or programs that provide trained manpower for a given Army subsystem can also be called a training system.

On Level IV, all the training systems that serve the Army subsystems can be taken together and be called the overall Army training system.

The only difference between the levels, as far as utility analysis is concerned, is not in the applicability of the process but in the complexity of the cost and payoff data that must be collected and analyzed. The *function* of utility analysis on all levels would be the same—that is, to provide decision makers with valid and reliable alternative cost and payoff information, whether it is for selection of methods and media at the lesson or course level, or a training policy decision at the overall Army system level.

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Chapter 5

TRAINING-COST ACCOUNTING AND ANALYSIS

THE PROBLEM

If training-cost analysis is to be used for comparing costs of alternative systems or alternative system components, such as different method-media combinations, it must include the techniques necessary to determine the following:

(1) The cost of an existing system if its redesign is proposed.

(2) The changes in cost that would result from redesign of an existing system.

(3) The costs of proposed alternative systems that have not been implemented.

Merely adding up the costs associated with different aspects of an existing system or of a single proposed system serves no other purpose than to show how much money should be budgeted to continue operation of a system or to develop a new one. This is a simple cost-accounting function.

If, however, the costs of alternative systems must be derived and analyzed, the cost-accounting techniques must be much more complex and tasks of cost analysts become more difficult. As Fisher (1) pointed out, the cost analysts must:

(1) Account for *all* sources of training cost, not just those that are obvious or that become readily apparent.

(2) Identify the cost sources that, when they vary, contribute most to changes in system costs.

(3) Determine and compare the magnitudes of cost changes and present the results to decision makers.

These responsibilities may seem fairly simple when stated in this way, but the problems rest in the necessities of:

(1) Providing the cost-accounting structures that will permit identification of *all* sources of training costs and division of these sources into subcategories that can be manipulated for meaningful cost comparisons.

(2) Selecting or deriving techniques for determining which cost sources contribute most to changes in system costs.

(3) Selecting or devising feasible means for determining or estimating magnitudes of cost changes.

(4) Selecting or deriving mathematical formulas for use in meaningful comparisons of cost differences in alternative systems.

The problem of deriving adequate techniques and procedures for Army training cost analysis involves identification of those costs that exist that may be applied to or be adapted for application to Army conditions and requirements, and development of new ones that may be needed to solve unique Army problems.

A thorough review of the literature revealed that although a number of cost analysis models have been developed, none are adequate for Army use. Some, however, have features that can be used or that can be adapted for use, and these will be discussed in the sections that follow.

COST-ACCOUNTING STRUCTURES

We agree with Kemp (2) that a useful instructional cost-accounting structure should have two major categories by which all sources of training cost can be classified: (a) developmental costs (basic expenditures that must be made before training can occur), and (b) operational costs (expenditures necessary for the conduct of training).

Kemp also provided the following examples of cost sources that should be included in each major category.

Developmental Costs

Planning time.	Percentage of salary for time spent by each member of the planning team on the project (or number of hours spent by each member multiplied by his hourly salary rate), and fees for consultants.
Staff time.	Percentage of salary for time spent by each staff member engaged in planning and production, and in gathering materials (or the number of hours spent by each person multiplied by his hourly salary rate).
Supplies and materials.	
Outside services.	Services necessary for preparing or purchasing materials.
Construction or renovation of facilities.	
Equipment.	
Installation of equipment.	
Testing, evaluation, revision, reproduction.	These include personnel time and costs during the system validation phase.
In-service education.	Training for teachers, aides, and others who will participate in the program during implementation (cost for time).
Overhead costs.	Expenditures such as utilities, telephone, furniture and room or building costs, or depreciation allowances, incurred during the developmental phase.
Miscellaneous.	Travel and other items.

Operational Costs

Administrative salaries.	Salaries (based upon percentage of time) chargeable to the instructional system.
Faculty salaries.	Salaries for time spent in the program—working with groups and individual students, planning daily activities, evaluating programs, revising activities and materials.
Other salaries.	Salaries for aides, maintenance technicians, and others.
Replacement of consumable and damaged materials.	
Repair of damaged equipment.	
Depreciation of equipment.	

Overhead.	Expenditures such as those for utilities, telephone, facilities, furnishings, custodial services
Evaluating and updating materials.	

The overall applicability of Kemp's list of cost sources to Army training must be determined by further study, but student maintenance, at least, should be added. When all Army cost sources are known, the costs of developing and operating a given training system can be established by calculating the costs related to each source and summing the amounts. This was done, in part, in a HumRRO study by Jolley and Caro (3) to compare selected costs of Army flight training and synthetic flight training. A similar HumRRO study was made by Caro *et al.* (4) for the Coast Guard. But this is not enough for our purposes.

To determine how various changes in systems design would effect changes in system costs, Kemp's cost-accounting structure must be refined so that cost factors can be specifically identified. This means that the training-time factor must be added and that various cost sources must be related in meaningful ways, such as students and instructors, so that various student-to-instructor ratios can be calculated.

An example of how a refined Army cost-accounting structure might appear is shown in Table 8. This example is merely illustrative, and it is not intended to show all the kinds of cost factors that might ultimately emerge.

An adequate cost-accounting structure must also provide for classification of cost sources according to the various functions involved in developing, operating, and evaluating a training system. At this point, seven training-function categories have been identified:

(1) Instruction. Expenditures connected directly with instruction.
(2) Practice. Expenditures connected with students practicing during the course.
(3) Non-instruction. Expenditures connected with student activities not a part of the instruction, such as testing, field trips, etc.
(4) Administration and Services. Expenditures for administration and other services.
(5) Operation. Expenditures for training facilities and utilities.
(6) Maintenance. Expenditures for maintenance of facilities, equipment, and students.
(7) Pre- and Post-Instruction. Planning, producing, evaluating, and other activities related to instruction, but not part of it.

Classifying cost sources according to functions is highly important so that specific changes in cost can be readily identified when changes are proposed in any of the functions. Therefore, identification of *all* Army cost sources which should be related to each function would be one of the first major research tasks.

Additional devices to aid cost accounting would merely be forms to facilitate the analyst's work. One form would be for categorizing changes in cost according to the previous training and training-related functions. Such a form would permit easy summation of costs in each category for each alternative system so that totals for each system could be easily compared.

Other forms would help analysts in calculating cost factors, such as student-instructor ratios, various costs per student, and costs per student-hour of instruction.

MATHEMATICAL FORMULAS FOR COMPARING SYSTEMS COSTS

Regardless of the cost factors and factor manipulations that may occur in designing alternative systems, the resulting total costs for each system will still be identified as

Table 8

Example of a Refined Cost-Accounting Structure[a]

Instructional Media

- Kinds
- Number used
- Percentage of time used
- Investments
  - Planning
  - Acquisition
  - Rental
  - Production
- Costs per student
- Costs per student-hour

Instructional Materials

- Investments
  - Planning
  - Acquisition
  - Rental
  - Production
- Consumption per student
- Costs per student
- Costs per student-hour

Instructional Facilities

- Classrooms
- Other space
- Percentage of time used
- Cost per student
- Cost per student-hour
- Peak use percentage

Instructional Equipment

- Total investment
- Investment per student
- Investment per student-hour
- Useful life
- Depreciation cost per student and per student-hour
- Percentage of time used

Instructional Function

- Number of instructors
- Number of students
- Average instructor hours per day
- Instructor cost per student
- Instructor cost per student-hour
- Student-instructor ratios
- Total number of hours
- Hours per student

Practice Function

- Number of instructors
- Number of students
- Average instructor hours per day
- Instructor cost per student
- Instructor cost per student-hour
- Student-instructor ratios
- Total number of hours
- Hours per student

Administration

- Personnel
- Facilities
- Space
- Cost per student
- Cost per student-hour

Maintenance and Janitorial

- Personnel
- Facilities
- Space
- Supplies
- Cost per student
- Cost per student-hour

Miscellaneous

- Office supplies
- School supplies
- Ammunition
- Utilities
- Other
- Cost per student
- Cost per student-hour

[a]The exact list of factors will depend upon the cost-analysis problem to be solved. That is, for each specific problem, some factors may be replaced by others.

developmental costs and operational costs. These two categories alone are enough for deriving mathematical formulas that can be used to meaningfully compare differences in system costs. Examples of mathematical formulas and their uses are given in Appendix C.

One mathematical formula, with slight variations, would yield training costs in terms of various training output units, such as cost per group of students trained in each replication of a course, cost per student, and cost per student-hour of instruction.

This formula, when used with each replication of a course, would be used to calculate changes in ouput-unit costs. When these changes for alternative systems are plotted in a graph, their relationships can be easily compared.

Another mathematical formula permits prediction of the time when the unit costs of two different systems would be equal.

A third formula permits calculation of cumulative unit costs (resulting from course replications) to yield alternative cost relationships that can be easily compared.

To avoid possible confusion in the following section, it must be emphasized that these mathematical formulas, or formulas similar to them, will be used for the comparison of alternative training systems, regardless of the techniques that are used to determine how system costs change when system designs change. In other words, the techniques discussed in the following section are not intended to replace these formulas; they are merely more sophisticated cost-accounting techniques for determining system costs and cost differences that should be compared.

COST ANALYSIS MODELS IN THE LITERATURE

To this point we have discussed the cost-accounting aspect of training cost analysis, identified the cost-accounting structure that must be used for computing output-unit costs, and provided (in Appendix C) mathematical formulas for calculating output-unit costs and graphical techniques for displaying the results of these calculations.

Attention must now be given to existing cost-analysis models to identify other problems not yet considered and to note additional techniques that may be helpful in deriving a model or models to meet Army requirements. Four elaborate models are summarized in Appendix D. These and other models are cited in the following paragraphs.

USEFUL TECHNIQUES

To facilitate the design of alternative training systems, cost analysts need additional techniques for predicting how much training-unit costs (such as cost per student-hour of instruction) will be affected when certain changes are made in a system's design.

If cost analysts can identify the cost sources that contribute most to changes in output-unit costs, systems engineers could then concentrate on those cost sources as the most important to consider in systems design. This is not easily done without the special techniques provided in the COST-ED model in Appendix D. These techniques are useful in determining:

(1) The interaction effects of cost factors, which show how changes in one cost factor effect changes in another cost factor. For example, this technique answers questions such as these: If more intensive use of training facilities is planned, how much will this affect the cost per student-hour of instruction? Or, if programed instruction is planned to reduce the number of instructors, how much will this change the cost of instructors and output-unit costs?

(2) Sensitivity of output-unit cost to changes in cost factors, which shows the degree of percentage changes in output-unit costs caused by changes in different cost factors. For example, a change of 10% in one cost factor might result in only a 1% change in unit cost, whereas a change of 5% in another cost factor might result in a 10% change in the unit cost.

These techniques can be used by the Army on all four levels of training decision making. Whether other features of the computerized COST-ED model would be useful to the Army would have to be determined by further study.

PROBLEMS IN DETERMINING COSTS

The usefulness of other existing cost-analysis models for development of an adequate Army model, or models, is found chiefly in their techniques for estimating costs. The problem of which cost sources should be considered is different on each level of decision making. In other words, the specific costing problems are determined by the purpose in performing cost analyses, which is different on each level.

At the lowest level, the costing problem is simplest because the purpose is to compare only the alternative costs of specific methods-media combinations within a narrow range of system design. But even at this level, one cannot always determine exact dollar costs, especially when production of media must be considered. As Fisher (1) correctly noted, dollar-cost values usually do not represent absolute costs; rather, dollars are conveniently used to represent time and cost sources.

As one proceeds to the higher levels of decision making, Fisher's statement becomes even more true, and it becomes increasingly important for cost analysts to provide for tradeoffs that can be considered to keep instructional costs within budget restrictions (Craig and Dietrich, 5).

Also, at higher levels the cost factors to be considered become fewer. A study done for the Air Force by Westinghouse Learning Corporation (Appendix D) provides an example. In analyzing the problem of selecting service-wide media for Air Force training (a problem for the highest level of decision making), only the costs of training materials production, media equipment, facilities, supplies, and personnel expenses were considered.

The Westinghouse researchers found that for purposes of comparing different system costs, they needed only the critical ones, not all possible costs. They also found that they needed only a useful order of cost magnitude, rather than accurate totals.

Sovergin (Appendix D), in a three-volume report prepared for the U.S. Office of Education, drew conclusions that generally support the Westinghouse approach.

