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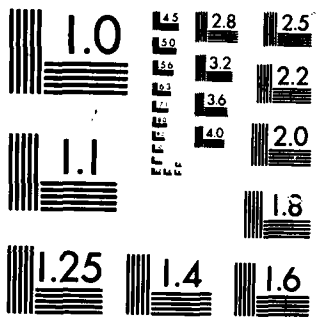

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Monterey, California

THESIS

A COST DETERMINATION MODEL FOR THE
FUNCTIONAL CONTEXT TRAINING REVISION
OF BASIC ELECTRICITY & ELECTRONICS TRAINING

by

Gregory J. McCannel
December 1985

Thesis Co-Advisors: L. A. Armijo
T. G. Swenson

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This study is an examination of the use of a cost determination model in assessing the costs associated with Navy training courses. Derived from a foundation of fundamental principles and cost concepts found in the structure of the Navy's training system, instructional methodologies, and economic analysis, a cost determination model known as COSTDEMO was constructed. The model was designed to provide an analyst or manager with a single, dollar cost of a course of instruction. Using the Navy's Functional Context Training (FCT) project program revision of Basic Electricity and Electronics (BE/E) training as a case study, COSTDEMO was used to compute the training costs associated with the three methods of instruction being evaluated by the project. A cost analysis was made between the alternatives from the cost data provided by the model.

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A Cost Determination Model for the Functional Context Training Revision of Basic Electricity & Electronics Training

by

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B.S.(Ed.), University of Idaho, 1975

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ABSTRACT

This study is an examination of the use of a cost determination model in assessing the costs associated with Navy training courses. Derived from a foundation of the fundamental principles and cost concepts found in the structure of the Navy's training system, instuctional methodologies, and economic analysis, a cost determination model known as COSTDEMO was constructed. The model was designed to provide an analyst or manager with a single, dollar cost of a course of instruction. Using the Navy's Functional Context Training (FCT) project program revision of Basic Electricity and Electronics (BE/E) training as a case study, COSTDEMO was used to compute the training costs associated with the three methods of instruction being evaluated by the project. A cost analysis was made between the alternatives from the cost data provided by the model.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

A. BACKGROUND

The United States Navy of today is far more technologically complex than it was in the days of wooden ships and iron men. Technological changes in ship construction, machinery, equipment, weapons systems, and so forth have required considerable changes in personnel abilities and capabilities to keep pace with technology. These capability changes have been necessary in order to maintain the Naval Forces in a state of readiness where it can respond promptly to any and all of its prescribed defense roles and missions. Current force readiness, as described by NWP-1 (Rev. A), depends on personnel readiness, material readiness, and training readiness [Ref. 1: p. II-2-1]. Training, from such a global perspective, appears to be the link for ensuring that the personnel capabilities required to most effectively utilize, operate, and maintain the Navy's current inventory of high technology hardware systems. The function and role of training in the Navy is essential to ensure current force readiness is maintained.

In a much narrower perspective, training is defined as a process where skills, rules, concepts, or attitudes that result in improved performance in another environment are systematically acquired through a change or modification of human behavior [Ref. 2: p. 3]. In the Navy, the task of training individuals with the required capabilities to keep pace with hardware system technology changes is readily emphasized. From the time an individual joins until he or she reaches his or her first operational billet, a major amount of time is spent in a formal training environment where the nature of the training is one of three general categories. Training can be of a general nature such as recruit and apprenticeship training, of a specific nature such as rating and occupational field specialized training, or a combination of the two. The primary emphasis of any initial formal training is job oriented where, at a minimum, the basic skills, rules, concepts, or attitudes taught in the training environment can be used or applied in the job environment by demonstrating an acceptable level of performance. An acceptable level of individual performance, it is often reasoned, aggregates into a unit level of performance which represents the unit's level of readiness. Unit readiness is then aggregated to achieve a perceived level of force readiness. Thus, when an individual has received preparatory job training, it is generally assumed that his or her on the job performance capabilities should be better than had the individual not received any training.

This particular issue creates a controversy between the trainers and the users. The operational units (the users) view an inadequate performance level as the fault of the system that trained the individual. Conversely, the training system views this as an individual problem since the person was taught everything needed to graduate from the training system. Neither argument on this issue is completely correct. The training system is not intended as a means for producing individuals who are taught everything they need to know for a job so that they can immediately perform with technical proficiency. On the other hand, the training system may not be teaching enough of what the individual does need to know to perform his or her job or the graduation standards may be so low that many individuals graduate with skills and knowledge below acceptable operational unit standards. An easy solution could be as stated by Gay and Albrecht:

> Since almost any set of job skills could be taught entirely on the job, formal specialty training could be totally discontinued without losing the ability to maintain an effective military force. [Ref. 3: p. 1]

As a solution, this suggested alternative is feasible since a large number of individuals are trained in operational billet skills through on the job training. But, this alternative is not very practical since there are more economical means of teaching job skills. On the job training is a training alternative which is extremely time intensive for the person who conducts the training and for the trainee. The person who conducts the training usually has other duties and responsibilities to perform which he or she must forego to supervise the trainee's performance. The non-availability of a dedicated instructor substantially increases the time to complete the training to a technical proficiency level for the trainee. Additionally, on the job training is usually limited to one-on-one instruction when highly complex skills are involved or instruction is limited to a very small number of students in most other situations. As a result, a sufficient number of trained individuals cannot be quickly produced by this alternative.

In contrast, formal specialty training is one of the most expedient means of producing an adequate number of trained individuals in a relatively short time. The primary duty of the instructor is teaching. The instruction concentrates on teaching the student the necessary knowledge and skills for his or her operational job. Formal training does, however, have one significant drawback--it is very costly.

The costs of formal specialty skill training have been increasing at a substantial rate. This adds another aspect to the controversy between the training system and the operational users. If the training system is getting so much money, then why are the graduates it produces not better trained? What is the training system doing with all of its money? These questions raise two major issues regarding the productivity of the Navy's training system: the issues of efficiency and effectiveness.

Efficiency is a critical facet of training which recently has received considerable attention as an area where improved efficiency may lead to substantial reductions in time, cost, or both [Ref. 4: p. iii]. The attention being given to training efficiency (and effectiveness) is needed for resolving controversies similar in nature to the one previously described. Therefore, the Navy's training must be efficient in two aspects: technological efficiency and in economic efficiency [Ref. 3: p. 1]. These two efficiencies require that training systems produce graduates of a certain level of proficiency and that this level of proficiency equals the level required by the operational unit for a specific job. Military training can best be summed up as follows:

> The sole objective of individual training for military personnel is to produce knowledgeable, disciplined, dedicated service members who are capable of functioning effectively in the military job structure and contributing to the combat capability and mission readiness of military units. The measure of training effectiveness, then, is the degree to which individual training meets this objective; the ultimate measure is combat success. [Ref. 4: p. 23]

B. THE NAVY'S FUNCTIONAL CONTEXT TRAINING PROJECT

In 1980, the Chief of Naval Operations issued an Operational Requirement (OR #Z-1382-PN) which emphasizes an operational training problem:

> The Navy has undergone major reductions in the resources applied to its specialized training. To prevent these resources from severely affecting its training results,

efficiency of training must be increased. The Navy uses a sequence of course content in its specialized training that begins with material remote from the job (Basic Electricity and Electronics, Aviation Fundamentals), and ends with job relevant material (C-School). Previous R & D has shown that other sequences are more efficient, in terms of leading to lessened training time, somewhat lower aptitude requirements, and more interested students. [Ref. 5: p. 1]

The operational requirement goes further to establish specific performance goals for determining the efficiency and effectiveness of training conducted under the Functional Context Training approach. Figure 1.1 is a list of the project performance goals.

