DOCUMENT RESUME

ED 083 711 EA 005 552

AUTHOR Pearson, Robert H.
TITLE An Instructional Management Guide to Cost Effective Decision Making.
INSTITUTION Instructional Science Associates, Madison, Wis.
REPORT NO TR-73-11-1
PUB DATE 73
NOTE 69p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Cost Effectiveness; *Decision Making; Educational Objectives; *Educational Planning; Management Systems; Models; Resource Allocations; *Systems Analysis
IDENTIFIERS *Instructional Management

ABSTRACT

This study attempted to identify the differences in cost-effectiveness analysis methods in order to select the most appropriate one as a decision-assisting aid for instructional management. The study is organized to explore and identify what cost-effectiveness methods are being used, identify and examine the differences among these methods in an analytical framework, and determine the criteria to be used in selecting the most appropriate cost-effectiveness method for instructional decisionmaking. The study results suggest that cost-effectiveness analysis provides answers by a systematic process that is reproducible as well as accessible to critical examination. It is believed that the use of instructional cost-effectiveness analysis will enhance the possibility that a decision will result in the selection of the best alternative. (Author/DN)

 Printed in the United States of America and published by Instructional Science Associates, 5 South Yellowstone Drive, Madison Wisconsin 53705.

TR73-11-1

AN INSTRUCTIONAL MANAGEMENT GUIDE TO COST EFFECTIVE DECISION MAKING

by

Robert H. Pearson, Ph.D.
University of Wisconsin-Madison

INSTRUCTIONAL SCIENCE ASSOCIATES

FOREWORD

Education currently consumes a vast amount of resources, and it appears almost certain that it will consume much more in the future. Since the systems analysis process makes possible the evaluation of alternative courses of action for the achievement of instructional goals and objectives within resource constraints, those in instructional management are enthusiastic over its potential as a viable base for decision-making. Cost-effectiveness analysis, one aspect of systems analysis, has been shown to aid in the better use of resources. There are, however, a variety of cost-effectiveness analysis methods and confusion has existed as to the respective advantages and disadvantages of each method. This guide, therefore, is directed towards the analysis of cost-effectiveness analysis itself from the point of view of instructional management. This approach is so that the most appropriate instructional cost-effectiveness analysis method may be selected as an aid to decision-making.

Robert H. Pearson
University of Wisconsin-Madison

PREFACE

There are a variety of cost-effectiveness analysis methods and these methods differ in approach and precision. This guide will attempt to present the most applicable cost-effectiveness analysis method as a decision-assisting aid for instructional management. Thus, the approach taken is to: (1) explore what cost-effectiveness methods are being used; (2) examine the differences of these methods in an analytical framework; and, (3) suggest the most appropriate cost-effectiveness analysis method for instructional management decision-making.

Due to the complexity of the area of systems/cost analysis, the study will be limited to the subject of cost-effectiveness analysis itself. In addition, the emphasis will be on the performance of the cost-effectiveness analysis by someone other than the instructional management decision-maker, as a service in support of the decision-making process. The decision-maker, in this case, might be: (1) a dean or department head of an academic institution; (2) a training manager or supervisor of industry or government; or, (3) a superintendent, principal, curriculum director, or program director of a school system.

Although the guide includes considerable detailed information involving the documentation of procedural steps in various cost-effectiveness analytical techniques, it is still less than would be required for an analyst to use all aspects of the procedure. An attempt was made, therefore, to limit the amount of detailed description to the minimum information requirements for the performance of a cost-effectiveness analysis.

R.H.P.

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ABSTRACT

The purpose of the study is to identify the differences in cost-effectiveness analysis methods so that the most appropriate one could be selected as a decision-assisting aid for instructional management.

The principal phases of the study are organized to explore and identify what cost-effectiveness methods are being used; to identify and examine the differences among these methods in an analytical framework; and, to determine the criteria to be used in selecting the most appropriate cost-effectiveness method for instructional decision-making.

The emphasis of the study is on the performance of cost-effectiveness analysis as a service in support of the decision-making process by someone other than the instructional management. The descriptive detail provided in the study is such that an analyst with moderate experience could perform the indicated activities.

The results of study suggest that cost-effectiveness analysis provides answers by a systematic process which is reproducable and accessible to critical examination. On the other hand, cost-effectiveness analysis cannot be a substitute for judgment in decision-making by inductive reasoning which is fully documented. It is believed that the use of instructional cost-effectiveness analysis will enhance the possibility that a decision will result in the selection of the better (or best) alternative.

INTRODUCTION

Education the world over is a vast enterprise and one that continues to grow. Estimates vary concerning the precise cost of education and training in the United States; "It's like asking how many trees there are in Russia," commented a training program authority who has attempted to determine exact accounting several times (Kleinschrod, 1967, p. 18). It is suggested that approximately 64-million persons in the United States are involved in some aspect of education and training and the annual cash outlay is estimated to be an expenditure of $90 billion[1] (Goodman, 1973, overleaf).

With the expenditures of resources of such magnitude and with the competition for these resources by other needed public enterprise, educators must search for ways to optimize utilization of the instructional[2] dollar. One possible way to attain maximum output from our instructional resources is to increase the effectiveness of our materials, methods, facilities, etc.

> This purpose has little relation to that once vaulted "cult of efficiency" that sought to bring business methods to bear on inefficient schools. The purpose of sensible economic practices in education has less to do with efficiency than with effectiveness. It is a question...of turning out the highest-quality product possible for the funds, talent, and time expended. [U.S. Congress, 1970, p. 24].

Another way to get more from instructional resources is to consider alternative methods of reaching a goal through systems analysis.

> The systems approach is an "economic" approach to education in the best sense of that word. It provides a rational method of using a given set of resources to provide a system capable of achieving a given set of objectives [Springer, 1967, p. 58].

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[1]About 50 percent of most municipal budgets are allocated to public education (Burnes, 1967, p. 39).

[2]For the purpose of this guide, the term "instruction" will be used to refer to both education and training.

To some, systems analysis is characterized solely by automatic data processing techniques and is dismissed as being modern gadgetry. This may not be true, for most systems analysis formulations are indistinguishable from descriptions of the scientific method. Consequently, systems analysis roots reach back past Roger Bacon to Aristotle, and not, as some believe, only to the RAND Corporation and the Department of Defense of the 1960's (Oettinger, 1968, p. 77). The newer approaches to systems analysis, however, attach more importance to the: (1) establishment of quantifiable objectives and alternatives; (2) identification of the alternatives cost and benefits; and, (3) provision for analysis time (McGivney, 1969, p. 32). It must be emphasized that systems analysis is most valuable as an analytic tool to aid in instructional management decision-making, rather than as a decision-maker itself (Oettinger, 1968, p.77).

Cost-benefit analysis and cost-effectiveness analysis make up that aspect of systems analysis which is concerned with the selection of alternatives based on consideration of the best use of the available resources to reach required objectives. This analysis of resource usage requires synthesizing knowledge about the student, the instructional setting, objectives, facilities, instructional method, staff, standards of achievement and other related factors. This systems/cost-effectiveness analysis approach has the goal of establishing improved relationships between these interacting elements so that the total instructional enterprise is performing more effeciently and at a higher level of excellence (Freedman, 1969, p. 32).

The need for and value of cost-benefit analysis and cost-effectiveness analysis has been recognized in public and private education. It was reported by the Commission on Educational Technology that in improving learning, cost and cost-benefit relationships were the areas of greatest uncertainty (Carpenter, 1970, p. 5). A prominent private committee recommended that:

> School systems must employ continuously the result of cost-benefit and cost-effectiveness analysis in order to allocate effectively the resources available to education and to distinguish among programs of high and low priority [Committee for Economic Development, 1968, p. 13].

In addition, President Nixon was quoted in the Washington Post as saying that for education, the 1970's will become the "Age of Accountability," and that one aspect will be the judgment of school programs relative to cost-effectiveness (Wentworth, 1970).

It would seem that the current position on system/cost-effectiveness analysis in support of instructional management decision-making is that many are enthused over the potentional of it (McGivney, 1969, p. 31)--but who will perform it and how it will be done are more difficult considerations. Systems/cost analysis personnel might come from the following areas:

- Government. Those individuals associated with the Department of Defense and their prime contractors who hope to transfer their professional and scientific capabilities from defense to education-oriented activities (Lieberman, 1968, p. 24).
- Business. Independent consultants with no vested interest in hardware or a product (Herbert, 1967, p. 45).
- Education. Educators and administrators responsible for planning (Heinich, 1969, p. 330).

Attaining a process by which cost-effectiveness analysis may be applied to instructional decision-making, however, is a more formidable task. One difficulty is that although much has been reported on the advantages of instructional cost-effectiveness, only a limited number of "how to do cost-effectiveness" studies have been published (Fisher, 1967, p. 69). Another problem is that the usefulness of cost-effectiveness analysis is not fully understood by many individuals. This lack of understanding is due to the apparent coldness of the tool as a measure of decision-making (Banghart, 1969, p. 206).

There are a variety of cost-effectiveness analysis methods in use today which differ in their respective advantages and limitations (Seiler, 1969, pp. 1-2). As new approaches develop, these methods constantly undergo subtle, but significant, changes (Kazanowski, 1968, p. 163). Although most of these new approaches are primarily mathematical in nature, a few are directed toward a better treatment of problems that cannot be handled by purely quantitative methods (Quade, 1968, p. 242).

With the apparent lack of understanding, limitations, and wide differences of approaches in cost-effectiveness analysis, the following question seems appropriate. How can this analytical tool, which was developed as a decision-assisting aid in the selection of technical systems, be used by instructional management increasing student achievement (Freedman, 1969, p. 31)? The attempt to provide an answer to this question is the purpose of this guide.

BACKGROUND OF COST-EFFECTIVENESS ANALYSIS

Cost-effectiveness analysis is not completely new. To some extent, it has always been part of industrial and government planning and procurement. As recently as a few years ago, however, the use and understanding of government cost-effectiveness analysis was inadequate for two major reasons: (1) all elements of cost were not included in the analysis; and (2) the probabilistic nature of system effectiveness was not recognized (Herd, 1965, pp. 79-80). By the late 1950's it became obvious that technical improvements in governmental programs were not always accompanied by improvements in total program performance and effectiveness. As a consequence, a foundation for more systematic and objective methods of measuring the effectiveness of alternative courses of action for military systems was developed and implemented in 1961 by the Department of Defense (Jakobsberg, 1966, p. 38). The next major step occurred when the President directed the introduction of an integrated planning-programming-budgeting system into the Executive Branch of the Federal Government; this system included cost-effectiveness analysis as a tool for resource allocation decisions.

Today, the cost-effectiveness approach has been adopted by many other activities of government as well as organizations of private industry (Seiler, 1969, pp. vii-1). According to Jarrett:

> The significance of cost-effectiveness analysis today stems from the increasing sophistication of our methods in relating cost to effectiveness as compared with methods available only a few years ago. It has been referred to as "qualified common sense", which actually is close to what cost-effectiveness is all about [Jarrett, 1967, p. 8].

PURPOSE OF COST-EFFECTIVENESS ANALYSIS

The purpose of cost-effectiveness analysis is to provide the decision-maker with data on the cost (resource consumption) and the probably effectiveness (quality of results to be achieved) for each of several alternatives, among which he must choose one course of action. Cost-effectiveness analysis involves clarifying the relationships between these two factors (cost and effectiveness) so that the decision-maker can strike the best balance between them. Cost-effectiveness analysis is not a substitute for judgment, experience, and common sense. It is a method for the systematic examination of all the subjective and objective data available (Heymont, 1965, p. 1).

PERFORMANCE OF COST-EFFECTIVENESS ANALYSIS

The current trend in the performance of cost-effectiveness is the application of the method by all levels of decision-making, in a variety of functions, and for both short-range and long-range planning (Heuston & Ogawa, 1966, p. 243). The analysis itself may be performed by the decision-maker, by a specialist within the decision-maker's organization, or the responsibility for cost-effectiveness analysis may be delegated to a specialized service organization (McGivney, 1969, p. 31). The latter approaches require close cooperation and coordination between the cost-effectiveness analyst primarily responsible for the study, the decision-maker requesting the study, and each of the other individuals providing informational inputs (Fields, 1966, p. 517). At best, cost-effectiveness analysis functions as a tool used in providing the decision-maker with an analytical foundation for making sound objective choices among the various ways a problem might be solved or an objective met (Jarrett, 1967, pp. 7 & 9).

DEFINITION OF COST-EFFECTIVENESS ANALYSIS

The definition of cost-effectiveness analysis varies, for the methodology is not precise enough to mean the same thing to all practitioners in the field (Seiler, 1969, p. 1). Broadly defined, it is an analytic study designed to assist a decision-maker in identifying a preferred choice among possible alternates (Quade, 1969, p. 1). The choice of alternates involves two approaches: (1) fixed-cost and flexible effectiveness approach; and, (2) fixed-effectiveness and flexible cost approach (Kazanowski, 1968, pp. 126-127). Several varieties of a more precise definition are graphically presented in Figure 1 to illustrate the emphasis different authorities have placed on specific nomenclature.

Attention should also be given as to what is not cost-effectiveness analysis. Kazanowski calls this the "maximum-effectiveness-at-minimum-cost fallacy" and defines this misconception as follows:

THE BASIC OBJECT OF COST-EFFECTIVENESS ANALYSIS IS TO ISOLATE THE ALTERNATIVE OR COMBINATIONS OF ALTERNATIVES THAT GIVE(S):

1. The minimizing of costs subject to some objective constraint	or	a maximizing of some physical measure of the objective output subject to cost constraint (Quade, 1969, p. 2).
2. The greatest objective effectiveness for a given expected cost	or	a given expected objectiveness for the least expected cost (Seiler, 1969, p. 1).
3. The greatest effectiveness for any given cost	or	a required or chosen degree of effectiveness for the least cost (McGivney and Nelson, 1969, p. 105).
4. The most productive alternative if the costs are equal	or	the least costly alternative that produces equal benefits.

If the alternatives are of unequal costs and produce unequal benefits, cost-effectiveness analysis will provide information for comparing costs and benefits (Office of the Assistant Secretary of Defense, 1971 p. 5).

