UNDERSTANDING COST ESTIMATING AND COST/TRAINING EFFECTIVENESS MODELS - A PLACE TO START

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Abstract

At a time when Government budget cuts are in vogue and increased military readiness is the goal, knowledge of cost estimating and cost/training effectiveness models is essential for decision-makers and training analysts. As with many aspects of our economy, costs associated with training continue to climb. Understanding and correctly using cost estimating and cost/training effectiveness models can help in the area of controlling the costs associated with training. This paper will present a number of the more common cost and training effectiveness models, describe the use of the models and develop a glossary of terms. The material presented here is by no means exhaustive. The intent is to introduce the reader to some of the techniques available and to provide a starting point for learning more about the subject. By being aware of and correctly using these and other types of cost estimating and cost/training effectiveness models, decision-makers will be able to increase the return on the investments made in military training systems. By using these techniques, it will become possible to achieve the goal of receiving better training for less cost.

Introduction

In order to make the right decisions concerning what type of delivery system is most appropriate for a given military training requirement, choices must be made about the costs involved, the effectiveness required and the risks associated with each of the options available. Decision-makers must have access to tools that will allow them to make intelligent choices. These tools are the models, methods and techniques used in conducting cost and training effectiveness analyses. Economic analysis is described as a conceptual framework for systematically investigating problems of choice. As such, it is one method which can aid in decision-making. There are also many others. The information presented here is an attempt to introduce the reader to the subject of cost analysis and cost/training effectiveness methods. For some, the information presented may be too basic; for others it may open an area which with additional study and inquiry, will help improve their decision-making capabilities in selecting training effective and cost effective training delivery systems. Specifically, the Economic Analysis Process will be outlined, with a separate sub-set of this process, Benefit Analysis, described. The Cost and Training Effectiveness Analysis Method will be presented and a short description of the Training Efficiency Estimation Model (TEEM), Training Effectiveness, Cost Effectiveness Prediction (TECEP) and Method of Designing Instructional Alternatives (MODIA) models will be given. As a way to introduce the reader to the subject area, a selected glossary is provided.

Economic Analysis Process

The economic analysis process, as shown in figure 1, draws on the theory of economics for the rationale and justification of the concepts applied. The end objective of this type of analysis is to identify the best return from available resources. Economic analysis helps the decision-making process by identifying the economic implications of alternatives. When performed correctly, an economic analysis will quantify cost and output variables, if possible, and identify those which cannot be quantified.

The main elements of the process are: 1) establishing and defining objectives; 2) formulating assumptions; 3) determining alternatives; 4) evaluating alternatives; 5) selecting an alternative; and 6) performing a budget analysis. Looking at the individual elements which make up the process, the first step in conducting an economic analysis of a training system would be the identification and definition of the intended training objectives. This provides the criteria

against which feasible training alternatives can be measured for efficiency and effectiveness. Next is to formulate assumptions about the analysis to be undertaken in order to set reasonable boundaries in which to work. This limits the number of variables and keeps the process manageable. After these assumptions are made, selection of variable alternatives is required. Identifying these options may well be a task for a training expert or instructional developer. The requirement is for a range of choices to be identified which can conceivably accomplish the task at hand and are sufficiently different from each other as to warrant a decision of choice. Once these alternatives are established, they must be evaluated. This evaluation consists of determining the costs of each alternative, the specific benefits to be derived from them and a comparison of the various alternatives on the basis of both cost and benefit. From this comparison comes a selection and then a budget analysis. The budget analysis determines the allocation and priority of funds to be expended and attempts to identify a best fit solution considering costs and available resources. If at this point in the overall economic analysis process all things are in concert, the decision should be made to execute the program. If a shortfall is identified in either available resources or training returns, the process should be repeated with the next most seemingly reasonable alternative. If this should fail and available alternatives are exhausted, a redefinition of objectives/constraints may be in order. In essence, the economic analysis process is a series of "best fit" comparisons between available alternatives and associated costs, available funding and expectant training returns.

