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ECONOMIC ISSUES IN COST-EFFECTIVENESS ANALYSES OF MILITARY SKILL TRAINING

Henry Solomon

March 1986

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ABSTRACT

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CONTENTS

SUMMARY

A review of the literature on cost-effectiveness analyses for military skill training reveals a number of obstacles to the successful evaluation of these programs, including a combination of conceptual and data deficiencies relating to measurements of costs and effectiveness.

Assessment and measurement of training effectiveness should at least relate to resulting on-the-job performance and, ultimately, to military readiness. Current management information systems do not provide the means for ascribing the contribution of training to job performance. In addition to data deficiencies, the difficulty in relating training to military readiness presents severe conceptual problems associated with the notion of military readiness. This paper suggests some possible near-term improvements in attributing training to effectiveness. One approach is to use sample surveys in assessing on-the-job performance of individuals and relating these assessments to differences in training. A second, quite different, approach is to relate differences in length of training periods due to alternative training technologies and methodologies, but which have equivalent effectiveness, to resulting changes in manpower requirements. In this way costs of alternative approaches to training may be compared with differences in costs of resulting changes in total manpower requirements.

[1] This study was performed for the Office of the Deputy Under-secretary of Defense for Research and Engineering (Research and Advanced Technology) under the technical cognizance of Captain Paul R. Chatelier, the Military Assistant for Training and Personnel Technology.

Estimates of training costs have been derived from and have been limited by financial accounting systems. The necessary formulation of production functions from which costs may be derived has been virtually ignored. Emphasis in this paper is on the need for and approaches to such formulations. The need stems from the required evaluations and decisions pertaining to changes in output levels, scale of operations, and technology. The approaches suggested are (1) the production function in conventional economic theory where the economic analysis presumes an optimum combination of factors of production and (2) activity analysis where the motivation is to determine the optimum combination of activities or training processes. The next step would be to evaluate actual production functions obtained at military training establishments when significant changes have occurred in either the input and/or the output. Such opportunities are present whenever, for example, changes are made in the number of instructors, the length of a course, or the introduction of new training devices.

INTRODUCTION

The training of individuals in the Department of Defense (DOD) is a major enterprise which includes a wide variety of activities and requires very high levels of funding and large amounts of human and physical resources. For Fiscal Year 1986, the expenditure for individual training is about $19 billion [1]. About 202,000 persons are engaged in support of training, with a workload of 263,000 student-years. The objective of this training is to contribute to the military capability and readiness of the services. The different kinds of individual training are classified, generally, as Recruit Training, One-station Unit Training, Officer-Acquisition Training, Specialized Skill Training, Flight Training, and Professional Develo-pment. For the Active Forces, 57 percent of the training load is for Specialized Skill Training and 21 percent for Recruit Training.

The purpose of this paper is to present a cost-effectiveness analysis for Specialized Skill Training, i.e., skill training at schools for enlisted personnel. Emphasis is on the application of economics to the analysis of cost-effectiveness. The objective is to present the highlights of what has been considered and accomplished in cost-effectiveness analysis of military training and to offer some suggestions for improving our understanding of the key factors.

The training enterprise must be concerned with training policies and procedures and these must be integrated with manpower policies that, in turn, must relate to necessary levels of military capabilities and readiness. Training policies may include such decisions as the amount and kind of training to be offered, e.g., on-the-job training vs. school training for various skills, the length and timing of training, and the required level of skill at various stages in this process. Procedures may include the preparation of a syllabus, the particular form of delivery of instruction, (conventional and/or computer-assisted instruction), the nature and frequency of tests, etc. These training policies and procedures must ultimately be related to such things as manpower levels, acquisition and retention policies, and promotion policies. For example, minimizing the cost of a particular training objective may not result in minimizing total manpower costs. Also, the results may not satisfy defense objectives. These relationships should be kept in mind, even though they are treated here only in a very limited fashion. The results of training must ultimately relate to productivity on the job and its contribution to military capability.