Based on the guidance of the operational requirement, a project plan for the Navy's Functional Context Training (FCT) program was initiated and issued in February 1985. The project plan is to develop methods for designing and delivering integrated instruction which will improve the trainee's comprehension, application, generalization, and retention of training. Additionally, the integrated instruction methods will be tested in training courses to determine FCT's effectiveness, any side effects, and costs [Ref. 6: p. 2]. The Basic Electricity and Electronics (BE/E) technical training course has been designated as the pilot course for FCT implementation.

SYSTEM PARAMETER	CRITERIA
Training time reduction	Floor: 4 % Goal: 8 %
Lowering aptitude requirements	Floor: 5 percentile ranks Goal: 10 percentile ranks
Student attitude	Favorable toward control course
Task performance ability	Increased for specialized training courses
Computer-managed instruction	Consistent with present system
Computer technology requirements	No additional requirements
Principle variable of change	Sequence of instructional topics

Figure 1.1 Functional Context Training Performance Goals

C. OBJECTIVE

This thesis will examine the principles of "functional context training," how these principles will be implemented, and the differences between the FCT method and the current method of BE/E instruction. From this basis, an attempt will be made to develop a training cost model which can be used to determine the cost factors for comparing the training efficiency and effectiveness of the two instructional methods. To achieve this, the research methodology in this thesis is organized in two separate but related areas.

The first area to be investigated will involve establishing and examining of the structure of the Navy's training system, the historical evolution of BE/E training, the position of the current BE/E course within the specialty skill training structure, and the current BE/E course instructional methodology. Next, an understanding of the functional context training principles and approach will be developed and the proposed FCT implementation plan will be examined. An understanding of the two methods and how they differ is essential for establishing a basis for investigating the second area--developing a cost model.

In developing the cost model, the first goal will be to determine and develop the relationships between training efficiency and training effectiveness. Next, the efficiency/effectiveness relationship will be linked to cost analysis where a cost model framework will be established. Once these two goals are met, then the relevant cost factors can be derived from the characteristics, differences, and similarities previously developed between the two methods. An endeavor to assess and compare the efficiency/effectiveness of each method will be made once the cost model is constructed.

The specific objectives of this thesis are:

- Develop a cost determination model for costing Navy training courses by stating the resource variable which must be identified for the model and the expected cost data output of the model.
- USING THE NAVY'S FUNCTIONAL CONTEXT TRAINING PILOT program revision to the Basic Electricity and Electronics course as a case study, apply the cost determination model to compute the costs associated with each alternative method of instruction being considered in the project and conduct a cost analysis of the data provided by the model.
- Recommend other applications of the cost determination model for management decision support within the Navy's TRAINING SYSTEM AND RECOMMEND APPLICATIONS OF THE MODEL in the analysis of costs between alternatives in other Navy systems.

II. NAVY TRAINING AND BE/E TODAY

A. NAVY TRAINING

Navy training can, in reality, be called vocational education or vocational training. It functions to discipline individuals with the rudimentary skills and knowledge or to increase the current level of an individual's skills and knowledge for a specific military job. Some recruits do have civilian occupational experience and skills which are complementary to a specific Navy rating or occupational field but few individuals have job skills that will fit exactly into the Navy's job structure. Consequently, nearly all Navy personnel receive some form of formalized training to orient the individual to his or her prospective job and job environment. The magnitude of training conducted to meet this requirement demands careful attention and management to ensure training meets its specific goal--produce individuals whose job performance will be improved.

1. Formal Navy Training

Formal training in the Navy is primarily "individual training and education" which can be described as the training of individual members in formal courses conducted by organizations whose predominant mission and function is training.[1] There is such an organization in the Navy whose primary mission is training and comes under the command of the Chief of Naval Education and Training. The Navy's training organization conducts individual training which is grouped into five, well-defined categories--recruit training, officer acquisition training, specialized skill training, flight training, and professional education and training. Of these five categories, specialized skill training is the category where the majority of the Navy's job skill (vocational) training is conducted.

2. Specialized Skill Training

The purpose of specialized skill training is to furnish officer and enlisted personnel with the skills and knowledge required for a specific job within the Navy's job structure. In order to have a sufficiently manned job structure, specialized training must provide the users with trained individuals to fill vacancies in the structure as they occur. This requires the training system to be responsive to the skill manning needs and requirements of the operational units.

Of particular interest is the specialized skill training of enlisted personnel since the enlisted manning

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[1]The description of "individual training and education" was derived from Military Manpower Training Reports prepared by the Office of the Assistant Secretary of Defense (M,RA&L). The description is identical in the reports for FY 1978, . . ., FY 1984.

levels are six-and-a-half times larger than the manning levels of the officer ranks. Most enlisted personnel enter the service with job skills which are not applicable to the Navy's job structure. Since the Navy's job structure is unique and highly specialized, these individuals must be trained with the skills and knowledge for a specific job position. The pattern and sequence of training that the majority of Navy enlistees receives is fairly standard. The individual attends recruit training to receive an initial orientation to military life, its discipline, and its environment. Next, nearly all recruits go to one or more of the four types of specialized skill training:

- Apprenticeship Training - training which is general in nature and concerns one of the six occupational grouping found in the Navy. These occupational groupings are Seaman, Fireman, Airman, Constructionman, Hospital Corpsman, or Dental Corpsman; considered as a part of initial skill training within DoD.

- Initial Skill Training - the lowest job entry level of skill training for a specific rating or occupational field.

- Skill Progression Training - Training given following operational job experience or immediately following initial skill training to achieve a higher level of performance or supervisory level of skills and knowledge.

- Functional Training - training in areas which are applicable to more than one rating or involve general duties and responsibilities of all Navy personnel such as damage control, firefighting, warfare specialty team training, and so forth.

As shown below in Figure 2.1, an individual, immediately following recruit training, will attend either apprenticeship training or initial skill training. If the recruit attends apprenticeship training, he or she may receive functional training before being assigned to an operational billet. Usually,the individual goes directly to a billet and job skills are gained through on the job training.