Benefit Analysis

As a result of the Economic Analysis, a Benefit Analysis considers the alternatives available. In order for a decision-maker to compare the various alternatives identified as part of the economic analysis, the returns or benefits of each alternative should be defined. The steps involved in a Benefit Analysis include: 1) determining, listing and defining relevant benefits; 2) establishing sources of information; 3) collecting and displaying the information; and 4) summarizing, evaluating and presenting the findings. When defining the benefits, it is desirable to list all those which can help determine the merits of each alternative considered in the economic analysis. Additionally, consideration should be given to the decision level for the economic analysis. Determining this decision level will help define the benefits relevant to each of the alternatives. Benefit characteristics, which are helpful in defining utility include: being discrete, quantifiable, and discriminative. If a benefit is discrete, it can be clearly and concisely identified and it does not overlap with any other measure. The benefit is quantifiable if it can be directly or indirectly measured using valid techniques. If it cannot be measured, it should be ranked or prioritized. A third characteristic of a benefit is that it should be discriminative. If it is discriminative, it is not spuriously related to the purposes of the decision.

In order to analyze these benefits, it is helpful to categorize them. These categories can be numerous and will include items such as operating efficiency, reliability, accuracy, acceptability, maintainability/ controllability, manageability, availability and quality. By doing this, it is possible to document benefits across categories. Collecting and determining the source of information for benefits is also a necessary part of the process. By accomplishing these tasks, it will be possible to summarize, analyze, evaluate and identify the benefits in a comparative form. By applying a weighting system to each benefit, it is also possible to develop a method to individually quantify each benefit. Some possible techniques which can be used to accomplish this include: graph analysis, regression analysis, decision theory, linear programming, and economic statistical modeling. If some benefits are determined to be nonquantifiable, it would be necessary to use expert opinion or a polling technique, like the DELPHI method, to establish ranking. With the development of a comprehensive benefit analysis, the decision-maker's job is made easier by assembling all information which will be needed to identify and defend specific alternatives to training problems.

Cost and Training Effectiveness Analysis Model

CTEA (Cost and Training Effectiveness Analysis) is described as a method for defining training alternatives, comparing those alternatives, and then defining the proficiency obtainable with each

training hardware combination. CTEA can be used with existing weapon systems in order to organize and present the information needed for decision-makers to select from alternative training approaches which increase man-machine system performance within cost constraints.

While some CTEA methods require empirical performance data, others require only human factors information or task descriptions. All CTEA methods have as their objective the capability to prescribe training program elements likely to be effective, diagnose weaknesses in training programs and predict the probable effectiveness and cost of training systems. This methodology can be used in the early stages of the acquisition cycle to identify existing data to define training options. The same methodology can be used later in the acquisition cycle as a forecaster and diagnostic tool to assess continually what changes in threat, tactics and operations have on the effectiveness of the training systems. The Army in particular has used CTEA methods extensively with their Life Cycle System Management Model (LCSMM) as a way to assure that weapon system development includes integration of user and trainer requirements. CTEA provides the information required for training analysis to assess training alternatives and associated training system costs. Because CTEA is an iterative process, it can be used throughout the entire weapon system life cycle to assess the cost and training effectiveness of the total training system.

Specifically, when used with the Army's LCSMM, CTEA can be used to ensure that training processes are initiated early and are accomplished in parallel with combat development processes. CTEA also ensures that the training subsystem is developed with the same degree of scientific application as is the parent tactical hardware system. The use of CTEA techniques ensures that training system alternatives are considered and that decision-makers are provided with information at critical points of the acquisition process concerning the training and hardware system.

Training Efficiency Estimation Model

TEEM (Training Efficiency Estimation Model) is a predictive computerized model for use with CTEA techniques developed by Jorgensen and Hoffer (1978). Because current acquisition policy requires effectiveness comparisons of the training alternatives of developing systems, and because systems often have no training programs to serve as a basis for comparison in the early stages of development, TEEM can be used to estimate these comparisons. TEEM, as diagramed in figure 2, begins with a task analysis, proceeds through selection of training media and methods, identifies information content and structure, and generates a cost/effectiveness ratio. By running iterations of this model for different training system options, a number of cost/effectiveness ratios can be obtained for consideration and comparison. TEEM uses a set of variables called "metalanguage" to describe the tasks to be learned and the means (media and methods) of learning them. When each variable in the description of the task is matched with the corresponding variable in the descriptions of the training program, an ideal training situation is identified. By comparing this ideal to one which must contend with real-world constraints, such as limited funds and resources, efficiency ratios can be obtained. By using these efficiency ratios, training options can be rank ordered and associated costs determined. With the use of TEEM, predictions of cost and training effectiveness of training programs are made available to decision-makers for use during the appropriate phases of the weapon system and training development process.

