DOCUMENT RESUME

ED 260 216 CE 042 051

AUTHOR Geroy, Gary D.
TITLE Validation of the Training Benefit Forecasting Method: Geometric Dimension & Tolerance Training. Training and Development Research Center: Project Number Two.
INSTITUTION Minnesota Univ., St. Paul. Dept. of Vocational and Technical Education.
PUB DATE May 84
NOTE 70p.; For related documents, see CE 042 050-057.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Adult Education; Career Education; *Cost Effectiveness; Job Skills; *Job Training; *Labor Force Development; Manufacturing Industry; Models; *Prediction; Skill Development; *Validity
IDENTIFIERS *Training Benefit Forecasting Method

ABSTRACT

The validity of the University of Minnesota Skills Training Cost-Benefit Forecasting Model (STCBFM) in a corporate setting was studied. Research and related literature suggested that a model for forecasting the economic benefits of training should include facility to identify and summarize costs and provide an assessment of the value of the resulting performance for a specified time period. The model (STCBFM) required that the increases in performance values, minus the training costs, and the resulting benefits be determined. The specific program addressed in the validation effort was a Geometric Dimension and Tolerance training program conducted at Onan Corporation, a manufacturing firm, in 1983. Participants were 136 employees who attended sessions before or after work hours. Four individuals composing a forecast group were presented with the model and asked to make forecasts regarding the costs and resulting benefits to be derived from the training program using minimal available information, such as shop rates, production down time, and current problem resolution time. All the forecasts proved to be conservative. The analysis of the actual cost-benefit reinforced the predictions made by the forecast group. (A paper describing the model is appended.) (YLB)

ED260216

TRAINING AND DEVELOPMENT RESEARCH CENTER

PROJECT NUMBER TWO

VALIDATION OF THE TRAINING BENEFIT FORECASTING METHOD: GEOMETRIC DIMENSION & TOLERANCE TRAINING

Gary D. Geroy

May 1984

university of minnesota
DEPARTMENT OF VOCATIONAL AND TECHNICAL EDUCATION • ST. PAUL, MINNESOTA

CE042051

Table of Contents

Chapter I

Introduction

Evaluation of educational and social programs have historically been carried out with the assumption that the purpose of evaluation is to determine if a program is any good (Anderson & Ball, 1978). In the last decade, program evaluation activities have undergone research to determine, develop, and validate the theoretical foundations associated with the evaluation process. As a result of the work by Sassone (1977), Scriven (1967), Cronbach (1963), Stufflebeam (1973), Stake (1967), and others, program evaluation is now viewed as having six specific purposes (Anderson & Ball, 1978). These specific purposes, which are not necessarily mutually exclusive, include: (a) to contribute to decisions about program installation, (b) to contribute to decisions about program continuation, expansion or certification, (c) to contribute to decisions about program modification, (d) to obtain evidence to rally support for a program, (e) to obtain evidence to rally opposition to a program, and (f) to contribute to the understanding of basic psychological, social, and other processes.

These specific purposes for evaluation have been defined in the literature along with supporting research that provides theoretical frameworks. Over-arching these specific purposes are the evaluative focus on psychological, sociological, and/or economic impact. Cost-benefit analysis is a major method of program evaluation in terms of economic impact.

What is important to realize is that the government was not the only organization investing in people. Increasingly, industry and indeed nearly every organization faces the realization that its workers (the human resource) are a critical component of their success. Since employee training is a major investment for creating human capital out of which labor services emerge, and since the private sector organizations exist to make those gains which are equated to profit, a concern for evaluating training programs both in terms of their effectiveness and economic efficiency exists.

Economically driven organizations will choose programs which have the greatest benefit return on the costs. In terms of human capital investment, this requires accurate cost-benefit evaluation of training which includes all the available training options. Valuing programs and summarizing these values in economic terms is the soul of cost-benefit analysis: assessing the good and bad aspects of a decision alternative by valuing them in terms of money (Thompson, 1980). Kearsly further defines cost-benefit analysis as a technique or method for assessing the relationship between results or outcomes and costs required to produce them (1982).

The purpose then is two-fold: (1) if investment is made in training employees (human capital), are the cost and benefits determined; and (2) if different options exist to do training, what is a reliable method for making training investment decisions based on cost-benefit analysis?

To accomplish these, a simple but powerful tool is needed by decision makers. The tool needs to be easy to use and not require the user to have an economics background in order to produce useful data. The most often used method is to apply cost-benefit analysis tcols designed to address capital investments.

Recently a cost-benefit model was developed at the University of Minnesota Center for Employee Training and Development. This model was presented by Richard A. Swanson and Gary D. Geroy in a paper entitled "Forecasting the Economic Benefits of Training" (1983).

To be useful as a tool for decision makers, this model requires validation in the arena of an economically driven organization.

Purpose of the Study

The purpose of this study is to study the validity of the University of Minnesota Skills Training Cost-Benefit Forecasting Model (STCBM) in a corporate setting.

Chapter II

Review of the Research and Related Literature

Cost-Benefit Perspectives

Employee training takes place in two general ways, formal or informal. Many workers increase their productivity by learning new skills and perfecting old ones while on the job through informal means. This on-the-job training, called unstructured training (Cullen, Sawzin, Sisson, & Swanson, 1976), takes place without benefit of a specific program and often takes place alongside an experienced worker who simultaneously continues to perform his or her regular duties. In their article, "Training, What's It Worth," these same authors define formal training as "structured training" in which training of a new worker takes place through a systematically developed educational program. They further submit that "Whether or not structured training is a frill or a needed production tool can only be assessed if its relative cost effectiveness is known" (p. 12). The objective of the Cullen, et al., experiment was to carry out and report a comparison made to evaluate the effectiveness of these two training methods in terms of training time, worker competence, development and training costs, production losses, reaction to production problems, and attitudes toward training. In their discussion, these authors submitted that in theory a structured training program could develop a better trained worker with objective evaluation of training costs. Additionally, they submitted that "At surface evaluation, unstructured training is inexpensive, effective, and easy to implement" (p. 13).

When viewed from an organizational perspective, training directors are the resource managers who are responsible for this profit or cost center in the company. Top management holds training managers accountable for the results of training in economic and productivity terms. Support of training comes about from training's ability to contribute to organizational objectives, not usually because training is inherently good or will satisfy employees. Cost-benefit analysis compares the cost of developing training programs to the economic benefit or gains from conducting training. It is important that "justification of training should be in organizational terms" (Monat, 1981, p. 47). Thus, cost-benefit analysis "is particularly useful in answering managerial/organizational questions" (p. 48).

Y. R. K. Reddy (1979) submits that "the basic purpose of evaluation is to identify and measure the changes in productivity or profitability associated with a change of training" (p. 50). Within this cost center context, Reddy views this purpose of evaluation from two standpoints. "Firstly, it is to estimate the change in cash outflows and inflows associated with the change in training methods. Secondly, it is to treat the 'benefits' as the change in results from training and the 'cost' as the change in economic sacrifice" (p. 50). The changes due to training can be direct, indirect, or subsequent (long term) (Jones, 1972). Changes in the elements of performance like reduction in machine or plant down time, increased output, waste/scrap, and quality control rejections are the primary sets of benefits that may arise out of direct changes. The second set of direct changes has been identified in the area of flucuations in training time. Under this, it is assumed that any shortening of learning time will result in trainees beginning to make their economic contributions sooner. The third type of direct benefits is identified as increased retention of the people who have developed skill in the particular jobs, i.e. reduction in labor turnover.

In addition, indirect changes were identified by Jones as (a) changes in demands on supervision allowing supervision to be productive in other directions, (b) changes in performance of others affected by the work of trainees, and (c) changes in the degree of flexibility or adaptability which can be used to benefit the company (1972). Jones further went on to identify the subsequent or long-term changes as (a) changes in the level of ability of people presenting themselves for training (i.e. improved recruitment), and (b) positive changes in factors limiting performances of the department or company.