Figure 1. Variation in Cost-Effectiveness Analysis Definition

> Many references can be found in which the statement is made directly or indirectly that cost-effectiveness is a technique by which one determines that alternative which yields the maximum effectiveness as a minimum cost. Or, in other words, that alternative is sought by which the effectiveness is maximized, while the cost is minimized. In reality the attempt to find such an alternative is doomed to failure at the onset because such an alternative does not exist. Hitch and McKean state: "Actually, of course, it is impossible to choose that policy which simultaneously maximizes gain and minimizes cost, because there is no such policy." [Kazanowski, 1968, p. 160].

DIFFERENCES BETWEEN COST-EFFECTIVENESS AND COST-BENEFIT ANALYSIS

Confusion also exists concerning the difference between cost-effectiveness analysis and cost-benefit analysis (Fisher, 1967, p. 66). The principal differences in these two methods are the elements of output and of time-phasing.

Output

The term "cost-effectiveness" usually applies to situations in which it is difficult to quantify the alternate outputs in terms of dollar values. Cost-benefit usually considers only the monetary worth of outcomes.

Time Phasing

The term "cost-effectiveness" is usually used to select the most appropriate choice from the predicted alternative outcomes; the term "cost-benefit" is most often applied in selecting the most appropriate choice from the calculated present (McGivney and Nelson, 1969, p. 105).

> Cost-effectiveness analysis is specifically directed to problems in which the output cannot be evaluated in market prices, but where the inputs are substitutable at exchange relationships developed in the market [Niskanen, 1969, p. 18].

SUBJECT APPROPRIATENESS FOR COST-EFFECTIVENESS ANALYSIS

Certain prerequisites should be met before a subject is appropriate for cost-effectiveness analysis (Kazanowski, 1968, p. 114). The primary appropriate prerequisite is that the subject should have two characteristics: first, and most important, the subject must be relevant; second, but less important, it should be capable of being measured both in required resources and outcome. These two characteristics often appear conflicting. The most relevant phenomena or events are often very difficult to measure, the least relevant are usually easy to measure (Niskanen, 1969, p. 20). Cost-effectiveness analysis should be performed only when the following appropriate prerequisites are met:

- The correct problem must be recognized.
- Realistic objectives that bear a functional relationship to the problem must be determined (Jakobsberg, 1966, p. 38).
- Common goals, objectives, or missions of the alternative must be identifiable and at least theoretically attainable.
- Constraints for bounding the problem must be discernible.
- Alternative means of meeting the goals must exist (Kazanowski, 1968, p. 114).

The meeting of these requirements is not always simple; consequently, if there is no freedom of choice in problem solving, cost-effectiveness analysis is not appropriate (Jarrett, 1967, p. 8).

RELATIONSHIP OF COST-EFFECTIVENESS TO SYSTEMS ANALYSIS

In order to place cost-effectiveness in proper perspective, it is first necessary to place it in relation to the systems analysis process. Cost-effectiveness analysis is not a method for measuring either cost or effectiveness after the fact, for its modern applications are concerned with the prediction and evaluation of an alternative's worth (English, 1968, p. 7). The term "systems analysis" is used to distinguish this broader analysis from a narrow cost-effectiveness aspect of analysis. Cost-effectiveness analysis is that aspect of systems analysis which emphasizes the systematic investigation of the decision-maker's alternatives relative to objective criteria, costs, and effectiveness comparison, in addition to the other trade-off factors associated with alternative selection (Quade, 1969, p. 3). Figure 2 graphically illustrates this emphasis.

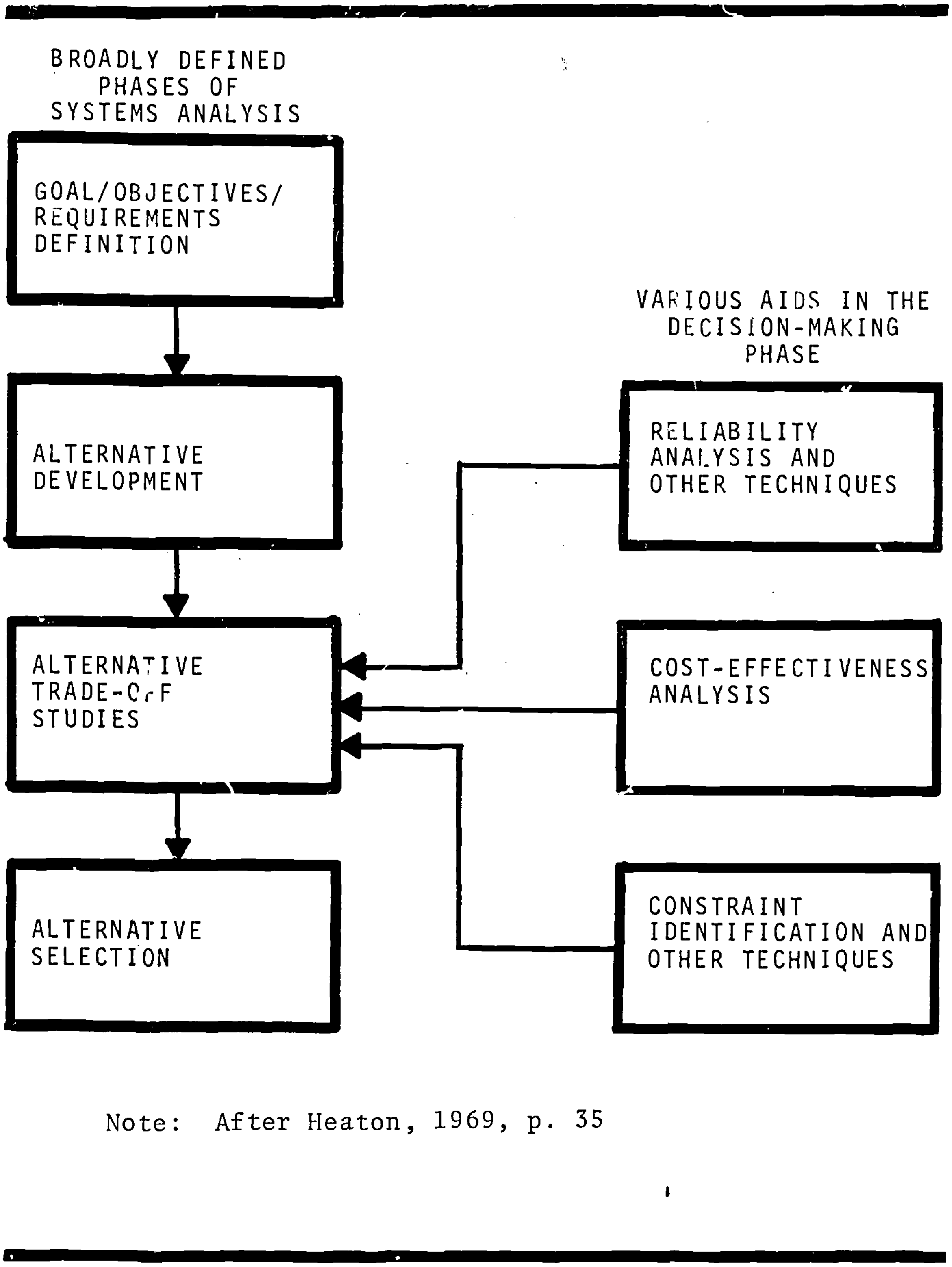


Figure 2. Relationship of Cost Effectiveness to Systems Analysis

> It can be seen, then, that the difference between cost-effectiveness analysis and systems analysis is a matter of emphasis. If the emphasis is on finding significant differences in the costs or resource requirements among the available alternatives for carrying out some specified task, the analysis is generally referred to as a cost-effectiveness analysis. The systems analyst, on the other hand, is likely to be forced to deal with problems in which the difficulty is deciding what ought to be done, not simply how to do it. System analysis thus puts greater emphasis on the suitability of the task and the augmentation of alternatives. In both system-analysis and cost-effectiveness work it is important to note, however, that after an appropriate evaluation one will be in a much better position to make a decision, even though he may not find the decision easier to make [Bell, 1964, pp. 1-2].

CATEGORIES OF COST-EFFECTIVENESS ANALYSIS

The confusion over the role cost-effectiveness analysis plays in the systems analysis process seems to arise from the fact that some practitioners perceive cost-effectiveness analysis to be the systems analysis process itself; whereas, others see the process of cost-effectiveness as being related to and a sub-set of the total systems design process. As noted above, both interpretations of the role of cost-effectiveness analysis could be appropriate, depending upon the time and conditions that the analysis requires. There are, however, three categories of cost-effectiveness analysis which, in practice, are not clearly distinct. These categories are: (1) system/component configuration study; (2) system comparison study; and, (3) suprasystem comparison study (Heuston & Ogawa, 1966, p. 245). The relationship of these categories is exhibited in Figure 3 and a detailed description follows.

System Configuration/Component Study

In this category the emphasis is on the selection of the particular configuration, or characteristics, of a single system with different components. For example, a closed-circuit instructional television system versus an open-circuit instructional television system. This category of study is probably the one most often performed.

Cost Treatment. Typically, system/component configuration studies have the following characteristics relating to the treatment of costs:

- Detailed costs are obtained on all components.

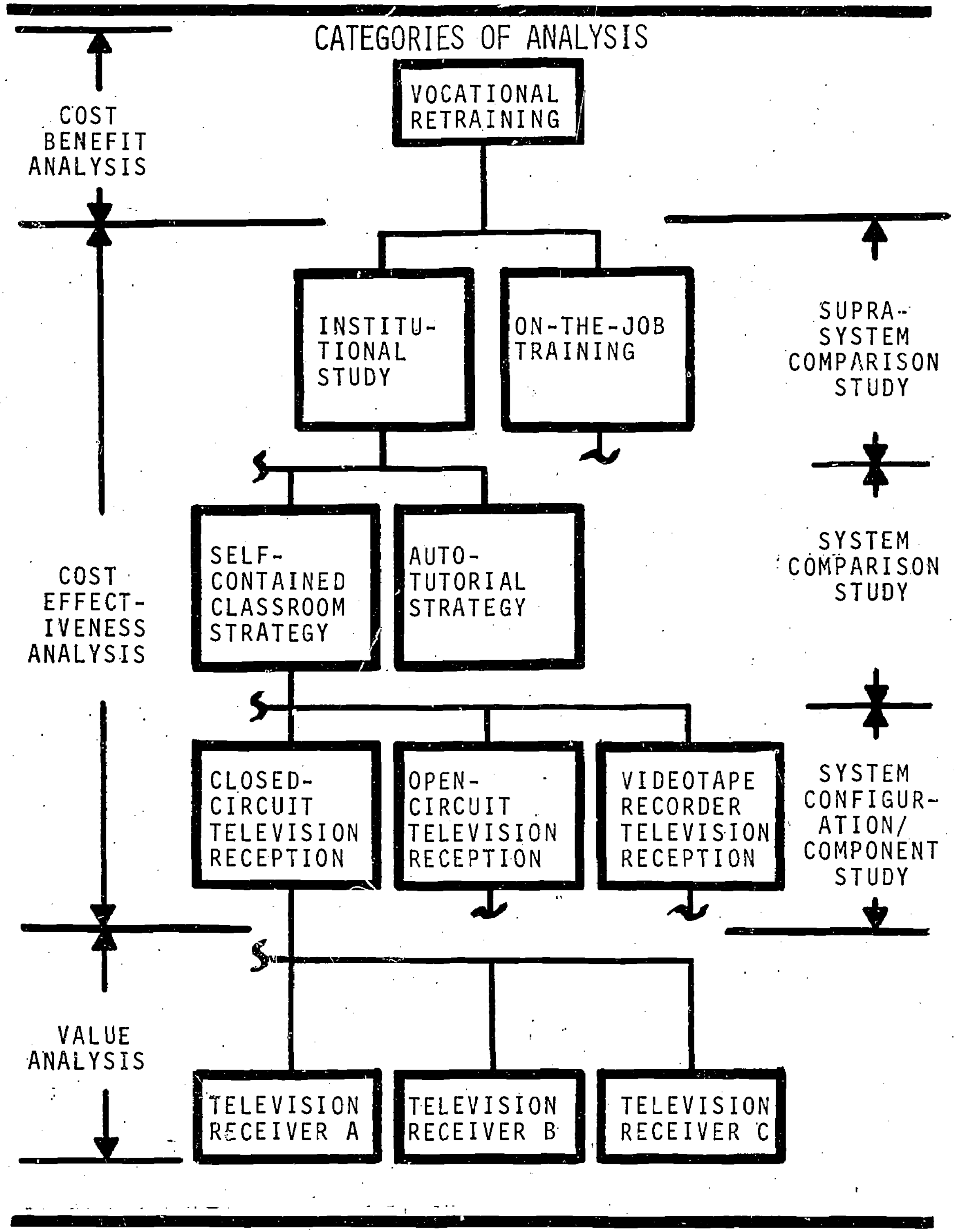


Figure 3. Cost-Effectiveness Categories of Analysis

- Various mathematical models are used to simulate and optimize different possible configurations of the components. The results yield the predicted overall costs of the various alternatives under study.

- Costs are compiled by summing the yearly costs over the life cycle of the systems rather than by compiling time-phased costs.

Effectiveness Treatment. As in the treatment of cost, the effectiveness measure used in the system configuration/component study will be detailed in terms of capabilities and performance. In most cases, effectiveness will not be a simple overall measure which ultimately would determine alternative selection (Hatry, 1969, pp. 45, 47-48).

It should be noted that trade-off analysis at the detail level of selecting subcomponents is classified as value analysis rather than cost-effectiveness analysis (Kazanowski, 1968, p. 153). An example of this type of analysis would be the selection of the least expensive instructional television receiver that complies with given specifications.

System Comparison Study

Here, the emphasis is on comparing two or more systems for the same objective. The emphasis is on intersystem, not intrasystem, analysis. It is presumed that each competing system has already been sub-optimized as to its configuration, through the system/configuration component study discussed previously. An example of this type of study would be to compare the merits of a programmed-instructional system versus an autotutorial system (where each has been instructionally validated).

Cost Treatment. Typically, the system comparison study has the following characteristics relating to system costs:

- Costs are generally required in less detail than in system/component configuration studies where the emphasis was on components of competing similar characteristics.

- The specific spread of costs over the life cycle of the system is usually ignored, or is treated as a secondary problem.