COST-EFFECTIVENESS ANALYSIS

The major reason for cost-effectiveness analysis is to provide a means of assessing decision-making alternatives. If there is more than one way of achieving an objective, specified as a particular level of output and/or effectiveness, (performance) the least-cost alternative should be identified. If there is a budgetary constraint, there should be a way of selecting the alternative that will result in maximum output and/or effectiveness. At the outset, it should be noted that the principal motivation for cost-effectiveness analysis has been the "Planning Programming and Budgeting System" (PPBS) initiated by the Department of Defense in 1960 and implemented on a government-wide basis a few years later, with very mixed results. Standard references on PPBS are [2] and [3]. The required major ingredients of PPBS are (1) to specify goals and objectives of the appropriate agencies and (2) to conduct cost-effectiveness or cost-benefit analyses, depending on the nature of the programs. The purpose of the effort reported here was to assist in the evaluation of alternative programs with a common objective, and to evaluate and suggest new programs for meeting the objective. As with any investment decision, it is necessary to weigh expected costs against returns during the lifetime of the asset or program.

Many difficulties have been encountered with PPBS. Probably the major ones are identification and specification of objectives, measurability of the appropriate objectives, and determination or estimation of costs. As will be evident in the discussion which follows, cost-effectiveness of training provides no exceptions to these difficulties.

MILITARY SKILL OCCUPATIONAL TRAINING

As indicated earlier, this paper treats the subject of specialized skill training for enlisted personnel as individuals, prior to unit or collective training. This training may be accomplished by formal course work at schools, formal on-the-job training, or a combination of the two.

Almost all those joining the military services as enlisted personnel have little or no relevant prior skill training or job experience. In order to meet the occupational requirements in the services, those with appropriate qualifications enter Individual Skill Training (IST) following Recruit Training. On completion of this formal training the individual is assigned a military occupational specialty at the lowest skill level--in effect, at the apprenticeship level. IST in 1,210 different courses is offered at service schools among all services [1, p. V-5]. These courses vary greatly in subject matter, complexity, and length (two weeks to a year). Depending on the service, the average course lengths are 50 to 70 days [1, p. V-7]. However, after some amount of work experience, another level of skill training at schools, called Skill Progression Training, may be available. This training is intended to raise skill levels, train individuals for supervisory positions, and accommodate the need for trained individuals to deal with recent technological changes. Among all services there are 3,412 such courses. Depending on the service, the average lengths of these courses are 20 to 58 days [1, p. V-9].

TRAINING EFFECTIVENESS AND OUTPUT

Training and Military Readiness

The ultimate purpose of training is to maintain or attain some level of military capability or readiness. Requirements for training relate directly to military manpower requirements for sustaining a force structure with a desired military capability. Training requirements are determined by estimating the probable future attrition of required levels and skill mix of personnel due to completion of enlistments, retirements, and the need for increases in personnel levels due to increases and/or changes in weapon systems and force structures. To relate the level and mix of military personnel to military readiness presents a huge conceptual and methodological challenge in itself; evaluating the contribution of individual training to military capability is even more difficult. Military capability is a function of the number and quality of personnel, material, equipment, organization, leadership, unit training, and the interaction among these. To measure or assess the increment or decrement in readiness due to the increment or decrement of any one factor presents great difficulties, which increase as the size or aggregation of the military unit under consideration increases. For example, assessing the contribution of a unit of a resource to the capability of an individual ship is less difficult than assessing the contribution of a unit of a resource to the readiness of the fleet. While not relating directly to individual training, a useful survey appears in [4].

Economic Evaluation of Training

Much of the economic literature pertaining to cost-benefit analyses of training or education programs stems from the work on human capital by Gary S. Becker [5]. With minor variations, the benefits of training are represented by changes in lifetime earnings resulting from the training. While training in the military may increase the lifetime earnings of individuals trained, creating an increase in economic welfare or the well-being of society, this clearly does not necessarily represent a contribution to military readiness. Hence, the economic literature is of very limited value for assessing the effectiveness of military training.