Though the classification of Jones has served the purpose of presenting a framework of possible benefits of training, Y. R. K. Reddy (1979) has criticized Jones for excluding what he

(Reddy) refers to as the "broader effects on the economy and adopting the company's investment angle" (p. 51). Reddy cites the example:

> A transfer of skill or turnover of trained labor from one company to another would be a financial loss to the trainer company. However, from the viewpoint of the society the mobility of skill within the economy is not a loss but merely a transfer. Thus the 'poaching' arguments from the company's point of view cannot be listed as a benefit or a cost in studies using cost-benefit techniques. (p. 51)

Reddy's summation of costs is that evaluative studies of training have taken into account two types of costs, "(a) direct expenditures which may be fixed or variable, and (b) costs of output foregone as a result of training" (p. 52). This difference between what could have been produced and what is produced has been coined "the opportunity cost" of the time spent in training (Becker, 1975). Jones, Moxham & Thomas (1969) also address this issue of opportunity costs. They contend that "all economic costs are opportunity costs; the cost of a factor input in the production of a commodity is the value of the output foregone in its other uses. If the factor has no other simultaneous alternative use, there will be merely an input which has no cost; there will be no output foregone" (p. 232). This approach to viewing costs in training raised the question of the correctness of viewing the wage value of the hours spent as a training instructor of experienced production or supervisory personnel. It is the contention of Jones et al. that organizations contain a certain amount of "slack" as a necessary condition of maximum effectiveness. They submit that:

> This is analogous to the small percentage of unemployment (moving from job to job) which is necessary to a full economy. If the use of workers intermittently as temporary training supervision were at the expense of this sort of slack, it would clearly be an opportunity cost. There may be 'over-manning', excess capacity or disguised underemployment due to restrictive practices or faulty management. In this case, the part time or even whole time use of craftsmen to undertake other activities, such as training, might well be costless to the firm. (p. 233)

Even with this consideration for slack, Jones et al. concede that "there will hardly be any instance where the training of unskilled recruits will be costless to the firm" (p. 236). What is being suggested is that in order to measure the expense of systematic training, it is necessary to cost the learning by doing, then to cost the training situation after the introduction of systematic training, and thus derive the increase in training costs.

What is significant about the earlier literature is the almost total concentration of identifying training costs and comparison of training cost of one method versus another as the strategy for selection of a training option. Alternatively, early literature purports the need to extablish the results of the "old" and the "new" training and then to quantify and evaluate the change in results. Under the latter scheme, none of the costs of training except the cost associated with wages and output during the training period are shown (Jones et al., 1969). In short, the benefits are the change in results. This also has been the traditional view towards formal training in the workplace. Rooted in this view is a philosophy that if unstructured and structured training result in the same results, then why spend the money for training programs? After all, unstructured (on-the-job) training doesn't cost anything.

Cost-Benefit Modeling

Little has been done to address the need for formalized, proven models to aid management in showing a return of training programs. Those investment return models which have been suggested are the same as those used to address capital improvement investments. Three such models which have recently been suggested as methods for justifying training investments are the Return on Investment, Benefit-Cost Ration, and Payback Period models (Barta, 1982) (Figure 1).

- Return on investment (ROI)

$$\frac{\text{annual revenue - annual expenses}}{\text{investment}} = \text{ROI}$$

- Benefit-cost ratio model

$$\frac{\text{training benefits}}{\text{training costs}} = \text{CB ratio}$$

- Payback period model

$$\frac{\text{investment}}{\text{annual savings}} = \text{Payback period}$$

Figure 1. Capital Investment CB Models

Barta also contends that in addition to generating hard dollar data concerning training investment, these models have appeal to managers and stockholders because they are models they are accustomed to dealing with. According to Barta, "The big unknown in training project justification concerns the length of time the return from the training will be effective" (p. 16), and as such provides a weakness in these models.

An original cost-benefit model, specifically to address training, has been suggested by Leonard E. Berry (1982) of Georgia State University in his article entitled, "Deciding on Discretionary Costs" (Figure 2).

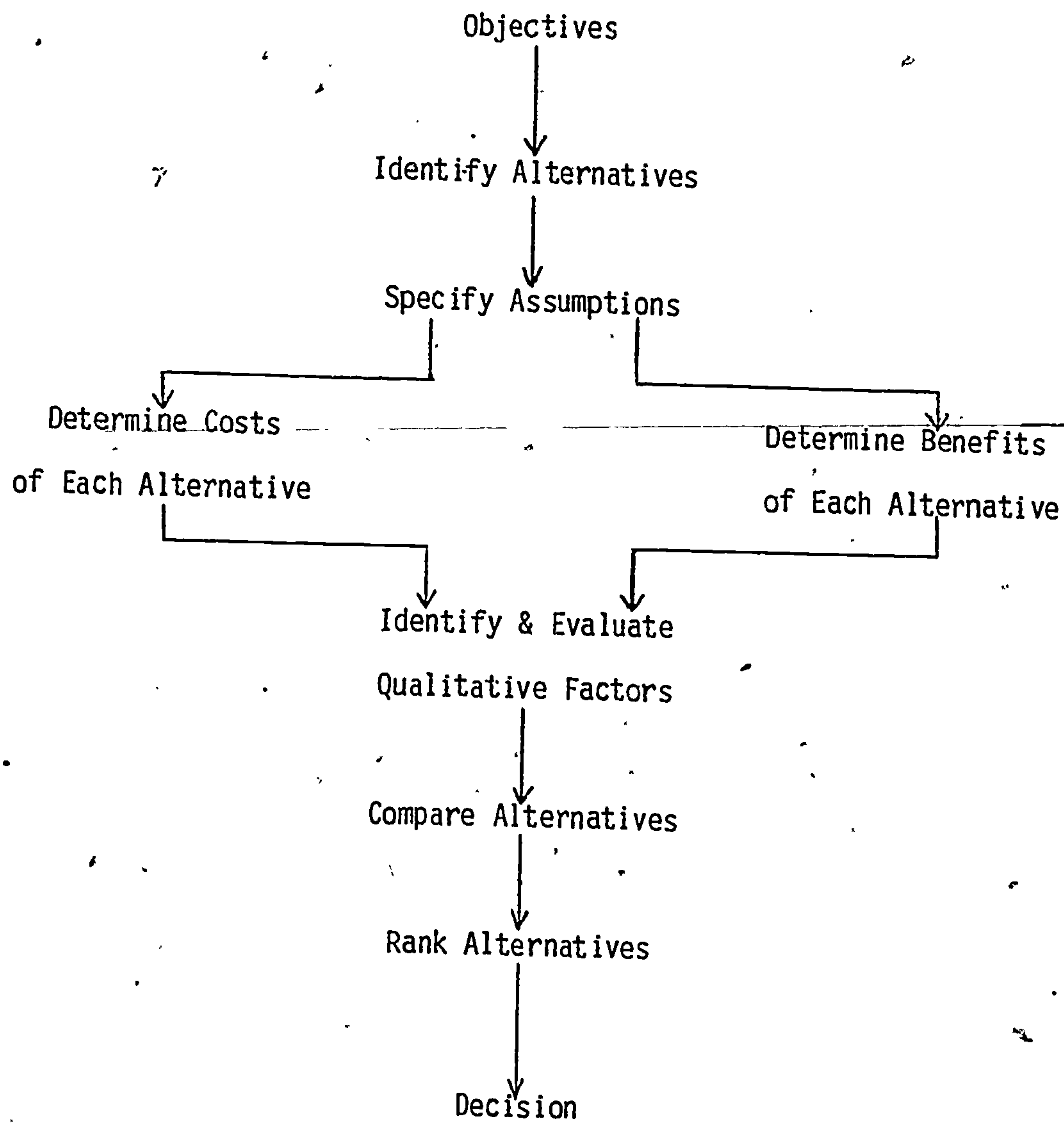


Figure 2. Discretionary Cost Model

Key to applications of this model are two specific assumptions that need to be established. The first is the project economic life and the discount (interest) rate. "The economic life is the time period over which the project is expected to provide benefits. The discount rate will be used to compare costs and benefits that occur at different points in time both now and in the future" (Berry, 1982, p. 39). The model restricts itself to only looking at differential (incremental) costs as relevant costs: "Only differential (incremental) costs are relevant. Differential costs are those costs that will differ among the alternatives. That is, if a cost will not increase (or decrease) if one alternative is selected over the other, then it is not relevant and can be ignored" (p. 39). Berry goes on to clarify that opportunity costs should also be included. "Opportunity costs should be included, too. An opportunity cost is a benefit foregone by selecting a specific alternative" (p. 39). The Berry model calls for the determination of the "incremental benefits". Although Berry does not discuss what an "incremental" benefit is, he submits that:

> This is the most difficult step in the analysis, since benefits may be difficult to quantify. There are three possible approaches for measuring benefits depending upon their characteristics: (1) those that can be measured directly in dollars; (2) those that cannot be measured directly in dollars but can be measured by some other

> quantifiable characteristics; (3) and those benefits that cannot be quantified and must be judgmentally valued. (p. 39)

A major concern should be acknowledged about the portion of the model which deals with the identification and evaluation of the qualitative factors. Berry describes this part of the model in this way: "Numbers, representing costs and benefits usually never provide a complete solution to an expenditure problem. There may be non-quantitative factors that should be considered, which may sometimes dominate the numbers themselves. Here experienced judgment is required in evaluating these factors" (p. 39).

