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GUIDELINES FOR COST-EFFECTIVENESS ANALYSIS FOR NAVY TRAINING AND EDUCATION

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FOREWORD

This development effort was performed under Work Unit Number ZPN07.30 (Adaptive Experimental Approach to Instructional Design). This project is one of four areas of effort that are part of this work unit. The area of concern in this report, development of guidelines for cost-effectiveness analysis in training and education, was initiated to provide capabilities for performing and/or monitoring this type of analysis and is responsive to an OP-99 statement of requirement.

Appreciation is expressed to Dr. John Carter, who served as project director, and Dr. W. E. Montague, principal investigator for ZPN07.30. The assistance of the staff of the Interior Communications School, Naval Training Center, San Diego, who provided cost data on the school, and Ms. Paula Southwick, who helped in gathering and compiling these data, is also acknowledged.

J. J. CLARKIN
Commanding Officer

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[illegible] analysis as applied in a military training context is intended to provide systematic information that can be used to select appropriate alternatives, methodologies, or settings in achieving training objectives. This form of systems analysis is designed to aid the decision maker in selecting from training alternatives by providing a concise and [illegible] review of relevant variables that bear on the training situation. [illegible] evaluative criteria such as those found in experimental or quasi-experimental designs are examined, but an additional component, cost analysis, is included. The present funding constraints in all areas of military training, and training research and development require that adequate consideration be given to the initial choice of alternative training and educational philosophies, methods, and media with respect to relative cost-effectiveness. This means that alternatives must be considered not only on the basis of outcomes but also in terms of the resources required to accomplish the level of effectiveness that is required or desirable. Secondarily, tools are needed for allocating these resources and re-evaluating them on a timely basis. Even though a training course remains static, earlier findings may become invalid without some continuing means of cost-effectiveness monitoring.

In consideration of these requirements, this project was undertaken to develop procedures and guidelines for conducting cost-effectiveness studies for military training and training research and development activities. These guidelines were designed to aid the analyst in determining when a cost-effectiveness analysis is feasible and appropriate, how best to conduct the analysis, the type of components to consider, and what kinds of answers to expect. This type of analysis is not a new form of evaluation but one that combines cost considerations with standard evaluation designs. A comparison of elements in cost-effectiveness terms can be used by decision makers at many levels to select alternatives that will maximize desired outcomes at specified levels of resource use or minimize costs for identified outcome levels.

Use of Guidelines

Procedures and guidelines were developed for use by trainers, educators, and researchers responsible for describing or comparing training alternatives. They will help the analyst to array data in a way that will aid in deciding:

- What level of expertise is needed to perform cost analysis
- What kind of analysis to conduct
- What components to include
- What general and specific criteria to use
- What kinds of answers to expect
- What format to use when reporting

Potential applications include: (1) determining the long- and short-term cost implications of various programs, (2) predicting the initial investment and continuing operating cost of an instructional innovation, (3) evaluating and improving the allocation of instructional resources, (4) costing and testing the economic feasibility of large- and small-scale plans, (5) assessing ways to improve training productivity and efficiency, and (6) judging the advantages and disadvantages of alternative instructional strategies.

The guidelines and examples presented in this report are designed specifically for the Navy training and training R&D communities. They provide an introduction into the field with additional sources of information clearly identified so that the reader interested in applying these guidelines should have an adequate basis for either conducting in-house cost-effectiveness studies or monitoring contractual studies.

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I. INTRODUCTION

A. Problem and Overview

The purpose of cost-effectiveness analysis in a Navy education and training context is to obtain information that might be used to choose among alternative strategies, methodologies or settings for achieving certain goals or objectives. Each alternative is analyzed for its actual or predicted effect as in any conventional evaluation model. Assumptions and caveats that accompany any experimental or quasi-experimental design are still relevant, but an additional major component, cost analysis, has been added.

Little needs to be said about the existence of finite budgets and other resources for Navy training and accompanying R&D activities. Recent civilian and military task forces have commented about the relationships between education and training, the impact of technology, and the requirements for cost-effectiveness analysis. In its final summary report, the Task Force on Training Technology for the Defense Science Board (1975) placed considerable emphasis on the need for cost-effectiveness analysis and developing the capability to conduct such studies. Although Navy training commands, schools, or centers may have relatively narrow mission profiles, there are presumably many feasible alternative methods for accomplishing those missions. Cost-effectiveness analysis requires that alternatives be considered not only on the basis of mission accomplishment (benefit or outcomes) but also the resources required by each alternative.

In brief, this type of analysis is not a new form of evaluation or economic research as much as it is one that combines cost considerations with standard evaluation designs. It is assumed that these designs will permit both ad hoc and predictive analyses. A significant portion of this approach is devoted to effectiveness or outcomes comparison. These data are then combined with analyses of the costs of implementation and operation in order to make cost-effectiveness comparisons. These comparisons will, then, theoretically help decision-makers at many levels select alternatives that will maximize desired outcomes at specified levels of resource use or minimize costs for identified outcome levels.

A later section contains more technical descriptions of various techniques or types of analyses that have potential for aiding in this task, but a brief comment on terminology is in order. Evaluators and economists often use the terms "effects," "outcomes," and "effectiveness" to refer to the definable results or products of a specified instructional system. Occasionally, indicators or proxy measures such as the number of students processed are also included under the effectiveness label. The term "benefit" is usually defined and used as an indicator or measure of the value of the above mentioned effects. These may include long-term individual or societal outcomes as well as system products. The goal is to generate a single indicator or unit of value that can then be compared with the dollar costs required to produce that benefit. This usually results in the translation of benefits to equivalent dollar value so that both cost and benefit indices are directly comparable. More will be said about these issues later.

B. Purpose of Guidelines

These condensed notes and guidelines for cost-effectiveness analysis are designed to be used by trainers, educators, and researchers responsible for describing or comparing instructional alternatives. The guidelines will help make decisions about:

- What level of expertise is needed to perform cost analyses
- What kind of analysis to conduct
- Which references and examples to review first
- What components to include
- Which general and specific criteria to use
- What kinds of answers can be expected
- What format to use when reporting

Although the first sections review the art and science of systems analysis as it is or might be applied to Navy education and training, the focus of the report is on one subset of the total process--cost-*effectiveness analysis*. To assume that cost-effectiveness or any subsystem is more important than another is to fall into the very trap that systematic analysis is theoretically designed to prevent, i.e., "we've got the solution, now where's the problem?" Consideration of this kind of analysis is important. A brief listing of several of the purposes it can serve illustrates the point. The process may be useful for: (1) determining the long- and short-term cost implications of various programs, (2) predicting the initial investment and continuing operating cost of an instructional innovation, (3) evaluating and improving the allocation of instructional resources, (4) costing and testing the economic feasibility of large- and small-scale plans, (5) assessing ways to improve training productivity and efficiency, and (6) judging the advantages and disadvantages of alternative instructional strategies.

This list is not intended to represent the total domain of cost-effectiveness nor is it to be assumed that the outcomes of such analyses or the use of such data will always be in the best interest of trainees. When such data are misused or abused, it is usually the result of naivete or misinformation. Hopefully, the requirement for increased accountability, productivity, and efficiency will also be accompanied by demands to assess the implications of alternative strategies aimed at meeting these requirements. Cost-effectiveness is one process that may allow collection, categorization, and assessment of the data needed to analyze those alternatives.

C. Scope

The following section relates the concepts and methodology of cost-effectiveness analysis to systems analysis terminology and modeling. The third section identifies a set of design considerations that must be resolved before any analysis, particularly cost-effectiveness analysis, can be conducted.

Sections four and five contain the primary ingredients of this document, the guidelines and recommendations for designing a cost-effectiveness analysis study. Section four is organized around a series of interrelated subsets of an analysis and includes accompanying descriptions and taxonomies to assist a designer. Section five is an expansion of one subset in section four. More extensive cost categorization considerations, cost model format and components, and a summary cost matrix are included.

An effort was made to limit the number and maintain the quality of references. A selected annotated bibliography is included for those desiring further clarification or examples. References in this section have been selected for maximum utility to Navy education and training analysts.

Appended are several documents. Appendices A and B describe the allocation of instruction costs, for facilities and personnel, respectively. Appendix C presents an actual executive level cost-effectiveness analysis report (U. S. Army Training Extension Course Cost-Effectiveness Study), and Appendix D summarizes a preliminary cost analysis of a Navy training course. Finally, Appendix E contains two prototype cost data collection instruments for use in obtaining costs for Navy training courses or programs.

Neither the guidelines nor the examples are intended to be used as blueprints since each setting will require potentially different resource mixes, instructional strategies, evaluative criteria, and the like. Planners and analysts conducting such studies should, however, be able to use these to design a comprehensive cost-effectiveness study that includes useful cost analysis categories and summaries as well as appropriate comparative criteria.

II. SYSTEMS ANALYSIS: A CONTEXT FOR COST-EFFECTIVENESS ANALYSIS

A. Discussion of Systems Analysis

As Navy training and education have grown both in scope and complexity, those responsible have become increasingly less secure in the decision-making process. Difficulties in predicting the effect of a particular alternative on the whole system of instruction is multiplying exponentially from year to year. Accountability requirements, tight money, and second-guess detractors continuously exert an inhibiting pressure on serious attempts to implement quality instruction, particularly when the attempts are innovative. In such contexts, systems analysis provides a method for identifying and clarifying the important elements in the instruction-learning process. Used appropriately, it presents the various components of the total instructional process, helps to describe the relationships between the components, and assists with assessing their influence on one another. The analyst can aggregate isolated constituents into an interacting whole and can resolve the anonymity of these elements into a dynamic process. This is not only a strong methodological approach for the unification of knowledge, but a facilitator of communication.

This section places cost analysis concepts into the context of the more comprehensive systems-analysis framework. This overview of systems analysis discusses both its principles and process. The principles emphasize the exigency of model construction, and the analysis process employs a taxonomic classification to describe concepts, purposes, and approaches. This brief explanation of relevant concepts provides a framework for interpreting the remaining sections.

Analysis of instructional alternatives is the focus of the power of training systems analysis. It is from results of careful systematic analysis that the alternatives indicating the greatest promise can be identified. Results of existing approaches in Navy training and the potential of new techniques can be compared, priorities can be set, and decisions can be made on the basis of comparative data from the analysis.

Before discussing possible approaches to systems analysis in education, a clarification of existing terminology may be helpful. The literature on systems analysis is quite extensive and redundant. A serious investigator might consult one or more of the sources described in the annotated bibliography. Each of those authors has contributed significantly to the state-of-the-art as it now exists. Two additional general references--Introduction to Operations Research (Churchman, Ackoff, and Arnoff, 1957) and Educational Systems Analysis (Banghart, 1969)--are particularly useful initial texts.

The term "systems analysis" coexists with many similar terms--operations research, economic analysis, cost-benefit analysis, etc. The important characteristic they all have in common is the emphasis on making comparisons systematically in quantitative and qualitative terms using logical sequences that can be retraced and verified. It is always with this paramount characteristic that "systems analysis" is used in this text. Kaufman's (1972) comments about the communication problems caused by the discrepancies in definition are worth reading. His definitions of "system," "system analysis," and "system approach" serve as a useful guide for all analysts. A lively discussion of the semantics issue may be found in Quade's Analysis for Military Decisions, 1964, pp. 2-12.

The term "analyst" denotes an individual or team of individuals interested in the process of systematically examining objectives, policies, strategies, costs, effectiveness, and feasibilities of training and education. Degree of proficiency aside, "analysts" may be evaluators, researchers, developers, or instructors, but application of the process of systems analysis also makes them analysts.

B. Systems Analysis Modeling

In this context, the goal of systems analysis is to aid in the formulation, analysis, and choice of future courses of action. Systematic consideration of any problem requires that some model be used. Depending upon your concept of "model," it may be unstated and undeveloped, but if a decision maker does something other than toss a coin in the air, a model of some type is being employed.

The assumption that humans base decisions on some type of mental model is an important factor in the rationale underlying systems analysis. If humans require a model, albeit only an intuitive one, then the model providing the best information should lead to better decision making. The better model is determined by its ability to provide a better description, explanation, or prediction. This, of course, must always be tempered by considerations of complexity and utility.

1. Analysis Process

It is important to emphasize that an analysis model is not a flowchart, but a process. Flowcharts, descriptions, and examples only serve to communicate the purpose and practice of the process.

There are as many approaches to systems analysis modeling as there are systems analysts. Churchman, Ackoff, and Arnoff (1957), Quade and Boucher (1968), Seiler (1969), and Fisher (1971) provide thorough model design guidelines although none are specifically intended for Navy training application.

The systems analysis process involves a series of iterations through several phases. Quade and Boucher (1968) describe these phases as formulation, search, evaluation, interpretation, and verification.

a. Formulation. The formulation (conceptual) phase involves the definition of the problem, clarification of objectives, and the establishment of evaluative criteria. Examples of techniques or procedures included within this phase include: front end analysis, needs assessment, values clarification, priority setting, and goal analysis. Common pitfalls in this domain include: failing to allocate and spend enough of the total time available for a study deciding what the problem really is, determining objectives and criteria carelessly, and trying to do too big a job.

b. Search. The search (research) phase includes the collection of data, the establishment of predictive relationships, and the generation of alternative strategies that might have some chance of solving the problem. A common pitfall associated with this phase relates to an analyst examining an unduly restricted range of alternatives.

c. Evaluation. The evaluation (analytic) phase involves the building of various models, the use of those models to predict the consequences of the selection of each alternative, and the comparison of the alternatives in terms of those consequences. Common pitfalls here include: forcing a complex problem into an analytically tractable framework by overemphasizing ease of computation, becoming more interested in the details of the model than in the real world, using improper costing concepts, and trying to do too big a job.

d. Interpretation. The interpretation (judgmental) phase involves the use of predictions obtained from the models and any relevant information to compare the alternatives, to derive conclusions from them, and to suggest a course of action. A common pitfall here is to become more interested in the details of the model than in the real world.

e. Verification. The verification (validation) phase involves testing the assumptions, conclusions, and recommendations against some set of criteria. One common pitfall here, particularly in large-scale projects, is a failure to take proper account of various uncertainties such as technical or theoretical advancements in the state-of-the-art, or large trainee demand fluctuations.

Although all of the phases are critical, Quade (1964) recommends particular emphasis be placed on the formulation phase:

> It is difficult to overemphasize the importance of a careful formulation. It should identify the subproblems involved, isolate the major factors, develop a vocabulary for dealing with them, stretch out the relationships between the variables as they appear, and even arrive at a tentative set of conclusions. The idea is to make clear the structure of the analysis, but more importantly, it offers a concrete hypothesis for others to probe. (p. 307)

An excellent discussion of the problems and pitfalls associated with the design of such studies is provided by Kazanowski in his chapter entitled, "Cost-effectiveness Fallacies and Misconceptions Revisited" (English, 1968, p. 151-165).

2. Model Building

Fisher (1964) comments that a model, depending on the nature of the problem, can be formal or informal, highly mathematical or not at all mathematical, computerized or manual. He emphasizes that a model need not be highly sophisticated or formal to be useful. He lists several points that a model builder should keep in mind:

- Model building is an art, not a science. It is often an experimental process.

- The major function of the model is the inclusion of those factors which are relevant to the problem at hand, and the judicious suppression of those which are relatively unimportant. Unless the latter is done, the model is likely to be unmanageable.

- The main purpose in designing the model is to develop a meaningful set of relationships among objectives, the relevant alternatives available for attaining the objectives, the estimated cost of the alternatives, and the estimated utility for each of the alternatives.

- Provision must be made for explicit treatment of uncertainty.

- Since by definition a model is an abstraction from reality, the model must be built on a set of assumptions. These assumptions must be made explicit. If they are not, this is to be regarded as a defect of the model design (Fisher, 1964, p. 10).

a. Model Types. Following Fisher's guidelines, the analyst prepares to select the model. The purpose of the analysis, the kinds of established criteria, and types of data available influence the analyst's final selection. Two models appropriate for education and training are mathematical models and tabular display (matrix) models.

Mathematical models are suitable when all the evaluative criteria can be quantified and are comparable. For most Navy training and education contexts, this is not feasible.

A tabular display model format, on the other hand, allows more flexibility. Using a variety of measures, the analyst can compare alternatives. This has the decisive advantage of allowing uncomparable common measures to be used as descriptors of alternatives. In the tabular display model, the analyst can, for instance, incorporate qualitative statements on relative effectiveness and efficiency. Unquantifiable measures are often times heavily value-laden and demand special consideration. This additional factor almost requires a tabular display model in most instructional systems analysis comparisons. Such articulation of values, priorities, and other various publicly stated evaluative criteria can be incorporated into a tabular array. Examples of tabular arrays are included in later sections of this review.

b. Uncertainty. Predictive analyses of instructional alternatives include many elements of uncertainty. These include uncertainty about the state of the world, Navy school-based training, or shipboard training, as well as uncertainty about change elements that might exist even if environmental uncertainties did not exist. Quade (1963), Fisher (1964), and Hitch (1960) have written extensively on the topic as it relates to national security analysis. Much of this can be applied, with modification, to Navy training analysis.

A technique for treating uncertainty that appears to have general promise is sensitivity analysis. For variables about which the analyst is very uncertain, application of this technique will at least provide several estimated values rather than one expected value. A range of values for a variable may be plugged into a model to see what effect each will have on the outcome. If there are many of these variables, considerable calculation is required and the question then arises as to the value of the exercise in relation to the usefulness of the information generated.

c. Validation. Accuracy of prediction is an indicator of the validity of a predictive model. It is difficult to validate a model without actually developing and testing generated alternatives. Cost and time constraints usually prohibit this type of testing. This is not an uncommon circumstance. Quade (1963, p. 20) suggests several criteria that can be used to check the validity of many types of models. He asks:

- Can the model describe known facts and situations reasonably well?

- When the principal parameters involved are varied, do the results remain consistent and plausible?

- Can it handle special cases for which we already have some indication as to what the outcome should be?

- Can it assign causes to known effects?

Each of these issues must be kept in mind when actually conducting a study. The following section, however, discusses several issues that must be resolved even before any analysis is begun. The apparently illogical sequence is intentional since an understanding of the context is important for judging the relevance of later sections.

III. PRELIMINARY CONCERNS

Before conceptualizing a model, the Navy planner must have a thorough understanding of the concepts, purposes, and alternative approaches to systems analysis.

This section describes five concerns that require careful consideration. These five are interrelated, but relatively exclusive. Each is defined and broken into subcategories. Whether the focus of an analysis in a Navy training or education setting is on an entire program, a unit of instruction, or a strategy, the following general concerns must be well defined:

- Level of decision making
- Function of decision makers
- Purpose of cost-effectiveness analysis
- Approach to cost-effectiveness analysis
- Type of analysis

Subsequent pages contain brief definitions of these concepts, additional subcategories, and initial guidelines for their use.

A. Level of Decision Making

One of the first determinations an analyst must make is the decision-making level the model must address. If the model is to be used only by top level commanders and program directors, the detail of the model need not be extensive. If the data are to be used by project managers and instructional designers, the information level reaches substantially below the program level, perhaps to the level of a unit of instruction or even the performance objective level.

It requires considerably more time and resources to collect and analyze data at these lower levels. If there is no need for detailed cost effectiveness and feasibility data, the analyst needs only to assemble information at the appropriate higher level of interest. The key is to determine the appropriate level or levels of interest, thus establishing the specificity of information the model must provide.