Speagle (Appendix D) listed only eight cost factors considered in his study of three major media systems (TV, computer access, and computer-assisted instruction). These factors were:

(1) Heavy, inherent overhead and fixed costs
(2) Cost-saving technologies
(3) Geographical concentration of the student population
(4) Cooperation among school districts and systems
(5) Machinery for evaluating the quality of and effectiveness of teaching techniques and materials
(6) Levels and types of teaching programs desired
(7) Rate of learning under innovative techniques
(8) Possibilities of replacing traditional teaching with instructional technology

Speagle was concerned with cost analyses on a high decision-making level, so the cost factors considered were gross. For decisions on lower levels, the cost accounting must be more detailed and precise. Gardner (6) concluded after surveying the cost-analysis literature, that a way is needed to avoid arbitrary assignment of costs to instructional functions. This means, he said, that there must be minute accounting of resource usage. He also observed that university faculties and administrators, with whom he was concerned, appear unwilling to accept the cost-accounting requirements. The degree to which these problems exist for the Army has yet to be determined.

The refined cost-accounting structure we proposed earlier in this chapter will greatly help in identifying specific training costs, particularly in the lower levels of decision making, but the overall Army policy level (Level IV) will continue to be fraught with many cost-uncertainty problems. All existing models designed for high-level cost analyses leave judgments of cost uncertainties largely to intuition, which can result in grossly inaccurate cost estimates.

In an effort to supplant intuitive cost judgments, Schafer (7) demonstrated that statistical analyses can provide cost probabilities for use in making better cost estimates. These techniques, combined with cost considerations found in existing high-level models, may provide the Army with the means of making the best possible cost estimates. Schafer's statistical models may also be quite helpful on the second and third levels in estimating proposed training costs.

The models summarized in Appendix D also provide other specific information that may be used for Army purposes, particularly in considering large media installations.

In addition, Rapp *et al.* (8) have provided a model for evaluating specific costs of alternative course designs which may be useful in analyzing Army course costs on Level II. Although this model was developed for evaluating costs of reading and arithmetic programs for junior high schools, application of its features for Army use should be studied.

Although numerous other cost studies were found in the literature, few seem useful as sources of information that might aid development of adequate Army cost-analysis models.

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Chapter 6

TRAINING-UTILITY ANALYSIS

The purpose of training-utility analysis is to provide decision makers with valid and reliable information for use in judging which alternative training system will yield the greatest payoff at the lowest possible cost. Training-utility analysis can be used to determine which system:

(1) Will cost least if all systems considered will yield the same payoff.
(2) Will yield the greatest payoff if costs of all the systems will be equal.
(3) Will yield the greatest payoff at the least cost.

These objectives of utility analysis will be discussed in the following sections in relation to specific problems.

PROBLEMS OF TRAINING-UTILITY ANALYSIS

As explained in Chapter 4, training-utility analysis includes five kinds of analyses: (a) cost; (b) benefit; (c) cost-benefit; (d) effectiveness; and (e) cost-effectiveness. Cost analysis and related problems were discussed in Chapter 5; the remaining kinds and their related problems are treated in the following paragraphs.

BENEFIT ANALYSIS

The benefit gained from adequate military organizations is national security, and this benefit consists of two sub-benefits: (a) deterring enemy attack, which is gained from the existence of adequately trained and equipped manpower, and (b) repulsing enemy attack when it occurs, which is gained from military action.

Each of these benefits can be subdivided into more specific benefits, such as deterring and repulsing attack on the home country and deterring and repulsing attack on allied countries, and so forth.

Another benefit often derived from training is reduction of the organization's operating cost.

The problems of benefit analysis are of two major kinds:

(1) Identification of specific benefits or portions of benefits that can be attributed to training.
(2) Determination or estimation of the dollar values of these benefits.

Identification and evaluation of reduced Army operating costs that can be attributed to training are less complicated than the same tasks in relation to national security, but they are still difficult.

In thinking of Army readiness, suppose that equipment down-time is a problem. Someone must determine whether excessive down-time is due to inadequately trained maintenance personnel or due to other factors, such as inadequate supervision of personnel or lack of spare parts. If down-time can be reduced by more adequate training, the operating costs that can be saved may be estimated by considering the following factors:

(1) Cost of parts lost because of faulty preventive maintenance.
(2) Cost of personnel time wasted because of down-time.
(3) Other excessive operating costs due to down-time.
(4) The percentage of the total that probably can be saved by training.

If the costs that can be saved are greater than the cost of more adequate training, the reduction in operating cost may be justification enough for training improvement. If not, the probability of losing national security benefits should be considered.

What might be the cost consequences of inadequate training if lack of readiness reduces the capability of repulsing attack? Or in time of war, what might be the cost consequences if battles or attack opportunities are lost?

Obviously, it would be very difficult to estimate dollar costs of such consequences, but despite the problems, a purist would say it must be done. Actually, someone does indirectly estimate the value of national security when military funding is being considered. This is necessary to justify appropriations, although the estimates may not be very accurate. And for training-utility analysis, as Quade (1) pointed out, dollar evaluation of benefits does not need to be highly accurate; the benefit-value and training-cost estimates must indicate only the relative merits of alternative training systems.

Quade compared these requirements to those encountered in cost-benefit studies of the proposed supersonic transport. He observed that no one could confidently predict the benefits of SSTs or determine whether demand would be great enough for their commercial success, but evaluations of competing designs were made anyway by comparing their relative merits.

COST-BENEFIT ANALYSIS

Training cost-benefit analysis involves evaluation of national security benefits and reduction of Army operating costs (which can be attributed to training) in relation to training costs. Analyses involving national security benefits probably would be performed on the fourth decision-making level, while analyses involving reduction of operating costs may be performed on both the third and fourth levels.

To emphasize the intended value of training-utility analysis, two aspects of cost-benefit analysis should be considered. One is merely estimating the utility value of a given training system. The other is comparing the utility values of alternative training systems to identify the most cost-effective system.

The process for estimating the utility value of a given training system is relatively simple. For example, if reasonable dollar-value estimates of national security training benefits can be made, the utility value of the existing overall Army training system can be estimated by subtracting the dollar cost of the system from the estimated dollar value of the benefits gained. The same could be done to estimate the utility values of training systems on the Army subsystem level. This kind of analysis alone is not helpful, however, in making choices between alternative systems.

Therefore, in addition to training-cost accounting and benefit analysis, training-utility analysis must include appropriate cost-analysis procedures so that the relative cost-benefit (utility) values of alternative training systems can be readily estimated and compared.

EFFECTIVENESS ANALYSIS

Training-effectiveness analysis is the process of measuring training outcomes to convert them to training payoffs. Training outcomes of interest may be tangible or intangible. For example, we may consider student job or job-related performance as tangible and student attitudes and morale as intangible. Whether tangible or not, every training outcome to be used in cost-effectiveness analysis must be measured. This is easy to state, but valid and reliable measurement of outcomes to obtain meaningful payoffs is difficult, and the intangible ones are more difficult to measure than the tangible.

Since the purpose of training is to prepare personnel for job performance, the most meaningful payoffs are those obtained by reliable job-performance appraisals. But reliable job-performance appraisals are difficult to obtain, so this kind of feedback from the field to schools is rare. For this reason, training decision makers usually base their judgments on data obtained by tests which are administered on the course level.

Such tests are intended to reliably measure student attainment of training objectives, and the test scores are used as measures of training effectiveness. However, for test results to be valid as effectiveness measures, they must reliably predict student job performance. To do so, the following conditions must hold:

(1) The training objectives and standards must be based upon job-entry performance requirements and standards.
(2) The tests must be based directly upon the training objectives and standards.
(3) The number of test items must be large enough to reliably represent the objectives and standards.
(4) The tests must be reliably administered.

To determine whether tests are valid predictors of job performance, the performances of students on tests must be compared with the job-performance evaluations of the same students. If the results of these comparisons show that test scores do predict job performance, then the tests can be considered valid, and this validity can be taken as evidence that the test scores can be used meaningfully as training payoffs.

Before proceeding, it must be noted that some authors consider reduced instructional time as a payoff. Although reduction of training time is often desired, it is a cost factor, not an effectiveness (payoff) factor, and training time must be taken into account as cost in cost-effectiveness analysis.

COST-EFFECTIVENESS ANALYSIS

Training payoffs are used in cost-effectiveness analyses to determine or estimate training-utility values and to calculate cost-effectiveness indexes.

If training payoffs are to be used for deriving training-utility values, they must have dollar values assigned to them. This does not mean that calculations cannot be done with non-dollar-valued payoffs, but it does mean that results of the calculations cannot be properly called "utility values"; instead, they should be called "cost-effectiveness indexes."

Cost-effectiveness indexes can be very useful as indicators of utility values. For example, suppose that Army officials are concerned about the malfunction rate in a weapons system and want to compare alternative training systems for reducing malfunctions. To get utility values as bases for comparing the systems, someone would have to assign dollar values to those malfunctions which each training system might eliminate. Usually, however, the training-utility analyst need not be concerned. He can assume that someone may assign dollar values if they want that kind of information. So he would calculate a cost-effectiveness index by using non-dollar-valued payoffs, such as valid test scores.

The problem of predicting future training payoffs for comparing systems remains, but it can be solved. Suppose, for example, that an existing course has been in operation for some time and that student test scores have been kept on record. Suppose also that the number of students that have been trained is a valid and statistically reliable sample of the student population yet to be trained. The test scores could then be used to predict the proportions of future students who would fall into specified student-performance categories.

If the design of this course is to be changed to make it more effective, the new course must be developed and tested with a sample of students large enough to validly and reliably represent the future student population. The test scores from this group could then be used to predict the proportions of future students who would fall into specified student performance categories.

The results of these two sets of figures might appear as shown below:

	Grade-Level Categories		
	I	*II*	*III*
Old course	.20	.25	.55
New course	.55	.25	.20

If the test standard is "Go, No-Go" the categories might appear as below:

	Go	*No-Go*
Old course	.75	.25
New course	.95	.05

If all students were trained to the same standard, such as "Go," effectiveness of the alternative courses would not vary, but training time probably would, and time represented in cost would still yield a difference between the cost-effectiveness indexes.

If intangible training outcomes, such as attitudes and morale, can be measured in some meaningful way, then they could become training payoffs, and the test scores could also be used in the way just described. It must be emphasized again, however, that tests used for obtaining training payoffs must be both valid and reliable, otherwise they would yield spurious data that could seriously reduce the validity of training-utility analysis and thus lower the quality of decision-maker judgments.

A MATHEMATICAL FORMULA FOR COST-EFFECTIVENESS ANALYSIS

Assuming that reliable cost estimates and valid effectiveness data are available for two alternative training systems, a mathematical formula can be applied to calculate the systems' cost-effectiveness indexes. If the effectiveness data are dollar values, then the systems' utility values could be calculated.

To demonstrate how cost-effectiveness indexes can be used to compare different training systems, a formula was derived for use on the course level. This formula is given in Appendix E where its use is demonstrated with actual training cost and test data.

Derivation of other formulas should await determination of the kinds of problems the Army wishes to treat in utility analyses.

TRAINING-UTILITY ANALYSIS IN GENERAL

Our limited knowledge of how utility analysis can be applied to solve Army training problems may have caused us to overemphasize use of the techniques on the course level. To show some implications for the process on all four Army decision-making levels, we have posed sample questions for each level that could be answered. These questions are given in Table 9. At this time, the questions must necessarily be general; only further study can determine the specific ways in which the Army can use the techniques.

LITERATURE PERTAINING TO UTILITY ANALYSIS

A thorough search of the literature pertaining to utility analysis revealed little information of specific value for Army purposes. The chief reason for this lack is that most of the literature pertains to public education problems that are not specifically

Table 9

Sample Training Questions

Level	Questions
I. One lesson or one subject-matter level	Which instructional procedure produces higher student performance?
	Which method-media combination will reduce training time?
	Which instructional-unit design will yield a lower rate of student failures?
	Toward which procedure do instructors and students have more positive attitudes?
II. Course level	Which course design will produce desired student performance in the least time?
	Which design yields the highest rate of high-performing students?
	Which design will enable low-ability students to achieve higher levels of performance?
III. Army subsystem level	Which training system will produce higher job performance?
	Which system yields a higher rate of skilled personnel?
	What effects will on-the-job training have on job performance?
	Which is the overall least-costly way of preparing personnel for their jobs?
IV. Overall Army system level	Which training policies are best for achieving defense-system readiness?
	What long-term investments should be made in training?
	Which training policy should be adopted for meeting future military needs?
	What implications do new technologies (weapon systems) have for Army training?
	Which training policies will be most effective for meeting state-of-emergency needs?

related to Army training. Of the few reports in the area of vocational training, most deal with interests of profit-making organizations that also have little in common with Army problems.

Nevertheless, some of the literature (cited in the following sections) may be helpful in tailoring training-utility analysis for Army needs.

QUESTIONS POSED

One future benefit found in the literature consists of questions raised and discussed which must be answered in relation to Army needs. Lumsdaine (2) asked three crucial questions and pointed out that they have different meanings on different levels of decision making. The questions are:

(1) What are instructional outcomes? (What outcomes are of interest)?
(2) What constitutes worthwhile differences in (instructional) effectiveness?
(3) How can differences in outcomes be measured?