In other words, as a cost-benefit model, its objectivity and effectiveness could be compromised by political and other subjective organizational realities. Unlike the Berry model, Swanson & Geroy (1984) have developed a model which does not provide for qualitative assessment during the cost-benefit analysis process. Additionally, the Swanson & Geroy model provides for valuing of performance as a key element leading to a benefit determination. Unlike other models, benefits are not the value of performance but rather the net of the performance value minus the costs incurred to achieve the performance change (Figure 3).

> Performance value is basically the financial worth of performance units in an enterprise. In its simplest form, cost-benefit forecasting requires that the increases in performance values, minus the training cost, and the resulting

benefits be determined. When performance value exceeds the cost, the training yields a benefit. If the costs exceed the performance value, no benefit results. (Swanson & Geroy, 1984, p. 7)

Option #1

Performance Value

- Training Costs

Benefit

Figure 3. Skills Training Cost Benefit Model (STCBM)

Other models have been identified in the literature, but none of them were designed to be of generic use across business but rather reflected a method that was peculiar to the organization which developed it.

Summary

A model for forecasting the economic benefits of training should include facility to identify and summarize the costs associated with the training and provide an assessment of the value of the resulting performance for a specified time period.

The cost analysis should include direct and indirect costs as well as the measure of the value of production units not produced or performances not accomplished during the training period.

Individuals concerned with cost-benefit analysis of training may not always agree on what should be considered a cost. What is important is that the analysis of training costs use identical criteria when costing each alternative training options under consideration.

Chapter III

The Skills Training Cost-Benefit Forecasting Model (STCBM)

The purpose of this section is to examine the skills training cost-benefit forecasting model (STCBM) (Swanson & Geroy, 1984).

Economic Foundations of the Model

Basic to the model is the understanding that benefits accrue from human capital. It is precisely this basic understanding and desire to maximize the firm's investment, capital and human, with which contemporary industry is grappling. Most firms are looking to the human capital side of their enterprise for significant gains and training is a partial key in unlocking the benefits.

Structured (formal) and unstructured (on-the-job) training have costs. Because an industry does not support a structured training program does not mean that they have escaped training costs. They may escape structured training development and delivery costs, but the costs of unstructured training generally involve a number of inefficiencies such as extended time to become competent, low production, and waste.

It is Swanson & Geroy's contention that organizations exist to make gains and that decision makers determine what gains will be pursued by establishing goals. They (decision makers) then allocate resources (financial or human) to attain the goals. In attempting to improve organizational performance, decision makers at the strategic planning level may choose to support training or non-training options. The training option includes both unstructured on-the-job training and structured training programs. Both incur costs.

Swanson & Geroy submit that while "accountants perceive costs as the outlays necessary to achieve a given set of outcomes, financial managers also perceive costs as the value of the alternatives foregone in order to pursue a particular course of action" (1984, p. 4). Accordingly, all the costs which an organization can identify and associate with its structured or unstructured training must be counted. Employees who are performing at the level of their performance goals are not incurring training costs. Training costs appear when any of the following situations exist:

1. A new employee arrives on the job performance site.

2. An experienced employee is transferred or promoted to a different job, which requires the acquisition of additional skills or knowledge or a change in attitude.

3. An experienced employee's job is modified and performance of the job requires transfer of skills, knowledge, and perhaps different applications of subject-matter expertise.

4. An experienced employee has a loss in knowledge and/or skill.

An analysis of training costs must include the measure of the value of production units <u>not</u> produced or performance <u>not</u> accomplished during the period of training. Finally, training costs include the salaries and benefits paid to trainees and others during the time they are engaged in the training process.

Swanson & Geroy go on to stress that what is "important is that analysis of training costs use identical criteria when determining the cost for each alternative under consideration. Furthermore, the time period for measuring costs should remain consistent in order to make valid comparisons of costs between training options" (p. 5).

The minimum measurable costs of on-the-job unstructured training is the value of employee performance that is below the performance goal during the training period. Swanson & Geroy cite a Johns-Manville study (Cullen et al., 1976) providing empirical evidence to support the position that the average performance per employee during the period of unstructured training is 50% of the performance goal.

The STCBM uses Webster's definition of "benefit" as "making a gain" (1972). They postulate that "positive returns on investments" are benefits. Specifically, they view positive returns on investments as benefits.

> The investment may be one of time or money or material, and the benefit derived may be quality (effectiveness) or quantity (efficiency) of product or service. Another type of benefit may be organization or individual performance gains to which value may be assigned. The value of performance is an

> important part of the training cost-benefit forecast model. Determining the value of performance requires that the total performance or performance units that make up the performance be identified. (Swanson & Geroy, 1984, p. 5)

Within the model, performance value is defined as the "financial worth of performance units in an enterprise." The STCBM stresses that this is not always as obvious as one might first think, but remains the critical task in each analysis effort.

<u>Cost-Benefit Forecasting Method</u>

In its simplest form, cost-benefit forecasting requires that the increases in performance values, minus the training costs, and the resulting benefits be determined. When the performance value exceeds the cost, the training yields a benefit. If the costs exceed the performance value, no benefit results.

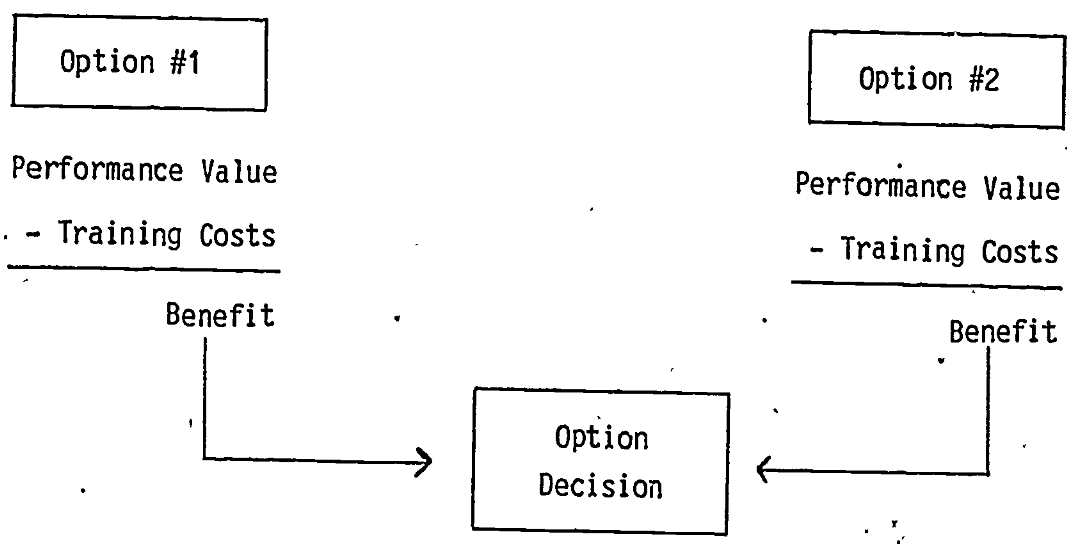


Figure 4. Cost-Benefit Forecasting Model (STCBM) Option Decision Method

The central core of the model is two critical analyses. The analysis of costs and the analysis of performance value.

> In analyzing costs, care must be taken to include all the costs attributable to a specific training option. Costs are calculated for staff time, trainee time, consultants, materials, space, etc., needed to complete each step in the training process; needs analysis, work behavior analysis, design of training, implementation, and evaluation. Accounting for costs may be expressed as total costs per training option or as costs per trainee in each option. Performance value is defined as the worth of performance units produced in dollars. (Swanson & Geroy, 1984, p. 8)

The parameter of the model is defined by the period of time that the analysis will address. Making valid comparisons of alternative training options requires the analyst to set a base time period to be used in calculating performance values for each training option. This time period is set at the longest period of time required by any of the training options under consideration to bring trainee performance up to the performance goal level. If on-the-job unstructured training is one of the options, this usually requires the longest time.