In an interesting paper, Sassone applies some concepts in welfare economics to the economic evaluation of training [6]. He introduces two notions, the "compensating budget variation" and the "equivalent budget variation" and defines these as follows:

> The compensating budget variation (CBV) may be defined as the maximum reduction in the training budget which will maintain the current level of effectiveness when the new type of training is introduced. The equivalent budget variation (EBV) is the minimum increase needed in the training budget to achieve the same effectiveness level without the new training as with the new training and with the initial budget. In other words, the CBV is the amount of money saved by using the new training in an optimal mix with the other forms of training to maintain the existing effectiveness level. The EBV is the savings achieved in reaching a higher effectiveness level with, rather than without, the new form of training in an optimal mix with the other forms of training [6, p. 13].

Sassone then introduces an "Effectiveness Cost Function," which relates budget expenditures to level of effectiveness. The Sassone study requires an "effectiveness production function," i.e., relating training and effectiveness, from which a cost function is to be derived.

Note that, while not stated clearly, the intention of Sassone's formulations do not differ from the conventional economic formulation in cost-effectiveness or cost-benefit analyses. That is, to minimize cost for a given level of effectiveness or to maximize effectiveness, given a specified budgetary constraint. In the literature on cost-effectiveness of military training, the importance of this formulation lies in specifying the need for a training production function. In other words, a functional relationship between outputs and inputs. Conventional economic theory specifies the need for the formulation and derivation of production functions to arrive at cost functions, even though, surprisingly, this has been ignored in almost all cost studies on military training. In referring to the task of economic evaluation of military training, even Sassone states "the standard economic approaches, which are market-oriented, cannot be brought to bear (at least directly) on this problem" [6, p. 2]. Certainly the derivation of cost functions, given production functions and factor prices, is a standard economic approach and should be brought to bear on the problem.

Training and Job Performance

The problems of representation and measurement of effectiveness still remain. One possible view of training effectiveness is to follow current practice and use a level of knowledge and skill represented by a score resulting from a test or a series of tests administered during the course. In almost all instances, information on effectiveness is limited to this type of measurement, i.e., student performance at school. The much more important and revealing measurement of training effectiveness is performance of the individual on the job following the school training. Unfortunately, it has rarely been possible to relate empirically the level of achievement in school to job performance, (productivity). Hence, it has not been possible to relate alternative training methods in schools to job perfomance.

Orlansky and String examined seven studies on job performance by maintenance technicians [17]. The indicator of productivity was the occurrence of unnecessary removal of good parts during actions taken to identify and correct equipment malfunctions. These studies demonstrated that good parts were removed in 4 to 43 percent of all corrective maintenance actions and accounted for 9 to 32 percent of the total man-hours expended on maintenance. The results point to poor and inefficient maintenance activities. How much of this is due to inadequate training remains an open question. As suggested by the study, poor maintenance can result from other causes, such as inadequate test equipment, tools, or documention in addition to inadequate training. Information on the attribution of these possible causes does not exist. Further, in addition to the possible causes cited in the studies, the removal of good parts may itself be a function of maintenance policies and not due to technicians' productivities. What is important is the need for the measurement of job productivity and the ability to relate training to productivity. Even this very straightforward approach is difficult to accomplish, if only because many of the job tasks in the military are services rather than manufacturing production where the output is a readily identifiable and defined product. In the training literature, the difficulty of obtaining objective measurements of job performance or productivity has been virtually ignored, probably due to the absence of information relating training to performance. Should it become possible to establish this relationship, the problems will not be ended, if only because of the troublesome task of deriving performance or productivity estimates for services. One major obstacle to developing such productivity estimates is that the performance of many services are likely not to entail repetitive or identical efforts.

Current large-scale information systems pertaining to maintenance events do not provide the required information about individual performance needed to relate individual training to productivity [8]. The information systems must be revised, probably at some cost, or the relevant data must be collected via work samples or sample surveys. Here again, considerable care must be exercised to account for the difficulties noted above in measuring outputs and productivity.