Miller (3) poses other questions that may also be asked by Army training officials, such as:

(1) What can I buy with a small increment in cost?
(2) What is the critical mass necessary to produce (instructional) results? (referring to the number of designers and producers of instructional systems)
(3) Can I find others to share the cost?

COST-EFFECTIVENESS MODELS

Various cost-effectiveness models have been presented in the literature for specific applications, some of which may be adapted for Army use.

Alkin (4) outlines a model that permits decision makers to compare outcomes that are measured in different units. His model is for evaluation of public school programs on five levels of financial input. The problems involved may be somewhat analogous to Army problems on the third and fourth levels.

Kiesling (5) attempts to relate problems of evaluating educational outcomes to those of evaluating government outputs in general, and his analytical procedure for determining costs of media and their place in an instructional system may be useful.

Tanner (6) developed "an expected opportunity loss" model that may deserve serious attention. His decision-making technique uses subjective data, which are rankings of courses according to their expected contribution to the total program.

If the Army should consider use of Computer-Assisted Instruction (CAI), the cost-effectiveness study by Kopstein and Seidel (7), which compared CAI systems and traditional instruction, probably would be useful.

MATHEMATICAL FORMULAS

Two sources probably will be helpful in deriving additional cost-effectiveness mathematical formulas that may be needed for specific Army purposes. These are Cronbach and Gleser (8) and Edwards (9). Both apply decision theory in developing mathematical formulas that may be adapted for special Army cases.

OTHER CONSIDERATIONS

Of growing interest in general education is the concept of "accountability" of teachers and officials for the results of education. The concept arose from the experiments of some public schools with performance contracting. This term refers to contracts made by private concerns with public schools to instruct students, which provide that the contractors be paid according to the degree of student achievement. In effect, these contractors guarantee student achievement or they do not get paid. The notion that regular teachers and school officials should likewise or somehow be held accountable for student achievement has elicited widespread concern. The concept has also grown to include educator responsibility for decisions made in expending funds and for the value of educational results.

Concern about accountability has resulted in numerous publications which pose questions, discuss problems, and propose means by which accountability can be achieved. The most important of these publications are Lennon (10), Stufflebeam (11), Barro (12), Wynne (13), and Roberson (14). In addition, two journals[1] devoted entire issues to accountability.

Whether the Army should be interested in accountability or in performance contracting are moot questions.

Kirby (15), in estimating the costs and benefits for both individuals and the Federal government in the Training and Technology Project, derived a "rate of return" analysis that the Army may want to consider in relation to training benefits, particularly in relation to volunteer Army concepts.

Other sources may also contain implications for Army training. Sands (16) provides a model for recruiting, selecting, inducting, and training sufficient personnel to meet specified quotas, and a wide range of manpower development problems is analyzed and discussed in a book by Warren (17). A study by the Air Force (McCall and Wallace, 18) to determine the degree to which Air Force training is transferable to civilian jobs may also be pertinent.

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Appendices

Appendix A

METHODS-MEDIA SELECTION PROCEDURES IN THE LITERATURE

Gagne (1) provided a matrix (Table A-1) for selecting media according to the degree ("Yes," "No," "Limited") those media can perform the instructional functions discussed in Chapter 3. The function categories are too gross and the media named are too few to be of much assistance to the systems engineer in precise selection of media for specific purposes. This criticism more or less applies to other media selection schemes presented in this appendix.

Table A-1

Instructional Functions of Various Media[a]

Function	Media						
	Objects; Demonstration	Oral Communication	Printed Media	Still Pictures	Moving Pictures	Sound Movies	Teaching Machines
Presenting the stimulus	Yes	Limited	Limited	Yes	Yes	Yes	Yes
Directing attention and other activity	No	Yes	Yes	No	No	Yes	Yes
Providing a model of expected performance	Limited	Yes	Yes	Limited	Limited	Yes	Yes
Furnishing external prompts	Limited	Yes	Yes	Limited	Limited	Yes	Yes
Guiding thinking	No	Yes	Yes	No	No	Yes	Yes
Inducing transfer	Limited	Yes	Limited	Limited	Limited	Limited	Limited
Assessing attainments	No	Yes	Yes	No	No	Yes	Yes
Providing feedback	Limited	Yes	Yes	No	Limited	Yes	Yes

[a]From Gagne (1). Permission to reprint given by copyright holder.

Allen, *et al.* (2) related instructional media to learning objectives in the matrix shown in Table A-2. Allen also presented two other matrices, Tables A-3 and A-4, to show equipment/media relationships and considerations, and to relate media and media characteristics.

Table A-2

Media Related to Learning Objectives[a]

Type of Instructional Media	Learning Objectives[b] Learning Factual Information	Learning Visual Identifications	Learning Principles, Concepts, and Rules	Learning Procedures	Performing Skilled Perceptual-Motor Acts	Developing Desirable Attitudes, Opinions, & Motivations
Still Pictures	Medium	HIGH	Medium	Medium	low	low
Motion Pictures	Medium	HIGH	HIGH	HIGH	Medium	Medium
Television	Medium	Medium	HIGH	Medium	low	Medium
Training Aids	low	HIGH	Medium	Medium	low	low
Audio Recordings	Medium	low	low	Medium	low	Medium
Trainer (Simulator)	Medium	HIGH	HIGH	HIGH	HIGH	Medium
Programmed Instruction	Medium	Medium	Medium	HIGH	low	Medium
Demonstration	low	Medium	low	HIGH	Medium	Medium
Printed Textbooks	Medium	low	Medium	Medium	low	Medium
Oral Presentation	Medium	low	Medium	Medium	low	Medium

[a]W.H. Allen, R.F. Filep, and S.M. Cooney. *Visual and Audio Presentation in Machine Programed Instruction,* OE Final Report, 1967, ©University of Southern California. Reprinted by permission.

[b]Each type of instructional media is rated on one of three levels of effectiveness ("low," "Medium," "HIGH") in obtaining the learning objectives.

Table A-3

Equipment/Media Relationships and Considerations[a]

Instrument	Media Used	Materials Production Considerations	Availability of Facilities and Equipment	Equipment Cost
1. Filmstrip or slide projector	35mm filmstrips or 2x2 slides	Inexpensive. May be done locally in short time.	Usually available. Requires darkened room.	low
2. Overhead transparency projector	Still pictures and graphic representations.	Very inexpensive. May be done locally in short time.	Available. May be projected in light room.	low
3. Wall charts or posters	Still pictures	Very inexpensive. May be done locally in a very short time.	Available. No special equipment needed.	very low
4. Motion pictures (projection to groups)	16mm motion picture (sound or silent)	Specially-produced. Sound film is costly and requires 6-12 months time.	Usually available. Requires darkened classroom.	moderate to high

(Continued)

Table A-3 *(Continued)*

Equipment/Media Relationships and Considerations

Instrument	Media Used	Materials Production Considerations	Availability of Facilities and Equipment	Equipment Cost
5. Motion picture projection as repetitive loops (8mm silent) to individuals	8mm motion picture film (silent)	Special production normally necessary. May be produced as 16mm film alone or locally at low cost and in short time.	Not normally available. Will need to be specially procured to meet requirement of instructional program.	low per unit, but moderate for groups
6. Magnetic tape recorder	¼" magnetic tape	Easy and inexpensive. Usually produced locally.	Available	low
7. Record player	33 1/3, 45 or 78 rpm disk recordings	Need special recording facilities. Usually commercially made.	Usually available	low
8. Display area	Trainers and training aids	May vary in complexity and in difficulty of production. Component parts easy to obtain.	Usually available	varies from low to high
9. Television (closed-circuit)	Live presentations. Motion picture film. Videotape recordings. Still pictures.	Normally requires large and skilled production staff.	Not normally available	moderate to high
10. Teaching machines & programmed textbooks	Programmed material	Some programs available commercially. But will normally be specially prepared for course.	Not normally available	low per unit, but moderate for groups
11. System combinations	Television. Motion pictures. Still pictures. Audio recordings.	Complex. Probably will be done locally to meet specific requirements.	Not normally available	moderate to high

[a]W.H. Allen, R.F. Filep, and S.M. Cooney. *Visual and Audio Presentation in Machine Programed Instruction*, OE Final Report, 1967, © University of Southern California. Reprinted by permission.

Table A-4

Contributions of Audiovisual Instructional Materials to Learning Media[a]

MEDIA CHARACTERISTICS	16mm. Sound Motion-Picture Films	8mm. Silent or Sound Motion Picture Films	Filmstrips	Slides	Flat Pictures and Learning Displays	Posters and Charts	Maps	Chalkboard	Community Study	Radio	Recordings and Transcriptions	Language Labs and Tape Recorders	Models and Specimens	Educational Television	Programmed Learning Materials
Visual															
Visually recreates situations involving motion which occur anywhere	X	X							X				X	X	X
Visually recreates the past	X	X	X	X	X	X		X					X	X	X
Visualizes theoretical ideas and microscopic life	X	X	X	X	X	X		X					X	X	X
Visualizes with natural color	X	X	X	X	X	X			X				X	X	X
Visualizes natural dimensions (three-dimensional)	X	X	X	X	X			X	X				X	X	
Audio															
Recreates characteristic of environmental sounds	X	X	X						X	X	X	X		X	X
Recreates events through dramatization	X	X	X							X		X		X	X
Utilization															
Sequence fixed	X	X	X											X	
Flexible organization permits rearrangement				X	X	X	X	X	X		X	X	X		X
Permits restudy	X	X	X	X	X	X	X	X	X		X	X	X	X	X

[a]W.H. Allen, R.F. Filep, and S.M. Cooney. *Visual and Audio Presentation in Machine Programed Instruction,* OE Final Report, 1967,©University of Southern California. Reprinted by permission.

References for Appendix A

1. Gagne, R.M. *The Conditions of Learning*, (1st ed.), Holt, Rinehart and Winston, Inc., New York, 1965.

2. Allen, W.H., Filep, R.F., and Cooney, S.M. *Visual and Audio Presentation in Machine Programmed Instruction*, OE Final Report, University of Southern California, Los Angeles, 1967.

Appendix B

MEDIA CLASSIFICATION SCHEMES IN THE LITERATURE

Meredith (1) attempted to provide an adequate media classification scheme by specifying four major categories to which he thought media should be related:

(1) Physical variables in the material and form of the medium providing the stimulus.

(2) Neuroanatomical variables in the sensory-motor structure involved in learner responding.

(3) Ecological variables related to architecture and other environmental factors among which the media would be placed.

(4) Collective variables that include time, memory, learning, student history, attention, purpose, expectation, imagination and anticipation.

Several somewhat similar attempts were made by Dale (2), Ely (3), Knowlton (4), and Lumsdaine (5). The most recent is by Bretz (6). His classification scheme, shown in Figure B-1, was criticized by Ely (7).

Tosti and Ball (8) provided a classification system in three dimensions: encoding, duration, and response-demand. These are shown in Figures B-2, B-3, and B-4 and are used to relate the dimensions to each other and to other media and instructional variables.

Gerlach (9) argued that selection of an instructional instrument (along with determination of the teacher's instructing behavior) is based upon its ability to provide the combinations and permutations of stimulus conditions that control directly or indirectly relevant student responses. He assumed that more than one instructional instrument will provide with equal effectiveness the required stimulus conditions. Thus, final selection of an instructional instrument may be based on what is available and what the teacher prefers to use.

He noted that activities prior to media selection include task analysis, statement of objectives in behavioral terms (such as identifying, classifying, naming, ordering, stating a rule, applying a rule), and development of Instructional Specifications.

He included in Instructional Specifications a statement of the objective, the instructional cue, eliciting cues, and the limits (determination of stimuli to which the response is attached and those closely related stimuli to which the response is not attached). Once the Instructional Specifications have been developed, he said, they control the teacher's instructing behavior (and selection of content, materials, media, and sequence). He noted that the best possible medium for presenting the stimulus of interest is determined by the stimulus-presentation characteristics of the various media. Finally, he put desired stimulus characteristics in a matrix with media (Table B-1), the media being subdivided into projected, nonprojected, recorded sound, and 3-D materials.

The major difficulties in media selection, according to Gerlach, are in defining relevant responses and in specifying the stimulus conditions that are to control these responses.