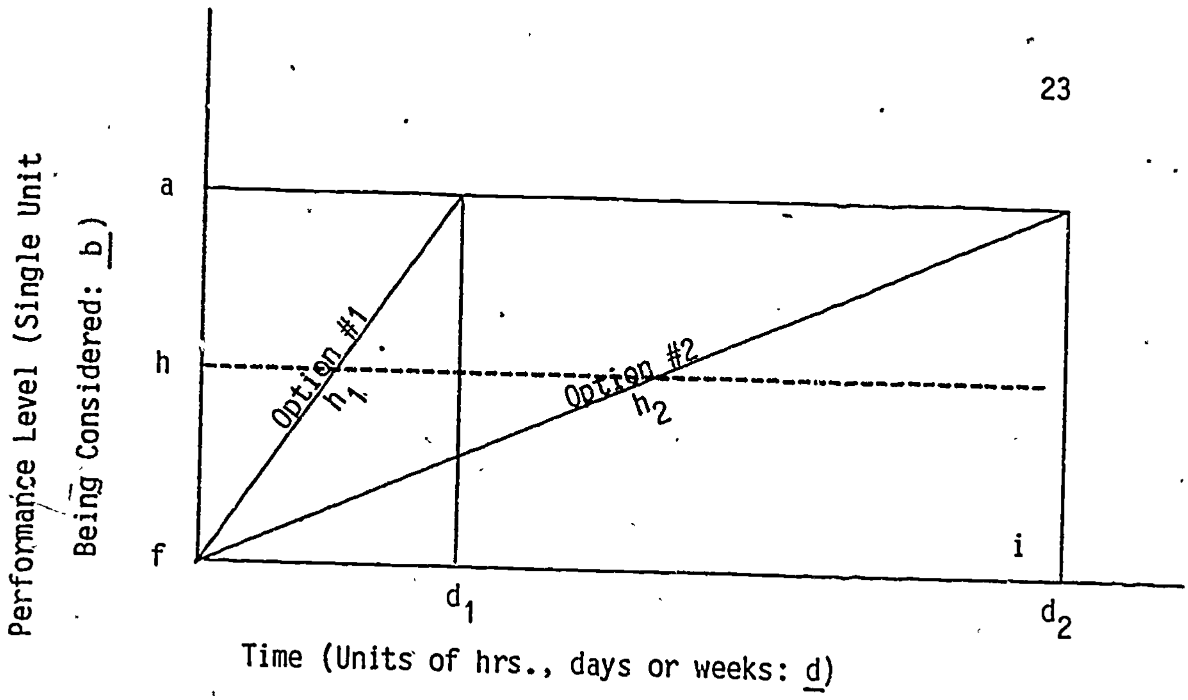


Figure 5. Performance Level Over Time Comparison of Training

Calculations and Required Data for the STCBM

The following data and calculations were required to implement the forecasting model:

(a) performance goal

(b) performance unit of measure

(c) currency value of each performance unit

(d) time required to attain performance goal

(e) number of performance units achieved during training period (i x h x a)

(f) existing level of performance

(g) number of trainees

(h) average performance level during training period

(i) period of comparison (longest "i" of options being considered)

(j) total performance units in comparison period $[(i - d) \times a] + e$

(k) total value of performance ($c \times j \times g$)

Chapter IV

Pilot Testing the STCBM

Pilot validation is the next step in the evaluation of the STCBM. Through a review of the literature, an examination of the theoretical basis for cost-benefit of training has taken place. Additionally, the underlying foundation of the STCBM has been examined and the structure of the theoretical model has been blueprinted.

Research Questions

To evaluate the theoretical model, the following research questions have been developed.

1. Does the STCBM have face validity to corporate users?

2. Does the STCBM reliably forecast (predict) training program cost-benefits?

3. Does the STCBM forecast (predict) valid training program cost-benefits?

4. Does the STCBM work for corporate users not versed in economics?

Procedures

To address these research questions, the following procedures will be used: (1) A training program within a manufacturing corporation which has been completed will be selected for use in their validation study; (2) selected individuals from the organization who are familiar with the objectives of the selected training program will be targeted to initiate and apply the STCBM; (3) a comparison of predictive costs and benefits submitted by the target population will be made; (4) an audit will be conducted to determine the costs attributable to the training program; (5) an audit will be conducted to determine the monetary value of the training performance objectives achieved as a direct result of the training program; (6) a cost-benefit analysis using the actual costs and performance values as determined by the STCBM will be performed; and (7) a comparison of the cost-benefit forecasts by the target population and the actual cost-benefit as determined by the STCBM will be performed.

The following Pert Chart (Figure 6) and the Validation Process Chart (Figure 7) summarize the procedures and processes involved in the validation study.

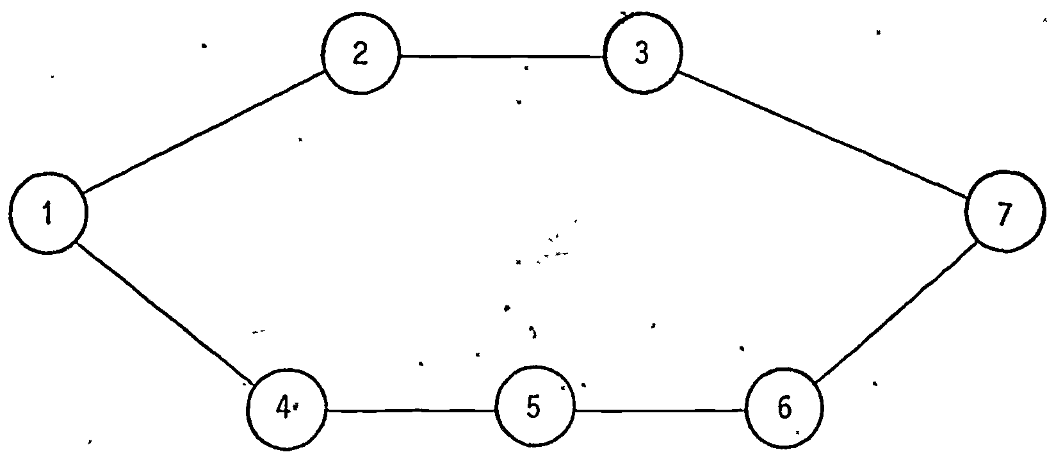
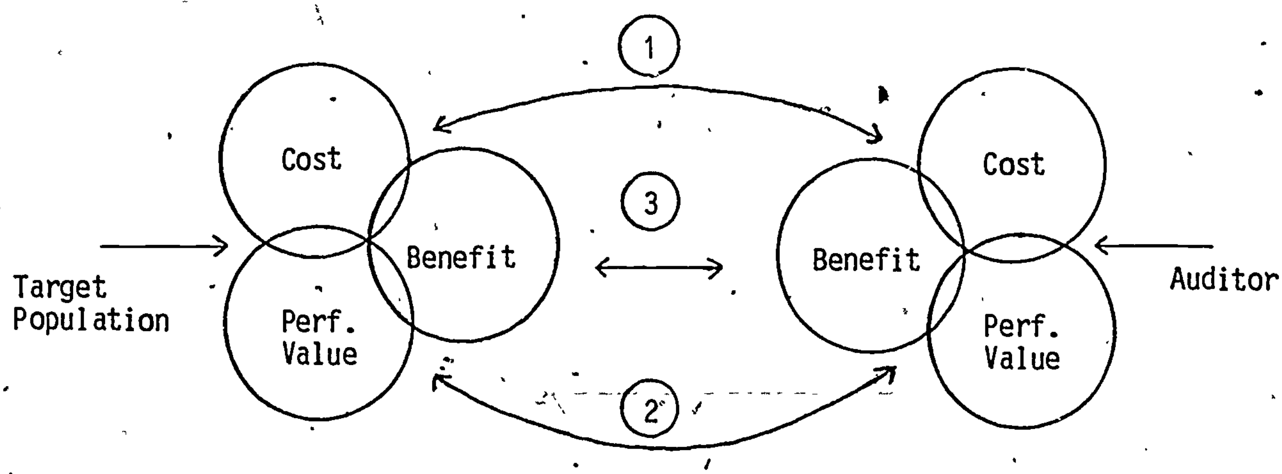


Figure 6. Pert Chart of Procedures



1. Comparison/Contrast of costs & summary of problems.
2. Comparison/Contrast of performance values & summary of problems.
3. Comparison/Contrast of benefits & summary of problems.

Figure 7. Validation Process Chart

Data Analysis

All financial data derived during the research procedure will be calculated in current dollars. In addition, all time measures will be calculated as "full time equivalents" (FTE) and expressed as work years of effort. The basis for 1 FTE is one work year which contains 2,080 hours. Identification of issues of cost, benefit, and performance will be consistent with organization's policies and practices. Furthermore, all cost-benefit calculations will be carried out within the framework of the STCBM.