Effectiveness Treatment. The effectiveness measure is basically quite similar to that used in system/component configuration studies.

Suprasystem Comparison Study

This third cost-effectiveness study category is less frequently performed as a strictly cost-effectiveness activity. Activities at this level of analysis are usually described as cost-benefit. The problem here is to assess the merits of alternatives of widely differing capabilities and cost elements. An example would be to analyze the cost-effectiveness of competing instructional systems such as institutional study as opposed to on-the-job training.

Cost Treatment. In suprasystem comparison studies, costs are each time-phased to the extent possible, to provide estimates of annual resource requirements (Hatry, 1969, pp. 48 & 50).

Effectiveness Treatment. The determination of a measurement of effectiveness is especially difficult for those cases where the systems are experimental, the objectives are of unequal priority, and the output varies in type and reliability (Heuston & Ogawa, 1966, p. 245).

The problem of the analysis of differing costs and capabilities of alternatives requires the development of some measure of structure for comparing these alternatives on a somewhat equal basis (Department of Defense, 1971, p. 5).

PROCESSES OF COST-EFFECTIVENESS ANALYSIS

In addition to the confusion from the differences of cost-effectiveness analysis categories, differences in the process of the analysis itself has compounded the lack of understanding. Yet, in all the variations, two processes are performed: (1) the procedural process; and, (2) the application process.

Procedural Process

This cost-effectiveness analysis process can be defined as the documentation or writing of instructions on how to perform the analysis in a step procedural sense. This type of process is also known as model building; i.e., a conceptual mock-up or detailed paper-pencil description of the actual analysis to be performed at some later time.

Application Process

The second cost-effectiveness analysis process refers to the application of the procedural process by applying a particular model to a real-world practical situation (Speagle, 1969, p. 22).

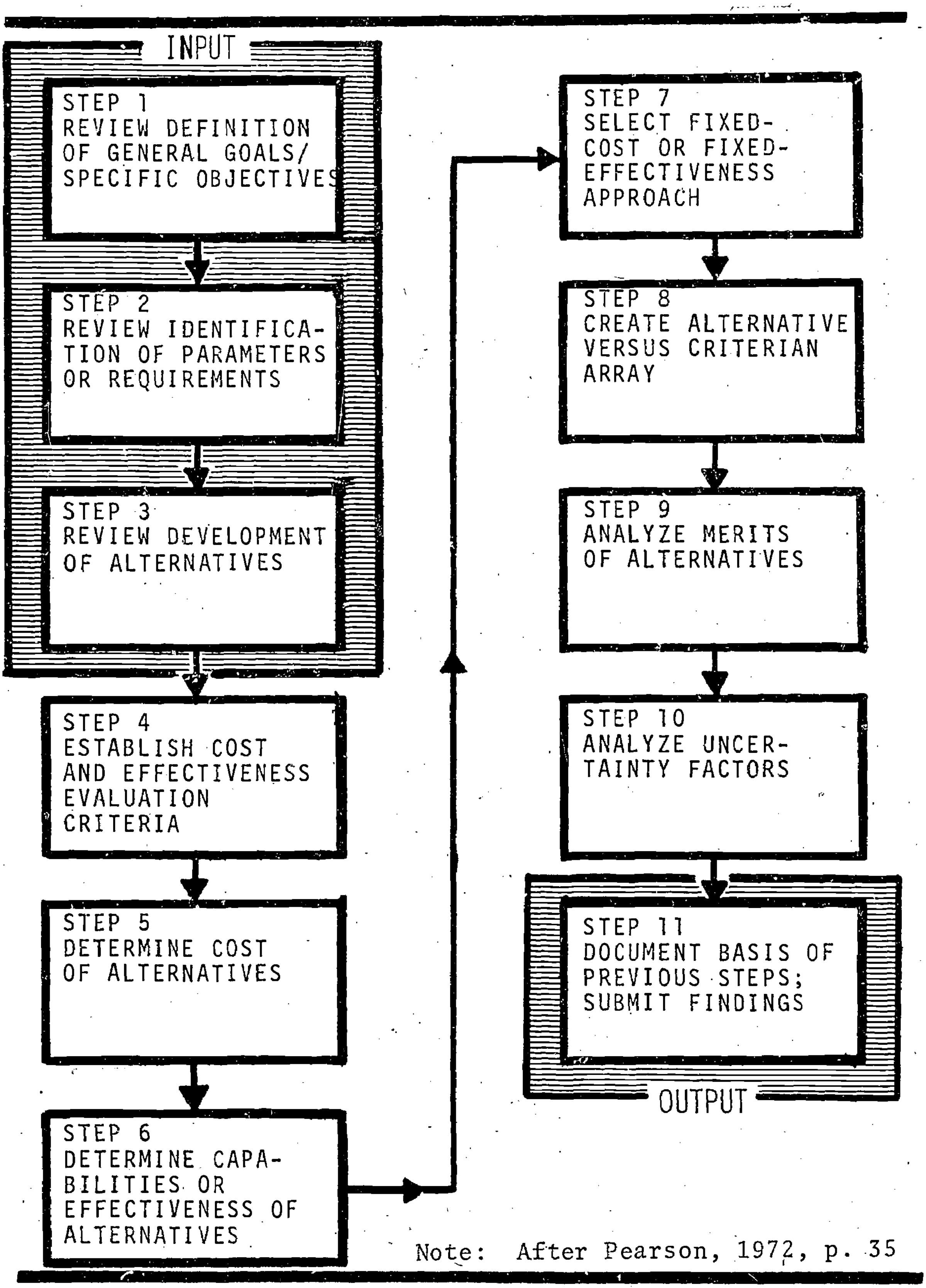
STANDARD PROCEDURE FOR COST-EFFECTIVENESS ANALYSIS

The chief value of cost-effectiveness analysis is its broad ability to provide a general framework to assist in the solution of problems in a wide range of topical areas. Cost-effectiveness analysis differs from many other decision-assisting tools which are limited to accepting only certain classes of problems.

The very fact that cost-effectiveness analysis can assume characteristics dictated by a unique objective and respond to the category, level, and process of analysis as required provides a lack of uniformity in the analysis itself (Jakobsberg, 1966, p. 37). In addition, the apparent lack of uniformity in most examples of cost-effectiveness analysis, and the lack of consistent documentation, has led some persons to question the merits of this type of analysis as an aid to decision-making (Kazanowski, 1968, p. 113).

On the other hand, certain authors and authorities in the field indicate that a complete "how-to-do-it" document, or a "cookbook," would be impossible to prepare (Jakobsberg, 1966, p. 37). This may be because, at the current stage of development, cost-effectiveness analysis is more an art than a science (Fisher, 1967, p. 70). Nevertheless, it is suggested that the majority of approaches to cost-effectiveness analysis have certain common functional elements which may be synthesized into a standard procedural approach. These steps are illustrated in Figure 4 and include the following inputs from others, analysis, and outputs:

- STEP 1: Review definition of the desired general goals and specific objectives that the design is to meet or fulfill.
- STEP 2: Review identification of the parameters or requirements essential for the attainment of the desired goals/objectives.
- STEP 3: Review development of the alternatives for accomplishing the goals/objectives/requirements.
- STEP 4: Establish an evaluation criteria (measures), for cost and effectiveness, that relate alternative capabilities to the goals/objectives/requirements.



Note: After Pearson, 1972, p. 35

Figure 4. Cost-Effectiveness Analysis Standard Procedure

- STEP 5: Determine the cost of alternatives in terms of evaluation criteria.
- STEP 6: Determine the capabilities or effectiveness of the alternatives in terms of evaluation criteria.
- STEP 7: Select fixed-cost or fixed-effectiveness approach.
- STEP 8: Create an alternatives versus criterian array.
- STEP 9: Analyze the merits of alternatives.
- STEP 10: Analyze the uncertainty factors.
- STEP 11: Document the rationale, assumptions, and analyses underlying the previous steps and submit findings (Pearson, 1973, p. 34).

The following discussion of these procedures suggests guidelines to be followed for a standardized approach to the analysis of system/cost-effectiveness. Although the presented steps are in an order in which they would usually be performed, changes in the sequence are acceptable and should fit the need of the subject under evaluation (Kazanowski, 1968, pp. 115-116).

STEP 1: REVIEW DEFINITION OF THE GOALS AND OBJECTIVES

Before cost-effectiveness analysis can be considered, the problem must be identified and the goals/objectives must be defined, at least in a general nature. Obvious as this may seem, the perception of the problem that needs solving, and the establishment of goals and objectives, are very often complex and involved tasks for which there are no techniques and tools besides "logical thinking" (Jakobsberg, 1966, pp. 37-38). Without such an identification of goals/objectives there is no framework for structuring the subsequent evaluations. The following are several points to consider in reviewing the general goals/objectives definition.

If goals/objectives specified are in too general terms, the constraints established for bounding the evaluation are often only the product of the analyst. In addition, care must be exercised not to identify the goals/objectives in such a manner as to bias the evaluation by including requirements of such specific nature that they exclude potential candidate alternatives from consideration.

On the other hand, care must also be taken not to make goals/objectives too specific or they will limit the scope of possible candidate alternatives by implicitly defining alternative concepts rather than just the desired goals/objectives. A potential danger always exists in that the goals/objectives originator may specify a goal/objective that is unattainable by means of current technology.

STEP 2: REVIEW THE IDENTIFICATION OF THE PARAMETERS OR REQUIREMENTS

The basic purpose of identifying and defining the general goals/objectives is to aid in the identification of requirements essential to attaining the defined goals/objectives. The goals/objectives and requirements should be identified and specified within the required parameters. This specification is used to further reduce the possibility of biasing the cost-effectiveness analysis. The confusion brought about by close relationship between goals/objectives and requirements is further compounded by the variety of categories of cost-effectiveness studies (i.e., suprasystem comparison study and system configuration/component study). The need for detailed specificity can be illustrated by the following simplified example of the general goal/objective of eliminating poverty of migrant agricultural workers by vocational skill training. One requirement would be the identification of current labor market vocations needed so that detail job performance training specifications could be formulted. The resulting requirement specification might detail tool or machine operator competencies needed, as well as conditions and level of performance expected after training completion. The major factors for consideration when reviewing the identification of goals/objectives and requirements, and the development of specifications are as follows.

- Verify the establishment of a relationship that converts goals/objectives into some unit of measure for both cost and effectiveness. For example, number completions at a given level of achievement.

- Be alert for errors of commission, which are just as important as errors of omission. If goals/objectives that are not necessarily essential are identified as requirements, they can strongly prejudice the subsequent cost-effectiveness evaluation (Kazanowski, 1968, pp. 117-119).

STEP 3: REVIEW DEVELOPMENT OF THE ALTERNATIVES

As in defining the goals/objectives and identifying the requirements, developing valid alternative means or courses of action that can satisfy the goals/objectives is a mental exercise for which no current scientific technique exists (Jakobsberg, 1966, p. 39). This activity is to create two or more alternative concepts of ways to achieve the goals/objectives within the defined parameters or specifications. Frequently, considerable imagination and creativity are required to develop effective competitive candidate alternatives. The results of cost-effectiveness analysis can be no better than the conception and development of attractive candidate alternatives (Kazanowski, 1968, p. 120).

There are several problems associated with the review of the alternative development. The most serious problem or source of defects is attention bias. This is frequently caused by a cherished belief or an unconscious adherence to what we might call a "party line." This attention bias may result in the unwarranted favoring of a particular alternative by the analyst (Quade, 1969, p. 8). Another problem is the degree of detail associated with available information on alternatives. Since the purpose of cost-effectiveness analysis is to aid the decision-maker in deciding which alternative should be selected, specific details on possible alternatives are generally lacking. Too little detail usually results in a large variance in estimated alternative effectiveness and cost. On the other hand, to require that the candidate alternative be designed in detail, before being evaluated, would defeat the basic purpose and value of cost-effectiveness analysis. In addition, the development of new and novel alternatives might be discouraged by detail design requirements. This factor would tend to favor existing or more traditional alternatives. The balance between inadequate detail and excessively rigorous specificity should be maintained.

STEP 4: ESTABLISH COST AND EFFECTIVENESS EVALUATION CRITERIA

The criteria specifies: (1) the measure of cost; (3) the measure of effectiveness; and, (2) the relationship between them. All will be used in the selection of one alternative from the several alternatives. The measure of cost must be consistent with the overall framework of the resource allocation problem; e.g., net future total cost of ownership for a certain number of years. The measure of effectiveness should express the extent to which the goals/objectives and requirements are being accomplished. The relationship between the cost and effectiveness must be expressed in functional terms; e.g., in a mathematic equation, graphic display, or model (Bryk, 1965, p. 1).

The selection of appropriate and adequate cost and effectiveness evaluation criteria is based on judgment and experience. The omission of significant criteria could readily invalidate the results of a cost-effectiveness analysis. The inclusion of numerous criteria to be on the safe side, however, can result in mental paralysis when the optimum alternative selection is being made. The greater the number of criteria, the greater the probability that even unlikely candidates will excel in some criterion, making alternative system selection difficult. One simple test of the adequacy or completeness of cost and effectiveness evaluation criteria is to question whether one alternative could excel in most of the criteria established and still not be selected as the preferred choice. If the answer is affirmative, important criteria could be missing. Considerable insight into the subtleties of the goals/objectives and requirements is usually necessary for the establishment of meaningful alternative evaluation criteria (Kazanowski, 1068, p. 123). Certain evaluation criteria of cost and effectiveness suggested by a variety of authors are shown in Figure 5.

Develop Measurers of Cost

The choice of a particular alternative for accomplishing the goals/objectives implies that certain specific resources will be consumed and could no longer be used for other purposes. These are the costs. In future time period analysis most costs could be indicated as money expenditures, but their true measure should be expressed in terms of the values of alternative opportunities which are precluded because of this expenditure (Quade, 1969, p. 4). One of the most difficult problems in establishing cost evaluation criteria is the determination of appropriate cost measures. The choice of the proper cost measure involves both difficulties and controversy within the broad categories of time-phased analysis (cost distributions over extended time periods) and non-time-phased analysis.

Cost Measures for Non-time-phased Analysis. For the purpose of non-time-phased analysis (such as applied to the system/component level configuration or system level comparison study) the following three cost measures are commonly suggested.