Gerlach and Ely (10) present a procedure in which selection of learning resources (performed following specification of content and objectives, assessment of entering

The Communication Media

Telecommunication	Sound	Picture	Line Graphic	Print	Motion	Recording
Class I: Audio-Motion-Visual Media						
	X	X	X	X	X	Sound film
Television	X	X	X	X	X	Video tape; Film TV recording
	X	X	X	X	X	Holographic recording
Picturephone	X	X	X	X	X	
Class II: Audio-Still-Visual Media						
Slow-scan TV; Time-shared TV	X	X	X	X		Recorded still TV
	X	X	X	X		Sound filmstrip
	X	X	X	X		Sound slide-set
	X	X	X	X		Sound-on-slide
	X	X	X	X		Sound page
	X	X	X	X		Talking book
Class III: Audio-Semimotion Media						
Telewriting	X		X	X	X	Recorded telewriting
Class IV: Motion-Visual Media						
		X	X	X	X	Silent film
Class V: Still-Visual Media						
Facsimile		X	X	X		Printed page
		X	X	X		Filmstrip
		X	X	X		Picture set
		X	X	X		Microform
		X	X	X		Video file
Class VI: Audio Media						
Telephone; Radio	X					Audio disc; Audio tape
Class VII: Print Media						
Teletype				X		Punched paper tape

NOTE: R. Bretz: *The Selection of Appropriate Communication Media for Instruction: A Guide for Designers of Air Force Technical Training Programs*, 1971, © The Rand Corporation, (6). Reprinted by permission.

Figure B-1

Presentation Dimensions

	Encoding	Duration
Stimulus	Environmental structure Pictorial Symbolic Verbal	Transient ↑ Length of time the presentation remains-intact ↓ Persistent

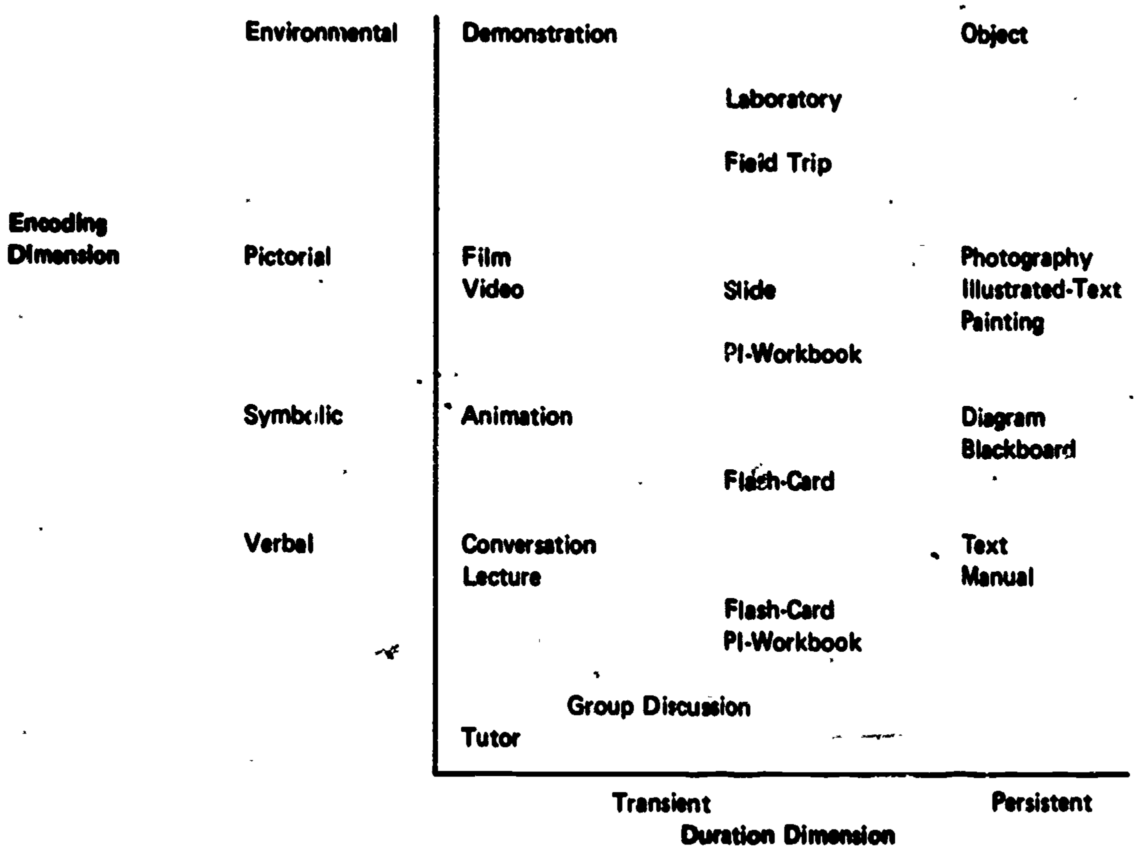
	Response Demand	Response Demand Frequency
Response	Covert Selective Constructed Vocal Motor Affective	Frequent ↕ Sparse

	Manager Purpose	Instructional Management Frequency
Management	Need Management Attainment Management Prescriptive Management Enrich Management Motivation Management Systems Support	Frequent ↑ Frequency of decision to change presentation ↓ Sparse

NOTE: D.T. Tosti and J.R. Ball. "A Behavioral Approach to Instructional Design and Media Selection," © *AV Communication Review*, (8). Reprinted by permission.

Figure B-2

Media Classified by Encoding Versus Duration



NOTE: D.T. Tosti and J.R. Ball. "A Behavioral Approach to Instructional Design and Media Selection," © *AV Communication Review*, (8). Reprinted by permission.

Figure B-3

Media Classified by Encoding Versus Response Demand

Encoding Dimension	Covert	Selective	Vocal	Constructed	Motor
Environmental	Demonstration Field-Trip	Item-Sort			
Pictorial	Film Video Slide Painting Photograph	Multiple-Choice- Teaching Machine		Illustrated- PI-Text	Laboratory
Symbolic	Blackboard Diagram	Card-Sort	Flash-Card		Diagram
Verbal	Lecture Audiotape	PI-Workbook	Conversation Role-Playing Audiotape		
	Text	Tutor	Tutor	Tutor	Tutor

Response Demand Dimension

NOTE: D.T. Tosti and J.R. Ball. "A Behavioral Approach to Instructional Design and Media Selection," © *AV Communication Review,* ([illegible]). Reprinted by permission.

Figure B-4

Table B-1

Classification of Media According to Their Stimulus Characteristics[a]

CHARACTERISTICS	MEDIA[b] Projected: Slides	Filmstrips	Overhead Transparencies	Opaque Materials	Non-Projected: Charts, Posters, Bulletin Boards	Chalkboards	Programed Textbooks	Recorded Sound: Tape	Records	Sound Track	3-D Materials: Motion Pictures	Realia	Models and Mock-ups	Community Trips
Black and white	X	X	X	X	X						X	X		
Color	X	X		X	X						X	X		
High reality	X	X		X				X	X		X	X	X	X
Simultaneous picture and text	X	X		X			X				X			
Flexible sequence	X		X	X										
Internally controlled pacing	X							X	X	X	X			
High enlargement	X	X									X		X	
High reduction	X	X									X		X	
3-dimensional												X	X	X
Movement											X		X	X
Simultaneous eliciting stimulus and feedback					X		X	X	X	X	X			
Sound accompanying	X										X			
Fixed sequence		X					X	X	X	X	X			
Externally controlled pacing	X	X						X		X				
2-dimensional	X	X	X	X	X	X					X	X		
Cueing of non-verbal responses											X		X	
Flexibility and variation of representation			X	X		X								
Differential illumination of components or pathways			X											
[illegible]ochromatic			X			X								
Provision for overt responses							X				X			
Static	X	X		X	X		X		X	X	X	X	X	X
Dynamic			X			X		X						
Successive approximations of terminal behavior							X							
Individual pacing							X	X						
Immediate feedback							X	X			X			
Adaptive to learner's responses							X							
Lip synchronization										X	X			
En route responses							X	X	X		X			

[a] V.S. Gerlach, "Selecting an Instructional Medium," chapter in *Media Competences for Teachers,* W.C. Meierhenny (ed.), (9).

[b] X means "Yes." A blank means "No."

behaviors, selection of approach and techniques, along with group size and time allocations) is based upon responses rather than on stimuli alone. They specified the following five factors for screening media:

(1) Appropriateness. Is the medium suitable to accomplish the defined task?

(2) Level of sophistication. Is the medium on the correct level of understanding for my students?

(3) Cost. Is the cost worth the potential learning from this particular medium?

(4) Availability. Are the material and equipment available when I need them?

(5) Technical quality. Is the quality of the material acceptable—readable? visible? audible?

The selection matrix used by Gerlach and Ely is shown in Figure B-5.

Media Selection Matrix

		Representations		Pictures				
	Real Things	Verbal	Graphic	Still	Motion	Audio Recordings	Programs	Simulations
Selection Factors								
Appropriateness		These factors must be considered first. If no barriers are present, then move to objectives below. If barriers are present, ask if they can be eliminated so that selection can be based on objectives.						
Level of Sophistication								
Cost								
Availability								
Technical Quality								
Objectives								
To Identify								
To Name								
To Describe								
To Order								
To Construct								
To Display Attitudes								
To Perform Motor Skills								

NOTE: Vernon S. Gerlach and Donald P. Ely, *Teaching and Media: A Systematic Approach*, ©1971. Reprinted by permission of Prentice-Hall, Inc., Englewood Cliffs, New Jersey (10).

Figure B-5

Two additional preconditions not integrated directly into the selection matrix are selection of group size and the events of instruction. The Gerlach and Ely media selection rule requires that a medium of instruction be selected on the basis of its potential for implementing the behavior stated in an objective.

Nunnelly and others (11) used a matrix (Figure B-6) to relate methods and media to learning tasks and suggested another matrix (Figure B-7) to relate job tasks to media, but they left the cells blank. The criteria they used for selecting training aids are given in Table B-2. Finally, they suggested cost-effectiveness and other criteria for selecting a single method-media combination.

Optimal Allocation of Method/Media to Learning Objectives

	Simulator	Part-Task Trainer	Animated Panels	Mock-up	Television	Moving Pictures	Still Pictures	Recorder	Programmed Instruction	Lecture/ Discussion
Learning Identifications	Yes	Yes		Yes	Yes	Yes	Yes	Aural Only		
Learning Perceptual Discriminations	Yes	Yes		Yes	Yes	Yes	Yes	Aural Only		
Understanding Principles and Relationships			Yes		Yes	Yes	Yes	Yes	Yes	Yes
Learning Procedural Sequences	Yes	Yes			Yes	Yes	Yes	Yes	Yes	Yes
Making Decisions					Yes	Yes	Yes	Yes	Yes	Yes
Performing Skill Perceptual-Motor Acts	Yes	Yes		Yes						

NOTE: Adapted from C.L. Nunnelly, *et al.* "The Instructional System Approach to Maintenance Technical Training: Development and Implementation Model," *Human Factors* (11) © Human Factors Society. Reprinted by permission.

Figure B-6

Parker and Downs (12) base media selection on the training objectives. The two criteria stated for selection of media are (a) its appropriateness to the particular task performance (from which the training objective is derived), and (b) its use to create an environment that best induces learning. They named five features that influence learning efficiency: trainee readiness, opportunity for correct response, guidance toward correct response, reinforcement, and motivation.

Parker and Downs also name five characteristics of effective training: appropriateness to initial performance level of trainee, relation to training objective, repeated practice of difficult performance, sample of problems of graded difficulty, and similarity to operational tasks. They also indicated cost as a selection factor, and consolidated their recommendations with first, second, and third choices. The results are shown in Table B-3. Their media selection matrix is shown in Figure B-8.

Wilshusen (13) classified many factors to be considered in selecting media according to four categories: learner characteristics, task requirements, materials, and transmission.

Method/Media Selection Matrix

	Simulator	Part-Task Trainer	Animated Panels	Mock-up	Television	Moving Pictures	Still Pictures	Recorder	Programmed Instruction	Lecture/ Discussion
Assemble-Disassemble										
Remove-Install										
Adjust-Align-Calibrate										
Test-Check Out										
Handle-Transport										
Package-Unpackage-Protect										
Connect-Disconnect										
Check-Inspect-Monitor										
Service										
Troubleshoot										
Record										
Communicate										
Supervise										
Operate										
Other (list)										

NOTE: Adapted from C.L. Nunnelly, *et al.* "The Instructional System Approach to Maintenance Technical Training: Development and Implementation Model," *Human Factors* (11) © Human Factors Society. Reprinted by permission

Figure B-7

Table B-2

Training Aid Selection Criteria and Task Specifications[a]

Level I: Requires *simple identification* of components; understanding of discrete perceptual, motor, and/or perceptual-motor behavior segments.

1. No emphasis in operational integrity.
2. No requirement for high simulation fidelity.
3. Low order of task complexity.
4. Learning objective:
   a. Awareness
   b. Discrimination

Level II: Requires learning of specific *procedures* using equipment which represents operational configuration. Emphasis on orderly sequences, parts relationships, test, check, etc.