Chapter V

Identification of the Host Organization, Target Program, and Target Participants

Host Organization

The study of validity of the STCBM was to have been done in a manufacturing organization. The Onan Corporation located in Fridley, Minnesota is a supplier of diesel and gasoline engines to industrial equipment manufacturers, is involved in the electric generator set market, and supplier in the growing market for electronic power conditioning equipment and uninterruptable power supplies for use primarily in the computer industry. Onan was the first manufacturer in North America to introduce a totally new family of medium horsepower diesel engines. This new L-series engine is utilized in portable air compressors, aircraft ground support equipment, and marine application.

Target Program

The specific program to be addressed in this validation effort is a Geometric Dimension and Tolerance training program conducted at Onan in 1983. A total of 136 employees participated in the program. The program was delivered on-site at Onan and participants attended sessions which were scheduled before and after normal work hours. The program content was the result of a joint effort by Onan Training Department personnel and representatives from three local technical education institutions who were the vendors who presented the program. The proposed content was reviewed by representatives from various departments which would provide participants before the final course was approved. The course structure provided for 32 hours of in-class instruction (16 meetings) and the cost per person included textbooks and materials.

Target Population

The 136 participant population was made up from members of several different departments with diverse responsibilities within Onan. The focus of this study will be the population of participants from the Experimental Machining Department.

The workers within the Experimental Machining Department at Onan Corporation perform: (a) custom production of prototype equipment and parts, (b) limited custom production runs, (c) experimental machining and fabrication of modifications to existing production units, and (d) evaluation of new designs for main plant production feasibility. The worker experience of the group ranged from three to fifteen years.

Chapter VI

Data: Discussion and Analysis

Prior to submitting a request for training assistance from the training department, the manager and work group identified two problems. Generally, they had difficulty reading and interpreting blueprints as they were received from the engineer group. Specifically, the machinists did not understand all engineering symbols and were unable to make inferences from scant engineering drawings that were often the only source of specifications for prototype production. Additionally, they felt that they lacked credibility with the engineering group. The machinists suggested that they lacked the theoretical background and formal methodology training to calculate changes in dimensioning to engineer-prepared designs. They also admitted that their "gut feelings" about whether or not a required operation would work or not, were ignored by the engineer group until a unit was completed and proven unsatisfactory or procedures which were called out in the design could not be carried out on existing equipment.

The manager and workers in the Experimental Machining Department suggested to the training department that a training program in geometric tolerance techniques would enable them to understand the engineer-prepared work drawings. This would result in less time in clarification as well as reduce scrap and labor due to misinterpretation. Additionally, they submitted that they would be able to calculate engineering-acceptable work drawing changes that would reflect procedural or layout modifications required to insure production feasibility.

The objective of the group was to reduce the amount of shop time spent on wasted prototype production effort by 50% on projects with problems and to identify those prototype projects with potential machining problems before set-up, jig making, and machining. This would be achieved by application of geometric and tolerance skills in pre-production review of drawings, for feasibility and by post "first-piece" production application of these skills in developing procedures and layout modifications to address problems identified during first prototype effort.

The group anticipated that 90% of the potential problems could be identified and resolved in the pre-production review and that the prototype machinists would be able to resolve those problems that were revealed during the first machining effort.

Procedural Activities

The early activities associated with this study took two foci: (a) the work group receiving the training, and (b) the individuals targeted to initiate and apply the STCBM.

A meeting was held with the experimental machining group to discuss the project and to request their support. Following this initial meeting (attended by all machinists and the unit manager), a second meeting was held. Discussion centered on the identification of specific data that represented both prior and current activities associated with prototype machining and related issues.

The data which was provided by the Experimental Machining Department is summarized as follows:

1. A typical prototype machining effort may take from four hours for general machining to five days for specialty machining.

2. The engineering group typically takes 2-20 hours of effort to resolve a geometric tolerance problem.

3. Shop rates for prototype work are $17.50 per hour for in-house and $150.00 per hour for out-of-shop work.

4. It was estimated that up to 50% of engineer drawings had potential or obvious problems that required the application of geometric tolerance skills for their resolution.

Additionally, the group was able to identify two specific projects whose problem resolution procedures were directly influenced by the training the involved machinists received. The performance values associated with the two projects have been determined and are represented in the data analysis of this study.

These two projects were considered significant by the machinists because they represented the two types of problem scenarios that were identified by the work group prior to the training. The first project was the machining of a transmission adapter plate required to accommodate an auto transmission to a diesel engine for an experimental fleet test. The production request was for fifty units.

The machinist involved stated that normally he would have set-up and run the pieces per the engineering sketch, but because of the training he recognized that the specification for the guide hole for mounting location had been drawn and dimensioned to the casting specifications and not to the machined surface specification. The net result would have been a scrapping of all fifty units.

The second project that was pointed out by a machinist as one where the training was applied, was the machining of flex plates for the same experimental fleet project. In this situation, the machining procedures involved welding and machine facing. The machinist's experience suggested that the machine faced plate would not hold a surface wide tolerance when the welding procedure was performed. The machinist related how he had been required to go ahead with a similar procedure during an earlier experiment. The result then was a 100% rejection rate of the ten units produced. The machinist calculated that a point-to-point tolerance on the machined face could be held if the dimensioning of the part was changed to allow for the required procedure. Failing this, a new and substantially more expensive procedure would have to be followed. In this project, the machinist used mate part dimensioning as a basis to calculate and annotate the drawings which were then routed back to the engineer group for approval prior to machining any parts. These changes ultimately became the permanent specifications for the flex plate. In this project, the issues of credibility, and blueprint reading and interpretation were addressed.

The other focus of activities was the individuals who would initiate and apply the STCBM. Four individuals were identified and agreed to participate in this study. They represented management, training, and manufacturing engineering backgrounds.

As a group they were presented with the model during a briefing of the study. Additionally, they were provided with the background information summarized in the preceding section and the summary of data from the experimental machining group. At no time were they informed of any of the outcomes of the training that had been identified and discussed by the experimental machining group.

The STCBM forecasting group was allowed ten days to develop individual cost-benefit projections. The cost-benefit forecasts submitted by the members of the forecast group are summarized on Table 1.

Forecaster #	1	2	3	4
Performance Value	$1,458	$1,008	$700	$1,232
Costs	66	81	81	95
Benefit	$1,392	$ 927	$619	$1,137
Ratio [Benefit:Cost]	[21:1]	[11:1]	[8:1]	[11:1]

Table 1

Cost-Benefit Forecasts for Experimental Machine Group

All participants agreed in this situation that there would be a benefit to investment in training. The ratio of benefit to cost prediction ranged from 7:1 (#3) to 21:1 (#1) with two forecasts agreeing on 11:1 (#2 and #4).

The actual costs of the training were determined by reviewing the invoices submitted by the vendor institutions to Onan. That cost was distributed equally across the trainee population and includes all support material and books (Table 2).

	Actual Costs
Total Cost of Training	$10,959.00
Total Number of Participants	136
Cost Per Participant	$ 80.50

Table 2

Cost and Performance Value Analysis

The analysis of the actual performance value of the training outcome has focused on two workers from the target group whose job performance was directly related to course content knowledge and skills acquisition. The result was the identification of two specific projects which had problems in layout and procedures that were treated with the newly acquired skills. In both cases, the performance value focused on the value of the saved time which was in keeping with the goal of the training (Table 3).

	Drive Disks	Transmission Adaptors
Value	$15.48 per hour per unit	$80.13 per hour per unit
Production Rate	2.0 hours per unit	4.5 hours per unit
Price per Unit	$15.48 x 2.0 = $30.96	$80.13 x 4.5 = $360.59
Price of Project	$30.96 x 50 (production order) = $1,548	$360.59 x 50 (production order) = $18,029.50
# Hrs. in Project	50 units x 2.0 hrs. = 100	50 units x 4.5 hrs. = 225
# Hrs. in 80 wk. days	640 hours	640 hours
Goal	save ½ of 50% of time in 80 days = 160 hours	save ½ of 50% of time in 80 days = 160 hours
Actual Performance Value	160 hr. goal value @ 100 hr. project rate ($15.48)= $2,476.80	160 hr. goal value @ 225 hr. project rate ($80.13)= $12,920.80

Table 3

Cost and Performance Value Analysis: Actual Performance Value

Chapter VII

Summary

The analysis of the actual cost-benefit is shown in Table 4. The data reinforces the predictions made by the forecast group that there would be a benefit derived from the training investment.