- Initial cost (including research and development and initial investment, to achieve the assumed goals/objectives) plus X years of operating costs. The choice of what X should be is a

I. STATIC
II. TIME-PHASED

A. SYSTEM COST TO ACCOMPLISH GOALS/OBJECTIVES
B. FUNDING RATE
C. RESOURCES REQUIRED
D. DISCOUNTING

1. RESEARCH AND DEVELOPMENT
2. INITIAL (MFG., DEPLOYMENT, TRAINING)
3. OPERATING (ADMINISTRATIVE, LOGISTICAL)
4. OTHER

MEASURES OF EFFECTIVENESS

I. STUDENT/GROUP-ORIENTED
II. SCHOOL-ORIENTED
III. COMMUNITY ORIENTED

A. UTILITY
B. PRODUCTIVITY
C. WORTH
D. MERIT
E. BENEFIT
F. GAIN
G. VALUE RECEIVED

1. PERFORMANCE
2. ECONOMY
3. SAFETY
4. AVAILABILITY
5. FLEXIBILITY
6. PRESTIGE
7. MAINTAINABILITY
8. RELIABILITY
9. PROBABILITY OF SUCCESS
10. EVOLUTIONARY DEVELOPMENT
11. REPAIRABILITY
12. GROWTH POTENTIAL
13. DEPENDABILITY
14. CAPABILITY
15. TECHNICAL CONFIDENCE
16. INFORMATION YIELD
17. VERSATILITY
18. SPILLOVER EFFECTS
19. TECHNICAL DESIRABILITY

Note: After Pearson, 1972, p. 42

Figure 5. Cost and Effectiveness Evaluation Criteria

problem but is is most commonly taken as five and occasionally ten years.

- Adjusted initial cost plus X years of operating costs. The difference here is only the use of adjusted initial cost in which case the costs are adjusted to take into consideration the estimated residual values for each alternative. The residual-value problem occurs most frequently when comparing choices between alternatives which either: (1) could be used for additional goals/objectives; or, (2) the life-cycle of alternatives differs widely. The latter situation is the most often cause for initial cost adjustment.

- The above first or second cost measure, but discounted in some manner. Discounting has been used in order to perform two functions: (1) as an adjustment for the increasing time period uncertainties; and, (2) to indicate economic impact.

Cost Measures for Time-Phased Analysis. For the suprasystem comparison studies, there are three general cost measures suggested to be used in examining each alternative. These are:

- Annual funding/budget requirements.

- Cumulative funding/budget requirements.

- Present expenditure worth at a selected discount rate.

The problem in all of the above measures is to determine how far out the study should be carried in order to consider all time periods pertinent to the purpose of the study. At some point the effect of the subsequent years would have negligible effect upon today's decisions.

There is probably no ideal answer to the question of the cost measure to be used, in either time-phased or non-time-phased analysis. No single cost measure incorporates all pertinent elements and it may well be desirable to use more than one measure to give the proper cost perspective (Hatry, 1967, pp. 64-67).

Develop Measurers of Effectiveness

Of all the components or constituents of cost-effectiveness analysis the cost-measure concept has found the least acceptance as a valid measurement criterion. Less difficult was the acceptance of the effectiveness-measure criterion (Breckner, 1967, p. 83). Proper effectiveness criteria selection, however, is one of the most formidable problems of cost-effectiveness analysis. If the goals/objectives are not trivial, then real world facets are generally complex and have widespread implications; consequently the effectiveness criteria may be broad and numerous. If the scope of the goals/objectives is reduced, usually so is the number of significant criteria. Even if the scope of the problem is significantly reduced, it is virtually impossible to reduce the total cost-effectiveness analysis to a single easily evaluated effectiveness criterion (Kazanowski, 1968, p. 152). On the other hand, the more narrow and fewer in number the measure of effectiveness criteria become, the more limited will be the eligible alternatives to be considered. It is often desirable, therefore, to broaden a cost-effectiveness analysis study to include more effectiveness criteria in order to insure a wider range of alternatives (Breckner, 1967, p. 58). Well defined and explicit measures of effectiveness are difficult to develop and rare. Typically, these measures are replaced by two devices: (1) performance identifiers; and (2) standards.

Performance Identifiers. These effectiveness measures relate to the administrative control of functions where output is inadequately defined. Usually, performance measures are specified on an activity basis to give an estimate of work performed. The performance identifier tends to be a device to measure work performance and is designed to detect the variations in work performance levels. In fact, however, performances may have little relation to the final output.

Standards. These effectiveness measures are much broader than performance identifiers. Government procurement activities are characterized by the use of standards, which may be of two types: technical performance standards, and generalized standards. Considerable overlap exists, however, and many problems are common to both.

- Technical performance standards exist throughout government and industry and are needed to give a vital measure of uniformity and interchangeability of parts, components, assemblies, and processes. For example, both the government Bureau of Standards and the industrial

Underwriters Laboratories develop operational and performance standards for electrical items. These standards are observed by those manufacturers who wish to market products in the United States.

- Generalized standards are identified to distinguish them from technical, and are used when specific output and effectiveness measures are difficult to determine. For example, certain accrediting organizations develop guidelines and standards for the evaluation and certification of public schools, academic institutions, and libraries. These standards are observed and maintained by those wishing accreditation (Teitz, 1968, p. 309).

Unique to instructional design there are three broad categories of instructional effectiveness measures: (1) student/group-oriented, (2) school-oriented; and (3) community-oriented.

Student/Group Oriented Measures. These effectiveness measures refer to academic achievement change (grades) resulting from an improvement in the instructional program.

School-Oriented Measures. These effectiveness measurers are characterized by three types.

- The change in number dropping out of school as a consequence of these achievement changes in a given school population in terms of changes.

- The number selecting the various available courses of study.

- The number and quality of those graduating (as indicated by scores on standardized tests).

Community-Oriented Measures. These effectiveness measures are characterized by two types.

- The average expected lifetime earnings potential of persons with different levels of education (economic factors).

- The reduced relationship between parental socio-economic level and individual achievement indicating increased equality of educational opportunity (social change) (Abt Associates, Vol. I, 1967, p. 3).

Although not applicable in all circumstances, the following ground rules may be observed in selecting appropriate measures of effectiveness.

- Do not force a quantification measure of effectiveness where no sound analytical basis for it exists.

- Some effectiveness criteria will be quantifiable, but many will not be.

- Nonquantifiable effectiveness criteria pose no particular difficulty in analysis when appropriate.

- When the analysis involves a mixture of quantitative and qualitative effectiveness criteria, the cost-effectiveness analyst must exercise caution in gauging the impact of the qualitative criteria. For this reason, quantitative criteria are usually preferred, and the result is interpreted in terms of the qualitative criteria (Jakobsberg, 1966, pp. 39-40).

A final consideration is to choose a measure of effectiveness which serves as a sufficient input to the next level of decision-making (Niskanen, 1969, p. 30).

A methodological consideration discussed in Step No. 4 dealing with measures of both cost and effectiveness is that no single criterion measure that is appropriate for all goals/objectives in known. Even if a single criterion measure is adopted for all goals/objectives, the present inability to quantify relationships suggests the use of a multidimensional scale for measuring results (Packer, 1068, p. 235).

STEP 5: DETERMINE COST OF ALTERNATIVES

Cost and effectiveness of alternatives must be determined in order to rationally allocate resources. Costs are considered easier to determine than effectiveness because dollars, manpower, and materials are homogeneous and measurable. Accurately predicting future costs is not simple, however, because consideration must be given to uncertainty of cost estimates, the unpredictability of inflation, and to the probable time-value of money due to discounting. Other factors that could also be included are the cost of opportunities lost and the effect of uncontrolled consequences of the outcomes (Packer, 1968, p. 247).

The problem of dollar-cost estimating often assumes so much importance in any cost-effectiveness analysis that the usefulness of the basic concept of cost (as it relates to the analysis) is lost. As a result, accounting/budget costs may take on an importance which may not be justified. It should be remembered that costs as prediction of the future can only be estimates and we always estimate future values on the basis of past experience. As a consequence, it is natural that records of past experience are reviewed in order to project future costs. Since the accounting/budget costs records usually include some aspects of actual past costs, a critical review is to ensure that past under or over cost expenditures will not prejudice the current cost estimate (English, 1968, p. 77).

The performance of Step No. 5 should deal with cost analysis for cost-effectiveness and similar analysis. The term "cost analysis," in one form or other, is also used for those involved in budgeting, accounting, and cost-control purposes. Although somewhat related, these methods are not considered here (Hatry, 1069, p. 44). In cost-effectiveness analysis, the development of highly detailed cost breakdowns are not required (Novick, 1967, p. 103). It should be also noted that the preparation of the cost estimate is usually performed by someone other than the cost-effectiveness analyst. It is axiomatic that the estimate cannot be better than the statement of the goals/objectives/requirements on which the cost estimate is based. These statements, however, sometimes reflect the cost estimator's own particular biased interests (Novick, 1963, p. 102). In the creation of a cost estimate in accordance with the goals/objectives/requirements, the cost-effectiveness analyst must verify that the cost estimator has provided the following cost data.

Identify Cost Categories

These categories cover the source of major costs (Herd, 1965, p. 81). Measures of cost (developed in Step No. 4) should be indicated, as well as the following elements:

- Matter-energy, information, and time.
- Human effort (student time and effort, teacher time and effort, administrative or technician time and effort).

- Monetary costs (short run and long run capital and operating activities) (Miller & Rath, 1969, pp. 21-24).

Identify Resource Constraints.

These constraints usually result in the indication that highly aggregated costs are useless; that costs must be broken down into relatively small units which will permit a variety of cost analysis approaches.

Calculate Costs.

Each category identified should be considered on an appropriate time basis as well as in total. (Although the alternative total cost may be within the total resources available, the annual expenditures may not be compatible with the budget or funding pattern.)

Identify Possible Cost Variances.

A single cost estimate does not indicate unknowns relative to other costs provided by others. Unknown factors in cost data elements should be identified for subsequent uncertainty analysis.

Verify Completeness.

Insure compliance of cost data elements with a checklist (Herd, 1965, p. 81).

Essential to the validity of all cost-effectiveness analysis is the availability of appropriate, accurate, and timely cost estimates. It is true that a poor cost-effectiveness analysis can misuse even the best cost data, but even the best of analysis cannot do much with inadequate cost data (Hatry, 1969, p. 55).

STEP 6: DETERMINE CAPABILITIES OR EFFECTIVENESS OF ALTERNATIVES

Once the effectiveness evaluation criteria have been determined (Step No. 4, pp. 25-27, above) the next step is to express the capabilities of the alternative systems in terms of the evaluation criteria. To save time, this is often performed concurrently with Step No. 5. Quantitative expressions of capabilities are preferred when they are available but qualitative expressions are acceptable when they are not (Kazanowski, 1968, p. 129). As is cost estimation, the estimates of the capabilities of alternative systems is dependent upon information and data supplied by someone other than the cost-effectiveness analyst. Although this is both an advantage as well as a disadvantage, confidence in the accuracy of alternative system capability may be lacking and may be subject to the biased interests of the estimator (Quade, 1969, p. 10).

STEP 7: SELECT FIXED-COST OR FIXED-EFFECTIVENESS APPROACH

In assessing alternatives, the procedure may now take either one of two analytical approaches:

- A desired level of effectiveness may be specified, and the analyst seeks the most economical way to achieve it, or

- The level of expenditure may be specified and the analyst explores the effectiveness offered by the alternative capabilities (Breckner, 1967, p. 43).

The choice of specifying either the fixed-cost or the fixed-effectiveness analysis approach oftentimes is the option of the analyst. This choice is important because, in most cases, real-world problems cannot be adequately dealt with in such a simple form as optimizing either cost or effectiveness. This is because in most studies unique measures of cost and measures of effectiveness can only be obtained by directing the analysis on a very small aspect of the total goals/objectives and requirements. The results of such an analysis is rather superficial and seldom reflects the real-world goals/objectives and requirements from which the decision-maker must select the best alternative. The selection of one approach, therefore, may more closely reflect the real-world options actually available to the decision-maker, whereas the selection of another approach might reflect options which are not available. Another factor in the choice of one approach over the other may also yield economies of analysis, depending on the availability, quality, and validity of data to be utilized in the cost-effectiveness analysis itself. The choice of fixed-cost of fixed-effectiveness approach is least affected by the constraints imposed by the decision-maker, therefore, the choice of approaches is vital to the integrity of the analysis.

Fixed-Cost Approach

A basic fixed-cost approach is first, the development of alternative systems that can compete in meeting the goals/

objectives/requirements (Step No. 3) in competition for the given resources. Second, the number of components of each alternative that can be developed, procured, and operationally implemented within the fixed resources, is determined. Finally, the alternative which satisfies the goals/objectives/requirements to the greatest extent is identified as the preferred choice.

Fixed-Effectiveness Approach

A basic step in the fixed-effectiveness approach is first, development of a measure of the effectiveness expressed in terms of the requirements identified in the prior Step No. 2. Then, alternatives are developed to meet the goals/objectives as in Step No. 3. The number of components of each alternative necessary to attain the goals/objectives is determined and, the costs and penalties incurred by each alternative are estimated. Finally, the alternative that exhibits the least aggregate cost penalty is identified as the preferred choice.

It is suggested that if inflexible constraints are imposed on the resources available, the use of the fixed-cost approach is indicated. Conversely, if inflexible constraints are imposed on the effectiveness required, the use of the fixed-effectiveness approach is indicated. In the absence of other guidelines, the presence of both a large number of significant measures of effectiveness criteria and a small number of measures of cost criteria usually indicates that the fixed-effectiveness approach should be used (Kazanowski, 1968, pp. 126-128).

Note that in using either the fixed-cost and or fixed-effectiveness approaches to evaluate alternatives, the measure of criteria (either the cost criteria or the effectiveness criteria) must be held constant so as to have a common basis for comparison. Methods in which both the measures of cost and the measures of effectiveness are allowed to vary are to be avoided because there would then be no common basis for comparison (Barfoot, 1963, p. 3).