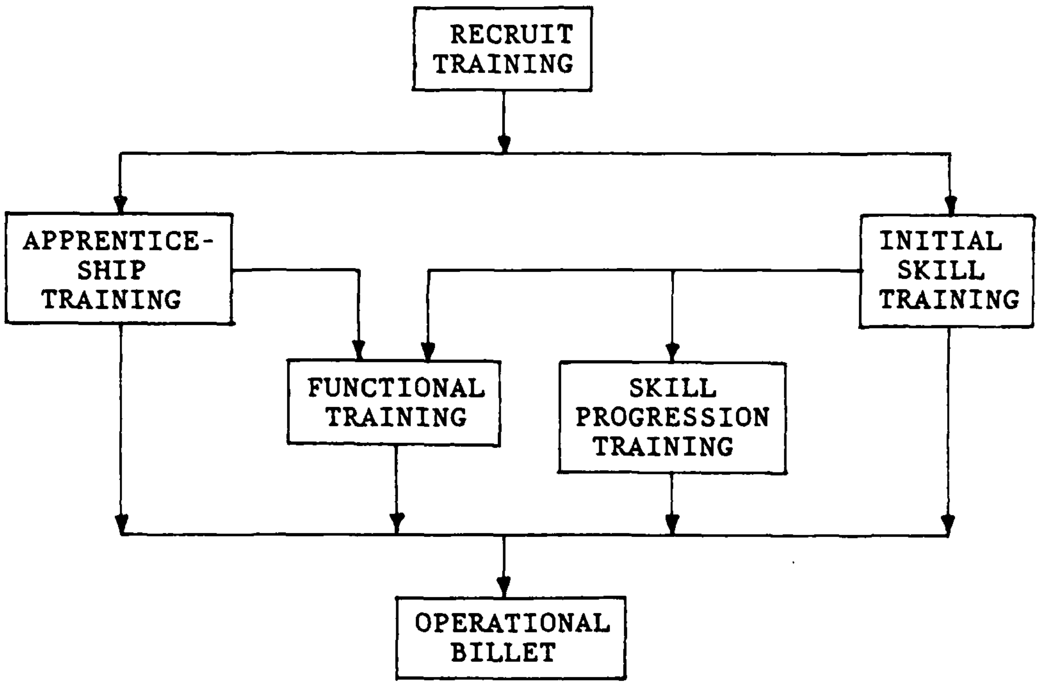

Figure 2.1 Typical Enlistee Training Path

The training path for the majority of enlistees is somewhat more complicated since these individuals attend initial skill training following recruit training. Upon completion of initial skill training, as shown in Figure 2.1, there are three primary assignment options. The first option is assignment directly to an operational billet which occurs most frequently. Second, is the option for skill progression training, followed by billet assignment. The third option is similar to the second except the individual attends functional training after initial skill training. There are many other possible assignment options such as skill progression and functional training following initial skill training and so forth. Providing individuals to fill job vacancies as the vacancies occur requires the specialized skill training system to have a frequent output of graduates to meet this need.

3. Training Student Loads and Costs

Training load is used as a measurement of the projected number of individuals who are undergoing training in order to fill anticipated job vacancies. The formula used to compute training load is shown in Figure 2.2.

$$L = \frac{E + G}{2} * t$$

L = Course training load

E = Number of entrants needed to achieve G

G = Desired number of graduates

t = Course length (expressed as a fraction of a year)

Figure 2.2 Training Load Computation Formula

Aggregating single course load by the type of training (initial skill, skill progression, etc.) and/or by training category (specialized skill, recruit, etc.) will provide a projection of the number of individuals who are undergoing training for specific skills. A training load value is most useful as a gross indicator of the number of students that are in the system at any particular time. Load values are susceptible to fluctuations caused by changes due to low reenlistment rates, an unexpected increase in the number of billets, and higher than expected attrition rates of the various schools and courses.

The number of active duty Navy personnel undergoing individual training and education at any given time is substantial. The Navy's average *student training load for* the past eight years is over 63,900 students[2] or nearly 31% of the 207,200 average active duty training load for DoD. This represents a sizeable number of personnel involved in training and education programs who could otherwise be operationally assigned as unskilled manpower. A point of equal significance is the number of Naval personnel receiving

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[2]All numerical values cited in this section were compiled from data found in Military Manpower Training Report for FY 1978 through FY 1984, inclusive, prepared by the Office of the Assistant Secretary of Defense (M,RA&L). The data reflects projected training load and funding requirement figures and may vary from actual figures loads and fund expenditures. The projected figures should be representative of actual figures.

specialized skill training where the average training load for the past eight years is over 39,600 students. This represents 62% of all Navy individual training and education. Table 1 depicts the Navy's active duty student training loads and funding required to conduct training in FY 1978 through FY 1984.

TABLE 1

SPECIALIZED SKILL TRAINING LOADS AND FUNDING
NAVY ACTIVE DUTY ENLISTED (FY78-FY85)

	TRAINING LOADS		FUNDING REQUESTED ($ M)			
FY	SPEC SKILL TRNG	TOTAL IND TRNG	NAVY SPEC SK TRNG	NAVY % OF DOD SPEC SK TRNG	NAVY TOTAL IND TRNG	NAVY % OF DOD TOTAL IND TRNG
78	36434	60767	n.a.	n.a.	1549.0	25.2
79	37435	57996	565.0	33.3	1641.0	27.7
80	37423	61913	691.0	37.6	2053.0	27.0
81	39850	64545	756.4	37.6	2336.5	26.6
82	39968	64285	905.2	38.0	2959.0	28.1
83	40911	66930	1044.0	36.2	3464.3	27.1
84	42228	66911	1214.0	38.2	3894.4	29.1
85	42799	67987	n.a.	n.a.	n.a.	n.a.

Note: n.a. entries were not available/not listed

The Navy spends almost one-third of its total training budget on specialized training compared to DoD spending only one-fourth of its total training budget on specialized training. Besides having the largest student training load, specialized skill training has the largest input and output of students. The yearly average is over 610,000 students who enter specialized skill courses which

TABLE 2

TRAINING INPUTS, OUTPUTS, & LOADS: SPECIALIZED SKILL TRAINING
NAVY ACTIVE DUTY ENLISTED (FY78-FY84)

FY	INPUT	OUTPUT	LOAD	NUMBER OF COURSES	AVG LENGTH (DAYS)	AVG ATTRITION (%)
Initial Skill Training (Includes Apprenticeship Training)						
78	165870	163867	20203	140	42	11.0
79	142287	130847	18202	144	42	6.3
80	165434	156511	21270	162	48	6.0
81	171837	162438	20822	165	43	6.0
82	163857	154994	20118	165	41	7.1
83	181195	170014	22563	158	43	6.9
84	182194	174628	24436	169	43	6.7
Skill Progression Training						
78	63372	62101	9916	1140	51	4.0
79	77459	75012	12818	1153	51	4.0
80	68398	67604	10385	1128	56	4.0
81	77821	72874	11154	1298	48	4.0
82	79550	74880	11423	1272	47	5.0
83	81772	77624	11257	1236	47	5.0
84	111347	107027	11287	1569	42	4.2
Functional Training						
78	353704	344344	4116	1448	4	n.a.
79	393025	383812	3845	1532	4	n.a.
80	348627	340948	3588	1404	4	n.a.
81	377012	372754	5102	1446	4	n.a.
82	397582	392895	5329	1430	4	n.a.
83	341654	337359	4409	1402	4	n.a.
84	337979	326452	4062	972	4	n.a.