Training Effectiveness, Cost Effectiveness Prediction

The TECEP (Training Effectiveness, Cost Effectiveness Prediction) technique acts as a performance aid for the training specialist to use in defining appropriate training strategies for training objectives, choosing an instructional delivery system capable of carrying out the training strategies, and identifying the relative cost of these alternatives. Although developed for use by training system designers who have expert knowledge of media, the technique can be used by others who need a performance aid in exploring the probable cost and effectiveness of various training alternatives, including innovations. TECEP is applied within the training systems development model as described in figure 3. The TECEP technique for choosing cost effective instructional delivery systems consists of three steps. The first step is to clarify and group training objectives according to the type of learning algorithm required to accomplish the objectives. The second step is to take each group of objectives and identify two or more

types of instructional delivery systems which will support the use of the required algorithm. The third step is to estimate the cost of using each alternative delivery system to train the required number of students to meet the objectives. After completing these steps, the final task is to select the most cost-effective instructional delivery system or mix of systems. As figure 4 indicates, the process flow for TECEP moves from a list of training objectives to producing a way to choose a viable instructional delivery system which can be used to accomplish training requirements at a cost that is acceptable.

Method of Designing Instructional Alternatives

MODIA (Method of Designing Instructional Alternatives) is a method useful for comparing well-developed training program alternatives. It does, however, require a greater level of detail and may be difficult to use very early in the life cycle of a weapon and its training system. MODIA has been described by its developers as being neutral in regard to effectiveness of training design. However, it does reveal the impact of design decisions and in this way encourages training designers to consider alternatives. Input to the model includes information such as whether the course requires unusually expensive or scarce resources, course content sequencing, maximum and minimum number of students, effects of tests on student progress, how each unit of the course will be taught, time required, attrition, and the availability and unit cost of resources. The outputs from MODIA include average and peak student load projections, average time to graduation or attrition, resources required, start-up, annual and five-year costs, as well as others. The method itself consists of four elements: 1) a description of options for course design; 2) a user interface; 3) a resource utilization model; and 4) a cost model. The relationships among these four elements are shown in figure 5. By allowing the user of the model to enter at various phases in the overall process, MODIA can be tailored to numerous training situations and the different levels of knowledge about those training situations which exist.

Summary

By becoming more knowledgeable about the methods and techniques available to estimate the costs and effectiveness of military training, decision-makers and training analysts can better define the impact and benefits from investments in proposed training systems. The techniques and methods described here are but a few of those available. By applying the appropriate techniques, alternatives and options can be examined and weighed. By using the proper methods and with the benefit of a thorough understanding of cost estimating and cost/training effectiveness models, and their role in the training process, decision-makers and training analysts can make objective decisions regarding how to achieve the goal of attaining military readiness by providing the best training for the most reasonable cost.

Glossary

This glossary is included to highlight some of the terms and acronyms associated with cost analysis and cost/training effectiveness methods. For a more comprehensive review of this subject area, the authors recommend the U.S. Army ARI references and the curriculum material, which is associated with the course "Cost Analysis for Decision-making," developed and offered through the School of Logistics Science, U.S. Army Logistics Management Center.

Alternative: One of several different ways of achieving a desired capability.

Budget: A financial plan serving as a pattern for control over future operations; hence, any estimate of future costs; any systematic plan for the utilization of manpower, material, or other resources.

Cost Analysis: The process of analyzing and estimating incremental and total resources required to support past, present, and future forces, units, systems, functions, and equipment. In its application to future resource requirements, it becomes an integral step in selection of alternatives by the decision-maker.

Cost Benefit Analysis: An approach to solving problems of choice involving a definition of objectives, alternatives, and what each alternative will yield in benefits. Often used interchangeably with economic analysis or cost-effectiveness analysis.

Cost-Effectiveness Analysis: The quantitative examination of alternative prospective systems for the purpose of identifying the preferred system and its associated equipment, organizations, etc. The examinations

aim at finding more precise answers to a question and not at justifying a conclusion.

Cost Estimate: The estimated cost of a component or aggregate of components. The analysis and determination of cost of interrelated activities and equipment is cost analysis. A result or product of a cost analysis which specifies the expected cost required to perform a stipulated task or to acquire a weapon system or equipment.

Cost Factors: A cost per unit of resource; hence, a value established on a per unit basis which, when multiplied by the number of units or program factor, yields the estimated cost.

Cost Model: An ordered arrangement of data and equations which permits translating physical resources into costs.

DELPHI Technique: A polling technique often used to make expert opinion estimates. The experts in a given technical area are then polled. They are asked to estimate the cost for a system displaying certain specified characteristics. Their responses are summed and a mean, standard deviation and range established. This data is then given back to the experts in another letter and they are allowed to change their estimates, if they desire. After several iterations, an order of magnitude estimate (the mean) results.