The analyst focusing on larger issues must identify the decision makers who have the authority to initiate, terminate, and alter policies governing the alternatives being analyzed. It is important to know how these people made decisions so that the results of the analysis can be properly structured and presented.

Consideration should be given to the the following questions which assist in the determination of specificity:

- Who will be using the information furnished by the model?

- Who is to be implementing the model?

- How is it to be implemented (hand calculations or sophisticated electronic hardware)?
- What is the complexity of that being represented by the model?
- How often is the model to be used?
- What degree of precision does the model need to have in relationship to the real world?
- How accurate are the data that will be used in the model?
- How accurate do the data need to be?

B. Function of Decision Makers

There are several decision-oriented activities to which systems analysis contributes. Each has a specific purpose and an identifiable outcome. Each may be closely dependent upon another. Four important such functions are control, planning, evaluation, and development.

1. Control

The educational manager, chief, trainer, or instructor must be able to effectively manage the resources under his responsibility. This management cannot be done after the vouchers or purchase orders are signed. Cost control practices in particular can only be implemented before the fact. However, after-the-fact cost and effectiveness accounting information will help decision makers control ongoing and future programs.

2. Planning

Cost analysis information allows planning for future changes in allocation of resources for a course or a program. This information can allow for planning of potential expanded uses such as extension courses, shipboard instruction, or joint service application. It can also provide general information for use in planning adaptations of successful techniques or strategies to other suitable learning situations. General analyses can also produce a range of potential courses of action by means of a systematic study of feasible alternatives.

Oftentimes, planners are concerned with optimizing their own programs at the expense (or exclusion) of other programs. Obviously, proper planning will not eliminate this "optimization of subsystems" phenomenom but it might help broaden some perspectives.

3. Evaluation

After-the-fact cost and effectiveness analysis data are valuable for use in comparison with planned costs and outcomes. This pre-post comparison yields better planning data for decisions about the value or utility of revisions or new projects. After-the-fact analysis information provides the decision maker with another basis for judging the success or failure of a program. The result may be greater instructional effectiveness or more efficient research and development efforts.

4. Development

Cost and effectiveness analysis information can assist in more efficient and effective development of materials and procedures for instruction. Such information can aid in the design of better plans and better management strategies, and in the development of better techniques for producing, validating, and reproducing instructional materials.

C. Purpose of Cost-Effectiveness Analysis

In addition to levels and functions, three general purposes of systems analysis--description, comparison, and prediction--must be considered. They provide guidelines for the design of all analyses, including components such as data collection instruments and procedures and report specifications. Figure 1 presents a graphic display of these relationships.

1. Descriptive Analysis

Descriptive analysis is employed to describe ongoing or completed programs. Accounting and assessment data acquired in the application of this type of analysis provide the basis for all other analyses. Cost analysis (accounting) is used to report dollar costs and, where possible, to relate costs to output. Effectiveness (or benefit) analysis, for example, may be conducted by measuring cognitive and noncognitive changes in learners (output) in relation to stated objectives.

2. Comparative Analysis

As stated earlier, the ultimate goal of systems analysis is to make comparisons. Comparative analyses are based on both descriptive and predictive analysis. Ex post facto comparisons can be made by using data from properly designed descriptive analyses. A priori comparisons make use of predictive analyses which in turn are built upon descriptive studies. For this purpose, distinctions must be made between the various types and approaches.

3. Predictive Analysis

Predictive analysis is used by those who wish to ascertain costs and benefits of proposed alternatives. This requires consideration of prior costs as a basis for a predictive cost analysis. It also necessitates determination of objectives, strategies, required resources, cost estimating relationships, and the costing of resources. Effectiveness analysis is used to predict the level(s) of output or effectiveness of each alternative. Predicting various levels of effectiveness based on previous studies is one of the most difficult and least precise activities a systems analyst can perform.

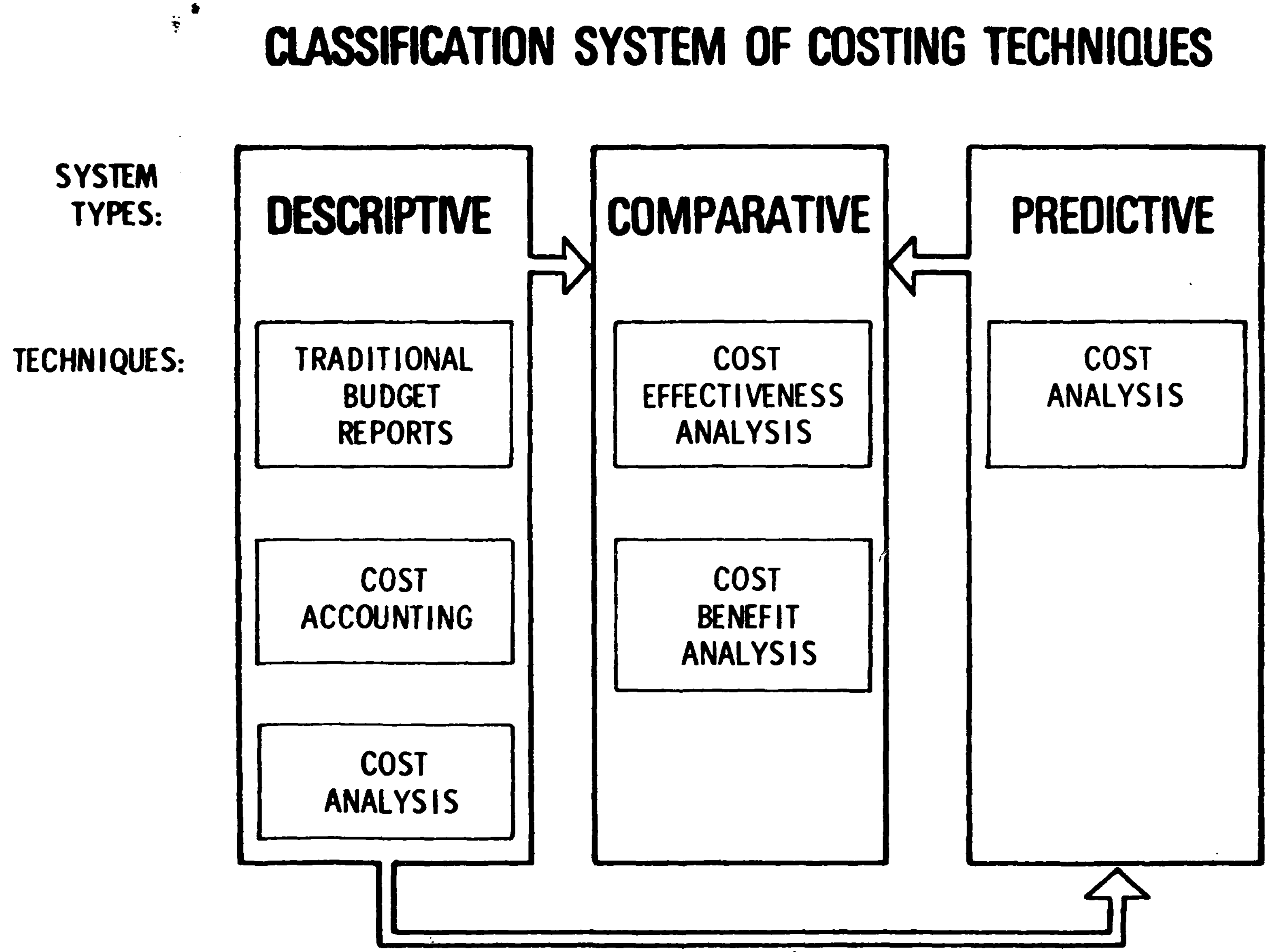

Figure 1. Classification System of Costing Techniques.

The inexact nature of such activities oftentimes leads to condemnation of the entire process; but systems analysis is primarily intended to reduce, not eliminate, the margin of error in the decision-making process.

Several additional subsets of these purposes can be easily identified. Examples include: (a) allocating resources among identified objectives, (b) choosing alternative means to meet the given objectives, (c) assessing the worth of different objectives, and (d) providing for the systematic generation of alternatives which were not originally identified.

D. Approach to Cost-Effectiveness Analysis

In comparing alternatives in terms of the data generated by the analysis model, two basic conceptual approaches--fixed effectiveness and fixed cost--may be used.

In the fixed-effectiveness approach, a desired level of effectiveness or output is specified and then the cost of alternative means of achieving that specified level is examined. The intent is to identify the alternative or combination of alternatives which will reach that level with the lowest expenditure of resources. This is appropriate if defensible, comprehensive indicators of effectiveness can be identified. Most instructional alternatives bring about learner change of several kinds and to different degrees so identification of such measures is one of the most difficult of the analytical tasks.

In the fixed-cost approach, a single budget level (cost) is fixed and then the level(s) of effectiveness that might be achieved through different alternatives is examined. The intent is to identify the alternative or combination of alternatives which will produce the highest effectiveness.

Carpenter and Haggart (1970) recommend the fixed-cost approach because it focuses the attention of decision maker and analyst on the effectiveness of alternatives which is by far the most difficult phase of the analysis process. The problems associated with comparing effectiveness of instructional alternatives would indicate that the fixed-cost approach is, usually, more suitable for Navy training purposes. Costs are usually fixed by adjusting the dimensions of each alternative (such as the number of trainees enrolled) so that each alternative incurs approximately the same total cost over a common time period.

A third hypothetical alternative allows both the cost and effectiveness to vary. This permits the naive idealist to request, "I would like to get the maximum possible effectiveness for the least possible cost." Carried to its logical conclusion, the approach would result in infinite effectiveness for zero cost. However, this usually reverts back to the fixed-cost approach, where, at some stage, limits are placed on the amount of resources available.

A variation of these two approaches is possible if alternatives differ in terms of their relative effectiveness and respective costs on some common evaluative criterion that can serve as the basis for a unit cost comparison. For instance, where one approach results in 70 percent on the criterion for cost X, and another results in 85 percent on criterion for cost Y. Where this occurs, disparate alternatives can still be compared by using two common variables such as total system (life-cycle) costs and the effectiveness measures.

In this case, however, comparisons between alternatives must be made upon a feasible range of activity since the unit costs for each will be likely to change as the scale or quantity of activity changes. An example of this would occur when a labor-intensive instructional alternative is compared to a "high technology" option. At relatively low levels of learner throughput, the low front-end costs of the labor-intensive option would make this one most attractive. At higher levels of activity, however, the economy of scale would begin to give the advantages to the high technology (higher initial but lower operating cost) alternative. An example of this kind of comparison can be found in the post-secondary education study reported by Doughty and Stakenas (1973).

E. Type of Analysis

To complete this section on conceptualization, six types of analysis of training and education programs in descending order of sophistication are described: (1) cost benefit, (2) cost-effectiveness, (3) unit-cost, (4) cardinal weighting, (5) ordinal ranking, and (6) best-guess decision making. Some mention of analytical approach is included where appropriate.

1. Cost-Benefit Analysis

Cost-benefit analysis is an analytical approach to the selection of alternatives on the basis of comparisons of benefits and costs. This option is appropriate only when alternative outputs can be quantified in dollar terms, thereby heavily incorporating judgments of value into the analysis. Estimates of social value of the output(s) of each alternative are given dollar values so that the benefits of each alternative can be expressed as a single measure--dollars. This is the only approach which will permit direct comparisons of alternatives with different objectives. By translating the output(s) of each alternative to dollar terms, the common comparisons are possible.

A benefit-cost ratio for each alternative can be derived by dividing the value of the benefits by the value of the costs. Once the costs and benefits are determined and computed, most authors indicate that total benefits should be greater than the total costs (B-C ratio greater than 1.0) if a program or alternative is to be considered. Computations must be made and a benefit-cost ratio derived for each alternative before comparisons can be made. Results or changes that are not related to specified objectives are not considered benefits. Many of these by-products or spillovers can be identified and analyzed but only as supplementary gains, not as benefits.

McKean (1958, pp. 34-37, 107-113) and Hitch and McKean (1960, pp. 166-167) have written lucid and enlightening discussions of the possible treacherous nature of ratios. Eckstein (1958), on the other hand, bases many of his analyses on the development and use of ratios. Dorfman's (1963) analysis is perhaps most insightful: "The heart of the matter lies in deciding what benefits should be included and how they should be valued. The debate about benefit-cost analysis centers on the question of whether the social value of benefits can be estimated reliably enough to justify the trouble and effort involved in a benefit-cost computation" (p. 8).

New statistical models and techniques hold great promise as solutions to some of the problems involved in calculating benefits in dollar terms. Additional research and development will help as the art becomes more scientific and better data are obtained.

2. <u>Cost-Effectiveness Analysis</u>

Cost-effectiveness analysis is appropriate when a market evaluation or value cannot or should not be placed on the outputs of the alternatives, but the resources (inputs) of the alternatives can be evaluated or measured in market prices (dollars). The approach is derived from contexts where the problem is to select a strategy or product from a set of alternatives designed to achieve specified objectives.

As mentioned in the previous section, the recommended approach is to construct fixed or equal-cost alternatives so that each will require approximately the same total cost for a fixed time. Projection of estimated costs of each alternative can be done with more confidence than projection of effectiveness, particularly since no single measure of effectiveness will likely reflect the total output of an instructional alternative.

Cost-effectiveness analysis is most useful for resolving problems that hinge on allocation of resources because the techniques and systems required for the analysis of costs are somewhat more sophisticated and better developed than those for the analysis of effectiveness. Stated differently, it is usually easier to specify the cost variables in an educational system than it is to determine the larger set of variables needed to account for effectiveness. This is not to say that precise accounting or prediction of such costs is easy. It should also be emphasized that the cost-effectiveness approach will provide little help in determining whether an alternative or an objective is worthwhile. Value judgments of this sort are left to decision makers and are not generally identified and quantified as in the cost benefit approach. However, many of the evolving needs assessment and futures generating processes (e.g., Delphi) have potential for assisting in this "data gathering for value decisions" area.

3. Unit-Cost Analysis

Unit-cost analysis helps a decision maker see what components comprise the cost for a course, alternative, or a strategy and how changes in these components will affect cost levels. Unit costs allow a decision maker to predict future costs when changes are introduced in instructor salary or rank, instructor work load, enrollment, or other variables.

Quantitative and qualitative effects of changes in alternatives are not usually measured or reflected in unit costs. Most unit-cost analyses are based on jurisdictional costs (usually derived from line-item budgets) which do not reflect the total costs required to realize some specified outcome. They are far too general to be used as a basis for cost-benefit or cost-effectiveness analysis. Those which do reportedly use functional costs (related to output) are able to provide the kinds of information that can better aid the decision-making process.

Care must be taken to avoid misconceptions that often result from the use of unit-cost analysis data. Use of unit cost alone emphasizes the fiscal aspect to the exclusion of the effectiveness of an alternative. There is a greater temptation on the part of decision makers to create more "efficiency" through cost reductions than to improve the effectiveness. It is also easy to make improper comparisons between courses, curricula, or departments which are not comparable in nature.

Although unit-cost information has been misused and abused historically, this need not keep unit-cost analysis data from providing valuable information. Proper design and implementation of unit-cost analyses and a thorough understanding of the nature of unit costs by decision makers can result in better decisions.

4. Cardinal-Weighting Analysis

Cardinal-weighting analysis departs from the quantitative approach except for the calculation of direct costs for each alternative. It relies on identification and specification of the advantages and disadvantages of each alternative. The more sophisticated analyst may consider cardinal weighting as amateurish, but listing and weighting advantages and disadvantages of alternatives, even if done on a value judgment basis alone, will most probably result in more clarity, honesty, and inter-judge reliability in alternative selection.

The method is quite simple, but can be very effective if properly applied. The analyst begins by listing the advantages of an alternative. Every advantage for an alternative is weighted by awarding each a number from 1 (lowest) to 10 (highest) in value. This process is followed for each advantage and the points are then added. The procedure is repeated by listing disadvantages of the alternative but with the values of the weighting scale running from 1 (least disadvantageous) to 10 (most disadvantageous). A cardinal-weighting index for the alternative can now be obtained by subtracting the total disadvantage points from advantage points. The procedure is repeated for each identified alternative and a comparison can then be made between the cardinal-weighted indices. The alternative with the greatest number of points should be the most valuable one. If the cost of that alternative is the same or less than lower-weighted alternatives, the recommended decision becomes obvious.

This procedure is useful only if: (a) the analyst lists as many advantages and disadvantages as possible for each alternative, (b) the weights are fairly assigned to each advantage and disadvantage, and (c) the decision maker realizes that the results of the analysis are only as useful and valid as the lists are comprehensive and the weightings objective.

This procedure will at least clarify the issues involved when considering alternative approaches or programs and will lend assistance when the data and personnel are not adequate for more sophisticated analyses.

5. Ordinal Ranking

Ordinal ranking of alternatives is an analytical procedure in which alternative programs are ranked in order on the basis of predetermined criteria. Criteria can be determined in many ways by many and diverse interests. How they are determined is as important as the ranking process. They might be developed on the basis of total or direct costs, time, number of key personnel, or learner satisfaction. Agreement on each criterion measure or basis of the ordinal ranking should precede the application of the analysis. Establishing criteria after the initial stages of the analysis have been completed is a less than objective approach. However, if new and valid criteria are discovered while conducting an analysis, there is nothing to prevent additional analyses being made using the new criteria.

6. Best-Guess Decision Making

Best-guess decision making need not be a totally unobjective process. A statement of the reason or reasons for recommending a given alternative can be based on considerable research and evidence. The reason may be logical, psychological, political, or otherwise. Much more sophisticated analyses may have preceded the solution, but if time and other factors prevent a more detailed documentation, a simple statement of why a particular recommendation was made will be of some help.

Figure 2 is intended to display the relationships of these preliminary analysis concerns. Although the arrangement of boxes and arrows indicates a rather linear sequence, in practice, all areas, except perhaps type of analysis (Techniques), must be continually reviewed and considered.

The purpose of this section on preliminary concerns is to emphasize the importance of careful preplanning and prespecification. To complete the picture, a look at the way various components are combined to form subsystems is necessary. A complex problem may require that many specific analytical models be developed. Other problems may only require one comprehensive model. Three primary analysis subsystems are discussed in the following section. Each is an example of an important class of subsystems.