Note: n.a. entries not available/not listed

graduate over 590,000 individuals. Table 2 illustrates the input and output of the three types of specialized skill training. Specialized skill training, and initial skill training in particular, is of interest in this thesis. The Basic Electricity and Electronics course is one of the major initial skill training courses. BE/E comprises twelve to fifteen percent of all Navy active duty enlisted initial skill training output.

B. BASIC ELECTRICITY AND ELECTRONICS

1. Background

The Basic Electricity and Electronics School originated from the Electronics Technician (ET) "A" School in 1960 and became a prerequisite course for electricity/ electronics related courses. The original course was a four-week, "common core" course which was mathematically oriented toward the basic theory and principles of electricity and electronics. The course structure was divided into two, two week sections of theory and circuitry. One section covered DC (direct current) topics and the other section covered AC (alternating current) topics. As a prerequisite for follow-on schools, the course dealt with subject topics that were needed to successfully complete the next school. Entry requirements for BE/E were based on the entry requirements of the follow-on school and comprised of specific ASVAB sub-test score combinations.

The original format was changed in 1962. At this time students in the BE/E school were grouped into a three track system. The groupings were by aptitude scores and the length of instruction was geared to aptitude. The higher aptitude group received seven weeks of training, the middle aptitude group received eight weeks, and the lower aptitude group received nine weeks. In 1968, with seven or eight new classes starting each week, all track lengths were shortened to six, seven, and eight weeks, respectively. This three track system was abandoned in 1969 when all courses were made a uniform six week length. This standardized six week course covered eight topic areas in 190 hours of classroom instruction. [Ref. 7: pp. 5-6]

The next major change to the BE/E school format occurred during the 1969 to 1971 time frame. The curriculum underwent a major revision from classroom instruction to individualized instruction. The course was expanded to 15 modules covering a wider range of electricity and electronics topics. While the curriculum was udergoing revision, the course instructional format was also being changed. The individualized instruction was being adapted to a computer-based format. A Computer Managed Instructional (CMI) system was being implemented where the number of modules of instruction required for each student was based on the follow-on rating school requirements. By 1970, full implementation of CMI had been completed and all BE/E courses were taught from a common core curriculum.

In 1975, the next major change occurred in the BE/E curriculum. A complete reevaluation of the curriculum was accomplished using task analysis developed from survey feedback provided by operational units. The emphasis of this revision concentrated on the skills and manipulative tasks required in electrical and electronics related jobs. Since 1975 to the present, only minor alterations in the BE/E course format and curriculum have occurred. Changes have been limited to maintenance of the course material currency, minor changes in the topic sequencing, and scheduling of the number of core modules required in each student's training. Scheduling of modules has varied the length of instuction from 4.9 to 7.2 weeks and is based on seasonal and historical trends in the data base of prior student performance.

2. Current BE/E School

According to the Catalogue of Navy Training Courses, the purpose of the BE/E school is to provide the basic knowledge and skills in electrical and electronics theory and application inherent in a broad spectrum of ratings [Ref. 8]. As in the past, the current course is prerequisite training for 21 Navy ratings with entry requirements determined by the follow-on "A" school rating requirements. Four training sites--Great Lakes, IL, San Diego, CA, Orlando, FL, and Memphis, TN--provide a varying number of courses for specific rating training pipelines.

Current BE/E courses are self-paced, self-study, individualized instruction. The length of each course varies from two to fourteen weeks and is dependent on the number of modules required by the follow-on school. The school curriculum is divided into 34 modules which cover topics ranging from basic electrical/electronic theory and circuitry to highly sophisticated solid state components and integrated circuits. As a consequence of the variable course lengths, number of modules, and follow-on school requirements, there are 41 different courses taught, each course being specific to a single rating or enlistment program. To meet operational needs for electrical/electronics technicians, the annual output of the school, as shown in Figure 2.3, is a large portion of the initial skill training output.

FY	BE/E GRADUATES	% OF OUTPUT*	AVG. LENGTH (DAYS)
78	20989	12.8	35
79	21180	16.2	53
80	22239	14.2	53
81	23761	14.6	54
82	24260	15.6	59
83	23585	13.9	60
84	24761	14.2	61

* Percentage of Initial Skill Training output as shown in Table 2.

Figure 2.3 BE/E Output, FY 78 - FY 84

As mention above, the courses given in BE/E school are individualized instruction. The student, therefore, can complete the course as quickly as he or she desires. When students begin their training, they are given a target time to complete all assigned modules. Each module consists of a text, a workbook, self-tests, and supporting texts. The subject matter contain in the modules is "decontextualized," meaning that it is generic in nature and not related to job content nor job functions. Decontextualization of the course material is necessary due to the number of ratings that the BE/E school supports. The student studies at his or her own pace and completes each lesson in the modules. At certain intervals, the student will self-administer a test for the material just completed. All testing is on a Computer Managed Instruction (CMI) system which scores the test and gives subsequent assignments or remedial study on the present module in the event of a test failure. A student must pass each test before proceeding to the next section. Once all modules are completed, the student graduates from BE/E school and proceeds to his or her follow-on school.

From 1982 until just recently, a revamping of the course sequence has been occurring. The course of instruction is adopting a criterion-referenced testing procedure for each of the end of module tests that the student takes. This criterion-refenced testing and course sequencing are aimed toward improving the student's performance in job related skills. Since late 1984, the BE/E course has been undergoing conversion to a group-paced instructional format. The criterion-referenced testing, course sequencing, and instructional format change will all be compared against the FCT project's revision to the BE/E course.

C. PROBLEMS IN SPECIALIZED SKILL TRAINING

As previously mentioned, operational units are frequently critical of the performance demonstrated by specialty training graduates. The broad issues appear to be whether or not the training system is meeting its objectives and whether or not the objectives that are being taught are those which support the knowledge and skills an individual needs for a particular job. From this perspective, operational units blame the training system for failure to meet the perceived job skill needs. Units appear to want personnel who can fill a job vacancy and go right to work. But, the function of the training system is not to train individuals to a fully proficient job skill level. In reality, every individual who enters an operational unit, regadless of the extent of his or her previous training, requires experience in the job to become fully proficient [Ref. 4: p. 27]. The training system is reasonably correct in assuming that operational units have too high expectations of what job skills a trained graduate is capable of performing. Regardless of these assumptions, there is a perception that a problem still exists. There may be merit to the accusations made by operational units since their perception may be that the job skill level demonstrated by the individual when entering the job is unacceptable and it is taking too long for individual to achieve full proficiency. Is this the real problem? If not, what is the problem? Is it a training system problem? Is it a problem with the individual? Or is it a combination of both? Perhaps the student was taught what was required for the particular job but either didn't retain the knowledge and skills or could not apply the learned knowledge and skills in a job situation? Maybe the problem is with the way the curriculum is developed or the manner in which the course material was communicated to the student?

All of these questions are, to some degree, valid problems found in specialty skill training. In the next section, the functional context method of instruction and a project applying the methods will be presented. The approach used may be the solution to the specialty training problems mentioned above as each of these are the objectives of the Navy's Functional Context Training Project.