Relative Standards of Achievement

One alternative to direct on-the-job output measurements is to use relative standards of achievement. A recently completed study by Quester and Marcus [9], using survey data, provides a good example of the application of a relative standard. By using data from the Enlisted Utilization Survey and Navy administrative records, they were able to compare the cost-effectiveness of formal school instruction and on-the-job training. The measure of effectiveness was net productivity of the individual at different times at the duty station. ("Net" referred to subtracting the loss in production of more experienced supervisory personnel required to train these individuals). This assessment by the supervisors was relative to the average specialist with four years experience. This as an example of a relative standard. The results of the study suggest that school training is more effective and also more cost-effective than on-the-job training.

Another measure of effectiveness of school training relates to differences in training techniques and methodologies, such as use of simulators vs. actual equipment. In a number of cases it has been possible to estimate these differences [10] and [11]. The limitation has been the difficulty in obtaining information on how these different approaches relate to on-the-job performance. Nevertheless, observed differences in required training time periods represent, or at least suggest, differences in effectiveness.

Relating Training to Total Manpower Requirements

Another possible approach to evaluating the effectiveness of training is to assess its relationship to total manpower requirements. Total requirements must accommodate the need for personnel to be in the pipeline for training. If the amount of time spent in training is reduced without reduction in effectiveness, total manpower requirements may be reduced. Also, if the time spent in training is increased, with a concomitant increase in effectiveness, the total manpower requirement may be reduced because of the increased productivity of the work force. The latter circumstance is much more difficult to identify and measure. In any case, it is relevant to relate training to military manpower policies. As indicated above, it has been possible to estimate differences in training time resulting from alternative training approaches. These differences in time of training, measured, say, in terms of man-years or number of personnel may be translated into differences in required personnel levels. This would permit a comparison of the costs of alternative training technologies with resulting differences in costs of personnel acquisitions and levels.

A simple numerical example illustrates this relationship. Suppose the requirement is for 50,000 persons with the designated skill assigned to operational units. Then, the total number of required personnel must be determined, given:

- A 3-year enlistment period
- That a man-year of training support is required for each man-year of training

- The original training period is 6 months
- The revised training period is 4 months

The original training period of 6 months will require a total of 70,000 persons to sustain the operating force requirement of 50,000. The revised, shortened training period would result in a total requirement of 62,500 persons.

COSTS

Accounting Costs

Information on costs is used for several purposes. These may include accountability and management controls, but the more interesting purposes, particularly from an economic (as distinct from an accounting) point of view, is to assist in decision-making and evaluation of management effectiveness. In the latter case, an attempt is made to answer the question, if something changes, what will be the effect on costs and whatever the appropriate figure of merit may be, such as revenue, effectivenss, or readiness? Changes may be in production technology, new products or programs, level of output, scale of operations, etc. For this reason, the economist emphasizes the need to determine changes in total or marginal costs. The context is a decision problem involving choices that will affect outcomes.

The conventional analysis of training costs hinges on an accounting framework of the following cost elements:

Direct Costs
- Personnel
- Instructors
- Materials and supplies

Indirect Costs
- Support personnel
- Base support, etc.

Investment

Research and development

Equipment

When the dollar values for the categories listed above are available, the values are tallied and, given the number of students per training cycle, an average cost per student is computed. When these data are available in either time-series or cross-sectional form, it may be possible to derive "cost-estimating relationships," employing some form of multivariate analysis. As applied to on-the-job training, a good example is cited in [12]. Such data are not usually available for any particular course, but even when they are the accounting allocations for elements such as those included under indirect costs are arbitrary and could be misleading. The point is that knowledge of the average cost is not very helpful in decision-making. Given no other information, and if fortunate enough to have available some time-series and/or cross-sectional data among equivalent or similar schools, the analyst may find the resulting cost-estimating relationships helpful, but limited in their usefulness for assessing effects of changes in technology, scale, etc.

The Production Function

Analyses within the cost-estimating relationship framework leave ambiguous or unspecified the production function for the training course, that is, the identification of the productive factors and the manner in which they are combined to produce a unit of output. When the production function is not specified, several important items cannot be determined, such as optimum technical organization of training; optimum combination of the productive factors, i.e., cost minimization for a given level of production; and optimum output levels. Since the production function is too often neglected in the training literature, it should be emphasized that these are three distinct stages of analysis and optimization.