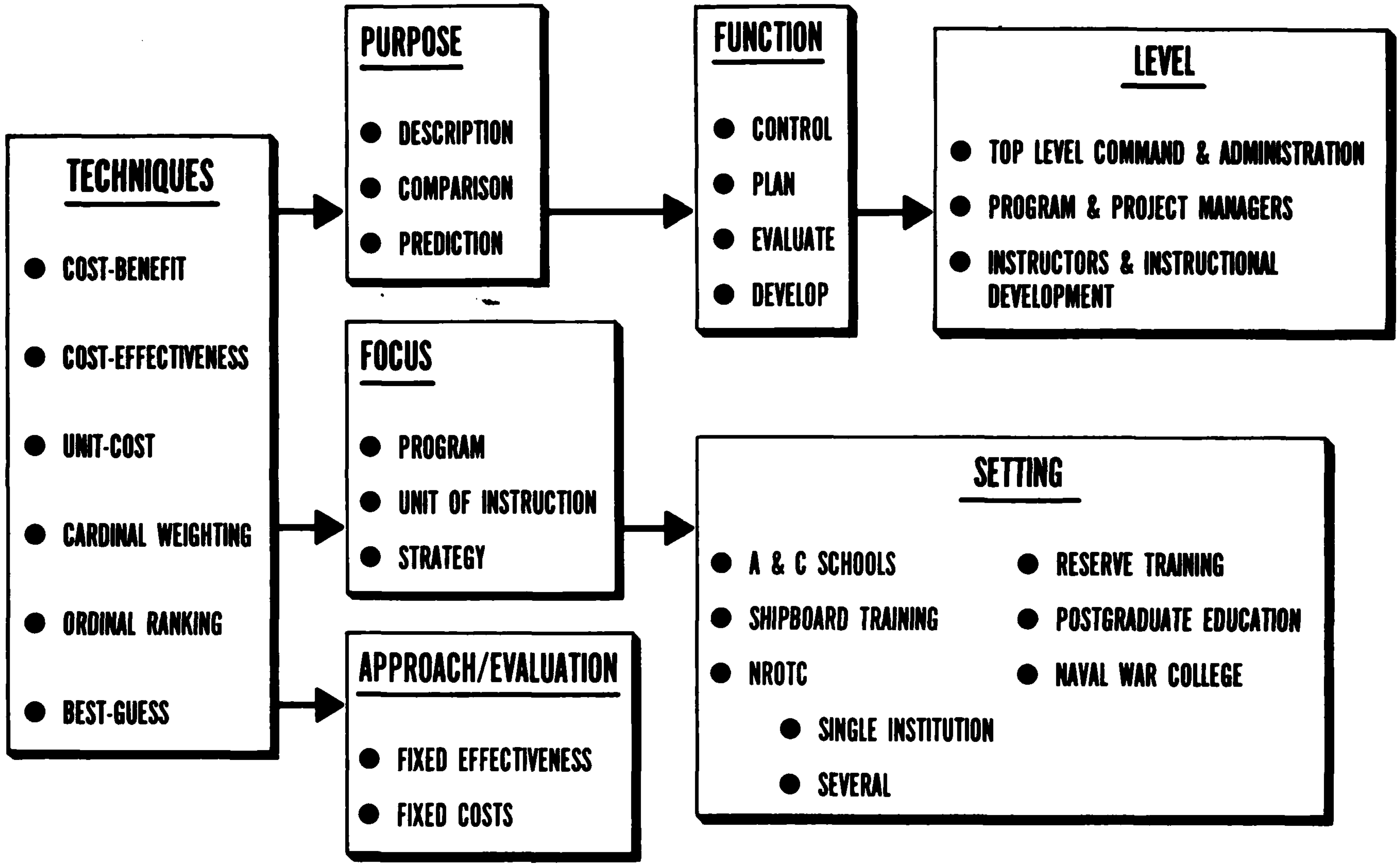

FIGURE 2. CONSIDERATIONS FOR EFFECTIVENESS/COST ANALYSIS MODELS IN NAVY TRAINING AND EDUCATION

IV. COMPONENT GUIDELINES

The analyst must report various kinds of data, including feasibility, context, process, effectiveness, and cost data. This section treats the collection and organization of these data as subsystems of the total systems analysis. The analyst must have data collection methods that provide for arraying and presenting these data in a meaningful way. The data, in other words, must become information for decision makers. Feasibility analysis, the cost model, the effectiveness model, and other components provide the framework for this process.

This section reviews the process and the considerations of each subsystem. Feasibility analysis leads to a tentative determination of the level, function, purpose, approach, and type of analysis. It defines the parameters of the system to be used. The cost model delineates and represents the dependence of the cost considerations, cost categorization, and cost estimating relationships. Instructional process and context description guidelines are provided as examples of terms or categories that can be used when analyzing those vital components. The effectiveness model defines its elements and describes methods for identifying and predicting the measures of those elements. A list of potential cost and effectiveness criteria is included at the end of this section.

A. Feasibility Analysis

The first section of this article reviewed systems analysis. Some mention was made about decisions involved in designing the structure of an analysis and selection of an approach, but little was said about the basis for those decisions. Why is one approach more appropriate? Why is one type of analysis most suitable? What needs to be considered before goals and objectives are specified? What alternatives can be considered? Each of these concerns along with many others make up the domain of feasibility analysis.

Preliminary feasibility studies can lead to tentative determination of the level, function, purpose, approach, and type of analysis. Once these tentative decisions have been made, emphasis can be shifted to the specification of goals and/or objectives for each alternative. Based on initial analyses and generation of alternatives, a decision maker often is forced to revise these program goals and objectives because of unrealistic expectations. Often both objectives and alternatives will need to be revised if a feasible solution is to be identified. The importance of this process of analysis, generation of alternatives, and subsequent revision cannot be overstressed. Hitch and McKean (1968) state: "It can, in fact, be argued that the chief gain from the systematic analysis is the stimulus that it provides for the invention of better systems" (p. 187).

Feasibility can be broken into two general categories - constraints and capabilities. Both have been mentioned but additional emphasis is warranted.

1. Constraints

Constraints can be defined as conditions existing both within and without a system which limit the achievement of specified objectives. These include factors associated with such issues as time pressures, manpower availability, political exigencies, and other resource availability. Uncertainty about such variables as future fiscal or political stability also presents serious constraints for the identification of feasible long-range alternatives.

Determination and selection of a preferred alternative must be made from a set of feasible alternatives. Most decision makers can think of highly desirable alternatives that for obvious reasons are not possible. It is necessary to carefully consider any constraints or factors that separate feasible alternatives from those that are not. Judy (1969) has outlined seven general constraint categories that can serve as review guidelines: (1) technological, (2) policy, (3) political, (4) organizational, constitutional, and legal, (5) resource, (6) target, and (7) imaginary.

2. Capabilities

Just as constraints have the potential for inhibiting specified activities, capabilities have the capacity for assisting the accomplishment of identified objectives. Using potential inherited facilities, equipment, and personnel will be discussed in the cost model section, but, as an example, consider an existing instructional system as a feasible future alternative. Rand analysts Carpenter and Haggart comment on such a possibility:

> In educational planning, one alternative, simply to continue current practice, should be included for baseline data. Although this alternative will usually not incur the same cost as will the innovative programs being compared, it is important to know its projected future cost and effectiveness so that the added resource and cost requirements incurred by the innovative programs may be estimated. Then the incremental requirements that are associated with improved effectiveness will be known. (It often turns out that these incremental requirements are small compared with the requirements simply to maintain current practice, even though they might seem large when considered in isolation.) Thus, the first step toward cost-effectiveness analysis must be to estimate the future resource requirements and effectiveness of current programs (pp. 12-13).

Of course, this applies only if continuation of programs is to be considered or if current programs indeed exist.

3. Documentation

Feasibility assumptions must be reported as part of an analysis, in the same manner as effectiveness and cost data. Regardless of the level, function, or purpose, upon completion of a thorough analysis of alternatives, the analyst or analysis team is required to make recommendations based on available data. Recommendations submitted by the analyst(s) must be accompanied by sufficient documentation. It should include assumptions under which the analysis was made, purpose(s) for the analysis, methodology, approaches used, and conclusions reached. Any limitations that were placed on the analysis or that should be placed on comparisons of alternatives should be listed so as to lessen the possibility that improper assumptions will be made by decision makers.

Carpenter and Haggart (1969) provide some guidelines for systems analysis documentation:

> In the presentation of the analysis, the qualitative considerations should be identified. This includes both those taken into account in the analysis and those that could not be made an integral part of the analysis itself. It is important to present the results of the formative quantitative analysis and interpret the results with special attention to the assumptions and limitations of the analysis. In addition, the analysts should attempt to identify the important qualitative considerations that the decision makers should try to take into account (p. 5).

B. Cost Model

1. Cost Considerations

As with the general systems analysis model, design of the cost model requires that analysts carefully consider many factors. Several of these (i.e., inheritance, research and development, and time) merit brief discussion.

a. Inheritance. Inheritance consists of previously procured tangible assets such as facilities, equipment (hardware), and software. The cost over and above the resources that can be inherited is the additional or incremental cost that will be charged to a new system or program. The goal of the analyst is to minimize this incremental cost by building on existing programs where possible and sharing the inheritance of other programs.

b. Research and Development. Care must be taken to distinguish between research and development, research in development, and research on development. Generally speaking, only those research and development costs that contribute directly to program goals should be included in the cost model. If resources are required for more basic research on development, those costs should be singled out from normal research and development costs and reported separately.

c. Time. There are several time functions that must be considered in education and training cost analysis. Four of these are uncertainty, discounting, depreciation, and obsolescence. Each has an impact on total cost but determining the degree of impact is quite difficult. Few examples of applications of these cost functions exist in general education literature, but military and industrial applications do provide guidelines. Uncertainty was mentioned earlier under feasibility analysis and will not be discussed here, but the importance of its consideration cannot be overemphasized.

McKean (1958) has written one of the better discussions on the various approaches and rationale to discounting. Hitch and McKean (1960) present several arguments in support of the process of discounting future cost. They comment that acquisition and use of a monetary unit in the present will cost less than acquiring and using it in the future. The practice is supported by the rationale that resources available today are worth more than those same resources available a year from now.

In addition to the question of whether to discount or not is the controversy over the appropriate rate to use. Various agencies use discounting techniques in their program plans, but the rates they use to discount vary widely. The rationale used for establishing a given rate is usually quite subjective but is an important concern, particularly for alternatives offering payment or expenditure schedules that differ considerably in terms of time and/or amount. In the case of Navy training research, this issue has been resolved by a Defense Economics Analysis Council Directive (DoDINST 7041.3) which establishes a 10% discount rate and requires it to be used in all economic analyses of proposed Defense investments. This does not prevent the conducting of alternative analyses using a different discount rate to compare potential impacts of such practices.

Depreciation and obsolescence in a training setting are valid time-based cost functions. Determination of depreciation schedules based on use, output, and obsolescence approaches true depreciation costs more closely than the present straight-line depreciation schedules now being used by most cost analysts. When technological innovation is accelerated or remains at a high rate, the expected life span of some equipment is shortened by the increased rate of obsolescence. Depreciation is usually considered a fixed cost, but consideration must be given to the fact that increased use affects the value of equipment by changing the expected life span. Straight-line computations of depreciation (for hardware and software) are precise but they are often misleading when used as the only basis for depreciation schedules. Analysts planning future programs often omit these considerations by assuming that there will be no replacement during a fixed time period and that there will be no residual value of equipment (or other assets) remaining after a program is terminated.

Many analysts use amortization accounting instead of depreciation. This requires making annual payments into a sinking-fund to replace original equipment at the end of its economic life. Interest earned on money in the sinking-fund aids in accumulation of replacement money. However, this process is not usually feasible in federal or other tax supported settings.

A useful distinction can also be made between the notions of cost savings versus cost avoidance. To actually save hard dollars in a relatively closed system such as the military requires careful consideration of those areas where an apparent dollar "saved" could actually be a resource reallocated to some other purpose or activity. Saving recruit training time does not cut total billet costs since those will continue and be charged to some activity. This is sometimes referred to as cost transfer.

Proper planning and implementation of an efficient training program could, however, lead to an avoidance of expensive training costs while increasing training effectiveness and overall system productivity. Such hard dollar savings in investment or operating funds are the most difficult to obtain since they are tied directly to staffing quotas, facility construction or renovation, and the conventional threat to empire.

2. Cost Categorization

One of the first tasks to be performed in conducting a cost analysis or in designing a cost model is that of defining and listing all the major cost categories of resources required by an instructional alternative. These categories serve to specify the segments that require analysis. Identification and tabulation of such interrelated and non-exclusive cost categories as joint costs, fixed and variable costs, and recurring and nonrecurring costs will help distinguish between instructional alternatives on a functional cost basis. In this way, predictive costs can be estimated more accurately and differential cost effects, both in magnitude and kind, can be identified as program elements within and between alternatives.

Results of any cost analysis can be easily biased by the exclusion of categories or the inclusion of inappropriate cost categories. Certain types of costs (sunk, discounted, and incremental) can easily invalidate an otherwise good cost model if handled incorrectly.

Sunk costs in particular are difficult to handle conceptually and politically. For instance, when comparing feasible alternatives, one option may well be to continue an existing system that has already been fully implemented. In this case, an equitable analysis would only consider the future cost of operating and maintaining that system, not the sunk costs that were allocated in the past.

If an existing system or subsystem can be used, its inherited assets from prior investment could give that option an initial financial and time-to-implementation advantage. Of course, the comprehensive life cycle cost implications could ultimately paint quite a different picture.

A problem arises when sunk costs are not documented since cost predictions for the future are usually based upon cost profiles from prior and ongoing programs or activities. Without those historical cost records, analysts must rely on other potentially less valid data to construct their predictive cost models.

In order to accurately predict total system costs, expenditures must be categorized in two classes--nonrecurring and recurring--so that long- and short-range cost predictions can be made. Nonrecurring costs include such areas as research and development activities and the initial investment to implement the results of those activities. Among the list of research and development costs are preliminary research and design studies, design and development of subsystems, and system evaluation costs. Initial investment includes costs for preliminary training, equipment, facilities, and installation expenditures. Recurring costs are composed of annual operation costs needed to maintain and evaluate a program. This includes items such as salaries, maintenance of equipment and facilities, and expendable supplies.

Analysts also must determine which costs included in an alternative are fixed (i.e., those that would not change because of changes in level of activity) and which are variable (i.e., those that respond to alterations in quantity or quality of operation). Such a separation provides the basis for estimations of how costs would be modified or what the marginal cost effect would be as a result of changes in enrollment, instructional strategy, criterion levels, etc.

A method of cost accounting which separates total system costs into three general classes is used by many analysts. The three classes can represent overlapping time-phased resource requirements of an instructional program. The classes categorize costs by: (a) research and development--which includes all costs necessary to bring the system into readiness for operation (nonrecurring), (b) investment--which includes all nonrecurring costs required in the process of phasing a system into operation (e.g., facility, equipment, and training costs), and (c) operation--which includes all recurring costs necessary for the operation of the system (e.g., salary and allowances, training, and maintenance costs). Occasionally a subset of the operating cost category called replacement is identified in order to separate these costs from normal operating costs.

The general scope of a cost model can be displayed in a systematic manner by using a cost table or matrix. The matrix approach classifies all general cost elements horizontally and system or phase elements vertically. For design and development purposes, the matrix could include the terminology of specific hardware and software components as well as consideration of various time or function phases. Examples of this matrix format and a list of activities that might fall within each category are provided in the following section.

3. Cost Estimating Relationships

The theory of cost modeling rests basically on two components or relationships. One concerns the matter of deciding what is to be costed and charged to an alternative. This task consists of listing and defining the appropriate categories of total dollar cost. The other concerns the technique of cost prediction. These relationships are generally termed cost estimated relationships. One relationship is the estimate of the cost per unit of each resource. The second type is the estimate of the number of units required to meet the necessary prerequisites for each alternative. These relationships are used to relate required resources to their costs. In developing the previously discussed predictive cost model, data from past experience or ex post facto cost analysis information can be used to derive many of these estimating relationships.

Ex post facto cost analysis or cost accounting does not require cost estimating relationships because actual costs are used rather than predicted costs. Data from cost accounting of after-the-fact cost analyses do provide valuable insight and guidelines for establishing estimating relationships for predictive cost models. These data are of little use, however, when a newly designed alternative includes few of the components of the operational program. Once a relationship for estimating the unit cost of a resource has been established, either from prior cost information or from estimates, the next step is to attempt to determine how many units of this resource will be needed to meet the requirements of the alternative.

A predictive cost model must serve as a device for estimating the costs of future alternatives by translating the descriptions of these alternatives into requirements for resources and then transforming those requirements for resources into costs. In order for the predictive cost model to be useful, this translation of alternatives to resources to costs must be relatively simple and explicit or so mechanized and flexible that users will not view the model as being too restrictive or difficult.

4. Limitations of Traditional Accounting Approach

There are many limitations in using a conventional line-item budget as a base for a cost model. Briefly, the primary problems involved are: (a) the difficulty of relating the budget to goals or objectives, (b) the difficulty of allocating resources, (c) the difficulty of projecting budgets and costs beyond the current budgeted year, (d) the impossibility of relating costs to outcomes, and (e) the lack of integration between planning and control (including budgeting) and the instructional or program element of an instructional system.

Most accounting systems are designed to ensure budgetary compliance rather than to determine program costs or to measure instructional effectiveness. Budgets are purposely designed to identify appropriate sources of funds and accounting for the source of budgetary expenditures rather than to assist in allocating resources. In order to generate alternative means or ways to accomplish some given outcome, a decision maker must be able to relate costs or expenditures to outcomes. When this cannot be accomplished, the generation of feasible alternatives to the achievement of objectives is not possible.

Construction and use of the traditional budget has historically been the domain of budget officers or finance experts and communication between them and those responsible for instruction has been minimal. Finance experts have not been expected to be responsible for instructional decisions and those with instructional responsibilities have avoided planning, allocating, or relating costs to outcomes.

The purpose of the Program Planning and Budgeting System (PPBS) approach is to provide the basic and essential information needed by all decision makers so that they can analyze feasible alternatives and make decisions based on more appropriate data. It should be noted, however, that most attempts to implement such a system in education and training have not centered around the information needs of instructors or program designers.

The absence of a PPBS-like system does not eliminate the possibility of an analysis study being conducted. The task of defining, costing, and analyzing the output of ongoing alternatives which have not been defined in a program format is difficult, however. A well designed cost analysis model will assist in accounting for costs of ongoing programs as well as in predicting costs of potential programs.

5. <u>Cost Analysis References</u>

A prospective cost analyst seeking assistance from the literature can easily become overwhelmed by the volumes devoted to costing, cost accounting, budgeting, etc. Although not specifically written for education and training, two of the more readable and useful sources are the previously mentioned books by Fisher (1971) and Seiler (1969). Application and adaptation of their guidelines and procedures should assist greatly in designing a viable cost analysis model.

Fisher relies on the military for examples of applications in his book, "Cost Consideration in Systems Analysis." The major emphasis is on assessing the cost implications of alternative future military capabilities. He does not discuss cost accounting, cost estimating for future operations, or cost analysis of detailed design activities, but much of what is included is applicable to these areas. Seiler's relatively brief (108 pages) text, "Introduction to Systems Cost-Effectiveness," assumes a basic understanding of calculus and probability theory, but mathematical applications are minimal and literary explanations are well done and ample. From the view point of a cost model builder, the most important guideline to be gleaned from these texts is that the cost-related information for each alternative must be transmitted to decision makers in a format that will accurately represent the alternative and permit meaningful comparisons.

An exceptionally well prepared document that places the cost component in a total systems analysis perspective is a DoD publication titled "Economic Analysis Handbook" (undated). This introductory manual, written and subsequently revised by the Defense Economic Analysis Council, is well organized, assumes little prior knowledge, and complements the contents of this document.

C. Instructional Process Description

In order to design or evaluate a well organized instructional system that meets the goals specified by the training objectives, alternative methods and media must be carefully considered. Adequate specification of these processes (sometimes referred to as pedagogies, instructional strategies, or management techniques) and their interactions is essential to properly interpret any training system effectiveness. If these components can be identified, then instructional process comparisons of alternatives will add considerably to a comprehensive cost-effectiveness analysis.

Several means of selecting these components are covered in an extensive review by Spangenberg, Reback, and Moon (1973). The most comprehensive and potentially useful set of procedures developed to date is reported in a series of reports published by the Training Analysis and Evaluation Group (TAEG). One of this series--"A Technique for Choosing Cost-Effective Instructional Delivery Systems" (Braby et al., 1975)--identifies procedures and models for choosing between media alternatives.