Net Performance Value		
Drive Disks	$ 2,476.80	
Transmission Adaptor	$12,820.80	
		$15,297.60
Cost of Training Program for 15 members of Experimental Machining Group		$ 1,207.50
Benefit		$13,929.10
Ratio [Benefit:Cost]		11:1

Table 4

Benefit Analysis (actual dollars)

Although there are differences between the values of the predictions for cost, performance value, and benefit, and the actual values that were determined, the predicted ration of benefit to cost for two predictors agreed with the actual 11:1 benefit:cost ratio.

The model was usable by the forecast group although there was some confusion on how to calculate some of the needed information. In addition, the participants experienced difficulty in defining what parts of the briefing data (Appendix C) should be used in preparing the forecast. The latter problem is not one which can be addressed by the model as it is very forecaster dependent.

The forecast group's difficulties on the model can be focused on the performance value calculations. The (a) sequence of the calculations of the performance value, (b) descriptors used in the performance value calculation, (c) lack of guidance leading to decision points, and (d) clarity of the calculations required were the main user criticisms of this part of the model.

The first issue focused on the calculation in item e, "estimated number of units achieved in training" (see Table 5). The calculation requires that elements i, "period of evaluation," and h, "estimated performance level during training," sequentially further into the model be known. It has been suggested that this calculation be sequenced between what are now elements i and j.

The second issue was the descriptors used in the elements of the performance value calculation. The participants in the forecast group found the cryptic descriptors difficult to use as guides to initiate activities for each element of the performance value calculation. Major changes in language should not be needed if the job aid worksheet (Appendix B) becomes the primary vehicle of effort for this part of the model. However, some minor changes should enable anyone to understand what is required in the performance value analysis. Their suggested changes in language are incorporated into a proposed revised performance value calculation model contained in Table 5.

a. Performance goal

b. Performance units of measure

c. Value of each performance unit

d. Estimated training time to reach goal

e. Estimated # of units achieved in training (i x h)*

f. Current level of performance

g. # trainees participating

h. Estimated performance level during training

o Did training produce during training? $\underline{\quad}$ No = ave. perf. = 0

$\underline{\quad}$ Yes = ave. perf. = $\frac{a - f}{2}$

i. Period of evaluation (the longest "d" of all options under consideration)

j. Total performance in period of evaluation [(i - d) x a] + e

k. Total performance value for evaluation period [c x j x g]

**l. Net performance value [k - (f x c x d)]

---

*formula changes

**additional calculations

Table 5

Summary of Changes for Proposed Revised Performance Value Model

The third issue of concern was the lack of explicit guidance leading to decision points. It was suggested that a job aid to assist users through decision steps would be very useful in the operationalizing of this part of the model. A proposed job aid to meet this need is the job aid worksheet (Appendix B).

This job aid also includes the recommended calculation sequence changes as well as the addition of one calculation to clarify how to determine net performance value gain resulting from the training. Additionally, a revision of the calculation to determine the average performance during the training period has been included. This responds to the fourth issue of concern by the forecast group that some of the calculations needed were not clearly set forth. Under the current calculation sequence, determination of the average performance of the trainee during training is based on a 50% of goal performance assumption. This is supported by studies but does not apply equally to situations where improvement of existing performance other than that of zero is the goal of the training. To aid forecasters in determining the average performance during training, if any performance takes place at all, it is suggested that the sum of the performance goal plus current level of performance, be divided by two (see item g, Appendix B).

The addition of a calculation to determine the net performance value gain of the training helps ensure that this calculation is carried out (see item l, Appendix B). This is in keeping with the models concept that the net gain in performance value measured during a specified period of training comparison must exceed the cost to make that gain if there is to be a determined benefit.

Chapter VIII

Conclusions and Recommendations

The STCBM allowed individuals to make forecasts regarding the costs and resulting benefits to be derived from a training program using minimal available information, such as shop rates, production down time, and current problem resolution time (see Appendix C). Furthermore, all the predictions were consistent regarding both the benefit to the training investment and the decision to implement the training.

Verbal feedback from the participants following their forecasts indicated a greater degree of difficulty using the model than they had anticipated after being briefed on it and reading supporting material (Appendix A). Yet, all participants felt the model usable and useful.

All the forecasts proved to be conservative (Table 1). The projected benefits were all less than the actual benefits derived (Table 4).

It is recommended that the changes suggested in the summary section be instituted in the STCBM and that other studies be performed using the modified STCBM. If possible, the STCBM should be used next in a skills training sequence where historic records of units' outputs are more readily available in order to provide a broader base of comparison.

References

Anderson, S. B. & Ball, S. (1978) The profession and practice of program evaluation. San Francisco: Josey-Bass.

Barta, T. (1982). Methods to determine returns on training investment. Performance & Instruction Journal, 21(1), 16-17, 24.

Becker, G. S. (1975). Human capital (2nd ed.). Chicago: University of Chicago Press.

Berry, L. E. (1982). Deciding on discretionary costs: A cost benefit approach. Cost and Management, 56(10), 38-41.

Cronbach, L. J. (1963). Course improvement through evaluation. Teacher College Record, 64, 672-683.

Cullen, J. G., Sawzin, S. A., Sisson, G. R., & Swanson, R. A. (1976). Training, what's it worth? Training and Development Journal, 30(1), 12-20.

Jones, J. A. G., Moxham, J. & Thomas, B. (1969). A cost-benefit analysis of industrial training. British Journal of Industrial Relations, 7(2), 231-264.

Kearsley, G. (1982). Costs, benefits and productivity in training systems. Reading, MA: Addison-Wesley.

Monat, J. S. (1981). A perspective on the evaluation of training and development program. Personnel Administrator, 26(7), 47-52.

Reddy, Y. R. K. (1979). Cost-benefit analysis of training--an appraisal. Long Range Planning, 12(24), 50-55.

Sassone, P. G. & Schaffer, W. A. (1977, March). Cost-benefit analysis and economic evaluation of business activity. Paper presented at seminar at Georgia Institute of Technology.

Scriven, M. (1967). The methodology of evaluation. American Educational Research Association Monograph Series of Curriculum Evaluation, No. 1, Chicago: Rand-McNally.

Stake, R. (1967). The countenance of educational evaluation. Teacher College Record, 68(1), 523-540.

Stufflebeam, D. L. (1973). A new conceptualization of evaluation competencies. Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Swanson, R. A. & Geroy, G. D. (1983, August). Economics of training. Paper presented at the 12th International Conference of the International Federation of Training and Development Officers, Amsterdam, Netherlands.

Swanson, R. A. & Geroy, G. D. (1984). Forecasting the economic benefits of training. Manuscript submitted for publication.

Thompson, M. S. (1980). Benefit-cost analysis for program evaluation. Beverly Hills: Sage Publications.

Webster New Collegiate Dictionary. (1972). New York: Merriam.

APPENDIX A

Forecasting the Economic Benefits of Training

Center for Employee Training and Development
University of Minnesota
St. Paul, Minnesota

STUDY NUMBER ONE

Forecasting the Economic Benefits of Training[1]

Richard A. Swanson and Gary D. Geroy

April 1984

[1]This article is based on a paper entitled "Economics of Training" presented to the 12th International Conference of the International Federation of Training and Development Organizations, Amsterdam, Netherlands, August 17, 1983. The authors wish to acknowledge the financial support received from Onan Corporation of Minneapolis, Minnesota, for the conduct of this research, and to Deane Gradous for her assistance in reviewing this manuscript.

Running Head: FORECASTING THE ECONOMICS

Forecasting the Economic Benefits of Training

A medium-sized manufacturing company that produces electronic circuit boards has had a steady and profitable life. Even with high employee turnover and a 12% product rejection rate, they make good money. With no formal training programs in place, the idea of training costs never entered management's mind. Consciously spending any money on training was a departure from normal practice. The $15,000 proposed by an outside consultant for training ten assembly workers seemed extravagent beyond reason.

The concept of cost-benefit analysis has been with us for decades. Despite this, it is a concept which management continues to use selectively. Baxter's law tells us that "an error in the premise will appear in the conclusion." To make human resources development decisions on only costs is a faulty premise that continues to plague management. In the introductory situation of circuit board production, the forecasted short-term benefits from training proved to be in excess of $200,000.

Most organizations are not at a loss for ways to spend money. When investment decisions are being considered, diverse options are generally available to management. In most instances, the human capital investment options are not accompanied by cost-benefit analyses. Yet, these human capital proposals are often competing with investment options in areas such as capital improvement and work method changes that are typically supported with explicit cost-benefit analyses.