III. THE NAVY'S FUNCTIONAL CONTEXT TRAINING PROJECT

A. BACKGROUND

The Functional Context training (FCT) project has been developed based on an operational need within the Navy. This operational need is comprised of three major aspects--training resource allocation, the training systems' ability to meet the user's needs, and the changing nature of the Navy's job structure.

The cost of training has and continues to increase to ever larger proportions of the military budget that a solution is needed to get "more bang for the buck." Total training resource allocation have grown in size, more than doubling in a six year period, while resource allocations for specialized training have grown at a slower rate. The need for specialty skill training in a formal, school-type environment is recognized as a means of producing skilled and knowledgeable individuals. The school-type environment is an expedient way to meet the skill manning needs of operational units with personnel who have entry-level training. Billet vacancies as a result of people leaving the Navy, moving into more specialized billets, or additional billets created as the Navy expands to a 600-ship fleet complicate the training and resource allocation process. The requirements for meeting the job skill needs of operational units, reducing training costs to ensure there are adequate resources, and meeting the needs of a changing billet structure while simultaneously improving the individual's abilities to perform in his or her assigned job is the difficult task that faces training system administrators. In short, the training system must develop a plan to produce better results at a lower cost.

B. THE FUNCTIONAL CONTEXT METHOD, PRINCIPLES, AND APPROACH

The functional context method of instruction was developed as a result of training research conducted by HumRRO[3] during the late 1950's. The research was conducted for the U.S. Army and aimed toward improving the training of electronics maintenance personnel. The results of the research generated an instructional system development approach which was the opposite of conventional methods of instruction.

1. Conventional Methods of Instruction

Conventional instruction methodologies most often begin with the student learning basic theory, principles, and concepts of the subject area. The rational used in this approach is to first establish a knowledge base and then build from there. The sequence of instruction under conventional instruction methods then develops and teaches the

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[3]HumRRO was formerly the Human Resources Research Office of The George Washington University, Washington, D.C. Now, it is the Human Resources Research Organization, a private, non-profit research firm in Alexandria, VA.

student the concepts, principles, and functions of the individual electrical components, circuits, and assemblies of electrical equipment. Once the student has sufficiently achieved this vast body of knowledge covering the theory, concepts, principles, and functions, the instruction focuses on teaching the relationships and interactions between the parts comprising the equipment. The final phase of conventional methods teaches the student the application of the abstract and conceptual knowledge required for maintenance and troubleshooting tasks.

The conventional methods of instruction uses the "theory first--application second" development approach. Abstract concepts such as electron (current) flow are explained in terms of other abstract concepts like molecules exchanging electrons or analogies of golf balls moving through a pipe. Mastery of the principles and theory is advocated as a prerequisite for understanding higher and more complex levels of principles and theory. This is a deductive or part-to-whole approach where the knowledge of basic electricity is built from an assemblage of the parts and then applied to job-oriented tasks and skills. [Ref. 9: pp. 53-4]

2. <u>Functional Context Method of Instruction</u>

a. The Theoretical Basis of Functional Context

The theoretical framework of the functional context method applies the theory of cognitive psychology to current instructional technology. Cognitive psychology addresses the theory of how an individual deals with the problems of resolving what the individual perceives in the environment and how the individual internalizes that perception of the environment to gain an understanding of himself and the environment; and how the individual's behavior (performance) changes in response to the resolution of those environmental perceptions [Ref. 10: p. 340]. The theory examines how people learn and how that learned information is applied in different situations. Learning can be though of as the process of developing new insights (a sense of or feeling for patterns or relationships) or modifying old insights [Ref. 10: p. 296]. The process of learning and how to transfer that learning into another situation is the goal for instructional programs. The knowledge base and processing skills inside a person's head are developed and modified or changed through training where new information presented has similarities to what is already known. The interaction between the processing skills and knowledge base due tc the perception of the external environment is the learning process. The individual retains the most current experience and the old knowledge is changed or modified.

When new situations are encountered, the perceptual similarities and relationships of the elements comprising the new situation are compared to those elements contained in experiences of the past. The individual's reaction to the new situation will depend on how many similarities can be drawn from past experiences. When matches between new and old are made, then the learning process is meaningful. When the relationships and similarities are meaningful, generalizations are developed which will promote future learning. Learning transfer occurs when generalizations, concepts, or insights which were developed in one learning situation can be used in others. For learning transfer to occur, the learner should not only generalize but understand how the generalization can be used and have a desire to use it. [Ref. 10: pp. 390-2]

The functional context method applies learning strategies embodied in the theories of cognitive psychology, learning, and learning transfer to current instructional technologies. Technologies in instructional design, development, delivery systems, and media devices are used to best facilitate the learning process. The training design used in the functional context method is where the components of the final performance tasks are identified; achievement of each component is ensured; and the learning situation is sequenced where transfer from one component to another is ensured [Ref. 11: p. 88]. All of these factors of design, theory, and technology combine to form a method of instruction which optimizes the learning process.

b. The Application of Functional Context

The functional context method of instruction is analogous to troubleshooting techniques. In troubleshooting, the technician begin the process by developing an orientation to the overall system that is affected by a problem. The pieces of equipment in the system are identified and related to their function within the system. From the nature of the problem, pieces of equipment are eliminated as not being probable causes of the problem. When the technician has eliminated all but one piece of equipment, he or she begins the decomposition of that piece into its major assemblies, subassemblies, and component parts. Eventually the fault is isolated to the smallest integral part in the system. In as much as the troubleshooting sequence is oriented in a whole-to-part approach, so is the functional context method of instruction.

The functional context method, in contrast to the conventional method of instruction, advocates a topic sequence where the material is taught within a context that is both meaningful to the student and relevant to the goals of the course [Ref. 9: p. 55]. The sequence of topics are arranged whole-to-part, concrete-to-abstract (known-to-unknown), and operational-to-theoretical. Instead of being based on theoretical knowledge of abstract fragments of a topic as conventional methods are, functional context methods are based on a functional, job-oriented context.

From this orientation, the functional context method begins by establishing a broad understanding of the functions of the job (such as electronic maintenance and repair) that the student is being trained to perform. Fundamental principles are introduced in a maintenance-oriented context as they relate to the job. The part (a principle) is related to the whole (the job). This approach stresses that knowledge of the whole does not presuppose knowledge of the part whereas, conversely, understanding the function of a part depends on prior knowledge of the whole that contains the part [Ref. 9: p. 55]. The fundamental principles contained within the context of the job are explained as to their relevance to the job and relationships to one another. The whole-to-part orientation is maintained throughout the sequencing of the instruction. The context emphasizes what a part does and how that part's functioning is relevant to the whole. This provides meaningfulness for the student by drawing on the student's past experiences.

The principles of equipment functioning are linked to the maintenance context of the instruction. Troubleshooting techniques are used to introduce and teach the functions of the various parts of equipment as they become relevant to the maintenance-oriented context [Ref. 9: p. 56]. The functional context method, from this point, begins to narrow the focus of instruction to equipment, electronic principles, more complex troubleshooting techniques, and so forth as they become relevant in the context of the job and goals of the course. The narrowing of the instructional focus brings into the student's experience base more complex job skills which are built upon previously learned, basic skills. Successively smaller parts are introduced only if they are relevant to the job context. Parts are explained according to what their function is and not how it performs its function. If "how the part performs its function" is relevant to the job, then the concepts and principles needed are introduced. The linkage between the functions of the assemblage of parts and troubleshooting techniques allows the student to develop general troubleshooting strategies. These strategies can be applied when isolating and correcting faults in different types of equipment which have functions similar to those that the student has already learned.