The following taxonomy of training methods should aid the analyst in adequately specifying or identifying employed or prospective process strategies.

1. Passive Presentations

a. Verbal Delivery. The presentation of any training material, typically by an individual speaker in a lecture format who has limited knowledge of student comprehension at the time of delivery. That is, the student feedback rate to the instructor is low and infrequent. Film, closed-circuit TV, or tape recordings are alternative presentation methods. Although support is not essential, visuals and other minor aids such as chalkboards are desirable.

b. Written Delivery. The presentation of any training material by print. The printed word has the advantage of being readily available and reusable. The organization is fixed and may not always be suitable. The student must participate to obtain the necessary information, but no overt response is required.

c. Demonstration. An exposition designed to show the operation of equipment or sequence of events necessary to derive a solution. This could be considered a subcategory under either verbal or written delivery where a specific procedure is being demonstrated. This form of delivery usually involves the use of equipment or mock ups. Media may be employed to provide the demonstration.

d. Dramatization. The presentation of any training material which has been dramatized to illustrate some objective and hold the student's attention. This can require extensive preparation, if live, or considerable expense, if prepackaged in some media form such as film or closed-circuit TV.

2. Student/Instructor Interactive Presentations

a. Discussion. The sharing of ideas, relations, experiences, and other types of information by a group of students. There may or may not be extensive questioning by a group leader or an instructor, or among the students. The group leader must exercise skill in directing the discussion for meaningful results.

b. Instructor Query/Student Response. An interactive presentation with multifold purposes: (1) to provide the instructor with feedback on prior training efforts, (2) to aid the student in understanding some concept, rule, or relationship, and (3) to allow students to exchange ideas on a more structured basis than discussion.

c. Student Query/Instructor Response. A means of allowing the student to clarify instructor presentation. This type of interaction may allow the instructor to partially determine the adequacy of his presentation. However, much time can be spent on peripheral questioning and it may be difficult to adequately assess student understanding, both qualitatively and quantitatively.

3. Print and Graphic Methods

a. Programmed Instruction. Typically, a written presentation requiring frequent student responses for progress. This method may provide a fixed sequence for the student, or allow some branching. Although potentially time consuming, 100% mastery can be attained by repetitive cueing.

b. Computer-assisted Instruction (CAI). This presentation method can include elements of all the schemes outlined above. The reader should be aware that almost every method has been computerized to some degree and more careful specification of methods other than "CAI" is probably necessary for adequate process description. See Fletcher (1975) for current military applications of CAI.

4. Functional Applications/Interactions

a. Laboratories. An interaction between student and some physical equipment under specific guidelines. The laboratory may be set up in such a way that the student is required to learn to operate equipment or to use equipment in learning a skill such as foreign languages or chemical analysis.

b. Simulation. An instructional situation that provides the student with practice in some sample of the actual work he is being trained to perform. This can range in form from a simple wooden mock up to a complex computer-driven multiposition situation trainer.

5. Course Management

After the instructional methodology has been determined, the strategy used in applying these techniques must be specified. Instructional strategy may be defined as a system for sequencing training methods that specifies the relationship between the methods, content, equipment, and facilities necessary to meet course objectives. Some of these relations may be under student control. Careful specification of the training strategy is essential in cost-effectiveness analysis, since, without it, little can be said about the relationship(s) between inputs (context, resources, etc.) and the outcomes of analyzed alternatives.

The following variables must also be specified:

a. Student Throughput. Unless throughput is sufficiently high, even the most elegant strategy may be judged inefficient because of high unit costs.

b. Appropriateness of Instructional Methods. The method must exploit both the technology and the skill to be learned. For example, using a high fidelity simulator to train a part-task operator may not be cost justifiable.

c. Student Management. Included in this category are several variables that can strongly effect learner outcomes. Student motivation would fall under this heading, as would class heterogenity, outside activities that minimize study time, and monitoring student progress. This last variable can be particularly important if the alternative is individualized.

D. Instructional Context Description

Whether the intent is to design a new instructional program, to evaluate an ongoing program, or to compare several existing or potential instructional alternatives, it is expected that an individual or team can obtain descriptive data that identifies the environment within which these alternatives exist. Such data would:

1. Provide a baseline of status information that describes the domain of concern, e.g., institutional setting, learner and staff characteristics, etc.

2. Identify the needs, goals, mission statements, objectives, problems, and/or opportunities that apply to the instructional system under examination.

3. Provide a basis for stating change objectives, evaluative criteria, and standards for judging the relative, absolute, or comparative merits of the instructional system(s).

In order to design, evaluate, and/or compare instructional alternatives, it is usually desirable (but not always possible) for them to be located in a common site, to contain similar content goals, to include students with comparable entering characteristics, etc. Examples of Navy context descriptors include school class (A, C, E, etc.), course classification definitions, and course content outlines. Without a clear program or course description, criteria may be selected which will lead to invalid comparisons or evaluations. The more precise the description of instructor expectations, learner outcomes, and program components, the greater the likelihood of valid comparisons.

A brief example of a basic course outline, including a subset of learner tasks follows. Explictly specified learner outcomes are a much more useful set of descriptors, but these may not always be available.

SONAR TECHNICAL INTERMEDIATE ELECTRONICS COURSE

General Content Outline

I. Basic Electrical Theory

- A. Mathematics
- B. Geometry and Trigonometry
- C. Safety
- D. Basic Electrical Theory and DC Fundamentals
- E. Basic AC Theory
- F. AC Circuits
- G. AC Generators and Motors
- H. Acoustical Energy
- I. Equipment Performance

II. Basic Tube Type Electronic Devices

- A. Electronic Tube Theory and Operation
- B. Power Supplies
- C. Amplifiers
- D. Oscillators
- E. General Electronic Devices
- F. Troubleshooting and Equipment Performance

III. Basic Transistor Theory and Equipment

- A. Basic Transistor Theory and Operation
- B. Amplifiers
- C. Oscillator Circuits
  (trainee outcomes:examples)
  1. Describe the operation of a transistorized Armstrong Oscillator.
  2. Define the function of a transistorized Hartley (series or shunt fed) oscillator.
  3. List the different bias requirements for a transistor oscillator compared to a tube-type oscillator.
  4. Describe the purpose(s) of a transistorized a -, mono -, and bi-stable multivibrator.
- D. General
- E. Simple Logic Circuits
- F. Servicing Equipment and Equipment Performance

IV. Electromechanical Devices

- A. Basic Synchro and Servo Systems
- B. Servo Motors
- C. Miscellaneous Electromagnetic Devices
- D. Computer Circuits

V. Introductory Computer Theory

- A. Basic Computer Functions
- B. Basic Fire Control Symbols
- C. Analog Computer Mathematics and Mechanics

E. Effectiveness Model

The analysis of effectiveness of training and education programs or alternatives should be as vigorously developed as the analysis of the resources used to implement them. Uses of systematic techniques for planning an instructional alternative should lead to the expansion and improvement of ways to relate the quantity and quality of the output of the alternative to the resources used to create that output. Decision makers also need criteria other than cost for measuring quality or usefulness. The criteria for these outputs (other than cost) can be grouped under the general term effectiveness. Just as cost is a measure of the resources that comprise an alternative, effectiveness is a measure of the output of that alternative. If possible, effectiveness is measured in terms of performance or change, but it can also be measured in general terms with qualitative interpretations.

Like any cost model or procedure, the effectiveness model can be described in terms of its elements and methods for identifying and predicting the measures of those elements. The kinds of components that can be used are as numerous as the kinds of systems and measures. The basic elements, by necessity, must oversimplify a very complex real world. What is required of these components is that they usefully express the relation between measures and performance, or, most specifically, the capability of the alternative to achieve specified objectives.

Each instructional alternative may be comprised of multiple objectives aimed at achieving specified goals. It is important to determine whether those objectives are unique or if they actually form a hierarchy with a single, assessable objective at the top. If a single measure of effectiveness can be determined from a set of objectives, it is much easier to interpret and report. Quade (1964) suggests several methods for combining and eliminating multiple objectives: "...elimination of any objective that is important only as a means to another objective ...selection of a higher level objective to which all of the competing objectives are means (pp. 159-160)."

1. Evaluative Criteria

In order to comprehensively evaluate an ongoing instructional system or to compare feasible alternatives, standards for judgment must be established. Such standards are necessary to help determine the relative importance of various outcome measures and to assist in establishing appropriate or acceptable levels of those measures.

An instructional system evaluation plan must consider not only learner performance, but also cost, time, and value criteria. Effectiveness criteria stated in terms of learner performance must reflect standards or norms selected by decision makers. The process used to establish standards and validate measures oftentimes requires considerable attention by many parties.

Consideration of costs, as stated previously, must be made in relation to other factors such as resources, outcomes, and constraints. Time is also closely related to cost, effectiveness, and efficiency. Consideration of time in relation to learners includes measures of total lapsed time (beginning and ending dates), learning time (actual time spent in learning), and retention over time (reliability-stability). Value and utility are the ultimate criteria since the payoff of an alternative must be eventually measured in those terms.

The value-added concept of learner assessment is also an important consideration. The concept does not lead to judgment of alternatives on their outputs alone, but by their outputs relative to their inputs. Learner change (in relation to learner capability) attributable to the effects of an alternative is the sought-after measure of educational value added.

As stated previously, no single measure of effectiveness can tell the entire story of the value or worth of an alternative because any instructional alternative generally promotes several different kinds of change in learners. Since the changes are varied and differ in kind, no single proxy measure can be used to represent all the changes attributable to the alternative. The effectiveness model should therefore allow output measures to be displayed as a set of measures and indicators.

2. Prediction

There is one major concern about the design and use of effectiveness modelling procedures. A simulation of costs and effectiveness of most instructional alternatives is difficult since valid predictive relationships between instructional inputs and process and instructional results or outcomes are nonexistent. Ex post facto effectiveness analysis is less speculative but still contains problems of measurement, attribution, and comparison. Techniques for effectiveness modelling are relatively underdeveloped both in military and civilian contexts. Considerable empirical and conceptual research is still required before it will be possible to identify useful predictive relationships between program components and outcomes.

Perhaps the best that can be accomplished in predictive comparisons of the effectiveness of instructional alternatives are qualitative estimates of the degree to which each alternative will contribute to the achievement of specified objectives. Although prior experience and data from related studies will help with these estimates, they will nevertheless remain crude estimates for the foreseeable future.

An example of an effectiveness-feasibility matrix reporting format can be found in the summary report by Doughty and Stakenas (1973). In it, various critiera are considered across four feasible instructional alternatives. Quantitative and qualitative data are thus reported in such a way that a range of levels of decision makers can easily compare and judge for themselves.

F. <u>Cost and Effectiveness Evaluation Criteria</u>

The following exemplary outline or taxonomy of evaluative criteria has been developed to show how a wide range of data could be used in an outcome or effectiveness analysis in a total C-E analysis. This list is not meant to be exhaustive, but rather to illustrate the categories of measures that are typically encountered.

TAXONOMY OF COST AND EFFECTIVENESS EVALUATION CRITERIA

I. Learner-Trainee Outcomes

A. Cognitive and Psychomotor Data

1. Prerequisite (Entering Behavior) Test Data
2. Pretest Data
3. Criterion-Referenced Posttest Data
4. Norm-Referenced Posttest Data
5. Pre-Post Test Gain Score Data
6. Performance Data
7. Criterion-Referenced Retention Data
8. Norm-Referenced Retention Data
9. Transfer of Training Data

B. Affective Data

1. Preinstruction/Training Attitude
2. Preinstruction/Training Satisfaction
3. Postinstruction/Training Attitude
4. Postinstruction/Training Satisfaction
5. Psychophysiological measures

C. Other Outcomes

1. Positive Side Benefits: System and Learner
2. Negative Side Benefits: System and Learner
3. Absenteeism

II. Efficiency/Time Criteria and Considerations

A. System

1. Front End Analysis Time
2. Design/Development/Validation Time

B. Learner

1. Chronological - Lapsed Time
2. Total Active Instructional Time: Time to Learn
3. Retention Time: Intervening time between test and retest

C. Other Considerations

1. Time Sequence Constraints
2. Repetition/Replication Spacing and Requirements
3. Replacement Schedule
4. Depreciation: Physical Life Cycle
5. Obsolescence: Technological Life Cycle
6. Operational Utility: Content/Doctrine Stability-Operating Lifetime

III. Feasibility

A. Appropriateness-Relevance
B. Availability
C. Capability
D. Convenience
E. Cooperability
F. Cooptability
G. Criticality
H. Dependability: Hardware
I. Evaluatibility-Measurability
J. Exportability

1. Diffusability
2. Marketability

K. Pervasiveness
L. Political-Legal Constraints
M. Reliability: Assessments
N. Social-Moral Concerns
O. Uniqueness
P. Utility
Q. Validity: Goals, Assessments

IV. Dollar Cost Criteria

A. Research and Development Costs
B. Investment and Production Costs
C. Replacement Costs
D. Operation Costs: One Cycle and Annual
E. Operation Costs: Lifetime
F. Total Lifetime Dollar Costs (Life Cycle Costs)

V. COST CATEGORIZATION GUIDELINES

A generalizeable cost categorization scheme that will meet all the needs of cost analysts has not been and likely will not be identified. The number of categories and the extent of detailed cost data contributing to each category should be determined by a user's judgment of the function and purpose of the analysis. Considerable differences could be noted between analyzing ex post facto costs, for instance, of an existing Navy 'A' school training program and predicting total dollar costs for an innovative shipboard oriented instructional strategy. If combinations of functions (control, planning, evaluation, and development) are to be considered, even greater effort should be devoted to determining what data are to be collected, how they will be obtained, and who will have access to the results. This last concern is vital because that decision often influences the validity of obtained and/or reported data. The threat factor is always a tremendous influence on data availability and accuracy.

Figure 3 illustrates some of the decision points in a "typical" Navy training cost analysis. The term initiator was selected to head the first column since may analyses are conducted for, but not necessarily by, higher level decision makers. Navy trainers, for instance, may use the results of cost analyses for personnel planning and course development purposes, but the same results or aggregates thereof may also be requested by research directors or DoD planners.

Program focus or scope will depend primarily on the analyst's (or initiator's) perception of function and purpose. For example, a school curriculum coordinator may be concerned with designing and developing an innovative instructional strategy. That strategy, defined as a program, could become the focus of a total analysis designed to predict dollar costs and trainer time as well as trainee time, satisfaction, and achievement. These data could be used by that coordinator for planning purposes and as development specifications.

A division director, on the other hand, may define a program encompassing all schools within his unit. In this instance, an ex post facto description approach may provide data useful for several functions, but careful consideration will have to be given to the procedures used to collect those data. An even more important decision will be the announced and unannounced use(s) of the data (i.e., performance review, course evaluation, budget allocation, internal planning) by that director. Validity becomes much more of an issue when both the purpose of an analysis and use of resultant data are perceived as threats by those supplying needed data.

Before any cost analysis summary can be constructed, the analyst must aggregate specific costs into larger cost categories. The following scheme is designed so that cost data may be aggregated by hand calculation. However, specific cost categories are open-ended, and a complete listing is not possible because of the uniqueness of particular programs. The following outline lists activities and categories that have been used in a number of cost studies.

DECISION POINTS FOR COST ANALYSIS

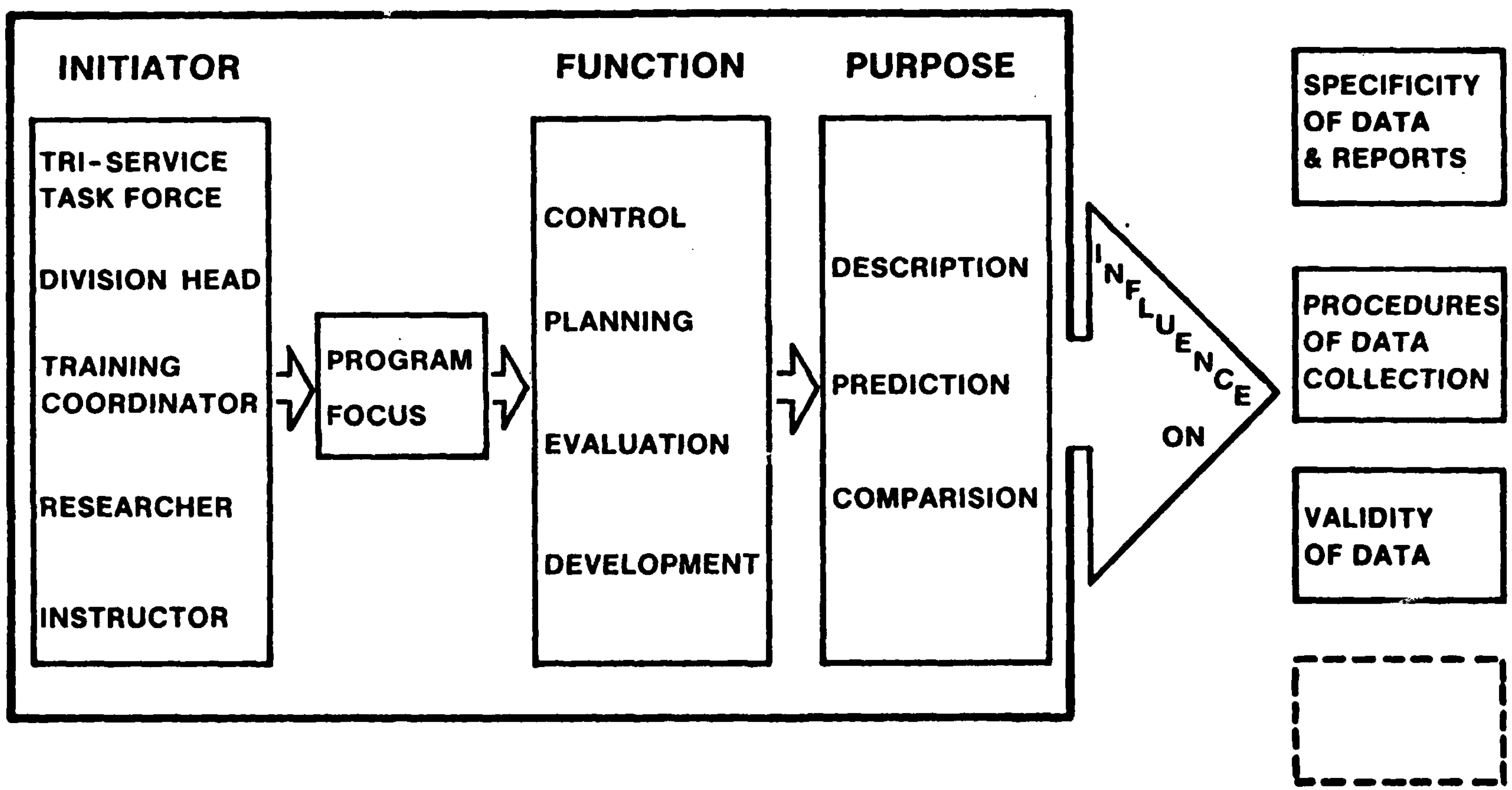

Figure 3. Decision Points for Cost Analysis.