1. Emphasis on feedback for test.
2. Emphasis on positive transfer to real equipment requirements.
3. No high simulation fidelity for internal operation of trainer to aircraft.
4. Learning objective:

Prerequisite	a.	Awareness
	b.	Discrimination
NEW	c.	Application within established order with self-initiated strategies

Level III: Task specifications require learning of single sets of tasks which represent only part of total operational requirements. Emphasis on operational integrity for maximum transfer to real world.

1. Emphasis on system operational identical to aircraft operation.
2. High simulation fidelity.
3. Emphasis on continuous feedback and system integrity for trainer.
4. High order of task complexity:
   a. Self-initiated responses based on continuous changing of S-R components (displays, controls).
   b. Responding to a variety of S-R configurations, requiring immediate and unique response modes.
   c. Real time continuous for operation model.
   d. Learning objective:
      (1) Awareness
      (2) Discrimination
      (3) Procedure Application
      (4) Application of analysis and decision-making commitments (problem solving strategies).

Level IV: Task specifications require learning of total operational task as required for actual full operation of aircraft.

1. Highest simulation fidelity.
2. Total feedback–response cycle required for aircraft operation in all normal emergency modes.
3. Highest order of task complexity.
4. Learning objective: Total operational proficiency for subsystem.
   a. Analysis, application, etc., through correct decisions at appropriate time, using correct procedures, and correct problem-solving strategy to achieve stated measure objective for aircraft.

[a]C.L. Nunnelly, *et al.* "The Instructional System Approach to Maintenance Technical Training: Development and Implementation Model," *Human Factors* (11). ©Human Factors Society. Reprinted by permission.

Table B-3

Example of Information Appearing in a Qualitative and Quantitative Personnel Requirements Information Document[a]

Item	Remarks
Task Index Number:	A numbering system is used to identify each task; usually corresponding to the numbering in the system functional flow diagrams.
Data Sources:	For each major source of data, as an aid in later verification, record the date and equipment status (see MIL-D-26239A) at the time the information becomes available.
Task Title:	The task title should be short and should tell what the man does in functional terms.
Job Operation:	A job operation is the performance of a support or mission function of a system; usually performed at a single location as a unit of work, i.e., it has a definite beginning and ending.
Duty:	The larger units of work under a job operation assigned to an individual in the execution of a position. Duties are made up of operationally similar tasks in a given operator or maintenance position.
Position:	The position-type title or AFSC to which it is believed each task should be assigned.
Work Area or Location:	The identification of the work area or location.
Task Description:	Normally, the following will be included:
a. Equipment:	–Describe to the levels of subsystem and component.
b. Indicator (Display):	–Information, perceptible to an individual, concerning some aspect of the functioning or operational status of equipment; includes communication with other personnel.
c. Action:	–Give a detailed breakdown of all (essential) actions to be performed in response to display indications.
d. AGE and System Equipment:	–Identify the aerospace ground equipment (AGE), or other system equipment including special tools, and test equipment, used in performing the task.
e. Feedback Indication:	–Describe the procedures and indications that inform the man of the adequacy or inadequacy of his performance.

Continued

Table B-3 *Continued*

Example of Information Appearing in a Qualitative and Quantitative Personnel Requirements Information Document[a]

Item	Remarks
Type of Task:	Indicate the qualities or characteristics of the task through the use of such categories as (a) fixed precedure, (b) variable procedure, (c) motor skill, (d) system analysis, (e) circuit analysis, etc,.
Frequency of Performance:	Use 1 for once, 2 for twice, etc., in conjunction with H (hourly), S (per shift), D (daily), W (weekly), M (monthly).
Performance Time:	An estimate in hours and minutes of how long it normally will take Air Force personnel to perform each task, if appropriate; also cite the maximum permissible time for task.
Criticality:	Indicate the effect of failure to perform the task upon the success or failure of the job operation or mission.
Newness:	Indicate the extent to which the task is new to the Air Force or the extent to which the task is partly new and partly old.
Other Air Force Positions:	Identify tasks whose performance depends upon or interacts with the performance of personnel in other position types; identify these associated positions and indicate the functional interrelation of the tasks involved.
Safety Factors:	Any known or presumed hazardous conditions or sources of danger, whether mechanical, electrical, or chemical, should be identified and described in sufficient detail to provide guidance for their solution.
Personal Equipment:	Requirements for personal equipment (including protective clothing).
Skills and Knowledges:	Define the kinds of job oriented knowledges and skills involved in performing the task.

[a]Reprinted from Parker and Downs (12).

The Selection of Training Media in Relation to Specific Training Objectives

Training Objectives / Training Media	Simulator	Procedures Trainer	Animated Panel	Chart	Training Film	Transparencies	Mock-Ups	Television	Teaching Machines
Learning Identifications	3	3		2		1	3		
Learning Perceptual Discriminations	2				1	3			
Understanding Principles and Relationships	1	2	1	2	1	2	1 (Oper) 2 (Non-Oper)	1	2
Learning Procedural Sequences	2	1			3				
Making Decisions	3				2				1
Performance Skilled Perceptual-Motor Acts	1	2							

NOTE: Reprinted from Parker and Downs (12).

Figure B-8

A matrix (Figure B-9) is intended only to remove inappropriate media from consideration on the basis of four separate groups of factors.

Decisions about learner characteristics and task requirements are necessary before entering the matrix. Wilshusen's directions for using the matrix indicate that skilled personnel would be required to develop both learner characteristics and task requirements:

LEARNER CHARACTERISTICS

Large, medium, small, individual: refer to sizes of groups of learners.

Visual: learner characteristics dictate that the stimulus material be visual.

Audible: learner characteristics dictate that the stimulus material be audible.

Learner-paced: learner characteristics dictate that the rate of presentation be controlled by the learner.

Response: the medium contains provision for incorporating demand for learner response.

Self-instructional: learner characteristics dictate that stimulus materials be so designed that learner is able to use them with little or no supervision.

TASK REQUIREMENTS

Motion: task requirements indicate that motion must be depicted.

Time (exp/contract): refers to the possibility of expanding or contracting length of presentation as compared with real-time experience of same phenomena (e.g., slow motion or speeded motion pictures, compressed or expanded speech devices).

Matrix for Selecting Media

If → / Then ↓	Learner Characteristics									Task Requirements								Materials				Transmission				
	Large 100 +	Medium 30–100	Small 2–30	Individual	Visual	Audible	Learner Paced	Response	Self-Instructional	Motion	Time (Exp/Contract)	Fixed Sequence	Flexible Sequence	Sequential Disclo.	Repeatability	Context Creation	Affective Power	Obtainability	Reusability	Time to Obtain	Cost (4 Copies)	Simplicity (Eq.)	Availability (Eq.)	Controlability	Freedom from Dist.	Darkening not Req.
Real Object	■	■						■			■					■						■	■		■	
Model of Real Object	■	■						■								■						■	■		■	
Live Voice					■		■		■	■	■				■	■			■		■	■	■			
Audio Tape Record					■					■			■			■										
Print						■				■	■		■			■						■	■			
Programmed Instruction										■	■		◩			■							■			
Chalk Board	■					■	■		■	■	■				■	■			■		■					
Overhead Transparency				■		■	■		■		■					■										
Filmstrip						■				■	■		■			■										■
Slide						■					■					■										■
Motion Picture													■													■
TV							■						■		◩				◩							
Flat Picture	■	■				■				■	■					■						■	■	■	■	

Empty Cell = applicable
Partial Shading = partially applicable
Full Shading = *not* applicable

NOTE: L.J. Briggs: *Handbook of Procedures for the Design of Instruction: Monograph #4*, © American Institutes for Research, reprinted by permission. An earlier version appeared in Wilshusen (13).

Figure B-9

Fixed Sequence: refers to characteristic of medium that does not permit change in sequence of presentation beyond forward or reverse.

Flexible Sequence: medium permits change in order of presentation of stimuli.

Sequential Disclosure: medium permits revelation of material bit by bit and allows retention of prior bits as further bits are revealed.

Repeatability: medium allows complete or partial redisplay.

Context Creation: refers to capability of media to transport learner from awareness of real world to context artificially contrived. Motion pictures are an obvious example, but it is our contention that all media have this capability to some degree. A book has it, for example.

Affective Power: all media have the power to move people emotionally to some degree.

MATERIALS

The items in this group are reasonably clear.

TRANSMISSION

Simplicity: How simple is the equipment to operate?

Availability: How readily available is the equipment required to display the stimulus materials?

Controlability: How much control over the transmission can be exercised by the instructor? (Start/stop, slower/faster, freeze frame, volume change, forward/reverse, repeat, switch to different medium.)

Freedom from distraction: To what extent does the equipment distract the learners from the intended stimuli?

Darkening not required: medium can be presented without necessity of darkening learner environment.

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13. Wilshusen, J.F., Jr. Interdepartmental Communication, Audio-Visual Department, Indiana University, Bloomington, February 11, 1969. A slightly modified version of this document appears in Briggs, L.J., *Handbook of Procedures for Design of Instruction:* Monograph #4, American Institutes for Research, September 1970, p. 155.

Appendix C

BASIC MATHEMATICAL FORMULAS FOR USE IN COST ANALYSIS

Mathematical formulas for use in training-cost analysis are rather simple equations for calculating and comparing training output-unit costs for alternative training programs.

Before stating the formulas, we must note that basic developmental costs, once the investments are made, do not contribute any more to the cost of training many students than they contribute to the cost of training a few. In other words, basic developmental costs can be amortized over the life of the course. Operational costs, however, remain the same for each group of students, regardless of the number of groups trained. In other words, it costs as much to operate the training system for the 15th group, for example, as it does to operate the system for the first group (provided the operational costs are not changed).

Therefore, as the number of groups of students increases, the basic cost per group (or per student, or per student-hour of instruction) decreases, but the operational cost per output unit remains constant. For these reasons, basic developmental costs can be thought of as variable costs and operational costs as fixed costs. For simplicity, these two kinds of costs will hereafter be referred to as "basic" and "operational."

The mathematical formulas for calculating training output-unit costs and comparing them can now be stated.

FORMULAS FOR CALCULATING OUTPUT UNIT COSTS (UNDEPRECIATED VALUES)

If output unit is a group of students

$$C_g = \frac{B}{N} + O$$

Where: C_g = cost per group

B = basic cost

O = operational cost

N = total number of student groups (output units)

Example: If B = \$45,000

O = \$5,000

N = 20 groups of students

We would have: $C_g = \frac{\$45,000}{20} + \$5,000$

$C_g = \$2,250 + 5,000$

$C_g = \$7,250$ (The output-unit cost of the 20th group of students)

If output unit is each student

$$C_s = \frac{B}{N} + \frac{O}{n}$$

Where: C_s = cost per student

B = basic cost

O = operational cost

N = total number of students who have taken the course (including the present group)

n = number of students in the present course

Example: If B = \$45,000

O = \$5,000

N = 600 (the number of students in 20 groups—the output units)

n = 30

We would have: $C_s = \frac{\$45,000}{600} + \frac{\$5,000}{30}$

$C_s = \$75 + \$166.67$

$C_s = \$241.67$ (cost per student in the 20th group)

If output unit is each student-hour of instruction

$$C_{s\text{-}h} = \frac{B}{N} + \frac{O}{n}$$

Where: $C_{s\text{-}h}$ = cost per student-hour

B = basic cost

O = operational cost

N = total number of student-hours accumulated for the course (including current student-hours)

n = number of student-hours in the current course

Example: If B = \$45,000

O = \$5,000

N = 24,000 (total number of student-hours required to train 20 groups of students)

n = 1,200 (number of hours required to train the 20th group)

We would have: $C_{s\text{-}h} = \frac{\$45,000}{24,000} + \frac{\$5,000}{1,200}$

$C_{s\text{-}h} = \$1.88 + \$4.17$

$C_{s\text{-}h} = \$6.05$ (cost per student-hour for the 20th group)

As the total number of output units, N, increases by course repetition, the basic cost per output unit, $\frac{B}{N}$ decreases so that with the accumulation of a large number of output units, the basic cost per output unit tends toward zero. So in the long run, the output-unit cost would be almost equal to $\frac{O}{n}$, the operational cost divided by the number of output units associated with one group of students. These cost relationships are shown graphically in Figure C-1.

Depreciated unit cost formulas will have the form:

$$C = \frac{B}{N \cdot n} + O$$

Where: n = depreciation time. Similar formulas can be developed for the different output units selected for cost analysis.

FORMULA FOR CALCULATING CUMULATIVE OUTPUT-UNIT COSTS

If training decision-makers want to know the relationships of output-unit costs in terms of their accumulated total costs for a number of output units, cost analysts can use the following formula. For simplicity, the formula shown is for a group of students (taking a course) as the output unit.

$$C_N = B + N \cdot O$$

Where: C_N = cumulative output-unit cost
B = basic cost
O = operational cost
N = total number of output units

The results of calculating cumulative output-unit costs can be shown graphically, as in Figure C-2.