STEP 8: CREATE ALTERNATIVE VERSUS CRITERIAN ARRAY

Ideally, it would be desirable to examine the cost and effectiveness evaluation criteria of the alternatives in the real world rather than in the simulated world of cost-effectiveness analysis. For many obvious reasons, such as excessive expense and/or the unavailability of the alternatives, this is not possible (Blumstein, 1969, p. 33). Two different analytical techniques of conducting cost=effectiveness evaluations within either the fixed-cost or fixed-effectiveness approach are often encountered. These are: (1) the tabular display technique; and, (2) the model technique.

The Tabular Display Technique

The tabular display technique is used when the alternatives are being evaluated by measures of cost, or measures of effectiveness, or by both measures of cost and effectiveness that are incommensurate with one another. In this technique, the evaluation criteria underlying the analysis are identified at the tops of columns and arranged in decreasing importance of criteria from left to right as indicated in Figure 6. The alternatives are then listed vertically, with the alternative that meets the most significant criterion to the greatest extent listed first, and so on. This technique is useful when numerous alternatives are being evaluated because the technique can be used to eliminate the less likely competitive alternatives and allow attention to be focused on the two or three major competitors. Whether the fixed-cost or fixed-effectiveness approach is used, the tabular array created will be very similar. In the fixed-cost approach, major emphasis is placed on the effectiveness attainable; however, cost data indicating how the total cost is divided and phased is significant and should be shown. On the other hand, in the fixed-effectiveness approach, major emphasis is placed on the total cost. The advantage of the tabular display technique is that the orderly presentation of alternatives cost and capability data is permitted so that their impact on the evaluation can be readily discerned and discussed along with the significant interrelationships. Conclusions, therefore, can be reached by visible traceable means.

The Model Technique

The model technique, in which either cost models or effectiveness models are created, is usually used when the basic differences between the alternative systems are relatively minor, so as to permit the valid expression of their essential differences by a single parameter (Kazanowski, 1968, pp. 129, 134 & 136). These models may be structured along a spectrum of abstraction as shown in Figure 7. First, and the least abstract to be considered is the real-world system, within which the analyst cannot work. Next the more abstract models of this real-world are examined. This includes the technique of operational exercise, gaming, simulation, and analytical modeling. Last, at the opposite end of the spectrum, is total abstraction, within which, again, the analyst cannot work.

COST TABULAR DISPLAY

	COST					
		DOLLARS PER NO. YEARS				
ALTER-NATIVE DESIGN	TOTAL	RESEARCH & DEVELOP	INITIAL/ ACQUISITION	OPERA-TIONAL	PER-SONNEL REQ-UIRED	MATER-IAL REQ-UIRED
X Y Z						

EFFECTIVENESS TABULAR DISPLAY

	EFFECTIVENESS				
ALTER-NATIVE DESIGN	DEGREE 1	DEGREE 2	DEGREE 3	DEGREE 4	DEGREE 5
X Y Z					

Figure 6. Tabular Display Technique Example

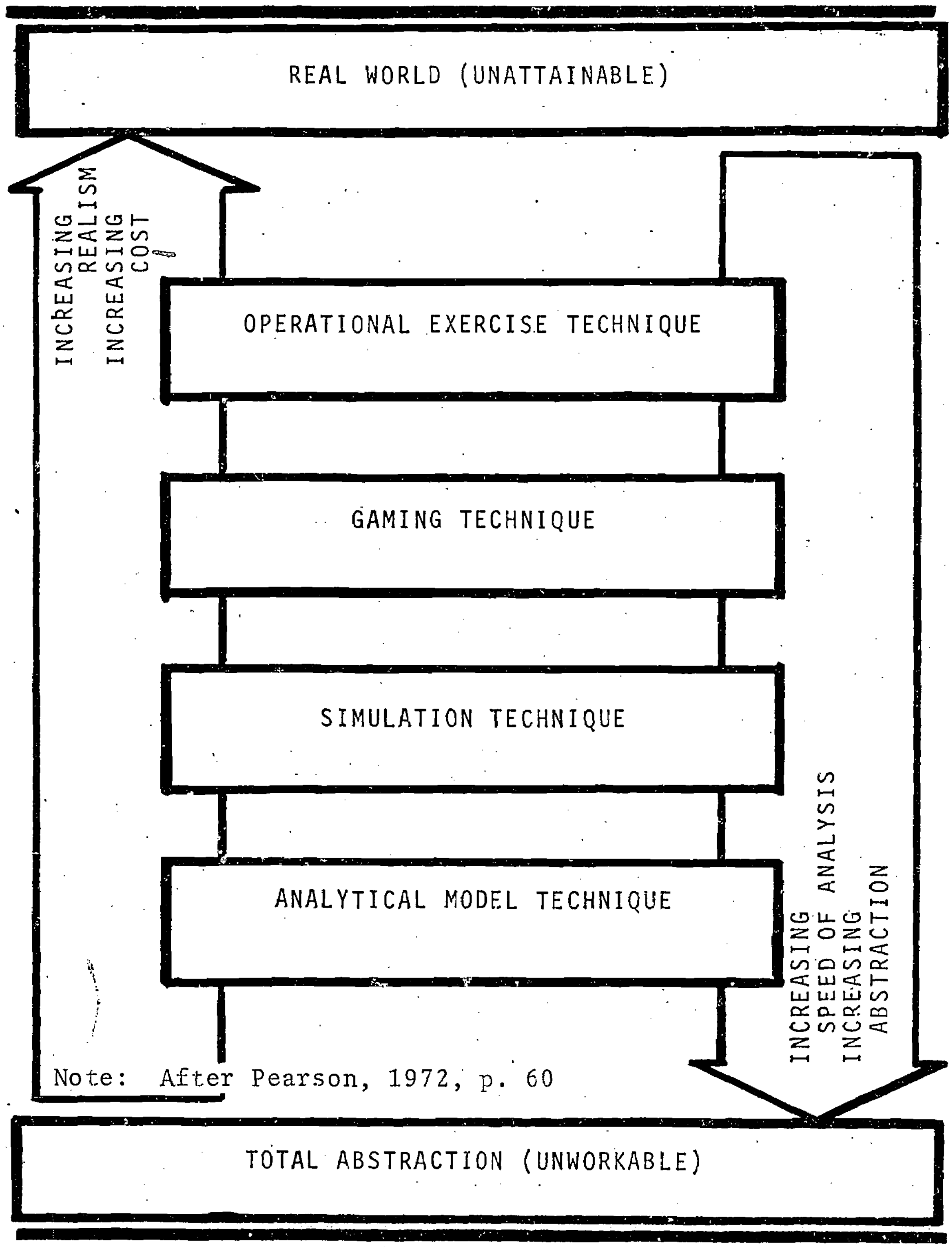


Figure 7. Model Techniques Spectrum

Operational Exercise Technique. The closest approximation to the real-world would be an operational exercise, using the actual situations with the alternatives under study. Operational exercise differs from the real-world in that the scale is smaller and many of the personnel are simulated. In addition, the consequences of failure are not considered. The operation exercise, consequently, is a very close approximation to the real alternative but contains certain factors that would not normally exist in the real world. The running cost of such an exercise is great and the number of alternatives which can be analyzed is small.

Gaming Technique. The next region down this spectrum of abstraction is gaming. Here are removed from the representation of the real world those components that can most easily be simulated by a simple analog such as a computer or some other device.

Simulation Technique. The next stage towards model abstraction is to physically remove the human decision-maker from the representation. At this point the merits and operation of the alternatives are simulated on a computer in which the human decision rules are explicitly programmed.

Analytical Technique. In those models already considered, although modified or compressed, there has been relationships between time in the real world and time in the model. In analytical models, even this relationship is abandoned. Here a system of equations is created: (1) that related the characteristics of the alternative; and, (2) that are related to the measures of effectiveness. Examples of this are linear programming models, graphic models, and the whole class of equations referred to as math models.

Model Considerations

The model spectrum (Figure 7) represents, from top to bottom, increasing abstraction from the real-world; or alternately, proceeding from bottom to top in the figure, increasing realism or closer approximation to the real world. It is also generally observed that both the cost of the analysis and the rate at which we can examine different situations decreases as the model used becomes more abstract. For reasons of economy and completeness of analysis, we would like to operate as close to total abstraction on this spectrum as possible. On the other hand, the possibilities of faulty assumptions increases as we move away from working in the real world.

In exploring considerations that go into modeling technique selection for a particular cost-effectiveness analysis it should be remembered that the basic function of the model is to determine the value of the measure of effectiveness when the controllable variables of the alternatives are used (Blumstein, 1969, pp. 34, 35 & 39). Here the term "model" is used in a broad sense. Depending on the nature of the goals/objectives, the model used in the cost or effectiveness analysis may be formal or informal, very mathematical or not so mathematical, heavily computerized, moderately computerized, or not computerized at all. The main point, however, is that the model need not be highly formal and/or mathematical to be useful. The following important points should be considered in the selection of modeling techniques.

- Remember that model building is an art, not a science. Often it is an experimental process.

- Emphasize those factors relevant to the goals/objectives, and suppress those factors that are relatively unimportant. The model is likely to be unmanageable if this is not done.

- Develop a meaningful set of relationships among: (1) goals/objectives, (2) the alternatives available for attaining the goals/objectives, (3) the estimated cost of the alternatives; and, (4) the estimated effectiveness for each of the alternatives.

- Base the model design upon the "building-block" concept, which accepts analytical data prepared during prior steps in the creation of a set of smaller or partial models. Each small model will be used in the construction of a larger subsequent cost-effectiveness model (Packer, 1968, p. 236).

- Make provisions for explicit treatment of uncertainty (see Step No. 10) (Fisher, 1967, p. 72).

Within the spectrum of modeling technique (from concrete to highly abstract models), there are two techniques that are most appropriate for the evaluation of measures of costs and measures of effectiveness. It would seem that the choice should be dictated by the category of the cost-effectiveness study as well as the goals/objectives. This choice is between simulation and analytical modeling techniques. Although the apparent difference between these two techniques is sometimes small, an analytical model is generally more efficient if the goals/objectives can be stated in terms such that available mathematical or graphic techniques can be used to solve for an optimum solution (Packer, 1968, p. 235). Both analysis of cost and effectiveness may make use of analytical models to represent: (1) each alternatives being analyzed, (2) its operating characteristics; and, (3) the management concepts of its operation and logistical support. These models are normally structured so that any parameter, or combination of parameters, can be varied to determine the relative effect on the alternatives' total cost and effectiveness (Heaton, 1969, p. 35).

There are several considerations which should be considered in the utilization of analytical models for both cost and effectiveness.

Cost Analytical Model Considerations. The cost model relates the goals/objectives/requirements and activity rates of the alternative, and of the personnel that operate and/or support it, to measures of cost (Bryk, 1965, p. 4). Mathematical cost models are the most frequently used to evaluate alternatives when goals/objectives can be mathematically formulated, when mathematical conditions can be met, and the solution can be computed (Miller & Rath, 1969, p. 18). The key advantage of the use of mathematical cost models is the speed with which a number of alternatives can be costed. While exhibiting significant advantages for specific applications, mathematical cost models also possess substantial limitations. Two major disadvantages are:

- In creating the cost model a number of implicit assumptions are made. After the terms of the initial equation are mathematically manipulated and condensed for efficient use, the initial elements of the cost are no longer visible. Thus, the analyst may forget his initial assumption and their limitations.

- Mathematical cost models are relatively inflexible and good basically for one concept and its minor variations. If a basic variation other then those accounted for by the model is to be costed, the model must be revised and possibly modified. This modification must be verified by comparison with conventional long-hand results and as a consequence, the advantage of mathematical cost modeling is lost (Kazanowski, 1968, p. 128).

To conserve time, cost modeling is often performed concurrently with effectiveness modeling (Bryk, 1965, p. 14).

Effectiveness Analytical Model Considerations. The effectiveness model relates: (1) the measures of effectiveness in achieving the goals/objectives to, (2) measures of the alternatives operational performance (Bryk, 1965, p. 2). The use of a mathematical effectiveness model is recommended when the alternatives under analysis are basically so similar that those evaluation criteria that cannot be readily validated, can be considered to cancel each other out. This leaves only the quantifiable and commensurable criteria for evaluation. It should be noted that this occurrence is relatively infrequent (Kazanowski, 1968, p. 129).

Analytical Model Computer Use Considerations. Analytic cost-effectiveness techniques have attained their present level of acceptance largely because of the availability of today's high-speed computers and the development of appropriate computer models. The analytical models permit the study of complete interactions and many alternatives heretofore too complex and time-consuming for manual or desk-calculator analysis (Bell, 1964, p.2). Prior to these computer programs, the cost-effectiveness analyst had to choose among several hand models, which were often unwieldy and unrealistic, and the older prototype computer models. These older computer models were frequently inflexible and failed to give insight into how conclusions were related to the assumptions (Quade, 196`, p. 243). The computerization of current analytical models is warranted, however, only when the analysis of alternatives involves repeated computation of complex functions (or when the same sub-routines are performed repeatedly). In addition, computerized analytical models of advanced future alternatives are oftentimes of limited value because the expensive programming is time-consuming and soon obsolete by today's standards.

Concerning cost analytical modeling, if the model is simple, it does not need to be computerized: if it is complex, the maintenance of the computer model and associated documentation may become time-consuming and expensive. A possible compromise might be to computerize those portions of an analytical cost model that are not subject to frequent revision. In a study directly related to instructional cost modeling, it was indicated that complex mathematical modeling would be incompatible with the concept of instructional cost-effectiveness development. This concept was to develop a procedure that was easy to use and not voluminous (Institute for Educational Development, 1970, pp. 3-4). Regarding effectiveness analytical models, these are seldom mathematical and as a consequence, computerization is seldom applicable.

Analytical Model Handbook Considerations. Rather than computerize generalized all-purpose analytical models, it has been found more functional to compile an analytical costing and effectiveness handbook. Graphical displays of cost and effectiveness relationships, along with their underlying goals/objectives/requirements and assumptions, can be readily compiled and utilized. The handbook both allows and makes publicly visible the exercise of judgment to ascribe the impact of subtle deviations from a basic or common design on the cost and effectiveness of various alternatives. The costing/effectiveness handbook also has the virtue of simplicity, speed, flexibility, and economy (Kazanowski, 1968, pp. 131-132). The Institute for Educational Development has developed such a handbook, for alternative instructional design selection, under contract for the Bureau of Naval Personnel and naval training schools (Institute for Educational Development, 1970, p. 1). This two-part document is noteworthy in both volume and level of detail. Another approach in the development of an analytical model handbook is a document distributed by the Department of Defense (Department of Defense, 1969, p. 1). This both outlines the procedure of analysis and encloses analytical forms to be used.