Economic Analysis: A systematic approach to the problem of choosing how to employ scarce resources and an investigation of the full implications of achieving a given objective in the most efficient and effective manner. The determination of efficiency and effectiveness is implicit in the assessment of the cost effectiveness of alternative approaches.

Economic Efficiency: That mix of alternative factors of production which results in maximum outputs, benefits, or utility for a given cost. Also, that mix of productive factors which represents the minimum cost at which a specified level of output can be obtained.

Instructional Delivery System: The instructional system which consists of the student and all of the elements with which the student interacts to achieve goals. Included are the instructional media, both hardware and courseware, the instructor, other students in peer instruction, and the direct supporting services for equipment maintenance and development.

MODIA: An acronym standing for Method of Designing Instructional Alternatives. MODIA is used for comparing well-developed training program alternatives and revealing the impact of design decisions.

Risk: As used in cost-effectiveness analysis and operations research, a situation is characterized as risk if it is possible to describe all possible outcomes and to assign meaningful objective numerical probability weights to each one.

TECEP: An acronym standing for Training Effectiveness, Cost Effectiveness Prediction. TECEP is a technique designed for experienced training system designers for use in identifying cost-effective instructional delivery systems.

TEEM: An acronym standing for Training Efficiency Estimation Model. TEEM is a predictive computerized model which generates cost-effectiveness ratios.

Training Effectiveness: The term refers to the specific effects that training has on the students who receive instruction. These effects are usually measured in terms of the time it took students to reach given training goals-objectives and/or according to the levels of achievement reached.

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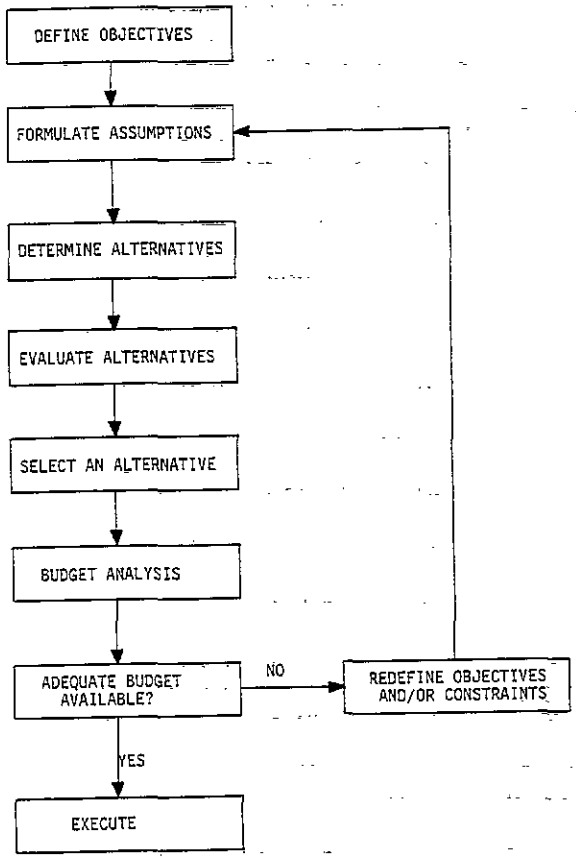

Figure 1. The Economic Analysis Process
(from TAEG Report No. 31)

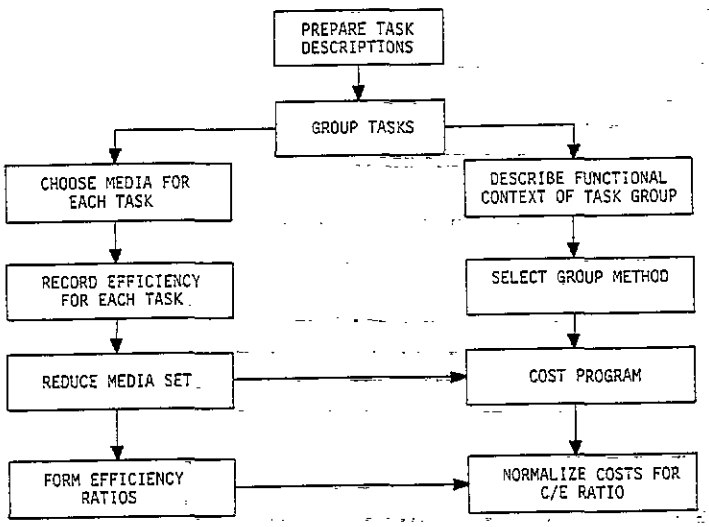

Figure 2. TEEM Overview
(from Jorgensen and Hoffer, 1978)