COST CATEGORIZATION FORMAT

Examples of Activities and Categories for Cost Analysis

I. Activities

A. Research and Development

1. Needs assessment - front end analysis - initial planning
2. Task analysis - job analysis
3. Curriculum design
4. Prototype development and testing
5. Formative evaluation - preliminary product and program review
6. Materials validation
7. Training program and equipment development
8. Initial personnel recruitment and/or training

B. Investment and Production

1. Acquisition - Installation - Start up costs
2. Procurement of initial stock of training hardware and software
3. Duplication of production masters
4. Construction - Renovation of facilities
5. Purchase of initial spare components
6. Modifications of existing systems
7. Initial deployment of training hardware and software
8. Initial dissemination of duffusion and implementation activities

C. Replacement

1. Attrition
2. Replacement as a result of:
    a. Obsolescence
    b. Depreciation: Normal use
    c. Theft - Vandalism - Breakage
3. Periodic (scheduled or unscheduled) updating of:
    a. Content - materials
    b. Equipment
    c. Procedures - management

D. Operation

1. Personnel
    a. Instructional: salary - travel - benefits (including retirement)
    b. Administrative - managerial
    c. Maintenance - support
    d. Students: salary - travel - benefits

2. Materials - consumables
3. Ongoing training and evaluation
4. Ongoing distribution - deployment of hardware and software
5. Facilities
6. Overhead

II. Cost Categories

A. Personnel: Salaries and Benefits

1. Instructional staff
2. Support staff: Non instruction - secretarial
3. Program administrative - managerial personnel - supervisors
4. Maintenance staff

B. Hardware

1. Simulators - trainers
2. Audiovisual equipment

C. Software

1. Instructional materials and supplies
2. Training aids
3. Expendable materials
4. Training manuals, technical manuals

D. Facilities

1. Classrooms
2. Laboratories
3. Self-instructional facilities
4. Administrative - managerial - support facilities

E. Institutional Overhead/Administration

1. Agency - institutional management
2. Libraries
3. Computer facilities
4. Contracted services - consultants
5. Institutional overhead

A. Cost Activities

Program activities are a major focus of any categorization system. Several referenced models employ functional category descriptors similar to those in the outline, but that is not to say that these categories are the only ones that might be acceptable. Several referenced reports include sections containing extensive specification and definition of program activity categories. For our purposes, a brief overview should suffice.

1. Research and Development

Costs include all funds expended to bring an ongoing or planned program (alternative-strategy) into readiness for implementation. R&D expenditure for front-end analysis, design, development, formative evaluation, staff (preservice) training, and procurement of R&D materials and equipment are essentially one-time nonrecurring costs and should be so identified. Some nonrecurring costs, however, should not be assigned to an R&D phase or function but to an investment and production function. This second major activity includes all dollar costs required to phase a program into operation. These include costs for facility renovation or procurement, instructional equipment acquisition, and production/duplication of instructional materials. If materials are commercially available, they are also charged to this activity.

2. Facilities

Many schemes include some prorated estimate of facilities or overhead cost in either the investment or operation phase. Considerable study still needs to be given this particular area, but if feasible alternatives being considered all require similar existing facilities, then these costs can conceivably be classified as a constant and perhaps be excluded from the analysis. This will not be the case if new or additional facilities or other overhead are required. Appendix A contains a brief discussion of the range of alternatives for costing instructional space.

3. Replacement

Many models also include various replacement costs for equipment and materials in the operation cost category. This may not be appropriate if alternatives being compared differ drastically in this area. To include the replacement cost of a computer or a simulator in the general operating category may be highly misleading. Within this area, predicting depreciation and obsolescence rates for instructional materials and equipment is often described as an art form. The traditional estimate of a 5-to-10 year lifespan for training hardware, for instance, is based on "normal usage." Factors such as maintenance schedules, amount of use, type of use, user sophistication, and theft rates should be considered and somehow factored into any replacement estimate. Obsolescence predictions for software will depend upon such variables as content stability, style changes in visuals, format (hardbound, cassette, workbook), and usage.

4. Operating

A considerable portion of the recurring costs for any program or alternative should be included in the operating cost category. Instructional personnel, periodic maintenance, expendable supplies, summative evaluation, in-service training and managerial overhead are all recurring costs and should be classified as operational costs. In a conventional setting, one-cycle operation costs might be the funds required to maintain one program (course) for one complete iteration (cycle). Innovative programs will present much more of a challenge. One cycle of an individualized, non-time-based, ship-based program is not so easily segmented, categorized, and costed. Considerable review, testing, and revision will be necessary before any existing conventional procedures will be useful.

A predictive model may make use of ex post facto data to establish cost estimating relationships. It is therefore important that a general cost summary be suitable for both descriptive and predictive data. When lifetime operation costs are required (and they are most important, albeit speculative) conventional programs present much less of a problem than newly evolving innovative types. Although predicting the obsolescence rate of course content, the number of times per year a course is offered, and the number of years it may continue to be offered (before major revision) is a challenge, it does not compare to the difficulty of estimating the scope, duration, and number of cycles in the "life" of a modularized individualized program.

Estimating life cycle costs for Navy personnel has been greatly simplified by analysts in the Personnel Plans Division of the Bureau of Naval Personnel. A sporadically published report, "Navy Military Manpower Billet Cost Data for Life Cycle Planning Purposes" (which was last published in 1973), contains comprehensive annual billet costs for both enlisted and officer personnel. Included in the reported figures are actual and estimated costs for retirement and other fringe benefits. Needless to say, these particular costs can be a significant factor when comparing alternatives with differing degrees of labor intensiveness. In addition, Appendix B contains a discussion of alternatives for determining personnel costs for an operational instructional system.

B. General Guidelines

A reasonable guideline for after-the-fact or predictive cost analysis is to devote attention to any particular category according to the proportion of the total budget reflected by that component. Obviously, personnel costs in most training and education contexts will account for a large percentage of any budget so an analyst's energies should reflect that fact. Fortunately, personnel costs hold few surprises or computational difficulties and may usually be guided by past cost experience or programs that employ similar types of personnel configurations. However, as a proposed program deviates more and more from conventional practice, the utility of conventional program data for guiding cost prediction diminishes.

A category that represents a small proportion of a total budget deserves less attention since even relatively large errors in accounting for or estimating these costs will not significantly effect the total cost figure. The temptation to diligently obtain the latest cost figures for paper clips and pencils and settle for rough estimates of expensive computer time should always be resisted.

The outline provided contains one general functional categorization scheme for Navy education and training R&D cost analysis. It is eclectic in that it includes components found in several but not all costing schemes. Many such schemes do not separate the replacement function from operation activities, but that decision can be made once data are obtained and levels of aggregation can be considered.

C. Program Cost Analysis Summary

Once cost data have been categorized, collected, and processed, one useful way to array or report the results is to construct a summary matrix. Such a matrix helps transform the data into information by identifying recurring and nonrecurring costs as well as fixed and variable costs. It also helps decision makers to review and compare instructional alternatives on a functional cost or program-oriented basis.

In Figure 4, general cost categories are listed on the horizontal axis. These are obviously gross categories, but this is intended to be used as a summary or a display of aggregated cost data. The vertical axis displays the previously defined activities with a subtotal now added to emphasize and isolate nonrecurring dollar costs.

The preceding sections have illustrated the all-important concern for initial emphasis on the function(s) and purpose(s) of any cost-effectiveness analysis. Cost categorization and matrix reporting schemes, such as the one shown in Figure 4, are important tools but should not be employed before the questions or problems are well defined.

CATEGORIES / ACTIVITIES	PERSONNEL	HARDWARE	SOFTWARE	FACILITIES	INSTITUTIONAL OVERHEAD/ ADMIMISTRATION	TOTAL
RESEARCH & DEVELOPMENT						
INVESTMENT & PRODUCTION						
REPLACEMENT						
TOTAL R&D INVESTMENT & PRODUCTION &REPLACEMENT						
OPERATION: ONE CYCLE						
OPERATION: LIFETIME						
TOTAL DOLLAR COST: LIFETIME						

Figure 4. Matrix for Isolating Activities by Cost Category.

VI. CONCLUSIONS

The use of cost-effectiveness analysis in establishing and reviewing military training programs is becoming increasingly necessary as all Department of Defense budget allocations come under closer scrutiny. The guidelines and examples presented in this report are designed specifically for the Navy training and training R&D communities and provide an introduction into the field with additional sources of information clearly identified so that the reader interested in applying these guidelines should have an adequate basis for either conducting in-house cost-effectiveness studies, or monitoring contractual studies.

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ANNOTATED BIBLIOGRAPHY ON COST-EFFECTIVENESS ANALYSIS

The following nine references have been carefully selected from a comprehensive review of cost-effectiveness analysis related reports, articles, and texts produced in the fields of systems, operations research, economic analysis, educational analysis, educational evaluation, and cost-effectiveness analysis. None require expertise in any particular discipline and, as such, are well suited to a wide range of reader interests and needs.

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

Most cost-effectiveness evaluations typically consider either alternative outcomes or costs. This report is concerned with developing a strategy for optimizing alternatives. It provides a set of guidelines for predicting cost-effective instructional delivery systems. These guidelines are just that, they require technical knowledge on the part of the user. The technique requires that the user (1) classify training objectives by characteristics, (2) identify instructional delivery systems that can be used in meeting common objectives, (3) estimate the cost of these systems, and (4) select the optimum mix of systems. Included is a FORTRAN cost model program that can be used for determining component and system costs.

Defense Economics Analysis Council, Handbook Committee, Ecnomic analysis handbook. Washington, D. C.: U. S. Department of Defense, 2nd Edition, undated.

The handbook presents the concepts and methodology used in economic analysis. The uninitiated reader is given a set of procedures as a guide through the major phases of economic analysis. These include: (1) a statement of objectives and presentation of alternative ways to meet the objectives, (2) determination and comparison of costs and benefits, and (3) use of sensitivity analysis in evaluating results. A description of several costing methods and explanation of such relevant concepts as "economic life" and "discounting" in relation to DoD policies are also provided.

Department of the Navy, SECNAV Instruction 7000.14A: Economic Analysis and Program Evaluation for Navy Resource Management. Washington, D. C.: Office of the Secretary, 14 March 1973.

This instruction provides the basic guidelines for conducting economic analysis, including cost-effectiveness studies. Included in the analysis are statements of objectives and alternatives. The major cost categories are defined, including inflation and economic life. How to handle output data is discussed and certain types of output analysis are explained. A series of format outlines and definitions of relevant economic terms are provided.

Doughty, P. L., & Stakenas, R. G. An Analysis of Costs and Effectiveness of an Individualized Subject Offering. In Sabine, D. (Ed.), Accountability: Systems Planning in Education. Homewood, Illinois: ETC Publications, 1973, 165-191.

A comparison of four instructional approaches (including lecture-lab and individualized audio-tutorial) in a university setting was used as the basis for validating a cost-effectiveness model. The cost model is provided, along with a statement of underlying assumptions and guidelines which may also be relevant in other educational applications. Included are the methodological and conceptual steps that are needed to develop a data base for this example.

English J. (Ed.). Cost effectiveness: The economic evaluation of engineered systems. New York: John Wiley and Sons, Inc., 1968.

This book is oriented toward military weapon systems and avionics, but many of the principles apply to any cost-effectiveness study. In particular, one chapter (A Standardized Approach to Cost-Effectiveness Evaluations) provides specific approaches for conducting cost-effectiveness evaluations where each step is described in detail. Examples dealing with space programs and military weapons systems are provided. Another chapter (Cost-Effectiveness Fallacies and Misconceptions Revisited) explains what not to do and how to avoid common pitfalls in evaluations. Other useful concepts covered in additional chapters include trends in analysis, basic decision theory, and analysis of the systems approach. Appendices include a cost-effectiveness bibliography and a list of potentially useful criteria for both cost and effectiveness categories.

Fisher, G. H. Cost considerations in systems analysis, New York: American Elsevier, Inc., 1971.

This well written book addresses specific cost analysis issues in a total systems analysis framework. The Defense Department sponsored this Rand Corporation endeavor in order to assist in the training of national security analysts. Concepts and principles of systems analysis and cost analysis are defined in the first three chapters while more specific applications, examples, and military-oriented problems are discussed in the remaining six chapters. Although the text focuses on cost considerations in systems analysis, effectiveness or outcomes criteria are incorporated in the total systems analysis context.

Petruschell, R. L., & Carpenter, P. MODIA applied in the design and cost analysis of an innovative Air Force course. R-1021-PR, December 1972, Rand Corporation, Contract No. F44620.73-C.0011, prepared for United States Air Force Project Rand.

This report describes a methodology for the design and cost analysis of a military instructional system. The methodology is designed to provide a means for designing instructional systems and the tools for assessing the alternatives in a timely manner. The specific example is used to show what the instructional system will cost and how it is developed. In order to do this, instructional process and strategy descriptors are developed, selecting specific media and determining proper instructor utilization are discussed, and a method for estimating the cost of the system is presented.

Seiler, K. Introduction to systems cost-effectiveness. New York: Wiley-Interscience, 1969.

This relatively brief (108 pages) text was initially designed for an audience with a basic understanding of calculus and probability theory. However, fundamental issues and concepts are well defined verbally and the mathematical models and notation present few barriers to the uninitiated. Sections in the book are organized as follows: I provides a broad over-relevant cost-related issues; II provides a definition (with examples) of system cost models; III defines an effectiveness model which includes criteria such as system performance, availability, reliability, and survivability; and IV defines and critiques various comprehensive cost-effectiveness analysis models. Each section contains a supplementary set of annotated references to operations research oriented readings.

Temkin, S. An economic assessment of Army training alternatives, Research for Better Schools, Inc. Submitted to Army Research Institute for Behavioral and Social Sciences, February 1975.

The Army has recently adopted a new training approach, Training Extension Course (TEC), which is an attempt to provide individualized training for a wide variety of topics at the battalion level. This study compared operational and developmental training costs of TEC versus operational costs for conventional group instruction. A limitation of this study is that only one alternative was compared to the conventional program. Future cost implications for expanded use of TEC and conventional instruction are considered. Appendices provide detailed cost breakdowns.

APPENDIX A

ALLOCATING COSTS OF INSTRUCTION:
ALTERNATIVES IN COSTING INSTRUCTIONAL SPACE

APPENDIX A

ALLOCATING COSTS OF INSTRUCTION: ALTERNATIVES IN COSTING INSTRUCTIONAL SPACE

Problems

When cost accounting principles are applied to educational or training institutions, it is common practice to allocate construction, operation, and maintenance costs of physical facilities to jurisdictional cost centers within the institution or center. The "accuracy" of the allocation varies with the types of data available. In some settings, the cost of a "building and grounds" operation might be equally distributed to all departments either as administrative overhead or as a discrete item. At other institutions, more complex distribution patterns may be followed.

The costs of operating and maintaining physical facilities are current costs. Allocations are based on the full cost incurred for a specified fiscal period. The costs of construction or housing, on the other hand, are not charged to a jurisdictional budget as the costs are incurred. While it might not be unreasonable to charge the full $3,000 cost of a newly partitioned office to a department's annual budget, it would certainly be unreasonable to charge the full cost of a $3,000,000 building to the annual budget. Such a charge could put a rather sizeable department $2,850,000 "in the red." In order to be fair and not penalize a department for constructing a new building or renovating existing facilities, cost accountants have devised means of depreciating facilities as an asset over a long-term period. Furthermore, whatever depreciation schedule is used, it can be applied to the $3,000 improvement as well as to the $3,000,000 building.

For institutional cost accounting purposes, the costs of construction, operation, and maintenance must be recognized. Similarly, and to help balance the books, the facilities are listed as assets and investments. Charges to units to defray the costs of operating and maintaining physical facilities are accepted as a fact of life. However, space, as facilities are frequently described, poses a special problem to the analyst attempting to identify costs associated with instructional programs.

Most studies that have dealt with instructional program costs have adopted the cost techniques of the home institution. That is, they allocated to the program some portion of the overhead charged by the institution to the department administering the program. Typically a mathematical ratio is used. For example, if there are 10 departments, one tenth of the institutional overhead is charged to a department. Then, if five of the department's fifteen faculty members work on the program, one third of the original 10% overhead might be charged to the program. There are, of course, any number of allocation formula variations that might be used. Student credit hours produced, faculty salaries, full-time equivalent (FTE) enrollment, and FTE staff are more common bases that might be used in space allocation formulas. The problem that quite clearly arises is just how accurate the resultant program costs are. If the program is composed of field exercises or on-the-job training, it is immediately obvious that the program makes far less demands on institutional space than, say, a biweekly lecture class for 50 trainees.

There is another caveat to consider when attempting to allocate the costs of physical facilities to programs on the basis of institutional costs defined by accountants. Not only is it difficult to accurately allocate the institutionally budgeted costs, but also those very costs are likely to be inaccurate in terms of actual out-of-pocket costs. The reason for this, of course, can be found in the "tricks" of accounting associated with asset depreciation and the problem of differences between historical costs and the current value of the measuring unit ... the dollar.

Buildings are often depreciated at a predetermined rate. Regardless of what is being, or has been paid, on the principal and interest resulting from the construction or purchase of the building, it is the depreciation rate that shows. The actual payments are, or were, likely "buried" in some other account. In reality, the depreciation is a fictional figure. It exists only because some means is necessary to recognize the possibility of loss in volume in an investment. Of course, frequently there is an appreciation in value, but the use of replacement costs in accounting records is a violation of the historical cost concept and of the necessary assumption that the dollar is a stable unit of value. Furthermore, there are no reliable techniques for measuring the current costs of replacing assets.

Alternatives

As cost studies have focused more and more on program-level costs, there is growing concern about how accurate these costs really are. There has been a growing realization that it is not necessary to adopt the institution's accounting procedures when costing a program, although that remains an option. Other bases which could be used to allocate space costs are to compute standard costs, rental costs, no cost at all, or to compute only costs that can be specifically related to the existence of the program. Each of these alternatives will be addressed.

A standard cost is defined as "the cost that should be incurred to produce a given product or to perform a particular operation under relatively ideal conditions (Meigs, Mosich, and Johnson, 1972, p. 781)." In reality standard costs may be averages or reasonable estimates by experts. The primary advantage of using standard costs for space is that all departments would be subject to identical unit costs for space of a given type. The variable would be the amount and type of space needed. The disadvantage of using standard costs is that they imply an accuracy which does not exist. If a 40-year-old building requires maintenance amounting to $10,000 annually while an average or ideal maintenance cost for comparable space is $7,000, there is no way that the $7,000 is a realistic figure. Standard costs do tend to place the costs for physical facilities in perspective; but, desirable as that may be, the use of standard costs can give misleading data.

The use of standard cost figures can be defended, however, when the intent is to export a particular program to other settings. Haggart (1971) illustrates the proper use of standard costs when she couples cost figures with the concept of incremental and replication costs. She reports average costs for a particular program and provides explicit information about unit resource requirements. An institution desiring to adopt the program first determines the cost of replicating the program per resource unit and then the incremental units required to meet specified needs.

Use of rental costs has advantages and disadvantages similar to the use of standard costs. Unless the space is actually rented, the rental cost is someone's estimate; it is not an actual cost. The use of rental costs as a base for establishing program costs loses more credibility when one considers a nuclear physics program that requires a cyclotron or a training program which uses a large simulator. Rental costs might be a more appropriate base than standard costs since unique needs are more likely to be considered, but the final result will remain a mere reflection of the actual costs.

Since the use of institutional procedures, standards, and rental costs are not likely to give accurate cost data, the possibility of not allocating facilities costs at all should be considered.