3. Summary

While the content of course material used in a basic electricity and electronics course taught by the two methods may be the same, the functional context method utilizes a different order and emphasis given to specific details in the material. Functional context methods are sequenced completely opposite of conventional methods. In contrast to the arrangement of the curriculum, functional context methods usually are of two types and depend on the variety of equipment maintenance skills that must be taught. If a wide variety of distinctly different types of equipment must be maintained, the instruction is arranged from simple to complex where the whole-to-part sequence is repeated for each piece. If maintenance of only a few basic types must be taught, the instruction can be arranged beginning with qualitative concepts and simple test procedures on simple equipment versions and progress to quantitative principles and complex test procedures on complex equipment [Ref. 9: p. 55]. The conventional method usually uses equipment only in its final stage and the equipment used is usually quite complex. Finally, reemphasizing the main features of the functional context method is important in understanding the uniqueness of this method of instruction. The features are:

- A meaningful and relevant context is provided for the learning of novel and abstract material.
- The use of relevant functional context bridges the gap between novel material and the student's past experience.
- The whole-to-part sequence of topics makes possible a close integration of basic electronics with trouble-shooting.
- The possession by the learner of relevant and meaningful functional contexts encourages questioning and problem-solving attitudes, which enhance motivation for the learning of new material.
- The relevance of a topic is readily judged when it is viewed in relation to established functional contexts which precludes inclusion of topics that lack functional significance.

- The use of a troubleshooting-oriented context for instruction makes it possible to represent the job situation realistically in training in terms of duties, types of maintenance problems, and equipment items encountered. [Ref. 9: pp. 56-7]

C. FCT PROJECT PURPOSE AND OBJECTIVES

The specific purpose of the FCT project is to increase the efficiency of Navy specialty training [Ref. 6: p. 2]. More broadly, the project will attempt to provide solutions to the training system problems of resource allocation, output quality, and meeting operational unit manning requirements. The training system to date is criticized for not properly preparing individuals for their job. Feedback from operational units report that individuals appear to lack an understanding of the foundations of their jobs; they do not retain what they have been taught; or they cannot apply what they have been taught in a job situation. To resolve these problems, the FCT project has objectives that are specifically focused on these problems.

1. Operational Objectives

The operational objectives of the FCT project are to provide the Chief of Naval Operations (CNO) and Chief of Naval Education and Training (CNET) with instructional design methods that integrate training by increasing the meaningfulness and retention of the subject matter and improving the students' ability to apply learning to situations encountered on the job. An additional objective of the project is to provide the CNO and CNET with information on the costs and effectiveness of the methodology. [Ref. 6: p. 2]

2. Technological Objectives

The technological objectives of the FCT project are: (1) develop and test a general FCT methodology by applying the theoretical foundations of cognitive psychology and advanced instructional technologies to improve student acquisition and use of conceptual and contextual knowledge and understanding; (2) develop curriculum design and instructional delivery methods based on cognitive psychology foundations and instructional technologies; (3) test and evaluate the methods in Navy technical training; and (4) if methods are successful, develop procedures and documentation for broader implementation. [Ref. 6: p. 2] From the technological standpoint, many of the design and development methods of FCT may appear to be quite similar to current traditional methods. FCT does differ significantly in the perspective that instead of a purely behavioral (stimulus and response) orientation, it combines the behavior aspects with the cognitive aspects of a job's content and job contexts.

D. THE PROJECT PLAN AND EVALUATION

1. Current Plan

The current plan is to take the FCT method and apply it to a portion of the BE/E and Avionics (AV) "A" School pipeline. Based on the objectives of the project, the portion selected must be unrelated to the job a prospective graduate could be assigned. The current BE/E school curriculum fulfills this requirement since the course materials are generic and abstract in nature. The FCT method will concentrate on bringing subject matter, content, and performance objectives relevant to the follow-on AV "A" School into the BE/E curriculum.

Course development begins with a statement of the overall course objective: To train personnel in basic electricity and electronics skills and knowledge which will provide needed prerequisites for follow-on "A" School training. This overall objective is used to generate a list of broad terminal statements which describe the performance required to meet the overall objective. Then, under each terminal statement a list of more specific tasks or competency indicators which, when properly performed, would indicate competency in the general abilities of that terminal statement. Competency indicators are further divided into the skills and concepts required to perform the indicated task. The terminal statements, competency indicators, and skills and concepts form the structural framework for the course and for curriculum development.

Curriculum development begins by using the overall course objective to determine the final context that will be used in the instruction to provide the prerequisites required for the follow-on school. Due to the marked differences in the current curriculum and that which is needed for the FCT version of training, the curriculum for FCT-BE/E will be rewritten in FCT format but will contain the same content as the current course curriculum. The curriculum material in the FCT revision will be designed and developed using "context carriers." A context carrier is an object which is familiar and known to the student. The knowledge and familiarity the student has with the context carrier establishes a starting point for learning increasingly more complex concepts, tasks, skills, and performance objectives. Working backwards from the final context carrier, the simplest context carrier or starting point for instruction is determined. For example, a flashlight is a common device which can be used as a context carrier for learning a number of basic principles of electricity, e.g., voltage, resistance, circuitry, DC current flow, and so forth. The next step in curriculum development is to determine the learning tasks. A learning task is basically the skills and concepts that can be taught using each context.

Several context carriers can be used to teach the same skills and concepts but this repetition is avoided. Learning tasks are used to develop individual lesson plans. The context carrier is used to establish meaningfulness between the course material and a student's prior experiences and knowledge. The components of a flshlight as a context carrier, such as the batteries, light bulb, switch, and conducting strip, are items the student can relate to when developing an understanding of theoretical, contextual, and conceptual subject material.

By sequencing the instruction in the course by using simple context carriers and proceeding to more difficult and complex context carriers, the students will have meaningful references as they build their electricity and electronics knowledge and skills. Context carriers also provide a media where job performance skills such as trouble-shooting can be demonstrated. The sequencing of the context carriers facilitates learning, practicing, and increasing job related performance skills. Since the cost of providing each student with the equipment found on the job is prohibitive, computer-based equipment simulation technology and electronic training mock-up units will be used for hands-on training and performance testing. As such, the FCT-BE/E will use a good deal of computer simulation of context carriers to support training. Students will participate in laboratory exercises with instructor supervision.

2. Project Evaluation

Since the ultimate goal of the FCT project is to increase efficiency, the evaluation of the effects of the FCT methods on Navy technical training is necessary. The present plan is to compare the FCT-BE/E course to self-paced BE/E and to grouped-pace BE/E. Specific evaluation objectives focus on:

- Differences in acquisition and retention of factual, conceptual, and theoretical content across the three course versions.
- Problem solving (trouble-shooting) performance.
- Student ability to transfer the training to a new situation.
- Course completion time and time engaged in training.
- Differences in performance between high and low ability groups.
- Student and instructor attitudes toward instruction.
- Attrition and set-back rates for the three versions.
- Resources required to support training for the three versions.