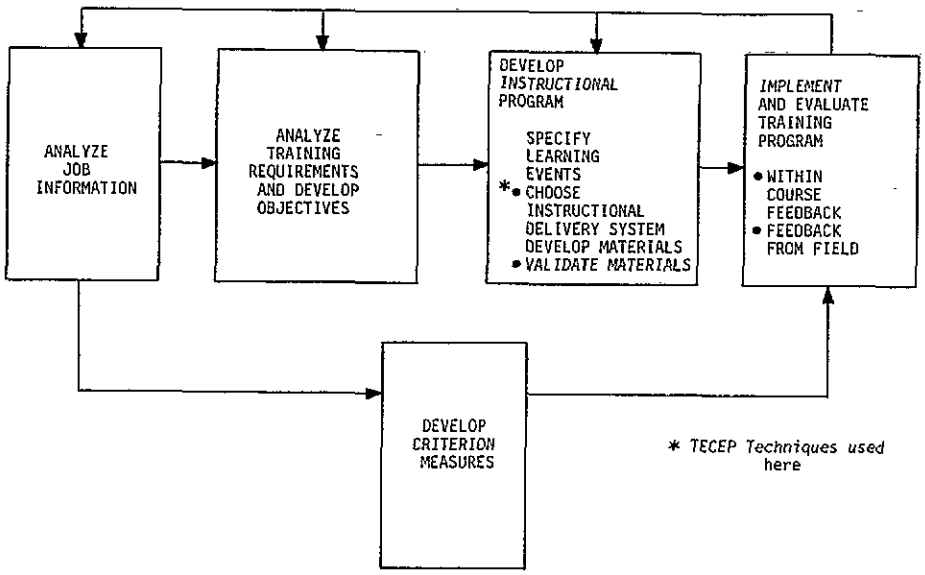

Figure 3. Training System Development Model
(from TAEG Report No. 16)

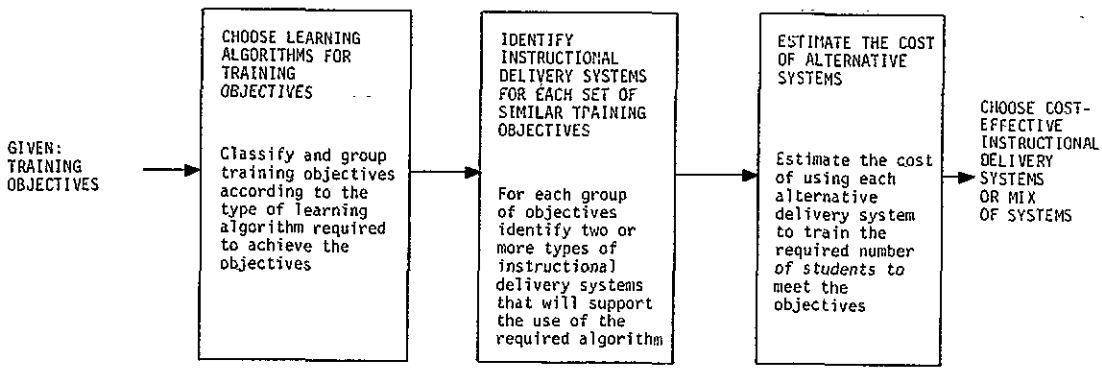

Figure 4. Process Flow in the TECEP Technique
(from TAEG Report No. 16)

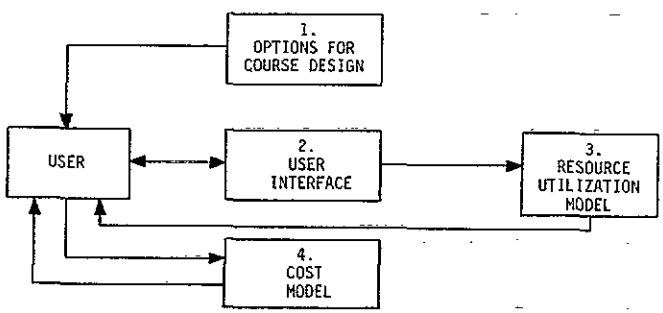

Figure 5. Relationships Among MODIA Elements and the User
(from Carpenter-Huffman, 1977)