However, if the basic costs are subject to depreciation over m output units, the cost will be:

$$C_N = N\left(\frac{B}{m} + N\right)O = N\left(\frac{B}{m} + O\right)$$

For $N < m$. When $N > m$, basic costs have been paid for, therefore:

$$C_N = N \cdot O$$

Although the output unit used to exemplify the formula for calculating cumulative costs was a group of students, the cost relationships for other output units (cost per student, and cost per student-hour of instruction) would also be depicted as those in Figure C-2.

To compare two or more training programs, the formulas for calculating unit costs and cumulative unit costs would be used for each program; and when the results are plotted in a graph, decision makers can easily compare the programs by noting differences in their unit costs per number of output units.

The value of these analyses for comparing training programs will be shown later with an actual example. But first, one more useful mathematical formula must be presented.

Relationship of Basic Costs, Operational Costs, and Combined Costs Per Unit to Number of Output Units for One Training Program

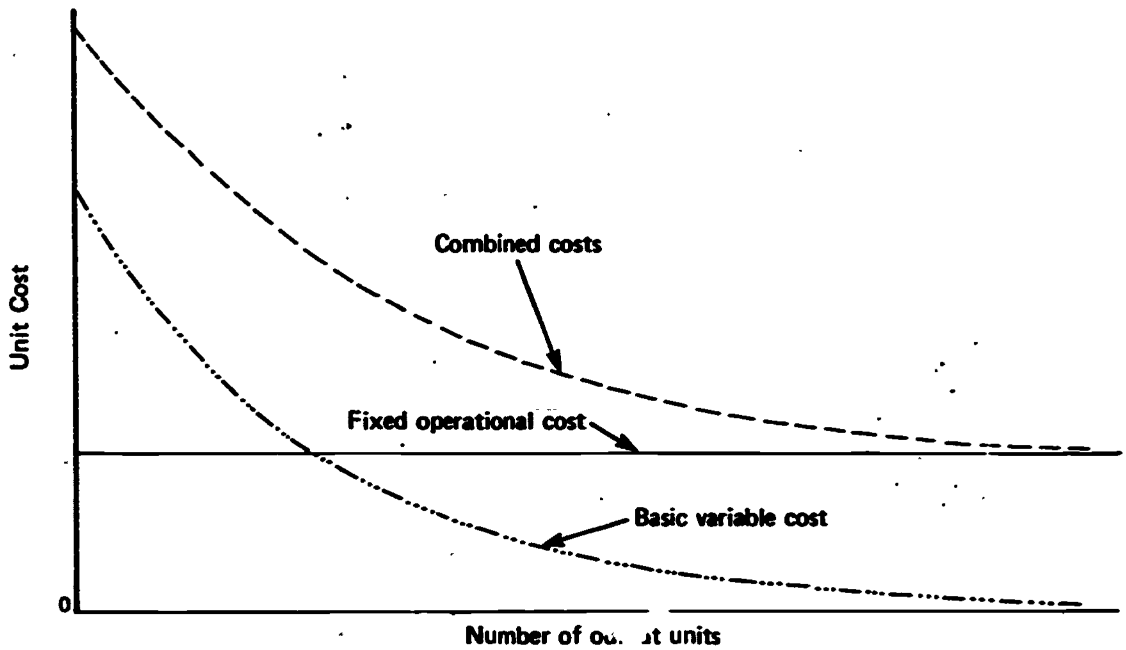

Figure C-1

Relationship of Cumulative Basic Costs, Operational Costs, and Combined Cumulative Costs Per Unit to Total Number of Output Units for One Training Program

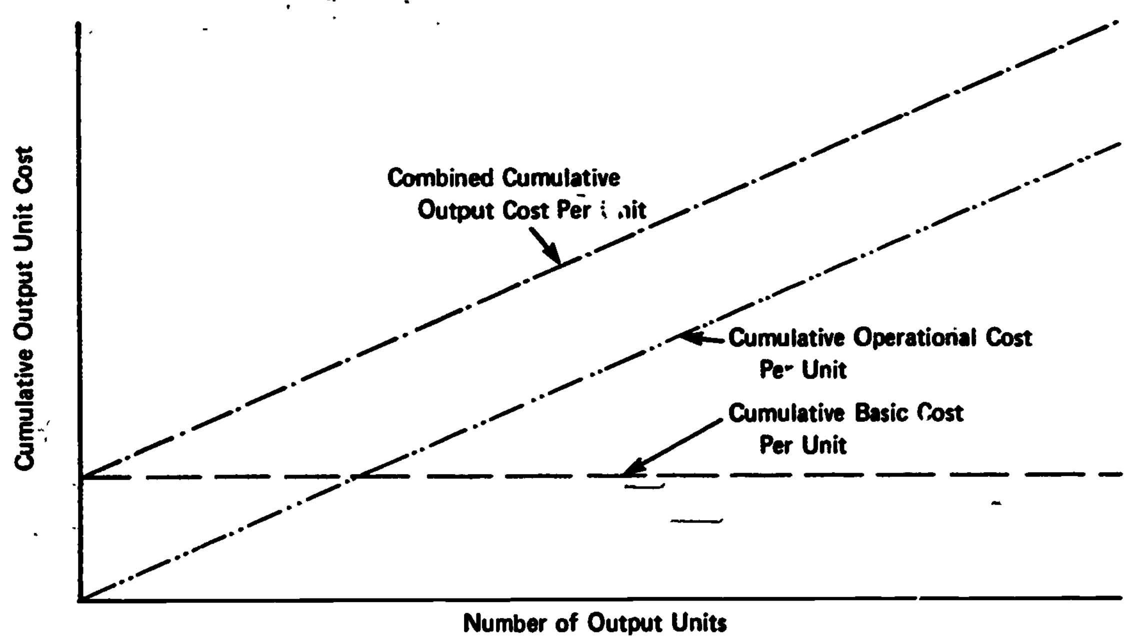

Figure C-2

A FORMULA FOR FINDING WHEN UNIT COSTS OF TWO PROGRAMS WILL BE EQUAL

By equating the unit cost for two programs, solving the equation for N, yields the number of output units for which the unit cost of the two programs will be equal.

$$\frac{B_1}{N} + O_1 = \frac{B_2}{N} + O_2$$

The solution for N:

$$N = \frac{B_1 - B_2}{O_2 - O_1}$$

Where: N = the Nth output unit (e.g., 4th, 5th, etc.) at which the unit costs will be equal

B_1 = basic cost of the first program

B_2 = basic cost of the second program

O_1 = operational cost of the first program

O_2 = operational cost of the second program

This formula can be used only under certain conditions:

(1) The output units for each course must be the same.

(2) If the value of N is a whole number and a fraction, the value must be rounded to the next whole number.

Both basic costs (B_1 and B_2) and operational costs (O_1 and O_2) must be unequal. If basic costs (B_1 and B_2) are equal, expenditures for the program with the larger operational costs will always exceed the alternative program. Similarly, if operational costs (O_1 and O_2) are equal, expenditures for the program with the larger basic cost will always exceed the alternative program (depreciation not considered).

This formula will be used in the next section with actual basic and operational costs for two different programs.

AN ACTUAL EXAMPLE

To provide an illustration of the use of these cost-analysis formulas for calculating output-unit costs and cumulative unit costs, they were applied to data from an actual R&D project designed to improve teletypewriter operator training.

The old program required 100 hours of training, but the experimental program reduced the number of hours to 30. The number of students trained in each course was 30. There were no significant differences in student performance on the final tests, but the rate of learning in the experimental program, was, of course, much greater. However, this criterion was not sufficient as a basis for a decision as to which program should continue in use, because the basic cost of the experimental program would be much more than the old one, so cost analyses were performed to compare the two programs.

The following program costs were accounted for:

The experimental program

Basic developmental cost

Investment	20,000
Salaries	2,000
Tape recorders	3,000
Overhead	1,000
TOTAL	26,000

(These figures are in arbitrary units, but are based on the actual project data.)

Operational cost

Instructors	600
Students	900
Maintenance	400
Space	600
Overhead	100
TOTAL	2,600

The old program

Basic developmental cost

Investment	5,000
Overhead	500
TOTAL	5,500

(Investments common to both programs, such as for teletypewriters and their installation, were excluded.)

Operational cost

Instructors	1,000
Students	3,000
Maintenance	1,000
Space	1,100
TOTAL	6,100

The output unit for each program was a group of 30 students.

Calculations were made for every other replication of the courses to predict changes over number of presentations, and the results are shown in Table C-1. The results for unit costs are graphically represented in Figure C-3.

Before the graph in Figure C-3 was prepared, the following formula was used to find the output unit at which their unit costs would be equal:

$$N = \frac{B_1 - B_2}{O_2 - O_1}$$

Where: N = the output unit at which the unit costs would be equal

B_1 = basic cost of the experimental program

B_2 = basic cost of the old program

O_1 = operational cost of the experimental program

O_2 = operational cost of the old program

Table C-1

Output Unit-Costs and Cumulative Output Uni: Costs for Illustration of Alternative Training Programs

Course Number	Experimental Program Unit Cost	Experimental Program Cumulative Cost	Old Program Unit Cost	Old Program Cumulative Cost
1	28,600	28,600	11,600	11,600
2	15,600	31,200	8,850	17,700
4	9,100	36,400	7,475	29,900
6	6,733	41,600	7,016	42,100
8	5,225	46,800	6,788	54,300
10	5,200	52,000	6,650	66,500
12	4,766	57,200	6,558	78,700
14	4,457	62,400	6,493	90,900
16	4,225	67,600	6,444	103,100
18	2,044	72,800	6,405	115,300
20	3,900	78,000	6,375	127,500
22	3,78:	83,200	6,350	139,700
24	3,683	88,400	6,325	151,900
26	3,600	93,600	6,311	164,100
28	3,528	98,800	6,296	176,300
3	3,466	104,000	6,283	188,500
35	3,343	117,000	6,257	219,000
40	3,250	130,000	6,238	249,500

Thus, $N = \frac{26{,}000 - 5{,}500}{6{,}100 - 2{,}600} = 5.857$, which is interpreted as 6.

The graph in Figure C-3 also shows that the unit costs would be equal with six output units. It shows, too, how much less the unit costs of the experimental program would be when total number of output units is greater than six. In addition, Figure C-3 shows that after eight output units, the output-unit cost of the experimental program is less than the operational costs per output unit of the old program. Thus, after eight output units, unit cost of the experimental program is less than the unit cost of the old program could ever be. (Operational costs represent the lower cost limit as the number of presentations increase and the basic cost per output unit approaches zero.)

Figure C-4 shows that cumulative output-unit costs of the two programs would also be approximately equal with six output units, and that for output units greater than six the cumulative cost of the experimental program compared to the cumulative cost of the old program becomes increasingly lower.

The formulas shown are sufficient for the cost analysis problems exemplified. For other more complex problems that may arise in Army training cost analysis, suitable formulas would be derived.