There is a certain amount of appeal to not allocating costs of space to instructional programs. Space is, in many instances, an incidental adjunct. The instruction could just as well occur in a tent, on the fantail of a ship, or (in milder climes) under a tree. Not costing space would have the same relative effect as using standard costs, that is, all instructional programs would be equal with regard to what is not always a bona fide cost of instruction. The problem here is that, in many instances, physical facilities are important to instruction. Previously cited examples of the cyclotron and the simulator are more extreme examples of instructionally relevant facilities. A minicomputer or a simple movie screen are less extreme examples. If the physical space is integrally related to instruction, it seems reasonable that it should be costed to the educational program.

Costing facilities specifically required for an educational program does present problems. A decision must be made about what is required and what is not. Should the floor space be costed? What about the chalkboard? There is also the problem of establishing a "fair" cost. In his study of costs of an individualized geology course, Doughty (1972) encountered the problem of costing resources used by the program. Rather than cost the space used, Doughty costed the space that existed only because the program existed, that is, actual investment in and modification of existing facilities was charged to the program. Such academic problems as determining the cost of inherited space was thus avoided, and a more realistic picture of actual expenditures was obtained.

Several assumptions underlie this approach to costings. One must assume that (1) all programs require certain minimal space (e.g.), a room which is supplied by the institution through overhead charges to the department, (2) these equal needs balance out in any comparison, and (3) the instructor is not to blame if he is placed in an old building requiring considerable upkeep. Thus, the only space costs that are recognized as relevant are modifications to space for the benefit of the program. In Doughty's study the modification was in the form of independent study carrels, wall removal, electrical renovation, and the like.

For an accountant this approach to costing is an anathema. However, for a program administrator, it represents a realistic picture of what a particular program is costing in terms of physical space. The problem is not, after all, a bookkeeping problem in which the books must balance. Rather it is one of determining actual cash outlay for a particular program. To solve that problem, an approach is needed that is independent of the stylistic, accounting-oriented approach.

APPENDIX B

ALLOCATING COSTS OF INSTRUCTION: INSTRUCTIONAL PERSONNEL

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ALLOCATING COSTS OF INSTRUCTION: INSTRUCTIONAL PERSONNEL

Problems

Salaries and wages for instructional personnel are typically the largest components of an education or training program's budget. Determining institutional budgets via conventional cost accounting techniques when there is no question about the accuracy of salaries and wages listed as expenditures allows the entire amount to be used. However, when attempting to allocate a salary or wage to specific programs, departments, or disciplines within an institution, the question of accuracy does arise. Short of actual time and motion studies, there is no precise way of allocating personnel time to specific programs. Even in the unlikely event of a costly time and motion study, the data obtained would be historical and the problem of joint (multifunction) costs would still exist. The nature of education and training is so fluid that staffing patterns are almost never constant. Therefore, a time and motion study could provide fairly accurate descriptive data, but the data would not be reliable enough to estimate future costs with the degree of accuracy required by a bookkeeper or accountant.

In spite of the imprecise nature of allocating instructional personnel time to specific programs, the magnitude of this cost component makes it imperative that the task be performed. The following options are articulated for higher education but may serve as useful models for Navy education and training contexts.

Options

At least four different methods can be used to assign personnel costs to programs, departments, or disciplines. Faculty and staff appointment is one such method. A faculty member may have a quarter-time appointment in one department, a half-time appointment in another, and a quarter-time appointment with a research project. Using faculty or staff assignments to allocate costs is administratively convenient. The information is readily available, and, as far as the institution's books are concerned, the method is accurate. Usually, however, personnel assignment does not reflect reality. It would be a rare instance in which faculty apportioned their time in direct proportion to the assignment ratios. Full-time Navy training settings are sometimes an exception. Consequently, while the method is a satisfactory accounting procedure on an institutional and jurisdictional basis, it does not truly reflect program costs or even departmental costs when personnel assignments cross jurisdictional boundaries.

A second method used to allocate instructional salary costs to programs, departments, or disciplines is based on credit hours or courses taught. Theoretically, this method allocates those costs in direct proportion to expended effort. The assumptions underlying this method of allocation are that all credit hours require equivalent amounts of involvement on the part of specified personnel and that all efforts can be tied to credit hours. Except in those instances where faculty or training staff are assigned full time to a specified program (course), the assumptions are not seriously defended. It is understood, for example, that faculty may spend considerably more time on a course which has never been taught before than on courses with which they are familiar. Furthermore, it is not always possible to attach committee work, research, and other responsibilities connected with faculty positions to credit hours.

Despite the unrealistic assumption underlying the method, allocation of costs based on credit hours taught is a common procedure. Of the 19 post-secondary education cost studies surveyed by Doughty and Beilby (1974), six used or recommended allocation of salaries based on the number of credit hours produced. The arithmetic ease of working with credit hours, in addition to the availability of such data, helps explain why the method is so widely used.

A third method of allocating faculty time employs the use of the staff contact hour. The staff contact hour is defined as the number of hours "taught" times the enrollment (the term "taught" may be flexibly applied to include individual instruction or self-instruction). The rationale behind the staff contact hour is that the credit hours assigned to courses containing "noncredit" labs or seminars do not adequately reflect faculty/staff effort. Furthermore, in order to determine contact hours, data describing instruction types, class sizes, faculty work load, and faculty needs must be collected.

The main argument against the use of the staff contact hour is that the increased accuracy concerning staff requirements and effort is not usually worth the considerable time required for data collection and computations. Another argument against its use is that it only considers time directly related to formal courses. Much staff time may be devoted to committee work, student advisement, research, and miscellaneous planning. This time cannot be accounted for in any of the allocation methods discussed thus far.

The fourth method used to allocate personnel costs is through oral/written reports from either the individual whose time is to be allocated or from the individual's administrative superior. Only three of the studies surveyed by Doughty and Beilby used this approach. The weaknesses of oral reporting are obvious. The person's ability to report accurate data is limited by memory, and is influenced by (1) the importance they attach to specific tasks, and (2) the announced or suspected use to which the data will be put. If an individual is being asked to report on a third person's time, additional variance such as feelings about the person, or frequency of meetings with the person, creeps in. As an accounting technique, the "oral report" method is clumsy and not very accurate for reporting costs that can be jurisdictionally defined. One might expect to account for anything from say 70% to 130% of a person's time. Balancing the books in the light of such findings could be quite a trick! Furthermore, the data are not conveniently obtained. Expensive, time-consuming interviews, diaries, or questionnaire analyses are required.

Two advantages of the "oral report" method of allocation are that it is less artificial than other methods and may be more accurate. Although, as previously noted, the "oral report" method may account (hypothetically) for anywhere between 70% and 130% of a staff member's time, that does not mean the recorded time spent is in error. Such figures may occur because of some arbitrary statement about the rate of pay based on annual salary. As bits and pieces of time are collected according to staff reports about their involvement in specific tasks or programs, more or less total time may be accounted for than was estimated to have been spent. In other words, the arbitrary statement about rate of pay is more likely to be in error than staff statements about how they spend their time. Admittedly, it is unlikely that data from oral reports will be totally accurate, but it is likely to be more accurate and useful than such proxies as credit hours produced, FTE staff contact hours, or administrative assigment. The neatness, convenience, ready availability, and frequency of use of these other measures for institutional accounting give them an aura of credibility that is unwarranted in fact.

Navy Manpower Billet Costs

Considerable assistance in obtaining total Navy personnel costs is provided by the Personnel Plans Division of the Bureau of Naval Personnel. The Division occasionally publishes a report and maintains a current computerized file that includes annual billet costs for Navy officer and enlisted personnel. These comprehensive cost (to the Navy and the Department of Defense) figures include the current and projected costs (retirement, etc.) of manning an established operational military billet or a military billet which would be established under a proposed alternative.

These figures differ considerably from organization-oriented budget data since the latter do not include such costs as retirement, transportation, and training. One option for analysts is to report both billet and annual salary costs when comparing instructional alternatives. Obviously, a high labor-intensive option will fare much worse when billet costs are used as the base than when significantly lower annual salaries are reported.

APPENDIX C

ARMY TRAINING EXTENSION COURSE (TEC) COST-EFFECTIVENESS ANALYSIS

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ARMY TRAINING EXTENSION COURSE (TEC) COST-EFFECTIVENESS ANALYSIS

I. INTRODUCTION

A. Military Problem

In an effort to achieve more dynamic training in combat arms units, the Chief of Staff of the Army, on 30 June 1971, directed the decentralizaton of training management to battalion level and lower. To help unit commanders carry out this increased responsibility, the Board for Dynamic Training was established at Fort Benning, Georgia. During its existence, the Board identified several critical problem areas and suggested potential solutions. The task of implementing these solutions was assigned to the Combat Arms Training Board (CATB), which succeeded the Board for Dynamic Training.

One problem area was the lack of a link between the service schools, with their enormous content and training expertise, and the units, with their increased responsibility to conduct training. Unit commanders were confronted with the problem of maintaining individual Military Occupational Specialty (MOS) competence as a prerequisite to developing and conducting challenging unit training. Without a minimum level of individual skills unit training was not profitable; however, the requirement to train for maintaining unit skills was virtually monopolizing the commanders' attention and pre-empting his use of available time for training individual skills.

The Board for Dynamic Training identified as a major initial step the development of carefully engineered training materials, which would be prepared by service schools and used within units in an audio-visual mode. To be known as Training Extension Courses (TEC), these materials would enable the commander to maintain individual proficiency in selected subject areas with a minimum of time and effort expended at the unit level.

B. Current Training System

At present, training in individual skills at the unit level is carried out by unit officers and NCO's. Usually, the designated unit instructor develops a custom-made program of instruction (POI) using available training literature (which is often outdated), and whatever training aids are available. The class is given and the POI is seldom used again. Little diagnostic testing on post-instruction performance testing is ever planned or conducted.

C. Proposed Alternative

The Training Extension Course (TEC) Training System is designed to assist individual soldiers and unit commanders in upgrading MOS/job proficiency. It consists of multimedia instructional materials prepared by service schools for use in the field. The prepackaged, soldier-validated lessons are interacting and performance-oriented. The TEC Training System is designed to improve individual training of soldiers in units.

Behind the TEC program is the basic proposition that Army service schools will provide training assistance to soldiers in field units, both Active Army and Reserve Components. This assistance is an important mission of the schools and should be provided on a continuing basis.

Unit trainers can use TEC materials to conduct group instruction to train squads, platoons, companies, etc., in individual skills. The TEC system can also be used by individual soldiers in a self-paced mode for study at any time.

Each of the lessons sent to the field is designed for a specific segment of soldiers. Some lessons apply to all soldiers, while others are appropriate for a particular branch of MOS.

Before a lesson is put into final form for distribution to units, it is tried out on soldiers. This is a critical step and represents a dramatic improvement in the development of Army training materials. At this point, the lesson must bring the soldier to a specified standard of performance. If it fails to do this, it is rewritten and retested as often as necessary to guarantee that it will teach effectively.

Another important improvement found in TEC lessons is that the soldier must actively participate in the training. Each lesson requires the soldier to demonstrate he can do each step in a procedure before moving on to the next step. This orientation on performance, as well as the field validation, guarantees TEC lessons will be effective--provided they are used.

D. <u>Current Versus Alternative System</u>

Some principal differences between the TEC and conventional Army training are:

1. TEC training materials are designed to emphasize performance--what the soldier will do as a result of the training. The instruction is developed and validated through empirical methods.

2. Unit commanders and trainers can use TEC diagnostic tests and evaluations to determine strengths and weaknesses in the job proficiency of individual soldiers. With this profile of strengths and weaknesses of his unit as a whole, the commander can take a prescriptive approach to training.

3. The TEC training materials and hardware provide the nucleus of a Battalion Learning Center. This center can be a composite of military training materials, GED materials, college materials, and commerically produced materials related to soldier needs and interests.

4. Training in units is enhanced because the TEC Training System provides trainers with high-quality instruction in a ready-to-use form that reduces the need for unit trainers to develop lesson plans and visit training aids centers, audiovisual support centers, post photo labs, or other agencies to obtain training materials. Trainers are thus permitted more time to concentrate on training rather than on platform presentations.

5. Most important, before going to units, these materials are actually "tried out" on soldiers from the target population. This validation process is one of the more important differences between empirically-designed training and conventional training. Because training materials are validated, trainers will have greater confidence that the training is efficient and effective.

II. EFFECTIVENESS ANALYSIS

A. Effectiveness Comparisons

1. The following information was extracted from a Cost and Operational Effectiveness Analysis Study conducted by the U. S. Army Research Institute for the Behavioral and Social Sciences and submitted to USACATB on 17 March 1975. This study was initiated by DA DCSPER in the summer of 1974 in order to critically evaluate the use of the Training Extension Course (TEC) at the unit level and to provide information to OSD for budgeting the TEC program. The full 146-page report may be secured from the U. S. Army Combat Arms Training Board (AV 835-5242, CPT Neal).

2. The study basically compared three groups of field soldiers in several subject areas. One group was pretested, trained by the TEC system, and then given two posttests--a written test and a performance test. The second group was tested identically, except they were trained by a unit officer or NCO using the same teaching objectives as the TEC lessons. The third group (BASELINE) was tested, but not trained.

3. The performance measure was the percent of test items correct.

B. Purposes of ARI Cost Effectiveness Study

1. To evaluate training effectiveness of TEC lessons compared to conventional training.

2. To conduct a cost analysis of TEC training compared to conventional training.

C. Overall Conclusion of the Study

The conclusion reached from the study is that in both Active Army and National Guard Units the TEC trained soldiers performed significantly better than those trained on conventional methods at lesser cost.

D. COMPARATIVE RESULTS
(Active Army Only)

		TEC	LIVE INSTRUCTOR	BASE LINE
Grenades	Pretest	46%	42%	51%
	Posttest	89%	54%	51%
	Performance Test	74%	43%	45%
LAW	Pretest	45%	44%	41%
	Posttest	83%	56%	41%
	Performance Test	57%	59%	45%
M-16	Pretest	43%	38%	39%
	Posttest	78%	48%	39%
	Performance Test	67%	57%	64%
81mm	Pretest	74%	56%	71%
	Posttest	93%	72%	71%
	Performance Test	72%	41%	26%
Surveyed Firing Charts	Pretest	42%	43%	41%
	Posttest	67%	57%	41%
	Performance Test	87%	72%	40%

NOTES:

1. Except for 81mm, all groups started with similar competence levels in each subject as shown by pretest scores across groups.

2. TEC groups did significantly better than the other groups in all cases on the posttest written examination.

3. Except for the LAW and the M16 rifle groups, TEC groups did significantly bettern than the others on the performance tests. For the LAW and M16 rifle, TEC and the live instructor scored equally well.

E. COMPARATIVE RESULTS
(National Guard Only)

		TEC	LI	BL
Grenades	Pretest	34%	36%	38%
	Posttest	90%	38%	38%
LAW	Pretest	44%	2%	49%
	Posttest	84%	53%	49%
M-16	Pretest	51%	47%	41%
	Posttest	84%	58%	41%
81mm	Pretest	37%	28%	33%
	Posttest	80%	42%	33%

NOTES:

1. Performance test scores were not available in documents received by USACATB.

2. The TEC group scored significantly better in all cases than the other groups on the posttest.

F. SUMMARY TO COMPARISON TO BASELINE GROUP

	ACTIVE ARMY	NATIONAL GUARD
BL	50%	50%
LI	55%	80%
TEC	80%	95%

NOTE: The BASELINE group mean was set as the norm. The mean of the BASELINE group represents the point where 50% of the soldiers are below the comparative average and 50% are above the comparative average. *The TEC and LI groups are* then compared to the established norm.

G. CORRELATION BETWEEN PERFORMANCE TEST AND GT SCORES, BY LESSON CATEGORY AND EXPERIMENTAL GROUP, ACTIVE ARMY

Lesson Category	Experimental Group		
	TEC	LI	BL
Hand Grenades	-.02	.61*	.24
LAW	.06	.54*	.44*
M16 Rifle	.02	.24	.43*
Mortar FDC	-.13	.27	.71*
Surveyed Firing Charts	.02	.11	.27

* Significantly higher than zero. $p < .05$

NOTE: This table shows that TEC teaches independently of GT score, whereas the degree of live instructor group learning is dependent upon GT score (i.e., innate learning abilities).

III. COST ANALYSIS

A. Although the TEC Cost Effectiveness Study followed the guidelines set forth in AR 37-13, it was impossible to use the exact formats specified in that regulation and still give an adequate statement of the impact of the TEC program. The hardware and software are complementary; neither can stand alone. USACATB has modified the formats of AR 37-13 in an attempt to summarize pertinent costs. The following format compares the costs of conventional training to TEC training in operational units over a 1064 battalion equivalent base of 100 hours of annual instruction. Under current funding TEC will not be fully implemented to support the 1064 battalion-equivalent units until FY 1977. Start up and initial distribution costs are shown from 1974.

B. The TEC system is not designed to teach all individual skills within a unit. However, best estimates indicate that at least 100 hours of instruction per man per battalion can be expected annually. Thus, the cost of providing that 100 hours under both alternatives is shown in this analysis.

C. ECONOMIC ANALYSIS PROGRAM EVALUATION SUMMARY OF COSTS FOR FORMAT A-1.

1. Submitted DoD Component: TRADOC (DA)

2. Date of Submission: 15 July 1975

3. Project Title: Training Extension Course

4. Description of Project Objectives: Provide individualized, self-paced, systems engineered instruction in individual soldiers job skills to soldiers in units.

5a. Present Alternatives: Conventional live instructor-oriented lectures, demonstrations, and conference-based instruction in units.

5b. Proposed Alternative: Individualized, self-paced, systems engineered standard instructional packages in audio-visual, audio only, and written format.

6a. Economic Life of Present Alternative: One year field research shows that present unit instruction is tailor-made for each instructional situation and almost never reused in subsequent sessions.

6b. Economic Life of Proposed Alternative: TEC hardware and software will have an estimated average economic life of six years. The development and revision of software is continuous.

Alternative a. - Conventional Training in Units

8. Program/Project Costs ($ Million)

Project Year	a. R&D	Non-recurring Investment	b. Recurring Operations OMA	MPA	c. Annual Costs	d. Discount Factor	e. Discounted Annual Costs
1974	0	0	4.588	41.296	45.884	1.048	48.096
1975	0	0	5.047	45.426	50.473	1.000	50.473
1976	0	0	5.552	49.968	55.520	.954	52.966
1977	0	0	6.107	54.965	61.072	.867	52.949
1978	0	0	6.718	60.461	67.179	.788	52.937
1979	0	0	7.340	66.507	73.897	.717	52.984
1980	0	0	8.129	73.158	81.287	.652	52.999

NOTE: OMA Funds are estimated to be 10% of the total cost of conventional instruction.

Alternative b. - TEC Training in Units

8. Program/Project Costs ($ Million)

7. Project Year	a. R&D	Non-recurring Investment	b. Recurring Operations OMA	Recurring Operations MPA	c. Annual Costs	d. Discount Factor	e. Discounted Annual Costs
1974	.154	3.091	4.473	1.809	9.636	1.048	10.098
1975	.375	2.636	4.292	13.883	21.186	1.000	21.186
1976	.400	4.546	20.401	15.007	40.354	.954	38.498
1977	.600	3.942	17.397	28.502	50.441	.867	43.732
1978	.700	5.315	19.563	30.457	56.035	.788	44.156
1979	.700	.500	21.333	39.106	61.639	.717	44.195
1980	1.000	.500	23.969	42.333	67.802	.652	44.207

NOTE:

1. These estimates include MPA funds. The majority of costs for both the conventional training alternative and the TEC training alternative is in MPA funds.