E. EXPECTATIONS OF THE FCT METHOD OF INSTRUCTION

1. Past Research

As mentioned at the beginning of this chapter, most of the early research using the functional context methodology was conducted by HumRRO. In two experimental tests, the results and findings concluded that the functional context method is superior to conventional methods of instruction. These two studies are significant to the current FCT project since the subject material used in the studies was basic electricity and electronics training. The findings of more recent research on the application of cognitive psychology theories and instructional technology support the findings of the earlier reports and are referenced in Cognitive Science and Human Resource Management [Ref. 12].

a. HumRRO Technical Report 58

This research study is titled Development and Evaluation of an Improved Field Radio Repair Course. In this study the functional context method was applied to the Army's Field Radio Repairmen Course at Fort Monmouth, New Jersey. Students with similar entry aptitude, civilian education, pre-Army electronics experience, and course interest characteristics were divided into an experimental group who received the functional context course and a control group who received the standard or conventional course. Both courses had the same number of hours of instruction over a 20 week period. The courses contained the same topic content but differed in the amount of time spent on topics. The broad objectives of the courses was to produce personnel qualified to perform field and depot maintenance on field-type radios and associated equipment. The experimental course had an additional objective to produce repairmen who would be immediate assets to their units, but not to the extent of being fully proficient repairmen.

(Note: By training doctrine, trained specialists were not expected to be fully qualified repairmen.)

Following the training, each group was administered a Field Radio Repair Proficiency Battery which consisted of three paper and pencil tests (Achievement, Manuals, and Schematics Tests) and four performance tests (Troubleshooting, Test Equipment, Repair Skills, and Alignment Tests). The results showed the following:

- The experimental group students were superior on the Achievement, Troubleshooting, Repair Skills, and Test Equipment Tests.
- There were no significant differences between the two groups on the other tests.
- The experimental group students were superior on each of the eight problems comprising the Troubleshooting Test. [Ref. 13]

b. HumRRO Technical Report 61

The title of this research study is <u>Basic Electronics for Minimally Qualified Men: An Experimental Evaluation of a Method of Presentation</u>. This study's prime objective was to present a basic electronics course of instruction to students whose aptitudes are just below the level required for course entry. Additionally, the study was to determine whether the method of presentation could make technical training easier for students with marginal aptitudes and which method of instruction is more feasible for students whose aptitude presently excludes them from training entry. The functional context principles were applied to the basic electronics portion of the Army's Field

Radio Repair Course at Fort Gordon, Georgia. The experimental instruction was conducted over the first three weeks of the course. (The research conducted earlier at Fort Monmouth used the experimental instruction over the entire course rather than being limited to the first three weeks.) Experimental and control groups of students were selected from seven classes taught by conventional methods and from thirteen classes taught by the functional context method. Results were compared on students in the two groups who were Army privates, white, of North American continent origin, and either draftees, regular enlistees, or reservists who had just completed basic training. The experimental and control groups contained 184 and 202 students, respectively, who met the analysis requirements. At the time of this study, the school entry requirement was a score of 100 in the Electronics (EL) area of the Army Classification Battery.

Following the basic electronics training, each class of the two groups were administered an achievement test battery consisting of ten subtests covering all topic areas presented in the course instruction. The result showed that the experimental group students answered nearly 5% more questions correctly of the 232 questions in the composite battery. (The number of questions in the composite battery was 252. Twenty question from the Troubleshooting subtest were dropped from the overall comparison since the schematic used in the testing was used by the experimental group during instruction. The experimental group students were consistently better on the Troubleshooting subtest.) Comparisons of the low (EL below 100) aptitude and intermediate (100-109) aptitude students in the two groups showed that the functional context method was more effective; both methods were equally effective for average and above (over 110) aptitude students. On average, the low and intermediate aptitude students in the experimental group did as well as the average (110-119) aptitude students in the control group. [Ref. 14]

c. Summary

The aggregate results of these two studies indicate that the functional context method appears to be superior to the conventional method of instruction. Specifically, students trained by the functional context method have a better knowledge of correct troubleshooting and repair procedures, can better demonstrate transfer of troubleshooting techniques to unfamiliar equipment, can better demonstrate proficiency in the use of troubleshooting test equipment, and can better demonstrate the manipulative and mechanical skills used in equipment repair. At the time of course graduation, the individual trained by the functional context method appears to be at least equal to, if not more, proficient in the performance of job related skills than an individual trained by conventional methods of instruction.

2. FCT Project Expectations

The operational and technological objectives of the project capture the essence of the combined results found in the two HumRRO studies. The project seeks to improve comprehension, generalization, application, and retention of the basic electricity and electronic skills and knowledge needed for follow-on training. Based on the past success of the functional context method experimentation, the current project can be expected to be equally successful. Although the previous two studies did not have the advantages of current instructional technologies available today, evaluation of the SP-BE/E, GP-BE/E, and FCT-BE/E courses should indicate differences between methods.

Assuming past results hold true and only sequence of topics and topic emphasis are the only differences in the three project courses, the FCT-BE/E course should be highest in performance test scores, diagnostic test concepts, retention tests, transfer tests, liked by the students, and lowest in course attrition rate. In all likelihood, the FCT project should achieve most of its performance goals.

IV. ECONOMIC ANALYSIS, EFFICIENCY, AND EFFECTIVENESS

Navy training system managers are continually faced with resource allocation decisions. Allocating the correct amount of resources to each of the various Navy training and education programs while ensuring each program meets its training objectives is an extraordinarily difficult and demanding task. Faulty decisions can have significantly varying impacts on the programs in the overall training system. For example, under-allocation of resources can cause a training program to be unable to produce the required quantity and/or quality of graduates. Over-allocation can result in a program wasting resources. Neither of these situations is desireable nor optimal. Decisions regarding resource allocation must be based on some type of analytical approach which determines an optimal resource allocation strategy. The analytical approach must have considerable flexibility so that decisions concerning resource allocation can be made in a variety of diversely unique situations. The decision situations faced vary from determining the amount of resources required for a single course to determining the allocations among courses of different training categories and types. Economic analysis provides a sequential and conceptual framework that a manager can use to determine the "best" strategy where resources can be allocated and used to achieve training objectives.

As shown in Tables 1 and 2, the funding requirements as well as the number of individuals being trained are increasing. Both of these factors are under close scrutiny with regards to how the resources are being expended and whether or not any resources are being wasted. With approximately 2700 specialized skill training courses consuming over a third of the Navy's training funds, prudent allocation of resources is required. Without sufficient resources to achieve output objectives, the primary source of skill training can expect increasing criticisms regarding the quantity and quality of its output. Therefore, economic analysis of the Navy's training system must be done to determine the best use of scarce resources.

A. ECONOMIC ANALYSIS

Economic analysis is a systematic process which provides a decision-maker with quantitative and/or qualitative information for comparisons between alternative uses of resources. The main goal of economic analysis is to determine what kinds and quantities of resources are used by each alternative and what the outputs (results, outcomes, or benefits) are expected or were produced from each alternative. A training system's output is the graduates it produces through the consumption of resources. Economic analysis of a training system provides information for comparing how well the system achieved its objectives.