Output Unit Costs Per Total Number of Output Units for Illustrative Comparison of Two Training Programs

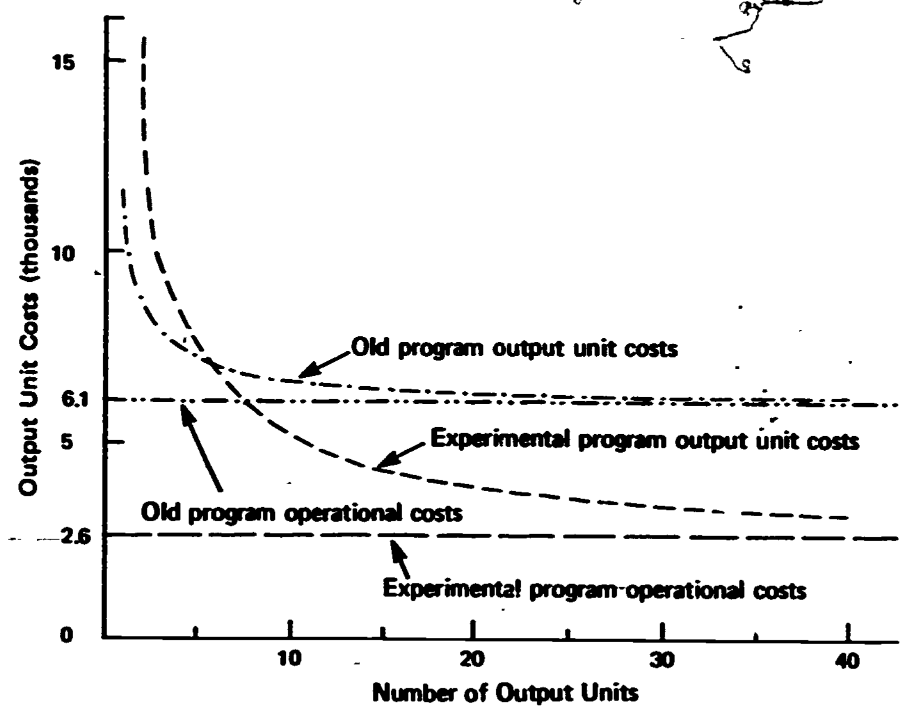

Figure C-3

Cumulative Output Unit Costs for Illustrative Comparison of Two Training Programs

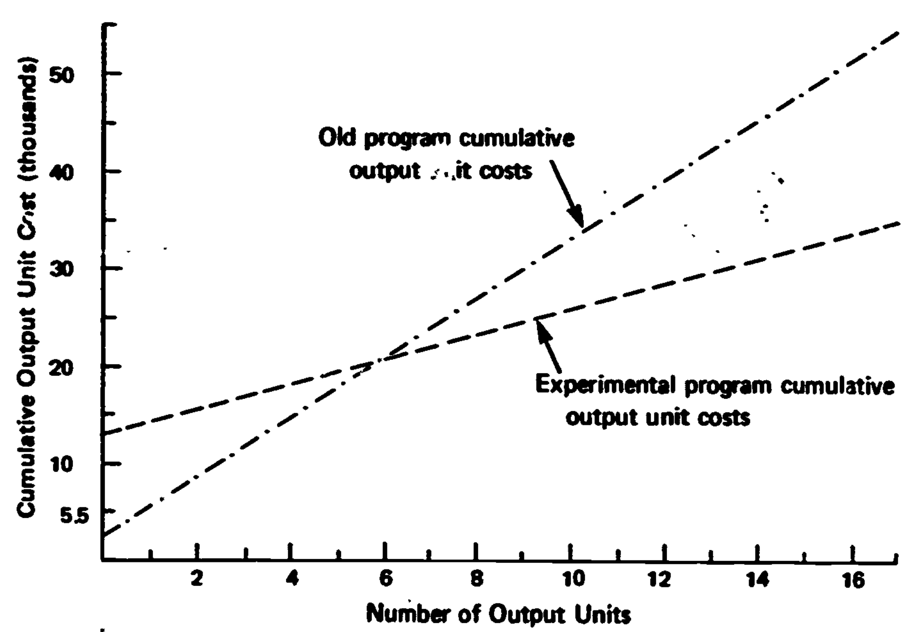

Figure C-4

Appendix D

USEFUL COST-ANALYSIS MODELS

THE COST-ED MODEL

The main features of the COST-ED Model may be described as follows:[1]

> "The COST-ED Model is a powerful analytic tool which Education Turnkey Systems analysts have validated and used in over 100 programs during the last 16 months in conducting economic analyses of instructional programs. COST-ED Analysis provides the school administrator with a managerially useful description of the costs of programs, plus the flexible capability to make equal-cost tradeoffs for instructional program redesign. . . ."

The following summary of the COST-ED Model is based upon a description provided by Educational Turnkey Systems, "The COST-ED Model, A New Economic Tool for the School Administrator."

The input data for computer analysis are provided by the client. The list of computer printouts that result illustrates the scope and kind of analyses performed:

(1) Cost-Analysis Summary. Provides a one-page digest of the key results characterizing an instructional program.

(2) Client Data Listing. Identifies, reviews, and validates all raw data used in constructing the COST-ED Model.

(3) Program-Cost Analysis. Shows in detail the manner and amount by which each economic factor contributed to the total costs, and gives the breakdown of total costs by function, by resource type, and by particular characteristics of each resource.

(4) Sensitivity Analysis. Shows how "sensitive" the total cost value is to changes in each economic factor or design feature.

(5) Economic-Factor Ranking. Focuses attention on those economic factors that have the greatest impact on total cost per student-year or per unit of achievement and shows the relative economic importance of individually managed program design features.

(6) Program-Comparison Summaries. Give summary descriptions of various COST-ED models for use in comparison of program characteristics with those of the basic model.

(7) Custom-Sensitivity Analysis. Shows how changes in one economic factor affect requirements for any other economic factor or cost subtotal.

(8) Custom-Tradeoff Analysis. Provides equal-cost alternatives for funds allocation between two economic factors, and shows how one economic factor, or corresponding program design feature, must be changed to absorb the cost differences related to a change in another feature; also shows how changes in total funds available may be split among changes in economic factors or corresponding program design features.

[1] Letter from C. Blaschke, President of Educational Turnkey Systems, to Y. Riback, Human Resources Research Organization, December 8, 1971.

THE WESTINGHOUSE MODEL

Rhode *et al.* (1) analyzed cost-analysis problems encountered in a study done by Westinghouse Learning Corporation to provide the Air Force with data to be used in making decisions in quantity buying of multimedia for service-wide training systems. This level of decision making is the same as Level IV, as defined in this report, the Overall Army System Level.

Rhode classified media into 17 categories according to the degree of their (a) adaptabi for individualization of instruction, and (b) economy (relative costs). To classify the ..edia according to adaptability and economy, Rhode evaluated them according to their requirements for (a) training materials that had to be produced, and (b) additional equipment, facilities, supplies, and personnel expenses.

Rhode found that attempts to establish costs of media installation and uses, apart from particular settings and purposes, were too difficult, so system sizes and operations were used as delimiting parameters. It also proved necessary to limit the number of cost factors that varied in the different systems. These factors were:

(1) Student Load. The number of students in training during given pe ods of time. (Student loads ranged from 200 to 1800 students.)

(2) Hour Load. The number of hours students are engaged in training (on the media). (Hour loads ranged from 150 to 1350 hours.)

(3) Duration. The duration of training programs.

(4) Course P n. The homogeneity of courses and the amount of course changes.

(5) Locati The location and concentration of students.

(6) Extended Time Frame. The length of the time frame serving as the focus of analysis (in years).

Cost considerations were further limited by defining initial costs as those incurred for purchases of equipment, facilities, and supplies that have useful values of more than one year or purchases that are not made each year, and by defining operating costs as those incurred in purchasing goods and services every year.

In defining these constraints on cost considerations, Rhode and his colleagues pointed out that for this high level of decision making it is not necessary to include all possible costs, but only all critical factors that have a major impact on total costs, so that various media combinations for specific purposes can be compared. Thus, the results give "supportable" cost approximations that can be arranged in an order of magnitude for comparison, rather than complete and unimpeachable cost totals.

THE U.S. OFFICE OF EDUCATION MODEL

Sovergin (2, 3, 4) prepared a three-volume report for the U.S. Office of Education pertaining to cost analyses of large-scale media installations for use by public school systems. In the first volume, Sovergin defines a hypothetical educational task as a basis for comparing costs of alternative media systems, and concludes that:

(1) Objective cost estimates for planning and operating media systems should be made after assessment of school environment factors and instructional factors (e.g., learning objectives and types of presentations).

(2) Specification of appropriate sensory stimuli and designs of alternative media systems must precede cost estimates for media production, distribution, and (TV and radio) reception.

In the second volume, Sovergin uses an instructional task and a hypothetical educational environment as the basis for analyzing media costs, and defines what he considers a feasible cost structure as a three-dimensional matrix. Each of three vectors defines cost sources as (a) media production, distribution, and (TV-radio) reception; (b) capital requirements for initial investments and annual operating costs; and (c) environmental functions—regional, state, metropolitan, city, and local.

Sovergin also estimates annual per-student costs for Instructional Television Fixed Service, airborne, satellite, UHF, and closed-circuit television, videotape recordings, film, radio, language laboratories, and computer dial-access systems.

In an appendix, Sovergin presents analyses of component and operating costs for five media systems: instructional television, audiovisual systems, educational radio, learning laboratories, and computer dial-access.

In the third volume, Sovergin presents the minimum costs of performing three specific instructional tasks and a detailed cost analysis of a computer-assisted instructional system, and stresses the importance of clear recognition of alternatives and cost-saving techniques as two essentials for cost analysis.

THE SPEAGLE MODEL

Speagle (5) presents estimated annual costs of installing and operating three major instructional media systems: television, computer access, and computer-assisted instruction.

To make these estimates, Speagle specified a hypothetical school district of 100,000 students and analyzed the costs of various media configurations that might be used by the schools. He demonstrated ways in which eight key variables (which include cost sources) may be manipulated to reduce the costs of using instructional media. The eight variables are:

(1) Heavy overhead and fixed costs

(2) Cost-saving technologies

(3) Geographical concentration of students

(4) Cooperation among school districts and schools

(5) Machinery for evaluating the quality and effectiveness of teaching techniques and materials

(6) Levels and types of desired teaching programs

(7) Rate of learning under innovative techniques

(8) Possibilities of replacing traditional teaching with instructional technology

Speagle predicts that the question of whether instructional technology should supplement or replace some of the variables will be answered by comparing costs per student-hour.

References for Appendix D

1. Rhode, W.E. *et al. Analysis and Approaches to the Development of an Advanced Multimedia Instructional System*, Report AFHRL-TR-69-30 (2 vols.), Westinghouse Learning Corporation, New York, May 1970.
2. Sovergin, M.G. "Guidelines for Determining Costs of Media," in *Cost Study of Educational Media Systems and Their Equipment Components*, Vol. 1, General Learning Corporation, Washington, D.C., 1969.
3. Sovergin, M.G. "Technical Report," in *Cost Study of Educational Media Systems and Their Equipment Components*, Vol. 2, General Learning Corporation, Washington, D.C. 1969.
4. Sovergin, M.G. "A Supplementary Report: Computer Assisted Instruction," in *Cost Study of Educational Media Systems and Their Equipment Components*, Vol. 3, General Learning Corporation, Washington, D.C. 1969.
5. Speagle, R.E. *The Costs of Instructional Technology*, Academy for Educational Development, Inc., Washington, D.C. 1970.

Appendix E

A TRAINING COST-EFFECTIVENESS INDEX FORMULA

This formula is for use with classification of students according to test-performance categories as training payoff data. The first equation is an adaptation of one presented by Edwards (1).

$$EU = \sum_{n=1}^{n} (p_n)(u_n)$$

Where: EU = expected utility value

p_n = the probability that an individual student will be in the nth category

u_n = the utility value of the nth category

n = the number of the nth category

M = the total number of categories.

The p_n values (probability values) are the same as the fractions (proportions of students) that fall in each of the categories, which will be given by:

$$p_n = \frac{N_n}{N}$$

Where: p_n = the probability that an individual student will be in the nth category

N_n = the number of students in the nth category

N = the total number of students in a course

Combining this expression with the symbol for the utility values of categories, gives:

$$EU = \sum_{n} \frac{N_n}{N} u_n$$

Where: EU = the expected utility value

u_n = the utility value of the nth category

N_n = the number of students in the nth category

N = the total number of students in a course

The cost-effectiveness index of a course can now be defined as:

$$CE = \frac{EU}{C} = \frac{\sum (N_n/N)(u_n)}{C}$$

The cost of training per unit of instruction when the unit of instruction is a *group* of students in a course was defined in Part II, Chapter 5, as:

$$C = \frac{B}{N} + O$$

Thus, by combining the above two terms we can define the cost-effectiveness index per *group* of students trained in a course:

$$CE_g = \frac{\sum (N_n/N)(u_n)}{B/N + O}$$

Where: CE_g = the cost-effectiveness index per group of students trained in a course

N_n = the number of students in the nth category

u_n = the utility value of the nth category

B = basic developmental cost of the course

O = operational cost of the course

N = the number of students in a course

If EU, B, and O values are held constant, the cost-effectiveness index per unit of instruction, CE_g, increases as the number of student groups trained increases, because the unit costs decrease over time as the course is replicated, and the unit cost eventually becomes almost the same as the cost of operating the course, O. Theoretically, then, the cost-effectiveness index is ultimately limited by the operational cost. The theoretical limit can be expressed as:

$$CE = \text{limit } CE = \frac{EU}{O}$$

Where: CE = the cost-effectiveness index

EU = the expected utility value

O = operational cost of the course

The use of the cost-effectiveness index for comparison of two courses is demonstrated in the following section with actual data. One example shows how the index would be used to compare two programs when both of them are new, while the second example shows how the index would be used to compare an old program and a new one.

COMPARING TWO NEW COURSES

Two programs for training teletypewriter operators were compared by calculating cost-effectiveness indexes for both courses projected over time. One course (experimental) trained 18 males and 12 females. The other course (control) trained 19 males.

Teletypewriting tests at the end of both courses yielded the mean typing-rate scores shown in Table E-1, together with the standard deviations. No significant difference was found between the groups.