2. It is projected that new state-of-the-art media (hardware) will be tested in the FY 1980 time frame.

3. Full implementation to 1064 battalion equivalent units will not occur until 1977; therefore, the $42.1M in 1975 dollars becomes $50.441 in 1977 dollars due to inflation (10% per annum).

10a. Total Project Costs Discounted Thru FY 1980:

Present Alternative	$363.404
Proposed Alternative (TEC)	$246.072

10b. Uniform Annual Costs:

Present Alternative	$ 51.915
Proposed Alternative (TEC)	$ 35.153

11. Terminal values cannot be estimated.

12. Net costs cannot be calculated (Sèe 10 & 11)

13. Source Derivation of Cost Estimates:

All costs were derived from the USARI study and FY 74 and FY 75 USACATB Comptroller files. A 10% inflation factor was used for FY 76 thru FY 80 and a 10% discount rate was used for derivation of present values.

14. Project Officer:

CPT William D. Neal
ORSA Project Officer
TEC Division, USACATB
(AV 835-5242)

D. The TEC Lesson Development Dollar, by Cost Category: In Percentage

Source: ARI COEA

Average Cost = $15,920

NOTE: The $15,920 represents the average total cost to develop the prototype TEC answer print.

E. Annual cost to support typical combat arms battalion in conventional instruction

The annual costs for providing an equivalent amount of conventional instruction to a typical combat arms battalion is: $47,437. Therefore, TEC is $9,158 less expensive per battalion per year on the average. This represents a cost avoidance in that TEC requires officer/NCO support at the battalion level; thus, these supervisors can devote more time to training in unit skills as opposed to individual skills.

F. Annual Costs at Full Implementation

Considering all costs--developmental and operational--the costs to support 100 hours of equivalent instruction per man per battalion over 1,064 battalion equivalent units annually in 1975 dollars is:

TE	CONVENTIONAL
$42,100,000	$50,473,000

Again this difference is a cost avoidance rather than a cost savings.

IV. NON-QUANTIFIABLE ELEMENTS ANALYSIS

The following statement was extracted from a paper written by Dr. Charles Schuller after two years of working in the TEC program. Dr. Schuller recently retired as Professor of Education and Director of the Instructional Media Center, Michigan State University.

SCHULLER, 12 February 1975

Benefits realized from Army TEC Program aside from specific cost measurable benefits.

Significant indirect benefits have been achieved by the TEC program in addition to the increased efficiency and effectiveness of the training directly involved. Notable among these are the following:

1. Throughout the Army establishment from top command to company commanders and platoon leaders in the field, attention has been redirected to major emphasis on the learning needs of trainees rather than on the teaching needs of instructors. This shift in emphasis to the learner represents a fundamental change in Army training policy and makes possible for the first time the development of scientifically based learning systems throughout the military training program. This development is a consequence of the fact that the TEC program initiated the thrust towards learner-centered training.

2. As a result of TEC's developmental work, the Army now has a training research and development capability (based in part on the CATB 28 step development model) which can readily be applied to other current and future training needs. The Army did not have that capability prior to the TEC program--and an investment of millions of dollars and hundreds of man years would be required to achieve the current status of R&D capability were such an effort just being initiated. At this time the R&D capability has been centered at USACATB and the nine TRADOC Service Schools in the TEC II and TEC III programs. As the TEC IV Schools begin to develop their material, the same R&D capability will be extended.

3. The experience of service school instructional staffs working on TEC programs has helped bring about closer self-scrutiny and re-evaluation of what they were doing in resident instruction. This influence of TEC is reflected in two significant ways: (a) changed attitudes on the part of instructors with respect to the effectiveness on their own instruction, and steps necessary to improve it, and (b) actual modification of course programs as indicated below:

a. At the U. S. Army Signal School, Fort Gordon, Georgia, TEC is currently programmed to replace an eight week long resident course—SWITCHBOARD OPERATOR, MOS 72C. There are 1600 jobholders for this MOS in field units. It will take approximately 26-28 TEC lessons to replace this course. They will start development in June 1975, and be available by Fall 1976. Additionally, every TEC lesson developed by the Signal School (currently 29 in number) will be converted to a non-resident sub-course. Conversion time is minimal and means more and better written sub-courses available without an increase in the number of course writers (resources) required. Currently, the three TEC lessons on the AN/PRC-77 have been so converted and have met with overwhelming success.

The Signal School is currently discussing the "conversion" of TEC lessons for classroom presentation by a line instructor. As soon as subject areas are developed as complete TEC packages, they will be converted and directed toward resident instruction.

In summary the Signal School will realize the benefits of TEC not only through TEC lessons for field use, but also for use in both resident and non-resident instruction.

The Field Artillary School (USAFAS) and Air Defense School (USAADA) have requested and received an additional issue of 75 and 60 TEC hardware machines respectively for use in resident instruction. These machines, and related software, will be used to both supplement and replace platform instruction. Likewise, the Infantry School (USAIS) has utilized TEC equipment for supplementary instruction since July 1973.

Comparable indicators from other schools make clear that TEC lessons are applicable in some degree to resident training in all schools and that this influence is expected to become of major significance over the next few years.

4. Additional Influences

a. TEC has rationalized doctrine at all schools. This has been prompted by a confirmation of high level reviews of TEC lessons and the specification required in the TEC lesson development process.

EXAMPLE - High level review of TEC lessons on patrolling brought about change in doctrine from highly specialized Ranger patrol techniques to more general techniques applicable to non-specialized personnel in field units.

b. TEC has corrected errors and omissions in GFM's.

EXAMPLE - Contractor brought to Armor School's attention the fact that a critical toggle switch in the tank turret was not identified or dealt with in any of the training or service manuals. The omission was brought to light through the learning task analysis steps in the CATB development model.

c. TEC has stimulated innovative training techniques.

EXAMPLE - The Armor School developed, inhouse, a tape recorder input to plug into the tank intercom system going to all stations so the whole crew could hear and train as a group. The material used initially was a TEC audio visual lesson designed for single individual; this was converted to audio-only and used in the above manner with highly successful results.

d. TEC is helping standardize training throughout the system. By reason of the care and precision of the development process and the fact that service school's content experts are responsible for their development, TEC lessons are of uniformly high quality. That, plus the fact that they are uniquely effective training materials makes for their ready acceptance and use throughout the system. This will result both in more effective and more standardized instruction wherever given.

e. TEC has upgraded the capability of the TRADOC Schools to manage R&D projects. Being a totally new and innovative program centered within the TRACDOC School system, the TEC project has forced managers within the schools to tackle and solve the typical problems of resource allocation, staff reorganization, and project control that are necessary for successful R&D program management. Prior to the TEC program, R&D management techniques were almost exclusively applied to hardware systems. TEC has made it necessary to apply the same techniques to a training system. Consequently, the TEC system has become a model of other training oriented R&D projects within TRADOC.

V. CONCLUSIONS

A. Relative Effectiveness Calculations

	Overall Effectiveness	Cost ($ Million)
TEC	87.5*	42.7
CONVENTIONAL	67.5*	50.5
BASELINE	50.0	50.5

*Active Army and National Guard averaged (Equal N's assumed)

1. Relative effectiveness (TEC vs Baseline) = 87.5/50.0 = 1.75
2. Relative effectiveness (TEC vs Conventional) = 87.5/67 5 = 1.30
3. Relative effectiveness (Conventional vs Baseline) = 67.5/50 0 = 1.35

B. Relative Cost Calculations

1. RC (TEC vs Baseline) = 42.7/50.5 = .84
2. RC (TEC vs Conventional) = 42.7/50.5 = .84
3. RC (Conventional vs Baseline) = 50.5/50.5 = 1.00

C. Relative Worth Calculations

1. RW (TEC vs Baseline) = 1.75/.84 = 2.08
2. RW (TEC vs Conventional) = 1.30/.84 = 1.54
3. RW (Conventional vs Baseline) = 1.35/1.00 = 1.35

D. Conclusions of the ARI Study

1. On the average TEC instruction teaches both written posttests and hands-on performance tests better than conventional, live instructor, instruction.

2. The state of training in individual skills in both the Active Army and National Guard is generally poor.

3. TEC teaches soldiers with low abilities and high abilities equally well, whereas conventional instruction is not as effective with low ability soldiers as it is with high ability soldiers. Over all ability groups TEC teaches "better."

4. Considering all costs, TEC is more cost-effective than conventional instruction.

APPENDIX D

NAVY IC SCHOOL COST ANALYSIS

INTERIOR COMMUNICATIONS "A" SCHOOL COST ANALYSIS

All of the physical resource requirements for implementing the IC "A" School have been broken down into the following categories: (1) Personnel, (2) Hardware, (3) Software, and (4) Facilities. Within each category several indices were sought. These include:

Personnel

Number of students
Average student salary cost
Number of instructors
Average instructor salary cost
Instructor pre-service training salary costs

Hardware

New procurement
Replacement
Maintenance

Software

Instructor course revision salary cost
Printing
Films, slides, manuals, etc.

Facilities

Classroom space
Utilization
Furnishings
Maintenance

Within these categories, some administrative costs are embedded. Whenever possible, they are specified. Many of the costs within the categories are derived indirectly because the funding comes from a variety of sources that are not readily identifiable. These indirectly-derived costs are indicated.

Personnel

Number of Students. The total number of student for FY75 was 1,032. Of these a sample of 200 was drawn from all classes to examine the rate structure. The results are shown below:

Rate	Pay Grade	N
Seaman Recruit	E.1	92
Seaman Apprentice	E.2	31
Seaman	E.3	65
IC3	E.4	7
IC2	E.5	4
IC1	E.6	1
		Σ=200

Of these, 19 receive commuted rations (COMRATS) (an additional food allowance), 39 have dependents and receive Basic Allowance for Quarters (BAQ). The average student is in the E-2 pay grade with less than two years service. Of the 51 classes covening in the last year, there was an average of 21.4 students (σ = 3.3) in each class. Of these, approximately five students (σ = 2.9) were set back during each cycle for a total of approximately six weeks/cycle. That is, of the average five students each cycle, some require more than one week of additional training.

Average Annual Student Salary Costs. This figure could be derived by determining the actual costs; which are the basic salary, BAQ, COMRATS, uniform allowance, and travel to the training center.

Average student salary (E.2 with < 2 yrs service)	$4600.80
BAQ (no dependents)*	810.00
COMRATS*	867.60
Uniform Allowance	68.40
Total Annual Salary Costs/E-2	$6346.80

However, by using the Navy composite standard military rate table, a comparable figure is obtained. For an E.2 apprentice the annual rate is: $6514.00

or, the salary per student per cycle (125.25/wk x 8 wks) = $1002.00

Student Salary Costs per Training Cycle

• Total salaries per cycle ($1002.00 x 21 students)	$21,042.00
• Additional salaries for setbacks per cycle ($125.25/wk x 6 wks)	751.50
• Travel (103.17/student x 21 students)	2,166.57
Total Student Costs per Training Cycle	$23,959.67

---

*All students receive BAQ and COMRATS in cash or kind. The majority recieve the latter.

Using the same cost categories, but with the total costs for establishing an operational billet taken into account, the total student costs per training cycle are: $45,819.00

Number of Instructors. There are presently three teams of six instructors each in the IC "A" School. Each team has an E-7 supervisor/instructor. Their rate structure is shown below:

Rate	Pay Grade	N
IC2	E-5	2
IC1	E-6	16
ICC	E-7	7
		$\Sigma N = 21$

The average instructor has three dependents and approximately 14 years ($\sigma = 5$) of service.

Average Annual Instructor Salary Costs. The average instructor is in pay grade E.6 with 14 years service and receives both BAQ and COMRATS.

Basic Salary (E.6 with 15 yrs)	$8,427.60
BAQ (average 3 dependents)	1,328.40
COMRATS	867.60
Uniform Allowance	100.00
Total Annual Salary Cost/E-6	$10,724.40

Again, by using the Navy composite standard military rate table, a figure taking these factors into account is obtained. For an E.6 PO1, the annual rate is: $11,788.00

or, the average salary per instructor per week -- $ 266.68

Taking into account all billet costs, the average instructor costs the government $22,305.00 or per week -- $ 429.00

Instructor Salary Costs per Cycle. These costs may be specified in many forms due to several variable costs that are encountered prior to and during the training cycle. These include:

• Instructor School (226.68/wk x 4 wks)	$ 906.76
• Classroom sit-in/familiarization (226.68/wk x up to 16 wks, average 8 wks)	1,813.57
• Off-platform duties (course revision, review board, etc.) (226.68/wk x 1 wk/cycle)	226.68
• Average Travel Costs/Instructor/Tour	1,668.33

In addition, certain support costs arising from the instructor school could be considered as accruing to training cycle costs.

If the average instructor serves a three-year tour instructing, then the above training and travel costs could be considered as being amortized over approximately 132 weeks of instruction, allowing for leave time. The cost to each cycle for each instructor becomes:

$906.76 + $1,813.92 + 1,688.33 = $4,380.61/16.5 cycles = $265.98/cycle

Instructor costs per cycle include the following components:

• Average instructor salary/cycle 226.69/wk x 7 wks	$1,586.83
• Total instructor salaries/cycle $1,586.83 x 6 instructors	9,520.98
• Training and Travel Costs $4,380.61/16.5/cycles	265.98
Total Instructor Costs/Training Cycle	$11,373.79

If the additional, off-platform duties are considered a cost accruing against the "A" School, then the following additional expense must be considered within each training cycle budget:

$226.69/wk x instructors	$ 1,360.14
+	11,373.93
	12,733.93

Hardware

Acquisitions. According to the "A" School materials office administrator, no new equipment was purchased last year. The present equipment includes the following items:

1 MK 11 Gyro Compass
1 MK19 Master Gyro Compass
1 MK27 Gyro Compass
8 PSM.4R VOM
12 PSM.4C VOM
2 USM.105A Oscilloscopes
15 USM.117 Oscilloscopes

1 Megger
13 URM 127 Audio Signal Generators
1 Mechanical Shaft Tachometer
2 Strobescopic Tachometers
2 Tube Testers
Several motors and generators (some inoperable)
Misc safety equipment (shorting bar, etc.)
Misc loudspeakers and microphones

1 LS-386 Intercom System
1 IC Switchboard
1 Ship's Service Distribution System
1 Fire Alarm Switchboard

20 16mm Projectors
2 8mm Cassette Projectors
25 OH Projectors
1 Reel-to-Reel Tape Recorder

Some of the minor equipment is not included on inventory. The two 8mm projectors are recent acquisitions that are "automatic" issue from the Material Support Officer (MSO).

Replacement. This category does not appear to be particularly applicable. Almost all equipment is obsolete at the time it is surveyed, thus it is typically replaced with a newer piece of gear that more readily fits the acquisition category.

All miscellaneous, small, consumable expenses are paid by the MSO. To cover these costs $100/quarter is allocated for administration and $1,500 each quarter for the "A" School. Examination of these records shows a typical expense at the division (administrative) level being approximately $100 for a bookcase, $15 for transistors, etc. At the "A" School, typical expenses involve wire and cable @ $125, smocks @ $75, answer cards @ $30, and a printing over run category, batch posting, which provided a $77 addition to the budget due to a return of funds committed the prior year. All of these costs recurred throughout the last fiscal year. Naturally, both the budgets are exhausted at the end of the fiscal year.

Maintenance. Equipment maintenance is handled in a number of ways. Test equipment is maintained by the Field Calibration Laboratory. This facility handles maintenance for all test equipment on the NTC compiler. They can furnish no exact figures for repair or calibration, indicating that wide variances in equipment are found. If necessary, some hourly estimate can be derived, but accuracy is unknown.

A similar problem exists for audiovisual equipment. Some repair is carried out by students at the AV Repair School located on the NTC compound. Some are sent to the Naval Educational Training Support Center. Both repair facilities have no fee schedule.

Maintenance on operational equipment appears to be casual. Students perform minor repairs to switchboards during training. Every fifth week, the instructors rotate "off-platform" to perform a variety of functions, including maintenance. However, no one is able to give any estimate of the percent of time spent performing these functions. It appears to be a low estimate. Office equipment is regularly serviced. This is handled by the MSO who spent $210 during the last FY for these services.

Present Budget. Both "A" and "C" Schools spent a total of $11,259 for "consumable parts and supplies" in the last FY of which slightly over half went to the "A" School. The anticipated FY76 budget has been cut; the total allowance being $7,600. To implement complete individualization of the "A" School, approximately $400,000 - $500,000 is needed for equipment and site preparation. Because this money is not available, CNTT, Memphis has informed MSO that implementation must be held off until 1978.

Facilities

Classroom Space. There is a total of nine lecture classrooms in use by the "A" School not including administrative and instructor office space. Each of these rooms is 24' x 31' which provides a total of 6,696 square feet of classroom space. In addition, one room is shared by two weekly sections for laboratory exercises and one room houses an IC control center mock-up. These two rooms are similar in size bringing the total space for "A" School to 8,184 square feet.

Furnishings and Utilization. Each of the nine classrooms is furnished with sufficient student desks to meet the needs of the particular class. This can vary from 12 to 25. Due to the fluctuation in the number of weekly student input, some shuffling of available desks is necessary, but no funds are expended for new desks. A similar situation prevails for tables, chairs, etc. The utilization rate for all furnishings varies with each weekly student input typically ranging from 12 to 25 students maximum. Any additional requirements are typically dealt with through unofficial channels.

Maintenance. The major source of labor for routine maintenance consists of entering students in a "wait" status. As they normally have no other duties during the wait period, their labor is not considered a cost accruing against "A" School operation. Minor facility replacement costs have been extremely difficult to ascertain. The total NTC maintenance budget for FY76 is $2,210,000, but what portion is applicable to the IC School is unknown. According to the staff, some maintenance of walls has been prevented for several years now due to a lack of funds.

Software

Course Revision. Several revisions occurred in the past year. The mechanism for initiating these revisions was a weekly meeting of approximately 15 instructors that lasted for 1-2 hours. Typically the instructor population of these meetings consisted of three Chiefs and 12 Petty Officers. Based on the decision made at these meetings, course revision was accomplished during the one week in five when the instructor rotated off platform. The approximate costs of these personnel can be obtained by examining the personnel costs. The meetings recessed in March and are not scheduled to be reconvened due to their impending individualization of this course. However, all instructors still rotate one week in five.

Printing. Minor noninstructional services for the "A" School are handled through the MSO. This amounted to $30 for the last FY. Student handouts and instructor lesson guides are handled through a reimbursible account. Examples of typical costs that have occurred during the last FY are given below. These figures include plates which could be reused, but due to frequent revision in the past, have usually been discarded.

	Total Copies	No. of Pages	Length of Use	One Side	Two Sides	Cost
1	2000	85	12 months	x		$1,127
2	1000	30	12 months	x		$ 340
3	2000	34	12 months		x	$ 416
4	1750	8	12 months		x	$ 87
5	1000	8	12 months		x	$ 55
TOTAL	7750					$2,025
	3000 one side x 115 = 3.45 x 103 pp = .00425/p					$1,467
	4750 two sides x 50 = 2,375 x 103 pp = .0023/p					558

Another potential source of prining costs arises from use of the Xerox. This is difficult to specify quantitatively, but it appears that some training material is reproduced from time to time on the copier.