Managers face a major problem. Knowledge of the economics of training, one of the major human capital arenas, is limited. Beyond a few studies (Cullen, Sawzin, Sisson, & Swanson, 1976; Rosentreter, 1979; Thomas, Moxham, & Jones, 1969), attention to the micro-economic analysis of training has been minimal. Searches through the literature on the costs and benefits of training will uncover large voids in the areas of economic descriptions of training efforts, forecasting of training costs and benefits, and experimental assessment of the economic factors of training. In addition, most cost-benefit experts focus on capital investment and depreciation decisions and not on the value of human performance. In this article, a method for forecasting the economic benefits of training is presented to fill the void.

Training efforts, training results, and the aggregation of their values in economic terms is the basis for making a cost-benefit analysis. Assessing the costs and the gains to be expected from training alternatives fosters rational decision making. Is it more cost-effective to conduct on-the-job training than it is to formalize training for a particular setting? Would it be wise to ask an outside expert to do the training for us? Trainers should be able to present the answers to these questions.

Forecasting Training Costs and Benefits

Organizations exist to make gains. Decision makers determine what gains will be pursued by establishing goals. They then allocate resources (financial or human) to attain the goals. In attempting to improve organizational performance, decision makers at the strategic planning level may choose to support training or non-training options. The training option includes both unstructured on-the-job training and structured training programs. Both incur costs. Therefore, managers and their trainers should consider the following principles in making training decisions:

1. Training professionals should be able to make decisions that result in acceptable cost-benefit relationships.

2. Given an economic organizational goal, all the costs and benefits of training should be converted into monetary terms.

3. If the organization is in financial difficulty, improving efficiency while maintaining effectiveness is the primary focus.

4. If the organization is experiencing problems with quality/ performance, improving effectiveness while maintaining efficiency is the primary focus.

There are alternative views of costs. Accountants perceive costs as the outlays necessary to achieve a given set of outcomes. Financial managers perceive costs as the value of the alternatives foregone in order to pursue a particular course of action. For example, by taking a worker off the job to receive training, the organization foregoes the worth of that worker's potential productivity had the worker remained on the job. Conversely, to retain an inadequately trained worker on the job eliminates expenditures for structured training while accepting below acceptable productivity until the employee finally reaches competence.

Cost Considerations

Training costs and, therefore, training budgets may be inaccurately identified by managers and trainers. All the costs which an organization can identify and associate with its structured or unstructured training must be counted. Employees who are performing at the level of their performance goals are not incurring training costs. Training costs appear when any of the following situations exist:

1. A new employee arrives on the job performance site.

2. An experienced employee is transferred or promoted to a different job, which requires the acquisition of additional skills or knowledge or a change in attitude.

3. An experienced employee's job is modified and performance of the job requires transfer of skills, knowledge, and perhaps different applications of subject-matter expertise.

4. An experienced employee has a loss in knowledge and skill.

An analysis of training costs must include the measure of the value of production units not produced or performance not accomplished during the period of training. Such training costs may be measured by comparisons of production lost among alternative training options. Training costs also include measures of expenses directly and indirectly associated with the development and delivery of structured training. Finally, training costs include the salaries and benefits paid to trainees and others during the time they are engaged in the training process.

Measuring Training Costs

Managers, trainers, and accountants may not always agree on what specific items should be considered training costs. What is important is that analysis of training costs use identical criteria when costing each alternative under consideration. Furthermore, the time period for measuring costs should remain consistent in order to make valid comparisons of costs between training options.

The minimum measurable costs of on-the-job unstructured training is the value of employee performance that is below the performance goal during the training period. A Johns-Manville study (Cullen, Sawzin, Sisson & Swanson, 1976) provides empirical evidence to support the position that the average performance per employee during the period of unstructured training is 50% of the performance goal.

The forecasting model proposed in this paper identifies generic categories of training costs for summarizing those costs which may be unique to the reader's organization. Categories for costs incurred from losses of time, material, and production/performance are included. General guidelines and examples of training costs are shown in Table 1.

Insert Table 1 about here

Benefits Profiles

Benefit is defined as making a gain. Positive returns on investments are benefits. The investment may be one of time or money or material, and the benefit derived may be quality (effectiveness) or quantity (efficiency) of product or service. Another type of benefit may be organization or individual performance gains to which value may be assigned. To illustrate, an increase in quantity of production per unit of time has a measurable value when viewed as time gained and available for producing additional products or services at a given performance level. Likewise, quality can be measured as a gain in the value of units produced (i.e., less rejects, lower service, and warranty costs) at the same level of performance. The value of performance is an important part of the training cost-benefit forecast model. Determining the value of performance requires that the total performance or performance units that make up the performance be identified. This is not always as obvious as one might first think and remains the critical task in each analysis effort.

Performance value is basically the financial worth of performance units in an enterprise. Performance units can be expressed in any manner indigenous to an organization. They should be judged on a common comparison time period when training options are being compared.

Cost-Benefit Forecasting Method

In its simplest form, cost-benefit forecasting requires that the increases in performance values, minus the training costs, and the resulting benefits be determined for each training alternative under consideration. When the performance value exceeds the cost, the training yields a benefit. If the costs exceed the performance value, no benefit results. The highest projected benefit among training alternatives leads the decision maker to the most desirable option (see Figure 1).

Insert Figure 1 about here

Analysis of Costs

In analyzing costs, care must be taken to include all the costs attributable to a specific training option. Costs are calculated for staff time, trainee time, consultants, materials, space, etc., needed to complete each step in the training process; needs analysis, work behavior analysis, design of training, implementation, and evaluation. Accounting for costs may be expressed as total costs per training option or as costs per trainee in each option.

Analysis of Performance Value

Performance value is defined as the worth of performance units produced in dollars. Making valid comparisons of alternative training options requires the analyst to set a base time period to be used in calculating performance values for each training option. This time period is set at the longest period of time required by any of the training options under consideration to bring trainee performance up to the performance goal level (see Figure 2).

Insert Figure 2 about here

If on-the-job unstructured training is one of the options, this usually requires the longest time. The following data and calculations are required to implement the forecasting model:

(a) performance goal

(b) performance unit of measure

(c) currency value of each performance unit

(d) time required to attain performance goal

(e) number of performance units achieved in training period (i x h x a)

(f) existing level of performance

(g) number of trainees

(h) average performance level during training period

(i) period of comparison (longest "i" of options being considered)

(j) total performance units in comparison period [(i - d) x a] + e

(k) total value of performance (c x j x g)

A Cost-Benefit Forecasting Case Study

In this real-life case study employees of a manufacturer of specialized circuit boards for electronic equipment have been trained by an unstructured on-the-job method. The firm's circuit board assembly workers read at an average level of seventh grade, and they all experience difficulty in understanding the English language. Approximately forty (40) working days are required for a new assembly worker to reach the acceptable performance level of three good circuit boards every two days. Each circuit board is valued at $600. Assembly workers are paid $9 per hour. Once workers reach the performance goal level, they generally experience a rework rate of one (1) circuit board out of eighteen (18) because of poor soldering or incorrect positioning of one or two installed parts. Management is considering designing or contracting for a training program to decrease the time required for new assembly workers to achieve the current acceptable level of performance. They are considering the use of a commercially available ten-day training course at a cost of $1500 per trainee. This course provides training in basic soldering technique, component identification, blueprint reading, instrument calibration, basic circuitry design, theory and practice, and systems diagnostics.

Additionally, management hired a training consultant to do a training needs assessment and propose content for an in-house training course as a possible alternative to meet the manufacturing skill needs of the company. The consultant submitted a report and a bill for $2,200. The consultant recommended that in order to meet the manufacturing skills needs of the company, the training should cover basic soldering techniques, identification of components for the circuit board, and electronic circuitry blueprint reading. He further recommended that the workers be provided with job aids to help them in identifying correct components and proper installation. The consultant recommended that the job aids should be 8" x 10" color photos of correctly built circuit boards. He felt this would facilitate workers' continued learning of the proper identification and placement of components. The consultant also recommended that the total training time would need to be eight working days at the conclusion of which the new assemblers should be able to produce at the rate of three boards every two days at the current quality level. Management believes that development and delivery of the in-house training course could be handled by the in-house training staff and the chief electronic engineer. Temporary clerical support will be hired to assist during the analysis, design, and development steps.