Much of the literature on cost-effectivenss of training focuses on comparing different delivery systems and/or technologies; for example, changing from school to on-the-job training or introducing computer-assisted instruction. In any training system there is an optimum technical combination of factors that will provide maximum output. If different procedures or technologies are introduced, there will be a different optimum combination of factors, that is, production function. How significant these differences in factor combinations and maximum output may be is an empirical question. This is also true of the least-cost combination of factors for a given level of output. For example, the introduction of computer-assisted instruction may not only require replacement of certain equipments and supplies but a new syllabus, and differently trained instructors as well.

Probably the most important notion neglected in cost analyses of school training is the specification of the production function, even though, fundamentally, costs must be derived from the production function and prices of the productive factors. One important exception has been the formulation and analyses associated with "transfer effectiveness ratios" in various forms. As applied to the use of flight simulators, the transfer effectiveness ratio measures the amount of flight time saved in aircraft as a function of the amount of training time spent in a flight simulator. A good discussion of these transfer effectiveness ratios appears in [13]. These studies had a relatively narrow focus, where any two procedures or technologies are related to determine the output resulting from combinations of their uses. An example is the combined use of flight simulators and aircraft for flight training. The problem has been a lack of information on the total production function. In other words, the way in which all of the other productive factors may or may not be changing to effect a technical optimum. Nevertheless, the use of transfer effectiveness ratios is clearly in the direction of formulation of production functions to yield the optimum technical organization of production. An elementary, but important, point is that the formulation of the production function is only the beginning; there remains the task of cost minimization for any given level of production. Before going on, a few specific elementary aspects of the production function should be stated.

In traditional economic theory, the technical or engineering conditions for maximum output are the maximum output, σ, which can be produced by a defined set of production factor inputs,

$$\sigma = f(x_1, x_2, \ldots, x_n).$$

The production function assumes a single product output and a maximum output for the set of inputs (a single valued function). It should be emphasized that the combination of factors should be expected to vary for different levels of output. From the economist's perspective, the production function is the result of the technical maximization problem. Note that this begs a major question in cost-effectiveness of military training. Specifically, what combination of factors will result in maximum output or training effectiveness?

From the conventional single-product production function two important concepts are presented. The first is that of marginal productivity of each of the production factors, i.e., the partial derivatives $\partial\sigma/\partial xi$. The second pertains to the relative changes in output and quantity of a productive factor, sometimes referred to as the "elasticity of production." That is, the change in output resulting from the increment in the productive factors.

Conventional production theory embodies several popular forms of production functions. One is the Cobb-Douglas production function, defined generally as:

$$O = KL^{\alpha} C^{1-\alpha}$$

Where,

O = output

K = constant

L = labor

C = capital

α = constant between 0 and 1

Assuming the function is appropriate, it is attractive because it is linear in logarithmic form. It is presented here for illustrative purposes since it appears in the literature on educational production functions. A good discussion on developing educational production functions appears in [14]. Other forms of the production function appear in the economics literature. A good critical discussion of the theortical and empirical issues in production function may be found in [15].

One complexity in production functions for training, education, and many other production activities is that the organization may be producing joint products. Chizmar and Zak have addressed this problem [16]. Their postulate is that school instruction produces both learning and attitudes and that, in addition to learning the skill, the training is likely to have an impact on attitudes toward the job, whether civilian or military.

In conventional production theory, joint production of two or more products can occur with technically fixed proportions or technically variable proportions of the output of the products. Of course, when two or more products are produced in fixed proportions, output may be considered to be a single product. That is, factor productivities and costs can be related to single-output levels. When product proportions change, production and costs cannot be related to total output levels, i.e., contributions of marginal productivities may vary for the increment of any one product output, as may the marginal costs associated with an increment in any one output. Of major consequence is that the average costs of total output levels do not exist, even though conventional accounting may attempt to arrive at these costs via arbitrary cost allocations among products. What can be determined is the increment in total cost (marginal cost) associated with the increment in any single product--an important measure for decision-making.