It should be emphasized the cost-effectiveness models can never be completely realistic for they are dependent on too many uncertain parameters. The reliance on expert judgment is indispensable to all analysis. Moreover, the virtue of cost-effectiveness analysis is the provisions of a framework that allows the judgment and intuition of specialists in diverse fields to be combined. This framework is the analytical model which represents a simplified, stylized representation of those aspects of the real world as appropriate to the goals/objectives (Quade, 1968, pp. 243, 246-247).

STEP 9: ANALYZE MERITS OF ALTERNATIVES

In this final step, the integration of the previously derived alternative cost and effectiveness analytical models is performed. The purpose of the integration is to combine the expected values of alternative cost and effectiveness into a single common framework (Seiler, 1969, p. 71). This framework may be based on either the tabular display technique or the model technique discussed in Step No. 8.

An example of the tabular display technique is found in Figure 8. This figure is, in addition, an example of the application process of cost-effectiveness analysis (previously discussed) in which the analysis is both structured and evaluation is completed. This display was developed consistent with information provided by a cost and effectiveness input similar to that found in Figure 6. The instructional designs under study represents a variety of alternatives for in-service employee training. These alternatives are listed in order of

RECOMMENDED INSTRUCTIONAL DESIGN FOR EMPLOYEE TRAINING IN ORDER OF PREFERENCE ACCORDING TO COST-EFFECTIVENESS SELECTION CRITERIA

	SELECTION CRITERIA						
ALTERNATIVE INSTRUCTIONAL DESIGN	ECONOMY	FLEXIBILITY	ADMISSION STANDARDS	EMPLOYEE ACCEPTABILITY	EMPLOYER ACCEPTABILITY	SPEED	TOTAL NUMERICAL EVAL.
DAY-RELEASE COURSES	1	6	5	5	3	6	26
FULL TIME SCHOOL	5	5	4	4	2	1	21
SANDWICH COURSES	4	4	3	3	4	3	21
VOCATIONAL TRAINING	6	1	6	6	1	2	21
BLOCK RELEASE COURSES	3	3	2	2	6	4	20
EVENING CLASSES	2	2	1	1	5	5	16

Note: After Drovet, 1968, p. 221

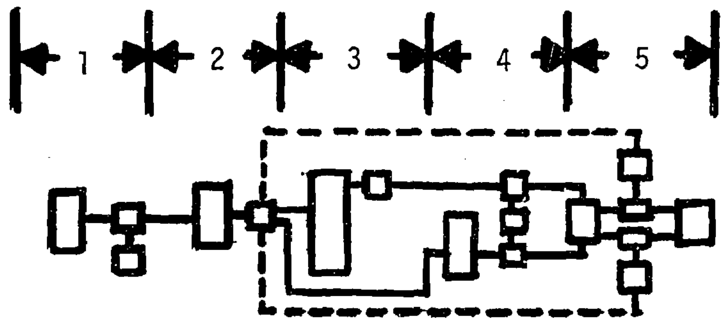
Figure 8. Cost-Effectiveness Analysis Tabular Display Example

recommended preference according to the cost-effectiveness selection criteria (Drouet, 1968, p. 221) on an evaluative scale of 1 to 6 (6 equals the highest or most preferred).

An example of the model technique is presented in Figure 9. This example illustrates both a graphic analytical model and the procedural process (also previously discussed) of cost effectiveness analysis. In this case, the analytical model illustrates the logic and procedure of the analysis of each alternative instruction design for service training. The model indicates that each alternative instructional design may be characterized by: (1) instructional requirements, (2) instruction time, (3) course duration, (4) student achievement, (5) facility requirements, (6) number of courses per year, (7) equipment, (8) course development, (9) instructional materials, (10) software development, and (11) student and instructor travel time. In addition, each instructional design can be distinguished by: (1) student achievement, (2) student attrition rate, (3) student proficiency on the job after graduation, and (4) student morale. Attributes concerning student performance and morale, during instruction or later, are identified as measures of effectiveness. This terminology is used because the effectiveness of the instructional design is measured in terms of the end products; i.e., student course completion. Other factors, such as instructor time per course and amount of instructional materials required are classified as measures of efficiency. The analytical model indicates that feasibility of the instructional design alternatives are determined initially, Next, the characteristics of the feasible alternatives are listed as well as the differences in the alternatives' effectiveness, efficiency, and costs. Risk factors are also considered in the analytical model. Last, the criterion for selecting the instructional design is applied (Institute for Educational Development, 1969, pp. 23, 25 & 26). This criterion is as follows:

> If the sum of incremental benefits in dollars of the new program exceeds its incremental benefits in dollars of the new program [sic., instructional design]...exceeds its increase in incremental cost [with acceptable risk], then the new program is randed higher than existing program and the existing program is eliminated from further consideration. If the reverse is true, the existing program is rated higher and the new program is eliminated [Institute for Educational Development, 1969, p. 29].

Regardless of the technique used, both the cost-effectiveness tabular display technique and the analytical model technique relate costs and effectiveness so that the merits of the alternatives may be analyzed for the selection of the preferred alternative (Bryk, 1965, p. 4).



INPUTS

INSTRUCTIONAL OBJECTIVES
- NUMBER AND TYPES OF GRADUATES
- TYPES OF COURSES
- STUDENT PROFICIENCY
- SCHEDULE FOR PRODUCING GRADUATES

CHANGES IN INSTRUCTIONAL OBJECTIVES
- INCREASE IN NUMBER OF STUDENTS TO GRADUATE

RESOURCE AVAILABILITY
- INSTRUCTORS
- STUDENTS
- FACILITIES
- INSTRUCTIONAL MATERIALS
- EQUIPMENT
- COURSE CONTENT DEVELOPMENT
- SOFTWARE
- FUNDS
- TIME

CHANGES IN RESOURCES AVAILABILITY
- REDUCTION IN NUMBER OF INSTRUCTORS

→ TEST FOR FEASIBILITY (BASED ON A COMPARISON OF OBJECTIVES WITH RESOURCE REQUIREMENTS) → To Sheet No. 2

↓

ELIMINATE INFEASIBLE ALTERNATIVES FROM FURTHER CONSIDERATION

Note: After Institute for Educational Development, 1969, p. 42

Figure 9. Cost-Effectiveness Analysis Analytical Model Example (Sheet 1 of 5)

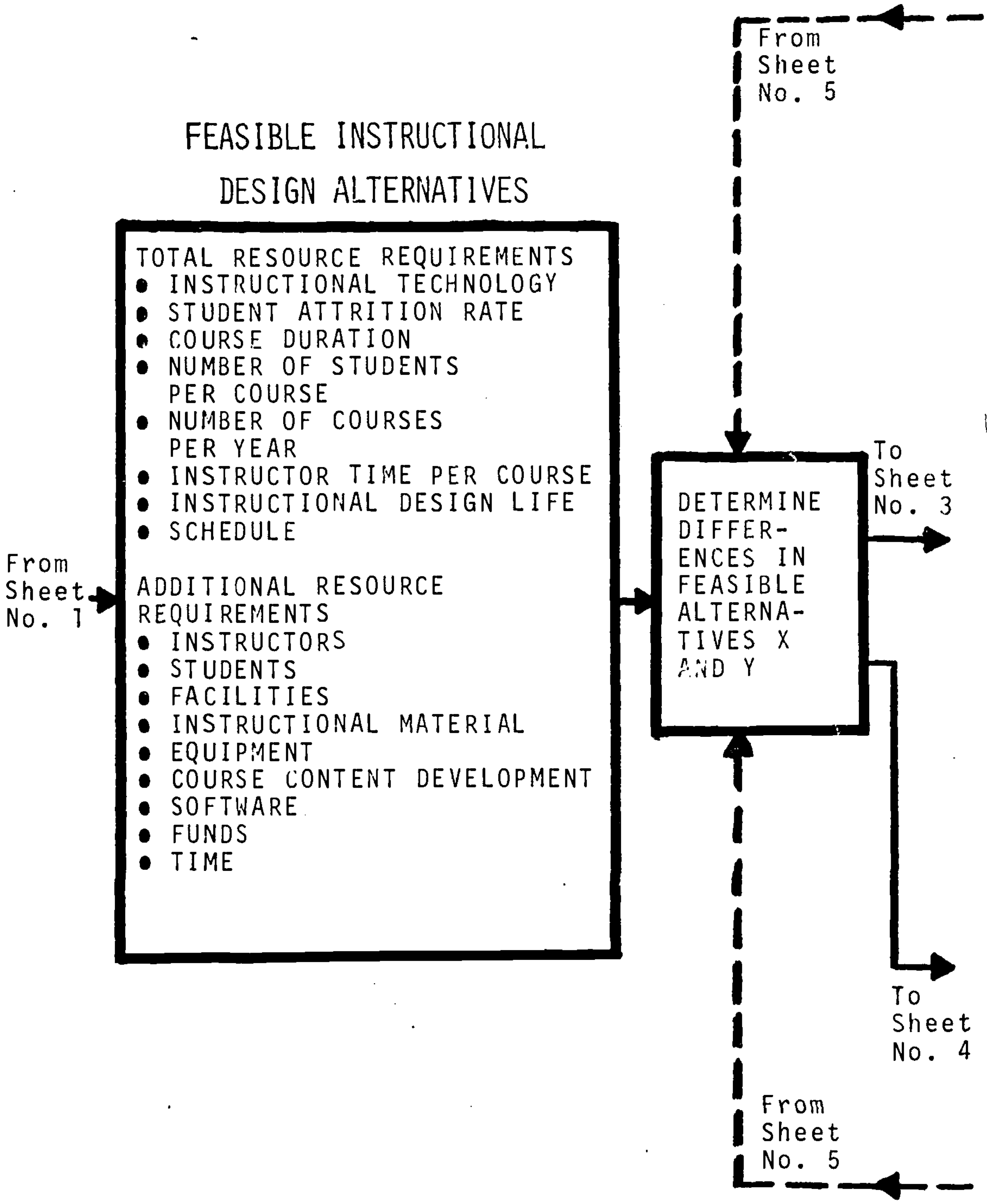


Figure 9. Cost-Effectiveness Analysis Analytical Model Example (Sheet 2 of 5)

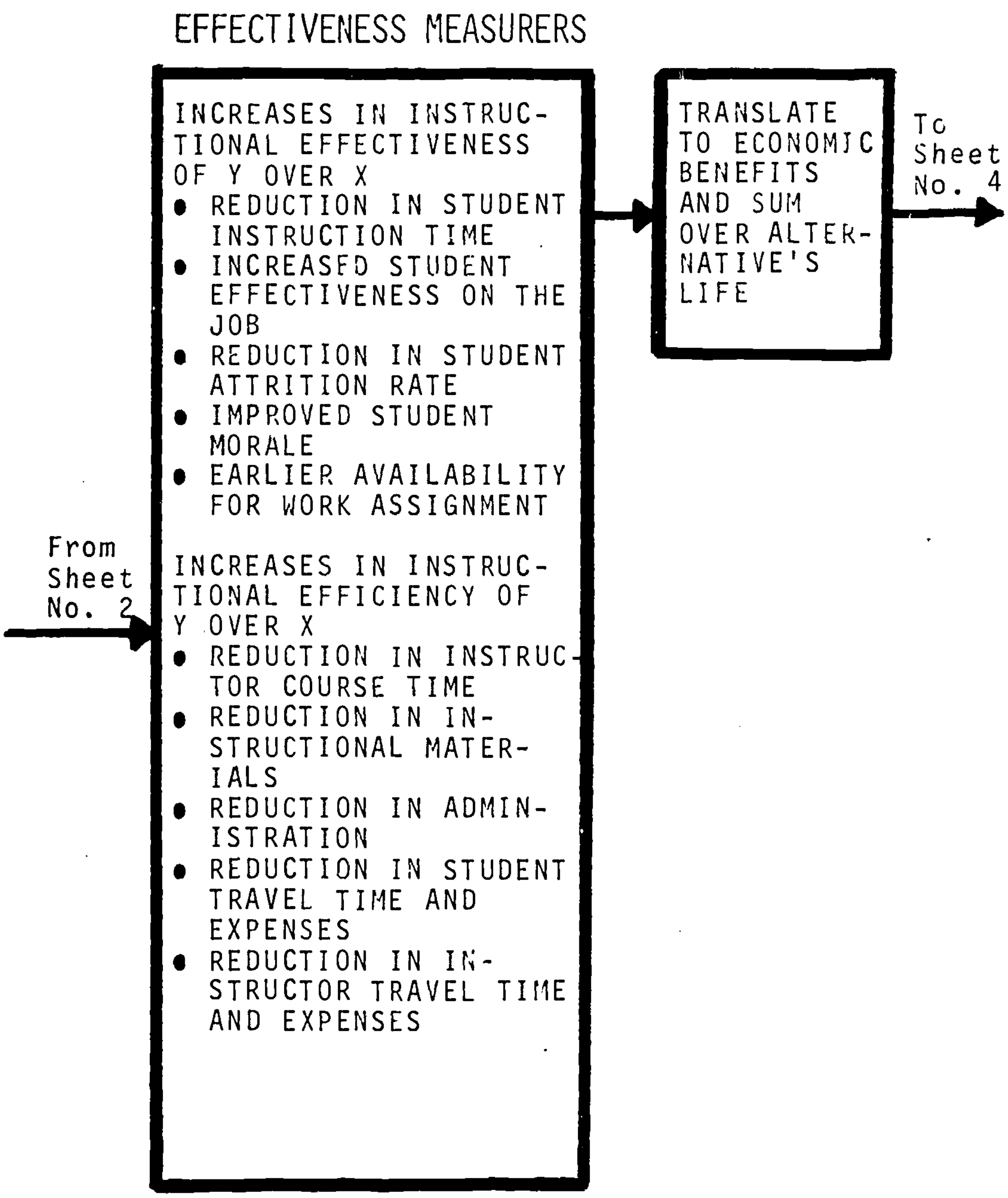


Figure 9. Cost-Effectiveness Analysis Analytical Model Example (Sheet 3 of 5)