Table E-1

Teletypewriter Mean Scores and Standard Deviations

Course	Mean Typing Rate	Standard Deviation
Experimental		
Males	15.6	3.36
Females	19.3	2.69
Males and Females	17.5	3.00
Control		
Males	15.3	4.60

The expected utility values for each course were calculated by using Table E-2. Table E-3 shows the cost-effectiveness indexes for both courses for every other course replication up to 40 groups of students. The cost-effectiveness indexes in Table E-3 are plotted graphically in Figure E-1, which shows that the experimental program would be more cost effective after four courses.

Table E-2

Calculation of Expected Utility Values

	Experimental Course			Control Course		
u_n[a]	N_n	$\frac{N_n}{N} = p_n$	$p_n u_n$	N_n	$\frac{N_n}{N} = p_n$	$p_n u_n$
-9	0	0	0	1	.0526	.450
10.5	3	.17	1.785	3	.1578	1.680
12.5	2	.11	1.375	3	.1578	2.000
14.5	2	.11	1.595	5	.2630	3.770
16.5	4	.22	3.630	3	.1578	2.640
18.5	5	.28	5.180	1	.0526	.925
20	2	.11	2.200	3	.1578	3.200
Total	18		15.765	19		14.665

[a]The u_n values are the mean typing rates for each of the seven intervals (categories of scores).

Table E-3

Cost-Effectiveness Indexes

N	Cost Effectiveness	
	Experimental Course	Control Course
1	.551	1.264
2	1.010	1.657
4	1.946	1.962
6	2.274	2.090
8	3.017	2.160
10	3.032	2.205
12	3.308	2.236
14	3.537	2.258
16	3.731	2.275
18	3.898	2.290
20	4.042	2.300
22	4.170	2.309
24	4.280	2.317
26	4.379	2.324
28	4.468	2.329
30	4.548	2.334
35	4.716	2.344
40	4.851	2.351

COMPARING AN OLD COURSE AND A NEW ONE

The data obtained in the two courses just analyzed are used again to illustrate what is involved in using the cost-effectiveness index to compare an old program and a new one.

Note in Table E-4 that the number of students has been increased to 30 for each course. This was done because 30 students at a time would be trained in the course to be adopted. Therefore, the expected utility values were converted to match the increased number of students. The results are in Table E-4.

Also for this illustration, the control course was considered as the old course, and the experimental course is the new course. For these calculations, it was assumed that, over time, the old course had demonstrated student mean scores of 15 with a standard deviation of 4.5 (to make calculations easier). For the new program the scores and standard deviation for the combined male and female group were used; mean score was 17.5 with a standard deviation of 3.00.

The new expected utility values derived in Table E-4 were used to calculate the cost-effectiveness indexes for both courses. The results are in Table E-5.

The cost-effectiveness indexes are shown graphically in Figure E-2, and it is evident from the graph that the new program will be more cost-effective than the old one after six courses. The intersection of the two curves on the graph indicates the point in time at which both courses would have the same cost-effectiveness index.

Cost-Effectiveness Indexes for Comparing Two New Courses

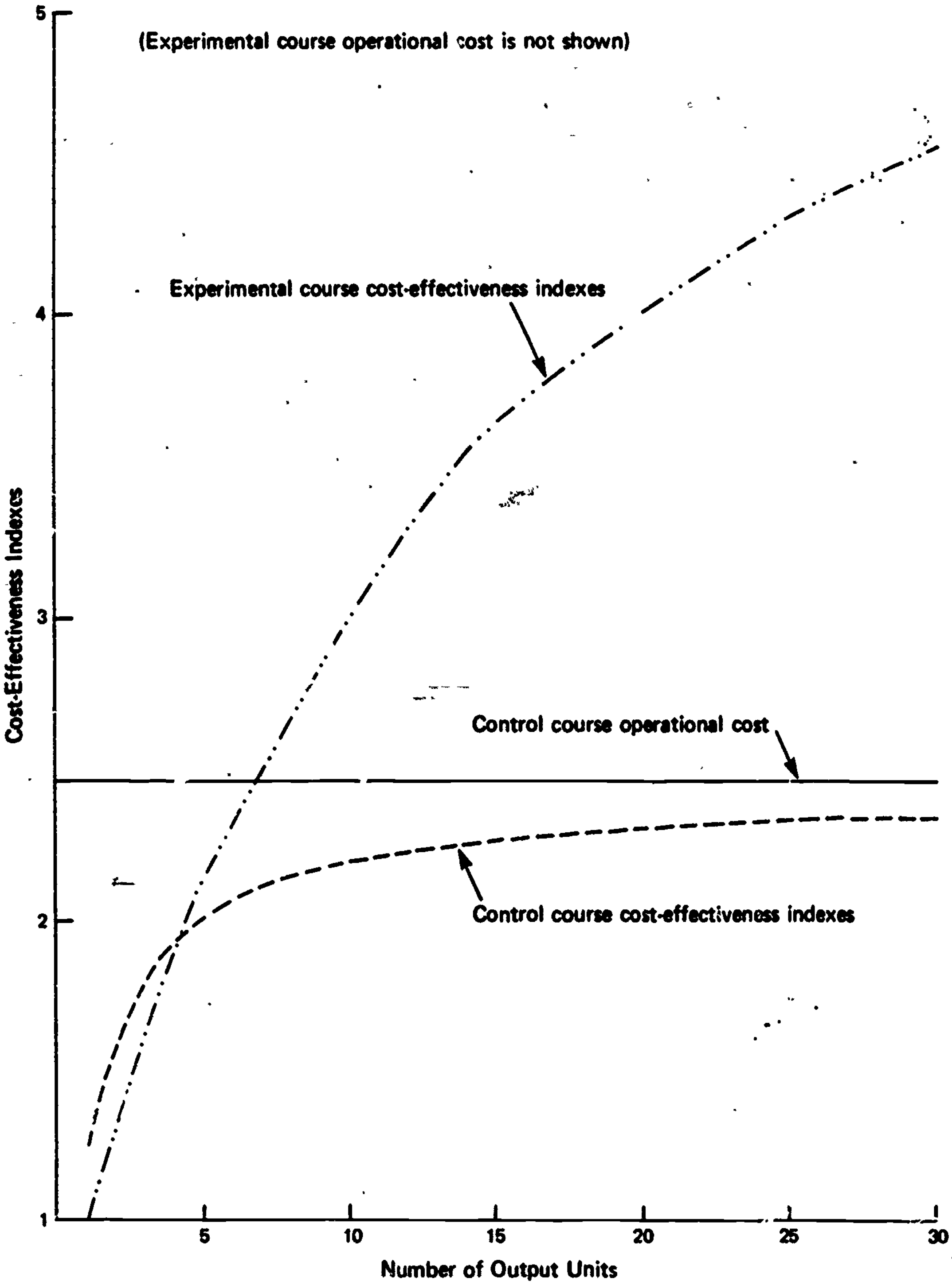

Figure E-1

Table E-4

Calculation of Expected Utility Values

New Course				Old Course			
u_n	N	p_n	$p_n u_n$		u_n	p_n	$p_n u_n$
-9	0	0	0	$\bar{X} - \frac{3}{2}SD = 7.5$			
					8.75	.1587	1.39
10.5	3	.100	1.050	$\bar{X} - SD = 10.00$			
					11.25	.1498	1.68
12.5	2	.067	875	$\bar{X} - \frac{1}{2}SD = 12.5$			
					13.75	.1915	2.63
14.5	4	.133	1.885	$\bar{X} = 15.00$			
					16.25	.1915	3.11
16.5	5	.166	2.805	$\bar{X} + \frac{1}{2}SD = 17.5$			
					18.75	.1498	2.81
18.5	7	.233	4.255	$\bar{X} + SD = 20.0$			
					21.25	.1587	3.37
20-	9	.300	6.000	$\bar{X} + \frac{3}{2}SD = 22.5$			
Total	30		16.870				14.99

Table E-5

Cost-Effectiveness Indexes

	Cost Effectiveness	
N	New Course	Old Course
1	.590	1.292
2	1.081	1.694
4	1.854	2.005
6	2.438	2.136
8	3.229	2.208
10	3.244	2.254
12	3.540	2.286
14	3.785	2.309
16	3.993	2.327
18	4.172	2.340
20	4.326	2.351
22	4.462	2.361
24	4.580	2.368
26	4.686	2.375
28	4.782	2.380
30	4.867	2.386
35	5.046	2.396
40	5.191	2.403

Cost-Effectiveness Indexes for Comparing a New Course and an Old One

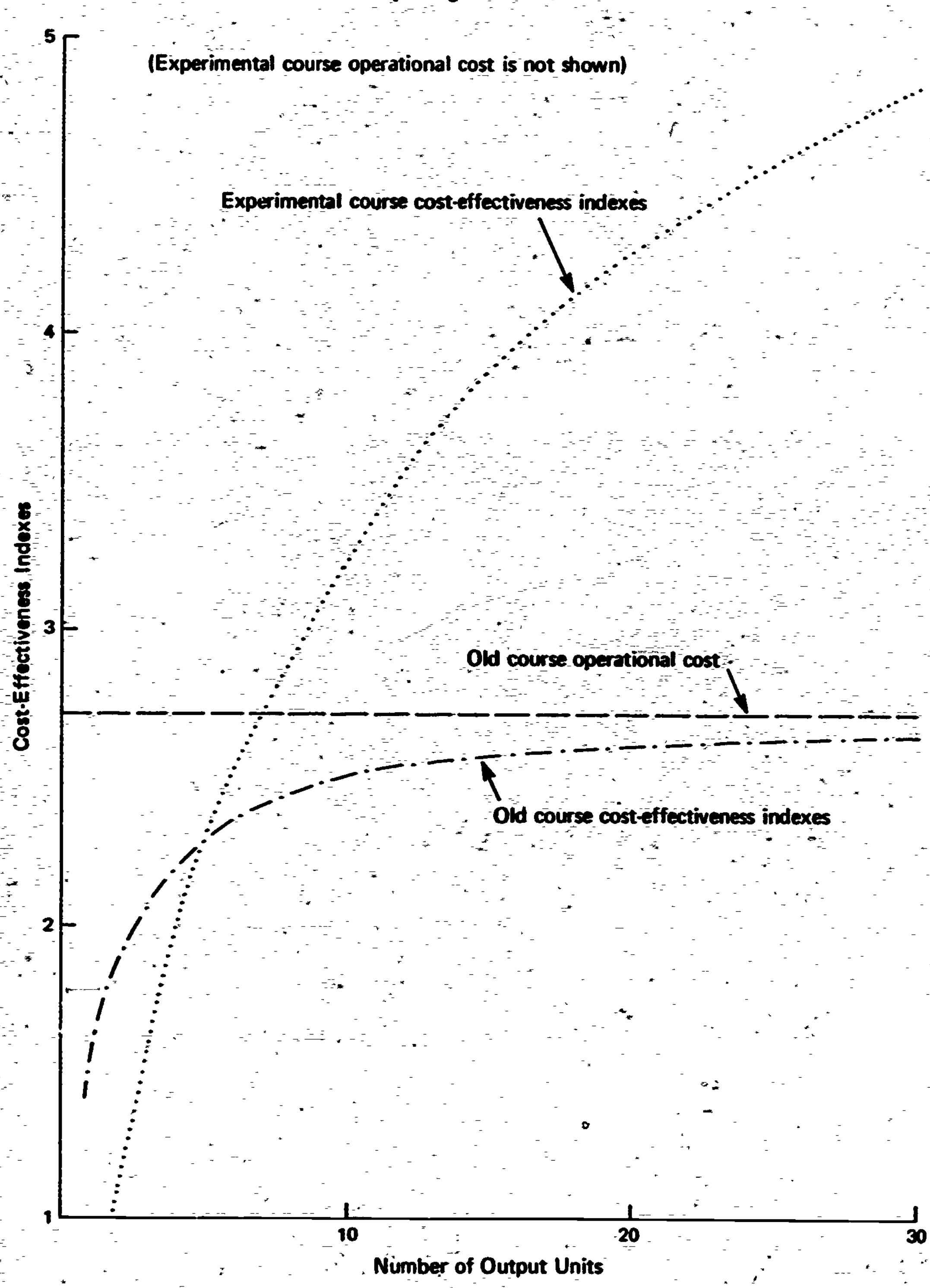

Figure E-2

Reference for Appendix E

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Appendix F

LITERATURE REVIEW: INSTRUCTIONAL METHODS AND MEDIA

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

Review and analysis of pertinent literature was the first step in research to develop criteria and procedures for optimal selection of cost-effective methods and media for use in Army training. The empirical data found in the review are insufficient as a basis for reliable selection of methods and media for specific training tasks. Also, existing methods-media selection procedures, training cost-analysis procedures, and suggested approaches for

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developing such procedures are inadequate for Army needs, although portions of some of these may be useful in developing procedures for Army use. Possible approaches for removing those inadequacies are discussed.

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