For purposes of evaluating the cost-effectiveness of military school training, it may not be very useful in the short-run to consider the differentiation of products such as skill level accomplishment and developed attitudes toward the job. It seems reasonable to assume, initially, that these products may vary in such fixed, or approximately fixed, proportions, as increases in skill level equal to increases in job satisfaction; at least they would move in the same direction.

The presence of and technical problems associated with joint products are of great practical concern, since the only source of cost information is the school. Training schools typically offer several courses (products) which are not likely to be offered in fixed proportions over any long time period. For reasons noted earlier, calculation of average costs allocated among the programs is chancy.

Emphasis here is on the production function method of determining costs. If factor prices and the production function are known, it is possible to derive cost functions and arrive at a least-cost combination of factors. Production and cost functions are directly related. Assuming constant unit factor prices, as marginal product increases (decreases), marginal costs decrease (increase).

Activity Analysis

Recently, the economic literature has included an alternative approach to the conventional production function discussed above. This is in the form of "activity analysis." An excellent description of the approach is given by Koopmans [17]. A major feature of this methodology is that technology is represented by "commodities" and "activities." Commodities include what are usually referred to as the factors of production in conventional analysis, for example, labor; intermediate products, such as materials and supplies; and final products. Activities are defined in terms of combinations of commodities relating inputs in fixed ratios to outputs. A particular activity, then, is defined by a set of coefficients, i.e., a_{ij} ($i = 1, 2, \ldots, n$) defines the j^{th} activity in terms of amount of i needed per unit activity of j. Technology of the organization can then be represented by a matrix of the activities. An important motivation for the analysis is then to seek the optimum combination of activities, given constraints on productive factors and an objective function for the organization. Notice that conventional analysis presumes an optimum combination of factors, while activity analysis seeks an optimum combination of activities. The newer methodology, aside from the important objective of optimization, presents what should be a useful schema for looking at the process of school training. For example, the definition of activities (lecture), supervisory support (on-the-job-training programs for instructors), student support (counseling). Although for different purposes, the United States Army Training and Doctrine Command has already defined and identified these activities [18]. A change in technology, such as the introduction of computer-assisted instruction may require a change in many, if not all, activities and combinations of these activities.

COST-EFFECTIVENESS ANALYSIS AND THE FUTURE

Current Obstacles to Measuring Effectiveness and Suggestions for the Future

A survey of the literature revealed several major difficulties in evaluating the cost-effectiveness of alternative training procedures and technologies. One major difficulty is the assessment and measurement of training effectiveness. A second is the lack of information on job performance resulting from training. Prospects of obtaining this information in the future on a servicewide basis are questionable, but perhaps this can be accomplished on a sampling basis. Information is not enough; concepts and methodologies are needed to develop job productivity measurements. A more feasible approach is to employ relative standards, such as the one used in the study by Quester and Marcus [9]. Since schools train individuals to a certain skill level, the most feasible way of judging effectiveness is to compare differences in needed training time periods associated with different training practices. As indicated earlier, this has been done in the past and it is suggested that the differences in training periods be translated into different resulting levels of total manpower requirements. It appears that this possibility has been ignored thus far even though it is a very appropriate and feasible measurement. If training time can be reduced with equivalent effectiveness via a change in technology, the cost of the new technology should not be compared only with the cost of the old technology. The cost comparison should include the impacts on manpower requirements and its associated costs.

Need for Training Production and Process Function and Suggestions for the Future

Information on costs have been difficult to obtain. Available data are generally limited by the financial accounting systems and it has been difficult to relate changes in detailed cost elements, such as cost of instruction or equipment utilization, to changes in technology, training procedure, or levels of training operations.

As emphasized earlier, costs of training have not been derived from training production functions. One narrow set of exceptions is related to the derivation of "transfer effectiveness ratios" (for example, use of simulators vs. actual equipment). There are problems in assessing the cost of using these equipments (e.g., treatment of research and development costs, amortization) and the impact of costs due to changing combinations of other productive factors such as the number of and level of expertise of instructors.