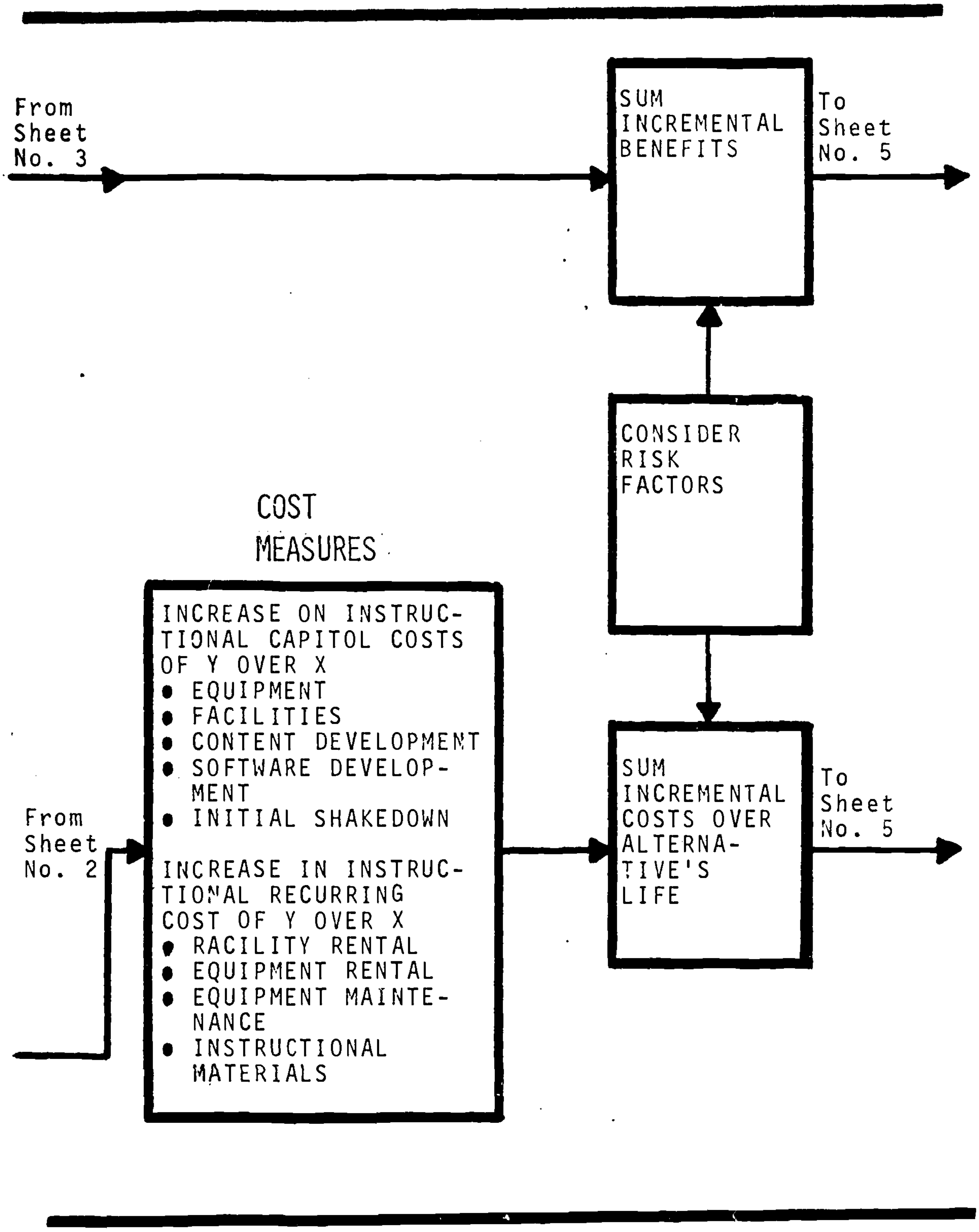


Figure 9. Cost-Effectiveness Analysis Analytical Model Example (Sheet 4 of 5)

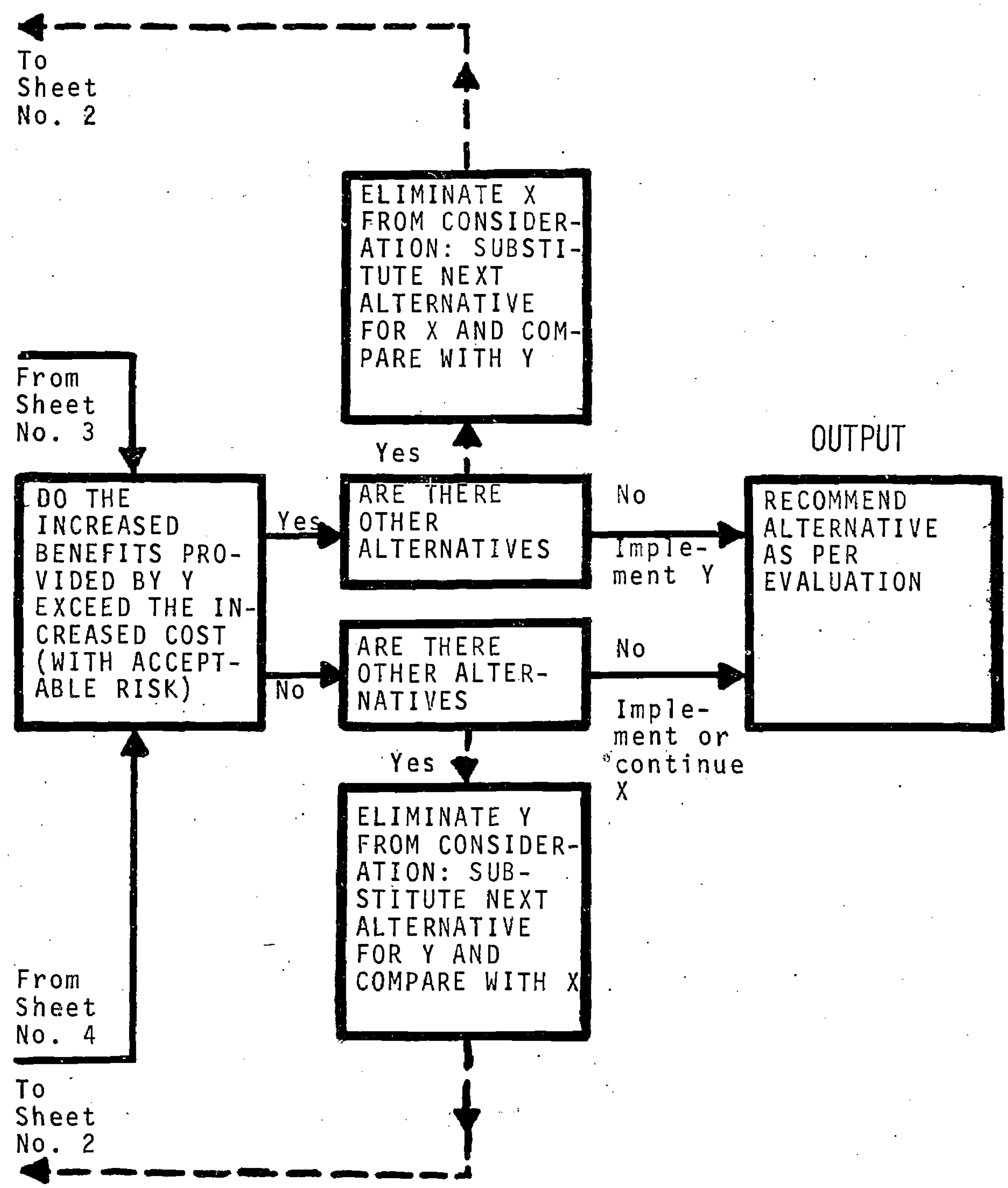


Figure 9. Cost-Effectiveness Analysis Analytical Model Example (Sheet 5 of 5)

Once the alternatives are arranged in order of their acceptability in relationship to the evaluation criteria, it is generally possible to eliminate the most obviously poorest competitors and focus attention on the top three or four. If the effectiveness and cost evaluation outcomes for the top alternative are consistently superior to the respective values of the other alternatives, then that alternative is the preferred selection. If the performance values for the top alternatives are virtually identical, and no significant difference in cost exists, the appropriate conclusion may be that there is no significant difference between the top candidates. In this case, the adoption of parallel study or development efforts of both top candidates may be indicated in order to identify the preferred alternative. This would mean that one alternative would be selected at a later date. If the costs of the competing alternatives differ significantly, and the evaluation ratings also vary significantly, the selection may need to be made on the basis of personal value judgments (Kazanowski, 1968, p. 135).

STEP 10: ANALYZE UNCERTAINTY FACTORS

All cost-effectiveness analysis studies include doubtful features that may not be satisfactorily specified or quantitatively resolved within the study itself (Brechner, 1967, p. 57). Important decision problems involve major elements of uncertainty. Consequently, a cost-effectiveness analysis of such problems must provide for the explicit treatment of uncertainty for consideration by the decision-maker.

Two main types of uncertainty may be distinguished: (1) uncertainty about the state of the world in the future; and, (2) statistical uncertainty about the data on the present state of the alternative. State-of-the-future-uncertainty stems from chance elements in the real world and would exist even if there were no ties of the state to the world of the future (Fisher, 1967, pp. 72-73). Statistical data uncertainty is most closely associated with cost-effectiveness analysis because, unfortunately, the choices between alternative candidates are seldom made on the basis of clear-cut data. Factors which add to the uncertainties include: (1) alternatives are frequently inadequate to fully attain the objectives; (2) measures of effectiveness may not actually measure the extent to which objectives are attained; (3) predictions from the cost-effectiveness model are apt to be full of uncertainties; and, (4) other criteria which look almost as attractive as the criteria chosen may lead to a different order of preference (Quade, 1969, p. 5). Three types of uncertainty analysis are most often used to treat statistical uncertainties. These are : (1) sensitivity analysis; (2) contingency analysis; and, (3) a Fortiori analysis.

Sensitivity Analysis

In many instances the output of a cost-effectiveness analysis is very sensitive to the assumptions made. The conclusions reached may be unknowingly yet significantly biased by some apparently innocuous assumptions which are essential to the analysis (Kazanowski, 1968, p. 138). For example, suppose in a given analysis there are several uncertain key parameters. In stead of using "expected values" for these parameters, the analyst could test for the influence of these assumptions by substituting several values (i.e., high and low) in an attempt to see how sensitive the results (the ranking of the alternatives being considered) are to variations in these uncertain parameters (Fisher, 1967, p. 73). Another example would be an instance in which the alternatives are nearly equal in merit. Here, it would be desirable to attempt to estimate the cost-effectiveness that would be derived from the candidate alternatives if they were cancelled at three or four different major life-cycle schedule milestones. It is also desirable to perform this analysis even when one candidate alternative appears to be clearly superior with respect to both cost and effectiveness criteria. Such an analysis may point out the need for caution in making an otherwise unqualified endorsement of the alternative (Kazanowski, 1968, pp. 138-139).

Contingency Analysis

This type of analysis investigates how the ranking of the candidate alternatives maintains ranking when a relevant change in criteria for evaluating the alternatives is postulated, or a major change in the general environment is introduced. These techniques assess the degree to which results are contingent upon any one factor, or each of several factors.

A Fortiori Analysis

This type of analysis would be applicable when in a planning decision problem the generally accepted intuitive judgment strongly favors alternative X. The analyst feels, however, that X might be a poor choice and that alternative Y might actually be preferable. In performing an analysis of X versus Y, the analyst may choose deliberately to resolve the major uncertainties in favor of X and see how Y compares under adverse conditions.

Although the three types of uncertainty analysis listed above may be useful in a direct sense, they may also contribute indirectly. For example, through sensitivity and contingency analysis the analyst may improve his understanding of critical uncertainties in a problem area. On the basis of this knowledge he might then be able to create a new alternative that would assume more protection against a wider range of uncertainties. This is often difficult to do but when it can be accomplished, it offers one of the best ways to compensate for uncertainty (Fisher, 1967, pp. 73-74).

STEP 11: DOCUMENT BASES OF PREVIOUS STEPS AND SUBMIT FINDINGS

The product of a cost-effectiveness analysis study, will in all probability be a report to the decision-maker. In support of this report a key element of systematic cost-effectiveness analysis is sufficient documentation of methods, assumptions, sources, etc., so that another analyst would achieve substantially the same results with the same material. Without such documented results, a cost-effectiveness analysis appeal for acceptance rests solely on faith in the authority and expertise of the analyst with critical examination of the way in which he arrived at the recommendations (Heymont, 1965 p. 20).

Particular emphasis should be placed on the adequacy of documenting the following:

- Specific goals/objectives to be attained.
- Essential requirements of those goals/objectives along with associated assumptions.
- Alternative capabilities and associated assumptions.
- Alternative costs and associated assumptions (learning curves, time, quantities, etc.).
- Alternative evaluation and associated assumptions (scenarios, criteria, etc.).
- Conclusions: The recommended alternative, the limitations, and the associated uncertainty factors.

The use of highly esoteric mathematics for documentation should be discouraged. With effort, imagination, and forethought, the analyst can usually suitably portray complex mathematical and functional relationships in simplified and perhaps graphic form. No judicious decision-maker can be expected to endorse a conclusion or recommendation whose rationale and derivation he cannot fully understand. It is the responsibility of the analyst to present the documentation in an appropriate and understandable manner. To have a high probability of acceptance by the decision-maker all elements of the cost-effectiveness analysis must be documented in such a manner that the entire process can be clearly followed (Kazanowski, 1968, pp. 139-140).