Manuals and Films. These costs are minor. Films seem to spring from the earth and are rarely replaced. Transparencies cost $.35 each and are rarely replaced. Technical manuals are purchased through the Naval Education Training and Development Center (NETDC) at unknown costs. An approximate figure of $5.00 per manual along with a 35% replacement rate is assumed.

Personnel Costs FY75
Interior Communications "A" School
Naval Training Center, San Diego, California

COST SUMMARY

Cost Category	Billet Cost (in $)		Composite Salary Cost (in $)	
	Cycle	Annum	Cycle	Annum
Instructor Salary	6,133	312,761	3,234	164,913
Instructor Training Salary	849	43,281	447	22,798
Administration/Misc Salary	6,073	309,759	3,213	163,885
Student Salary	35,822	1,826,914	20,563	1,048,689
TOTAL	48,877	2,492,715	27,457	1,400,285

These data are based on the following information:

1. An eight week training cycle.

2. A total of 51 training cycles during FY75.

3. An additional 6 student weeks per cycle for setbacks and additional training.

4. An average of approximately 20.2 students per cycle.

5. A total of 1032 students during FY75.

6. A total of 21 instructors and supervisors (providing the equivalent of 14 full time instructors).

7. A total of 7 administrative personnel (including the instructors administrative time, there is the equivalent of 14 full time administrators).

Training Cycles and Student Training Time

There are 51 cycles per year, with a new cycle beginning every Monday (except Christmas week). A week of "Electrical Gyros" is offered during every cycle and a week of "Mechanical Gyro" is offered every other cycle. When both gyro classes are offered in a single cycle, they are conducted concurrently by different instructors. The majority of students need only one or the other; thus by rearranging schedules the necessary training is readily provided. Students which require only electrical gyros progress through eight sequential weeks. Students receiving instruction in mechanical gryos may or may not sequence through in the same fashion as students in the electrical gyro sequence. However, the end result is the same; both groups receive eight weeks of training. As some students require both weeks of gyro training, these students may be considered as "set back" an additional week which increases student training time. The cycle parameters are:

1. Basic number of student training weeks/cycle
   (20.2 students/cycle x 8 weeks) = 161.6

2. Number of additional student weeks due to setbacks and additional gyro training/cycle = 6

3. Total number of student training weeks/cycle
   (161.6+6) = 167.6

4. Average number of student training weeks/cycle
   (167.6/20.2) = 8.3

5. Total number of student training weeks/year
   (1032 students x 8.3 weeks) = 8566

Example of Allocation of Instructor Time

Instructors spend 37 hours per week on the job (class is dismissed 3 hours early on Friday, thereby shortening the normal 40 hour workweek. This works out to 296 hours per cycle (8 sequential weeks/cycle x 37 hours/week) spent by each instructor on the job. Of these total hours, the following are devoted to non-platform duties.

Number of Hours

37 The average instructor is diverted completely from instructional duties for a week out of every cycle. During this time, he participates in a variety of activities (e.g., lesson plan review, equipment repair).

8 Tuesday morning staff meeting 1 hour

4 Friday morning personnel inspection 0.5 hour

5 Student indoctrination - Monday morning of 1st week

5 Monitoring student medical care - Monday morning of 7th week

7.5 Barracks cleanup - Wednesday morning of 1st, 3rd, and 5th weeks (2.5 hours each week)

66.5 Hours

66.5 hours ÷ 296 = 22% = percentage of time spent by average instructor on non-platform duties.

The rest of the instructor's time can be analyzed in a similar fashion. This was done for all cost categories. The resulting analysis is shown below:

INSTRUCTION/ADMINISTRATIVE TIME ALLOCATION

	INSTRUCTORS				STUDENTS	
	Instructors E-6 (# instructors = 18)	Sandburg E-7 Team Supervisor/ Instructor	Olson E-7 Team Supervisor/ Instructor	Wright E-7 Team Supervisor/ Instructor	Students E-2 Number of students = 1032	Student setbacks E-2 Number of students = 1032
Percentage of Salary Attributable to Cost Category Indicated	69%	45%	45%	45%	15%	.6%

	INSTRUCTOR TRAINING				SUPPLIES EQUIPMENT MAINTENANCE
	Instructors E-6 (# of instructors = 18)	Sandburg E-7 Team Supervisor/ Instructor	Olson E-7 Team Supervisor/ Instructor	Wright E-7 Team Supervisor Instructor	Owens E-6 Material Assistant
Percentage of Salary Attributable to Cost Category Indicated	90%	90%	90%	90%	100%

	ADMINISTRATIVE/INSTITUTIONAL/ MISCELLANEOUS					
	Michales W-2 Division Director	Duncan E-8 "A" Course Coordinator	Hockaday E-7 Night Instructor/Supervisor	Cooper E-7 Personal Affairs Counselor	Instructors E-6 (# of instructors = 18)	Data Management Group
Percentage of Salary Attributable to Cost Category Indicated	75%	100%	100%	100%	22%	4%
	Sandburg E-7 Team Supervisor/Instructor	Olson E-7 Team Supervisor/Instructor	Wright E-7 Team Supervisor/Instructor	Neal E-7 Administrative Assistant	Bor[illegible] E-6 Administrative Assistant	
Percentage of Salary Attributable to Cost Category Indicated	46%	46%	46%	95%	95%	

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These time allocations were then translated into billet and composite military pay costs as shown on pages D3 and D4.

APPENDIX E

NAVY EDUCATION AND TRAINING COST ANALYSIS PROTOTYPE DATA COLLECTION INSTRUMENTS

NAVY EDUCATION AND TRAINING COST ANALYSIS
PROTOTYPE DATA COLLECTION INSTRUMENT

INSTRUCTOR SURVEY SCHOOL/SETTING ____________________

NAME ____________________________

The term "cycle" will occur throughout this questionnaire. Cycle refers to the period of time required to plan, design, implement, and evaluate a unit of instruction within the program being analyzed. In this questionnaire, the cycle to be considered is:

____, hereinafter described as the "cycle under discussion."

The term "course" will be used also. If you do not follow the traditional course structure, interpret the term loosely.

PART I: Personnel

This portion of the questionnaire focuses on the amount of time you spent on the program (course/school).

1. You spend a certain amount of time on matters related exclusively to the instructional program. You are also likely to spend time on matters related to other aspects of Navy life. Such involvement might include working on committees, advising trainees, instructing outside the program arena, conducting Navy research, and communicating with visitors, potential recruits, and colleagues.

   Estimate what you believe represents your average weekly involvement in these two categories of activities during recent cycles.

   Instructional program activities: ______________ hrs/wk

   Other Navy-related activities: ________________ hrs/wk

2. List below the name and official number of the "courses" in the program in which you were involved and were taught during the cycle under discussion. NOTE: Not limited to courses you taught. (You may not require all of the five spaces provided; conversely, if more space is required, provide attachment.) In the last two columns, indicate the number of trainees enrolled and how often you've taught the course.

   1. ________________________________ ______ ______

   2. ________________________________ ______ ______

   3. ________________________________ ______ ______

   4. ________________________________ ______ ______

   5. ________________________________ ______ ______

   The numbers 1 through 5 above will be used as a shorthand method of identifying your courses in the remaining portion of this questionnaire.

EXAMPLE:

How many hours did you spend this last cycle evaluating materials and/or the instructional process?

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

If the question does not apply, enter "NA" or "0."

NOTE: If for some reason you are involved in, say, eight courses, insert the additional data in the space below the response line.

3. This question deals with design/planning functions. These activities may have occurred far in advance of actual instruction. They must have been performed only for the cycle under discussion, i.e., if you've taught a course three times and modify materials for each cycle, consider only the modifications made for the cycle under discussion. Give total hours per cycle, not hours per week. You might want to review the following descriptions before you respond in order to avoid duplicating your time estimate figures.

   A. Planning the form, structure or content of the program (not individual courses); i.e., arriving at a general idea of what program will be:

      TOTAL: ________

   B. Planning form, structure, and general content of courses i.e., arriving at a general idea of what course will be:

      1. _____ 2. _____ 3. _____ 4. _____ 5. _____

   C. Planning form, structure, and content of instructional materials, i.e., specific descriptions of course:

      1. _____ 2. _____ 3. _____ 4. _____ 5. _____

   D. Planning facility improvements:

      1. _____ 2. _____ 3. _____ 4. _____ 5. _____

   E. Designing instructional materials after having decided form, structure, and general content (if you incorporated this data in C, go on to F).

      1. _____ 2. _____ 3. _____ 4. _____ 5. _____

   F. Selecting instructional material already existing:

      1. _____ 2. _____ 3. _____ 4. _____ 5. _____

   G. Research to increase personal knowledge about the program and instruction in the program.

      TOTAL: ________

H. Formative evaluation of process, content, modules, or materials:

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

I. Support activities for any of the above (include supervision of support personnel):

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

4. This section focuses on investment/production functions. While the activities may have been performed far in advance of instruction, they must have been performed only for the cycle under discussion.

A. Purchase of hardware or equipment:

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

B. Purchase of materials (books, paper, etc., but not office supplies not used for instruction):

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

C. Purchases for renovation of facilities for specific instructional purposes:

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

What was the total cost (including hired labor) of facility renovation?

TOTAL: $__________

D. Production of materials for instruction or for trainee evaluation (not design of materials, but physical production of them):

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

E. Management of personnel involved in the production or purchase of materials or equipment:

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

F. Support activities for investment/production (comparing prices, using catalogs, meeting sales personnel, etc.):

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

5. This section focuses on activities closely related to instruction during the cycle under discussion.

A. Instruction. (If self-instructional materials were used, there may have been no instruction. Lab supervision, distribution of materials and similar tasks can be accounted for in B):

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

B. Activities supporting instruction (include organizational and logistical activities for specific classes, but not design of materials for those classes):

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

C. Advising trainees in your courses

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

D. Advising other trainees enrolled in program:

TOTAL: __________

E. Trainee evaluation/assessment:

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

F. Summative evalution of materials for the instructional process:

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

G. Dispensing information about the program:

TOTAL: __________

H. Management and leadership connected with any of the above (include instructions to secretaries, clerks, and assistants):

1. _____ 2. _____ 3. _____ 4. _____ 5. _____

PART II: Software

This part of the questionnaire attempts to identify the cost of software which was consumed for the design or operation of the cycle under discussion.

Directions: The following page provides three columns. Column one lists classifications of softwar... In column two, you are to list, using the number system 1 through 5 developed in PART I, by courses the value of the software consumed for design activities. (The actual time that the money was spent is not relevant here. If you use paper that was purchased a year ago, for example, treat is as if you were purchasing it at the time of consumption.) In column three, perform the same task for software consumed during the instructional activity.

Guideline: The value of xerox copies of a chart produced for class distribution should be listed in column three. The earlier consumption of material for designing the chart (probably of very little value) should be listed in column two.

EXAMPLE:

Software Category	Value of Software: Design	Value of Software: Instruction
(1)	(2)	(3)
Paper	1 = 25¢, 2 = $3.00 3 = 0	1 = $10.00, 2 = $35.00 3 = $2.00

(1)	(2) (design)	(3) (instruction)
PAPER	____________	____________
PRINTING	____________	____________
FILM	____________	____________
FILMSTRIP	____________	____________
SLIDES	____________	____________
STILL PHOTOS	____________	____________
TRANSPARENCIES/VIEWGRAPHS	____________	____________
VIDEO TAPE	____________	____________
AUDIO TAPE	____________	____________

PART III: Equipment and Hardware

In this part of the questionnaire, you are asked to identify the number of hours that equipment and hardware was used in order to implement your courses during the cycle under discussion.

1. Use the checklist below to identify hardware and equipment used for the design, production, or implementation of your course.

HARDWARE

Cameras:
_TV
_16mm
_8mm

Projectors:
_Overhead
_Opaque
_Slide
_Filmstrip
_16mm film
_8mm film (reel)
_8mm (filmloop)

_Screens
_TV Monitors (Viewing)
_Tape Recorders (reel)
_Cassette Recorders
_Record Players
_Teaching Machines
(identify type: ________
____
________________________)
_Microphones
_Headsets

EQUIPMENT

(if more than one, identify specifically)

_Typewriter
____
____
____

_Thermofax
_Ditto
_Offset

_Xerox
_Other duplicating equipment (specify type)

_Calculator

2. The table on the following page should be filled out as follows:

Column I: Name the piece of equipment or hardware. BE SPECIFIC. Provide information that will allow investigators to estimate value.

Column II: Identify source (example: "dept.," "media center," "my own").

Columns III and IV: Enter the number of hours the equipment was used according to the nature of the task (Des. = design, and Inst. = instruction). Provide estimates by individual courses, using the number system 1 through 5.

Column V: Check if you used this equipment or hardware outside of the program being analyzed.

EXAMPLE:

(I) NAME/ID	(II) Source	(III) Hrs. used this cycle	(IV)	(V) Non-Program
		Des.	Inst.	
Cassette Sony 0120	own	2=5	--	
16mm Projector	Media Center	--	1=1 3=2	X
Xerox 4000	Inst. Div.	1=1/2	1=1/2 2=1/2 3=1/2	X

Notes concerning Xerox Example: <u>Design Time</u> = Rough drafts; Inst Time = Class handouts.

HARDWARE AND EQUIPMENT

(I) Name/ID	(II) Source	(III) Hrs. used this cycle: Des.	(IV) Hrs. used this cycle: Inst.	(V) Non-Program

PART IV: Services

The following page contains a sample completed matrix identifying possible instructional services, how they were "paid for," and utilized. The next page is a matrix for you to use in identifying any services used in the cycle being analyzed.

IV. SERVICES

NAME ____________________

Step 1: In the first five rows, indicate services used and method of payment by checking appropriate cell (enter dollar figures where possible). Also indicate, by way of a simple statement, how the service was utilized.

Step 2: In the last three rows, indicate the purpose for which the service was used (i.e., Design, Investment/Production, Operation) by entering in the appropriate cell EITHER the number of hours the service was used OR the manner in which the service was apportioned to various types of activities. IDENTIFY BY COURSE.

Services / Method of Payment/Purpose	Library	Media Services	Printing	Duplication	(Other):
Bookkeeping (Institutional overhead), prorated	Research & reserve manuals for trainee use	Slides, Transparencies, Module Design, Hardware			
Direct charge for services rendered					
Cash Transaction					
Voucher			$200 Off-set	$10	
(Other):					
DESIGN	2 hrs. all courses	1 = 2 hrs. 3 = 8 hrs.	0	0	
INVEST/PROD	0	1 = 1 hr. 3 = 1 hr.	1 = 30% 2 = 60% 3 = 10%	2 100%	
OPERATION Related to Instruction	1 = 1/4 hr. 2 = 1/4 hr.	1 = 1 hr. 2 = 2 hrs.	0	0	

IV. SERVICES

NAME ____________________

Step 1: In the first five rows, indicate services used and method of payment by checking appropriate cell (enter dollar figures where possible). Also indicate, by way of a simple statement, how the service was utilized.

Step 2: In the last three rows, indicate the purpose for which the service was used (i.e., Design, Investment/Production, Operation) by entering in the appropriate cell EITHER the number of hours the service was used OR the manner in which the service was apportioned to various types of activities. IDENTIFY BY COURSE. See next page for example.

Services / Method of Payment/Purpose	Library	Media Services	Printing	Duplication	(Other):
Bookkeeping (Institutional overhead), prorated					
Direct charge for services rendered					
Cash Transaction					
Voucher					
(Other):					
DESIGN					
INVEST/PROD					
OPERATION (Related to Instruction)					

PART V: Support Personnel

In this final part of the survey, you are asked to identify all support personnel who have worked for you on the program and indicate the number of hours they worked. Support personnel are secretaries, assistants, and other helpers, paid by the unit administering the program, who assisted you in some manner. Also identify trainees who also served in an assistant/aid capacity.

V. SUPPORT PERSONNEL
(Sample)

Staff ID	Pay Rate	Average Work Week	TOTAL HOURS WORKED FOR YOU THIS CYCLE Design	Invest/Prod	Inst
Marg Brown Clerk Typist	?	39 hrs.	5 hrs.		
Ronald Smith Consultant	100/day+ ($120 travel and logging)		1 1/2 days	1/2 day	0
Tine Jones Trainee	3400/year	20 hrs.			
Barb White (Fill in secretary/ office help	$4.00/hr.	varies	0	0	2=12 hrs. 3=1 hr.

Use separate form titled "Support Personnel" for your response.

V. SUPPORT PERSONNEL

This table to be used for answering the last item in booklet.

Staff ID	Pay Rate	Average Work Week	TOTAL HOURS WORKED FOR YOU THIS CYCLE		
			Design	Invest/Prod	Inst

THIS IS THE LAST PART OF OUR SURVEY.
THANK YOU SO MUCH FOR COOPERATING!

NAVY EDUCATION AND TRAINING COST ANALYSIS
PROTOTYPE DATA COLLECTION INSTRUMENT

ADMINISTRATOR SURVEY NAME ______________

The activities on which this questionnaire will focus are those associated with the ____________________________ program/course/cycle.

1. Estimate what you believe represents your average total weekly involvement as an administrator. Include all activities which relate specifically to your position as an administrator:

__________ hrs/wk

The following questions refer only to your involvement in the identified program.

2. Identify the total amount of time spent as an administrator, planning and designing the program relative to the _______________ cycle:

__________ total hrs/cycle

3. Identify the total amount of time spent which was most closely related to purchases for the program:

__________ total hrs/cycle

4. Identify the total amount of time spent on matters in support of the execution of the __________ cycle:

__________ total hrs/cycle

5. Estimate the cost of materials consumed in support of the administrative activities described in Items 2, 3, and 4 above.

$________________

6. Identify any consultant retained for the program. List fee and expenses and briefly describe his contribution.

7. Identify the extent to which you used institutional resources for administration of the program by completing the following page (page three is an example of how the form may be used).

ADMINISTRATOR SERVICES

NAME ______________________

Step 1: In the first five rows, indicate services used and method of payment by checking appropriate cell (enter dollar figures where possible). Also indicate, by way of a simple statement, how the service was utilized.

Step 2: In the last three rows, indicate the purpose for which the service was used (i.e., Design, Investment/Production, Operation) by entering in the appropriate cell EITHER the number of hours the service was used OR the manner in which the service was apportioned to various types of activities.

Services / Method of Payment/Purpose	Library	Media Services	Printing	Duplication	(Other):
Bookkeeping (Institutional overhead), prorated	Research	Transparencies-Viewgraphs			
Direct charge for services rendered				$10 Handouts for meeting	
Cash Transaction					
Voucher			$75 Brochures		
(Other):					
DESIGN	2 hrs.	1 hr.			
INVEST/PROD	0	0	100%	100%	
OPERATION (Related to instruction	0	0			

ADMINISTRATOR SERVICES

NAME ______________________

Step 1: In the first five rows, indicate services used and method of payment by checking appropriate cell (enter dollar figures where possible). Also indicate, by way of a simple statement, how the service was utilized.

Step 2: In the last three rows, indicate the purpose for which the service was used (i.e., Design, Investment/Production, Operation) by entering in the appropriate cell EITHER the number of hours the service was used OR the manner in which the service was apportioned to various types of activities.

Services / Method of Payment/Purpose	Library	Media Services	Printing	Duplication	(Other):
Bookkeeping (Institutional overhead), prorated					
Direct charge for services rendered					
Cash Transaction					
Voucher					
(Other):					
DESIGN					
INVEST/PROD					
OPERATION					

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