It is somewhat surprising that so little has been done or said about the production function for training, whether military or non-military. One of a few exceptions is an interesting work by Verry and Davies [19]. This major application of econometric techniques uses cross-sectional data, i.e., estimated economies of scale and marginal costs of the higher education objectives. The study stresses the importance of the education production function and its use in estimating costs. Another exception in the military context, at least in terms of problem or model formulation, was offered by String and Orlansky in describing a "generalized model for estimating training costs" [20, pp. 66-103]. More recently, McMichael has suggested the usefulness of a production function approach [21].

In place of a production function approach in estimating costs of training, "cost-estimating relationships" have been derived. Typically, this means that a statistical cost function is derived for the cost per trainee and is formulated as a function of cost elements such as cost of trainee time, instructors' or supervisors' time, equipment and material costs, etc. This approach, which is not unusual in costing of military systems, implicitly assumes a production function. The data base, generally the financial accounting system, does not provide information on parameters such as use of resources, capacities, or scale of activities, and is likely not to represent a least-cost combination of factors for different output levels.

One proposed way to proceed is to focus on a single school and use a conventional production function as a reference point. This would include the collection of programmatic and resource information. Information would include items such as:

- For each course, the number of students entering and completing each cycle
- A definition of the course curriculum, such as tasks to be completed satisfactorily
- The number of hours of instruction for each student and the length of each course
- The number of instructors (by skill level) and the number of instructional hours
- The number of equipment hours used per course, equipment acquisition cost, and equipment life
- The dollar value of supplies, materials, and equipment maintenance and repair for each course.
- Assuming no changes in standards for graduation and number of students in a cycle, what would be the estimated changes in the above noted resources if the calendar length of the course should increase or decrease by 10, 20, 30, 40, and 50 percent?
- Assuming no changes in the length of the course, what would be the estimated changes in the resources

noted above if the number of students entering each cycle increases or decreases by 10, 20, 30, 40, and 50 percent?

It should be anticipated that percent increases in students or decrease in course length greater than those specified are unrealistic and therefore certain constraints must be placed on the system. The main purpose of the questions is to gain insight into optimum combinations of factors for different levels of output. To obtain answers to the kinds of questions listed above, historical data would have to be supplemented by technical judgments because financial accounting systems do not provide information on the use of facilities, human factors, and processes. At present, a detailed cost-accounting system useful for the analysis of costs of training does not exist. The proposed cost-element structure by Knapp and Orlansky would go a long way in accommodating data for managment and cost-effectiveness analysis [22]. A very worthwhile venture would be to adopt the cost-element structure for one school on an experimental basis and in parallel with the existing system. Even these data would have to be supplemented by technical judgments to assess cost impacts of different rates and/or levels of output and to the supposed impacts of technologies not yet in place.

An alternative way to proceed is "activity analysis." This technique would provide a quantitative description of the training process. Some promising efforts already underway describe activities associated with school training. While the objective of these efforts has not been activity analysis, the Army Training and Doctrine Command (TRADOC) has made a start in defining a total set of activities [18]. The objective of these studies was to develop statistical estimating equations for determining instructor manpower requirements at TRADOC service schools. The effort lead to a description of the detailed direct and indirect activities of the training system. The importance of this description is that it identifies a set of related activities which may be quantified. This may permit the attribution and evaluation of costs of the existing training process. Further, it may provide the basis for estimating and evaluating costs associated with such changes in the technology as computer-assisted or computer-managed instruction. The long list of activities provided by TRADOC are categorized as "Direct Academic Instruction" or "Indirect Activities." The former includes such activities as lectures, administation of written tests, and self-paced instruction. The latter includes activities pertaining to "Course Support," such as maintaining course publication files; "Supervisory Support," for example, preparing schedules; "Input Class Support," such as preparing laboratories; "Student Support," including reviews of students' records; and "Instructor Support," for example, formal in-service training.

Of course, if the activity analysis approach is to be pursued, more information than a description of the activities must be obtained, principally on the "commodities" representing the inputs and outputs of these activities. What difficulties may be encountered in using historical data and/or technical judgment are yet to be determined, but some exploratory efforts should be initiated.

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