SUMMARY

Cost-effectiveness analysis can be used as an effective decision assisting aid:

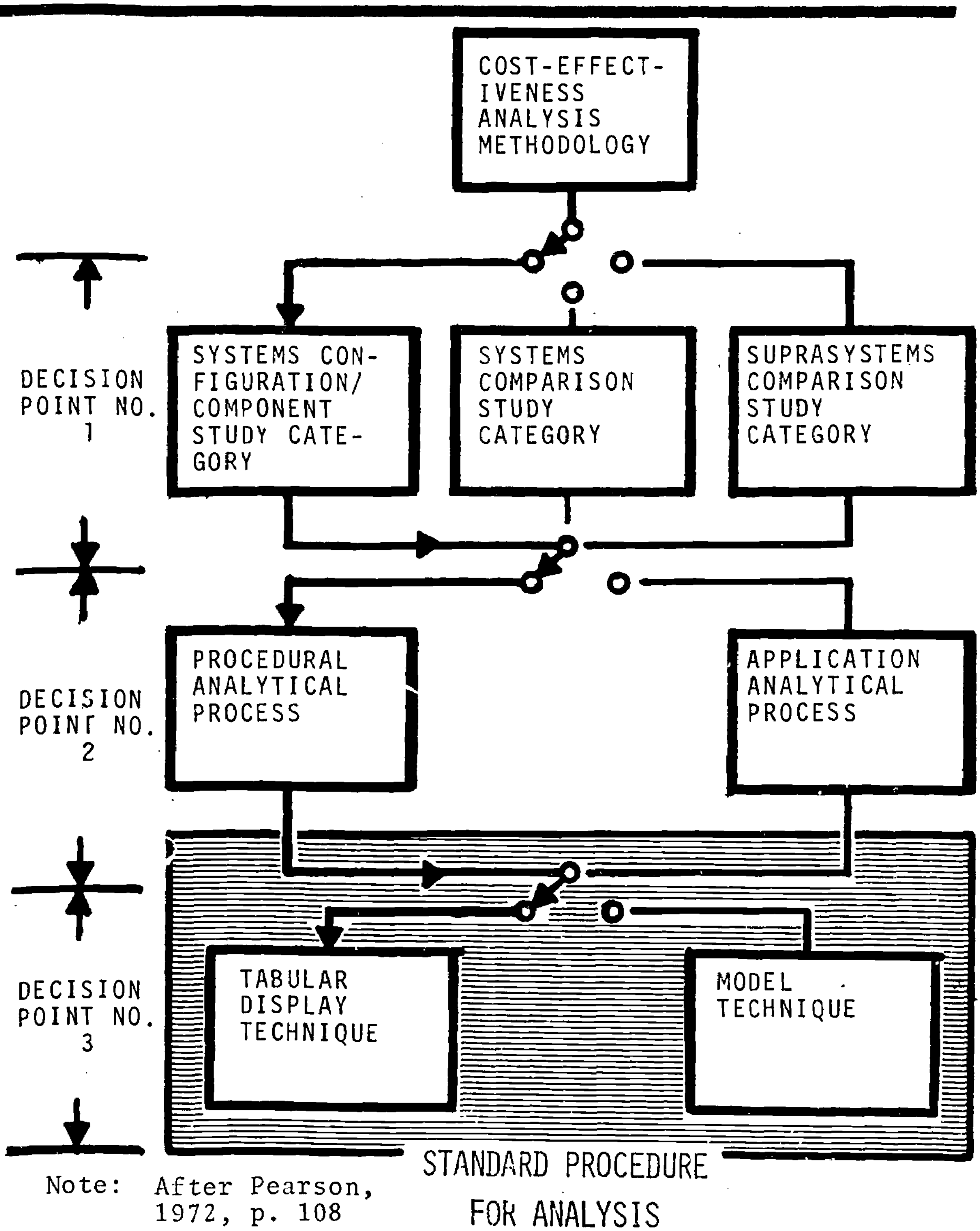
- To demonstrate the interactions among the factors that characterize alternative courses of actions.
- To enable the consequences of these alternative courses to be systematically and objectively assessed.
- To promote objective decision-making (Jakobsberg, 1966, p. 42).

OPERATIONAL FACTORS OF COST-EFFECTIVENESS ANALYSIS

Figure 10 was developed to graphically illustrate the methods and operational factors available for cost-effectiveness analysis. Cost-effectiveness analysis is a methodology whereby the choice of one of three broad categories of studies may be performed. These are (1) system configuration/component study; (2) system comparison study; and, (3) suprasystem comparison study. The next involves choice of the analytical process to use. This choice is either: (1) the procedural process; or, (2) the application process. The third decision involved the choice of elements of the standard procedure of the actual cost-effectiveness analysis itself. This was a choice of analytical techniques between: (1) the tabular display technique and, (2) the model technique.

FUNCTION DIFFERENCES AND CHARACTERISTICS OF COST-EFFECTIVENESS ANALYSIS

From the cost-effectiveness analyst's point of view, the selection of study category and analytical process to be used usually is determined by requirements outside of the control of the analyst. Only within the standard procedure of the cost-effectiveness analysis itself does the analyst have a choice in analytical technique. Figure 11 was developed to illustrate the function, differences, and characteristics of the various cost-effectiveness methods.



Note: After Pearson, 1972, p. 108

Figure 10. Cost-Effectiveness Analysis Methodological Elements

COST-EFFECTIVENESS ANALYSIS STANDARD PROCEDURE

FUNCTION	DIFFERENCES	CHARACTERISTICS
STEP 1 REVIEW DEFINITION OF GENERAL GOALS/ OBJECTIVES		
STEP 2 REVIEW IDENTIFICATION OF PARAMETERS OR REQUIREMENTS		
STEP 3 REVIEW DEVELOPMENT OF ALTERNATIVES		
STEP 4 ESTABLISH COST AND EFFECTIVENESS EVALUATION CRITERIA	COST MEASURES • NON-TIME PHASED ANALYSIS • TIME-PHASED ANALYSIS	CHOICE DETERMINED BY CATEGORY OF STUDY
	EFFECTIVENESS MEASURES • PERFORMANCE IDENTIFIERS • STANDARDS • UNIQUE EDUCATIONAL	CHOICE DETERMINED BY GOALS/OBJECTIVES/REQUIREMENTS
STEP 5 DETERMINE COST OF ALTERNATIVES		

Note: After Pearson, 1972, pp. 112-114

Figure 11. Cost-Effectiveness Analysis Function, Differences, and Characteristics (Sheet 1 of 3)

FUNCTION	DIFFERENCES	CHARACTERISTICS
STEP 6 DETERMINE CAPABILITIES OR EFFECTIVENESS OF ALTERNATIVES		
STEP 7 SELECT FIXED-COST OR FIXED-EFFECTIVENESS APPROACH		
STEP 8 CREATE ALTERNATIVES VERSUS CRITERION ARRAY	TABULAR DISPLAY TECHNIQUE	CHOICE DETERMINED BY EVALUATION CRITERIA; RECOMMENDED WHEN CRITERIA VARY WIDELY
	MODEL TECHNIQUE • OPERATIONAL EXERCISE • GAMING • SIMULATION	NOT RECOMMENDED FOR INSTRUCTIONAL COST-EFFECTIVENESS ANALYSIS BECAUSE OF COMPLEXITY
	• ANALYTICAL	RECOMMENDED FOR USE WHEN THE GOALS/OBJECTIVES/REQUIREMENTS CAN BE STATED IN TERMS SUCH THAT MATHEMATICAL AND GRAPHIC TECHNIQUES CAN BE USED

Figure 11. Cost-Effectiveness Analysis Function, Differences, and Characteristics (Sheet 2 of 3)

FUNCTION	DIFFERENCES	CHARACTERISTICS
STEP 9 ANALYZE MERITS OF ALTERNATIVES	TABULAR DISPLAY TECHNIQUE	CHOICE DETERMINED BY EVALUATION CRITERIA; RECOMMENDED WHEN CRITERIA VARY WIDELY
	MODEL TECHNIQUE • OPERATIONAL EXERCISE • GAMING • SIMULATION	NOT RECOMMENDED FOR INSTRUCTIONAL COST-EFFECTIVENESS ANALYSIS BECAUSE OF COMPLEXITY
	• ANALYTICAL	RECOMMENDED FOR USE WHEN THE GOALS/OBJECTIVES/REQUIREMENTS CAN BE STATED IN TERMS SUCH THAT MATHEMATICAL AND GRAPHIC TECHNIQUES CAN BE USED
STEP 10 ANALYZE UNCERTAINTY FACTORS	SENSITIVITY ANALYSIS	RECOMMENDED FOR USE WHEN SELECTION CONCLUSION MAY BE BASED ON ASSUMPTIONS
	CONTINGENCY ANALYSIS	RECOMMENDED FOR USE WHEN EVALUATION CRITERIA MAY BE UNCERTAIN
	FORTIORI ANALYSIS	RECOMMENDED FOR USE WHEN SELECTION MAY BE BASED ON INTUITIVE JUDGMENT
STEP 11 DOCUMENT BASIS OF PREVIOUS STEPS AND SUBMIT FINDINGS		

Figure 11. Cost-Effectiveness Analysis Function, Differences, and Characteristics (Sheet 3 of 3)

Function

The following functional elements (in the form of a standard step procedure) are necessary in the performance of a cost-effectiveness analysis.

- Step 1: Review definition of general goals/objectives.
- Step 2: Review identification of parameters or requirements.
- Step 3: Review development of alternatives.
- Step 4: Establish cost and effectiveness evaluation criteria.
- Step 5: Determine cost of alternatives.
- Step 6: Determine capabilities or effectiveness approach.
- Step 7: Select fixed-cost or fixed-effectiveness approach.
- Step 8: Create alternatives versus criterion array.
- Step 9: Analyze merits of alternatives.
- Step 10: Analyze uncertainty factors.
- Step 11: Document basis of previous steps and submit findings.

The grouping of the above functional elements inevitably leads to some duplication of material, but without the performance of these elements, the cost-effectiveness analysis will be of lesser quality and the findings questionable.

Differences

Differences occur in the performance of various cost-effectiveness analysis in several functional elements of the standard procedural steps. These differences are found and described in some detail in Step 4, Step 8, Step 9, and Step 10 of Figure 11.

Characteristics

Characteristics of the differences in Step 4, Step 8, Step 9, and Step 10 of the functional elements of the standard procedure are also considered in Figure 11. It was noted, however, that the principle differences in cost-effectiveness analysis methods are in Step 8 (create alternative versus criterion array) and in Step 9 (analyze merits of alternatives). These two differences are actually the same; i.e., the choice of using the tabular display technique or the analytical model technique. Thus, this is the only methodological choice available to the cost-effectiveness analyst not determined by others or influenced by outside conditions.

CONCLUSION

Cost-effectiveness analysis, in contrast to other management aids, provides answers by a systematic process which is reproducible, assessible to critical examination, and readily modified as new data becomes available. At the very least, cost-effectiveness analysis can supply a means for selecting the numerical quantities related to an instructional design in a logical and consistent manner. But before quantitative analysis can be of assistance to the decision-maker, it must be tempered with and used alongside of experience, experimentation and judgment (Quade, 1969, p. 15). Indeed, cost-effectiveness analysis cannot be a substitute for judgment. Judgment must be involved in determining what elements shall be considered in the analysis and how they shall enter. Therefore, cost-effectiveness analysis supplements judgment by inductive reasoning which is fully documented. Human judgment, however well informed, can still lead to wrong decisions. It is believed, however, that cost-effectiveness analysis can at least enhance the possibility that the decision is the best one. After an appropriate analysis, the instructional management decision-maker will be in a much better position to make a decision--although he may not find the decision easier to make (Herd, 1965, p. 79).

APPENDIX

DEFINITION OF TERMS USED

Cost. Unit of resources that is the limiting constraint. Dollars are used in most cases but other resources, such as manpower, materials, and facilities will also be considered as measurers of cost (Hatry, 1969, p. 44).

Cost-benefit analysis. A problem solving approach which requires the definition of objectives, and identification of the alternative that: (1) yields the greatest benefit for a given cost; or what amounts to the same thing, (2) that yields a required amount of benefits for the least cost. The term usually applies to situations in which the alternative outputs can be quantified in dollars. A chief characteristic is that the aim is to calculate the present value of benefits and costs, subject to specified constraints.

Cost-effectiveness analysis. A problem solving approach which requires the definition of objectives, identification of alternative ways of achieving the objective, and identification of the alternative that: (1) yields the greatest effectiveness for any given cost; or what amounts to the same thing, (2) that yields a required degree of effectiveness for the least cost. The term is usually used in applications in which the alternative outputs cannot be easily quantified in dollars (McGivney and Nelson, 1969, p. 105).

Cost-utility analysis. Same as cost-effectiveness analysis (Anshen, 1967, p. 3). Numerous terms currently convey the same general meaning (i.e., systems analysis, operations analysis, cost-effectiveness analysis, and operations research); however, they have varying connotations to different people (Fisher, 1967, p. 66). Because of such confusion in terminology and meaning, cost-effectiveness will be the term used to reflect the level of intent of the study.

Discounted cost. An analytical technique that accounts for the fact that money to be paid in the future yields investment return until the point in time when it is actually spent; consequently, present money spent is worth less than future money spent (Seiler, 1969, p. 17).

Effective. The accomplishment of the recognized objectives (Beynon, 1968, p. 84).

Initial cost. Investment in goods and services required to establish and operate a system. These goods have a useful value of longer than a year; thus the costs are not repeated every year (Esseff, 1970).

Life cycle costs. Combined initial costs and operational costs for the estimated useful life of the system (Esseff, 1970).

Model. Relations used to portray real or expected conditions, actions, or effects in order to predict the outcome of actions (Heymont, 1965, p. 56).

Objective. A statement that describes in observable and measurable terms the expected output performance of the product of the system (Banathy, 1968, p. 89).

Planning, programming, and budgeting system (PPBS). Cost-benefit analysis on a large scale (Commission on Instructional Technology, 1070, p. 90). A conceptual approach to decision-making which emphasizes outputs, program activities, and accomplishments. Long-range planning, analytic evaluative tools, and economic rationality are basic ingredients (Hartley, 1968, p. 258).

System. An integrated relationship of people, equipment, and methods appropriately organized to accomplish defined tasks (Heymont, 1965, p. 59).

Systems analysis (systems approach). Self-correcting and logical methodology of decision-making to be used for the design development of manmade entities. Strategies of this methodology include: (1) the formulation of performance objective, (2) the analysis of functions and components; and, (3) implementation (Banathy, 1968, p. 91).

Time-phased cost. The presentation of costs by the time period in which the costs occur rather than a total cost figure (Heymont, 1965, p. 60).

Trade-off. The weighing of alternative means to be employed for the accomplishment of required functions (Banathy, 1968, p. 91). Cost-effectiveness represents one aspect of trade-off analysis.

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