Management must decide whether ten new employees will receive the in-house training, whether they will attend the commercially available training course, or whether they will be trained on the job as in the past. A cost-benefit analysis of the three training options under consideration--unstructured, commercial course, or in-house training--will lead the decision maker to the highest projected benefit, which in this case is option #3, in-house training (Figure 3). The forecasted benefit was $270,444.

Insert Figure 3 about here

Table 2 illustrates the cost analysis and Table 3 the performance value analysis that lead to benefit analysis and option decision.

Insert Table 2 about here

Insert Table 3 about here

This real-life case study was the first of a series being conducted in Onan Corporation by the Center for Employee Training and Development, University of Minnesota. Studies presently underway include forecasting the costs and benefits of geometric tolerancing training, welder training, secretarial grammar and punctuation training, and manager writing skills training.

Conclusion

Analysis of the economics of training has become one of the most important issues of the decade for business and industry. The quality of the analysis tools available to managers and training professionals will affect the quality of their training decisions. The cost-benefit analysis described in this article demonstrates that training decisions can be made on the basis of rational thought and economic analysis.

Cost-benefit forecasting methods, such as the one presented here, are important decision-making tools in the workplace. Managers and trainers who can discuss training activities in economic terms will be at an advantageous position in contributing to the strategic plans for the human capital in their firms. As management thinks more seriously about human capital and about strategic planning for human resources, the training function will become more central to the firm. Furthermore, those who understand the economics of training will be in a better position to contribute to the vitality of their organizations.

References

Cullen, J. G., Sawzin, S. A., Sisson, G. R., & Swanson, R. A. (1976). Training, what's it worth? Training and Development Journal, 30(8), 12-20.

Rosentreter, G. E. (1979). Economic evaluation of a training program. In R. O. Peterson (Ed.), Training and Development: Research Papers from the 1978 ASTD National Conference (pp. 164-182). Madison, WI: American Society for Training and Development.

Thomas, B., Moxham, J., & Jones, J. A. G. (1969). A cost benefit analysis of industrial training. British Journal of Industrial Relations, 7(2), 231-264.

Table 1

Cost Analysis Categories

Cost analysis categories	Guidelines/Examples
Staff	Wages of clerical/secretarial, hourly or salaried subject matter experts, trainers or other employees involved in the training effort.
External Consultants	Fees and associated expenditures for externally hired subject matter and training design experts involved in the specific training effort.
Materials	Items which will either become a permanent part of the specific training effort or which will be consumed in the training related effort.
External Support Costs	Professional, skilled, or semi-skilled labor or services required to support any or all aspects of the training effort.
Trainee	Wages, mileage, lodging, and meal expenses associated with trainee

(table continues)

Cost analysis categories	Guidelines/examples
	attendance of training effort.
Facilities	Expenses associated with room or equipment rental, utilities, or facility modification directly related to the specific training effort.
Tuition/fees	Expenses directly related to school tuition, fees, books and materials, and lab costs associated with a given training effort.

Table 2

Cost Analysis

	Option:	Commercial	In-house
1. Needs analysis/planning			
Staff	$		624
External consultant costs			2,200
Materials			400
	subtotal $	0	3,224
2. Work behavior analysis			
Staff			410
External consultant costs			0
Materials			100
	subtotal $	0	510
3. Design			
Staff			2,440
External consultant costs			0
Materials			500
External support costs			600
	subtotal $	0	3,540

(table continues)

Option:	Commercial	In-house
4. Development		
Staff	$	270
External consultant costs		0
Materials		100
External support costs		750
		600
subtotal $	0	1,720
5. Implementation		
Trainee (#10)	7,200	5,760
Facilities		
Tuition/fees	15,000	0
Staff		294
Materials		2,000
subtotal $	22,200	8,054
6. Evaluation		
Staff		208
External consultant costs		600
subtotal $	0	808
Total costs $	22,200	17,856
Cost per trainee $	2,220	1,785

Table 3

Performance Value Analysis

	#1 Unstruc	#2 Commerc	#3 In-house
A. Performance goal	1.5/day	1.5/day	1.5/day
B. Performance unit of measure	boards	boards	boards
C. Currency value of each performance unit	$600	$600	$600
D. Time required to attain performance goal	40 days	10 days	8 days
E. Number of performance units achieved in training period (i x h x a)	30	0	0
F. Existing level of performance	0	0	0
G. Number of trainees	10	10	10
H. % performance level during training	50%	0%	0%
I. Period of comparison	40 days	40 days	40 days
J. Total performance units in comparison period			
#1 [(40 (i) - 40 (d)) x 1.5 (a)] + 30 (e)	30		
#2 [(40 - 10) x 1.5] + 0		45	
#3 [(40 - 8) x 1.5] + 0			48

(table continues)

	#1 Unstruc	#2 Commerc	#3 In-house
K. Total value of performance			
#1 600 (c) x 30 (j) x 10 (g) =	$180,000		
#2 600 x 45 x 10 =		$270,000	
#3 600 x 48 x 10 =			$288,000

Appendix B

Performance Value Calculation Worksheet

(a) What is the performance goal of the training? ______

(b) What units of measure will be used to describe performance? ______

(c) What is the value of each unit of measure? ______

(d) What is the estimated training time to reach the goal? ______

(e) What is the current level of worker performance? ______

(f) How many workers will participate in the training? ______

(g) What is the estimated performance level during training?

Will trainee produce during training?

____ No = 0

____ Yes = $\frac{a + e}{2}$ ______

(h) What is the length of the period being evaluated (the longest "d" of all options under consideration)? ______

(i) What is the estimate of the total # of units (b) that will be achieved during training? [h x g] ______

(j) What is the estimate of the total performance for the evaluation period? [(h-d) x a] + i ______

(k) What is the value for the total performance for the evaluation period? [c x j x f) $______

(l) What is the net performance value gain? [k - (e x c x d)] ______

Appendix C

Experimental Machining Work Group Interview Summary

The workers within the Experimental Machining Department at Onan Corporation perform:

* custom production of prototype equipment and parts
* limited custom production runs
* experimental machining and fabrication of modifications to existing production units
* evaluation of new designs for main plant production feasibility

The worker experience of the group ranges from 3 to 15 years.

The manager and work group identified the following problems:

* Difficulty with reading and interpreting blueprints
  - Machinists did not understand all engineering symbols and were unable to make inferences form scant engineering drawings.
* Credibility with engineering group
  - Machinists lacked the theoretical background and formal methodology training to calculate changes in dimensioning to engineer-prepared designs.
  - "Gut feelings" about whether or not a required operation would work or not, were ignored by the engineer group until a unit was completed and proven unsatisfactory or procedures which were called out in the design could not be carried out on existing equipment.

The manager and workers in the Experimental Machining Department have suggested that a training program in geometric tolerance techniques would enable them to understand the engineer-prepared work drawings. This would result in less time in clarification as well as reduce scrap and labor due to misinterpretation. Additionally, they submitted that they would be able to calculate engineering, acceptable work drawing changes that would reflect procedural or layout modifications required to insure production feasibility.

The objective of the group was to reduce the amount of shop time spent on wasted prototype production effort by 50% on projects with problems and to identify those prototype projects with potential machining problems before set-up, jig making, and machining. This would be achieved by application of geometric and tolerance skills in pre-production review of drawings for feasibility and by post "first-piece" production application of these skills in developing procedures and layout modifications to address problems identified during first prototype effort.

It was anticipated that 90% of the potential problems would be identified and resolved in the pre-production review and that the prototype machinists would be able to resolve those problems that were revealed during the first machining effort.

Data which has been provided by the Experimental Machining Department:

* A typical prototype machining effort may take from 4 hours for general machining to 5 days for specialty machining.
* The engineering group typically takes 2-20 hours of effort to resolve a geometric tolerance problem.
* Shop rates for prototype work:
  - In house: $17.50 per hour
  - Out shop: $150.00 per hour
* 50% is the estimate of engineer drawings that have potential or obvious problems that the machinists would be able to resolve with geometric tolerance skills.

Appendix D

Conversion of Old Model to Proposed revised Model

Elements	Formulas
a = a	
b = b	
c = c	
d = d	
e = i	$(i \times h) = (h \times g)$
f = e	
g = f	
h = g	No = 0, Yes = $\frac{a - f}{2}$ = No = 0, Yes = $\frac{a - e}{2}$
i = h	
j = j	$[(i-d) \times a] + e = [(h-d) \times a] + i$
k = k	$c \times j \times g = c \times j \times f$
* l	$k - (f \times c \times d) = k - (e \times c \times d)$

* new element