Before the economic analysis process can begin, the system being analyzed must be clearly defined in terms of its boundaries and objectives. Since the characteristics of a system can be thought of as a group of elements or parts that are organized to achieve a common objective or objectives, determining the points where the process of achieving the objectives begins and ends is often very difficult to establish. Interactions among elements in different systems often causes difficulties in determining which system a particular element belongs in and, thus, complicates the task of defining boundaries. The boundaries of a system describe the environment where the process of the system takes place. In the context of economic analysis of training, the boundaries of a training system must be defined in terms of where the resource allocation begins and ends and where the process of training begins and ends. The objectives of the system assist in refining the boundaries by specifying where the system process ends. Working back from that point, all elements or components involved in the process are identified to determine where the process begins. If an element is not part of the system process, then it should be excluded from the system definition. Once the beginning point has been established, the system being analyzed has been defined. The following example will illustrate the difficulty in defining a system for analysis purposes.

Since economic analysis is concerned with gathering resource allocation information, a training system must be clearly defined as to where the allocation and training processes can be easily identified and evaluated. Analyzing the whole Navy training system as a single system would be a very difficult task due to the complexity, variety, and scope of training involved. Navy training is a part of the total military training system. The objective of military training was described previously in the following quote:

> The sole objective of individual training for military personnel is to produce knowledgeable, disciplined, dedicated service members who are capable of functioning effectively in the military job structure and contributing to the combat capability and mission readiness of military units. [Ref. 4: p. 23]

This quotation clearly states the objectives of military training. By substituting "Navy" for "military" in the quote, the objectives of Navy training would be clearly stated but the boundaries where the resource allocation process begins and ends are still not well defined.

Most systems usually have a logical, hierarchical structure which can be divided into decreasingly smaller parts or subsystems. The procedure of dividing system elements into smaller and smaller part is conceivably limitless. Consequently, the procedure is usually done by dividing a system down to the smallest element in the hierarchical structure where the system's process and a process of interest (resource allocation) are clearly defined by the same boundaries. The military training hierarchy can be divided from the military training system into the Navy training system into the specialized skill training system, and so forth. Each smaller subsystem has its own elements organized to achieve training objectives which are more specific than the training objectives of the larger system. The boundaries of the system process are becoming better defined but the allocation process boundaries are still unclear due to the differences in the types of training possible. Within the categories, other elements, such as initial skill training within the specialized skill category, can be found that display the characteristics of a system. Finally, a specific course of instruction is the smallest element that can be described as a system where the boundaries of the system process and the resource allocation process are the same.

Economic analysis can be conducted at any desired level of the hierarchy. The lowest level in the hierarchy where the system process and the process of interest share common boundaries must be defined. Analysis of the whole Navy training system is not possible until analysis of each element that can be defined as its own system has been completed.

Once the system to be analyzed is well defined, economic analysis can begin by evaluating the components of the course. This approach provides a logical sequence of tracking resource flows through each system. In the FCT project, three different instructional methods will seek to achieve the same objective. In this instance, each of the three methods can be treated as a separate training system and analyzed separately. The analysis will produce information for comparing the output of each system against the resources to produce the output. The three courses can be compared with the results produced by the others and a decision can be made as to which of the three is the "best" alternative. From this perspective, each of the courses or training systems can be described by a conceptual model which defines its process. This conceptual model, as shown in Figure 4.1, is called the cybernetic model [Ref. 15: p. 4]. In a training context, the cybernetic model can be used to track resources through the system where the nature of the inputs and instructional process determine the final state of the product [Ref. 16: p. 16].

The economic analysis based on the input, process, output components of the training system is a means to examine what resources go into the system, how the resources are utilized, and what output is achieved. Analysis of a system in this fashion provides the feedback to system components as shown in Figure 4.1. As a form of feedback,

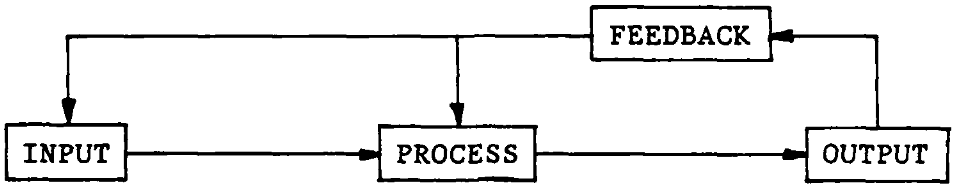

Figure 4.1 The Cybernetic Model

economic analysis usually generates a single indicator or unit of value that can be used to compare the dollar costs of the resources required to produce the output [Ref. 17: pp. 1-2]. The comparison of the resource costs to the outputs achieved provides the decision-maker information for selecting alternatives which will either maximize the desired output at a specified level of resource use or minimize costs to produce a specific level of output.

The analysis of a training system can provide similar information which represents opposite ends in a spectrum of possible decisions. At a given level of resource allocation, the training system can produce a limited number of graduates who have the knowledge and skills for a specific job at the highest degree of proficiency. A decision made on this rational is one end of the spectrum where the issue of concern is the output quality rather than the quantity of output. Higher levels of proficiency require more resources, and therefore, fewer graduates can be produced for a fixed amount of resources. On the other hand, the training system can produce a large number of graduates who have minimum job entry level skills while minimizing the resource costs to achieve that level. A decision based on this rational is the opposite end of the spectrum and is more concerned with the output quantity rather than the quality of the output.

Training systems in the Navy should be concerned with both quantity and quality, where, for the minimum cost possible, as many graduates as possible are trained to the highest level of job knowledge and skills possible. As mentioned in the previous chapter, FCT is expected to be able to produce a large number of graduates who possess greater proficiency in basic electricity and electronics. The minimum cost aspect is one of the FCT project evaluation objectives that will be determined once the pilot program is implemented.

The output of a training system is a direct result of the system's productivity. Much like any corporate enterprise, the productivity of a system is the ability of the system's process to yield results, benefits, or a favorable outcome. Economic analysis is a means to determine the productivity by examining the input, process, and output components comprising the system. Each of these three components can be examined in terms of the resource quality, quantity, and cost information generated from the analysis. From this information, the system's productivity can be measured by its efficiency and effectiveness. The midpoint of the decision spectrum is where the training system is efficient and effective in producing its output.

B. EFFICIENCY AND EFFECTIVENESS

1. Efficiency

From an economic analysis context, efficiency can be defined as the relationship between the resources a productive activity consumes (its costs) and its output [Ref. 4: p. 3]. In the same sense, efficient, the root origin of efficiency, can be defined as using no more resources than are required to achieve its objective [Ref. 4: p. 1] or productive without waste [Ref. 18: p. 362]. These definitions deal with two aspects of a training system's productivity--output and costs. Economic analysis does provide the cost and output information needed to develop measures of efficiency or measures of efficient production.

a. Efficiency Measures

Since the comparison of resource costs and output is made, efficiency measures are generally a ratio relationship of the costs to the output. Resource costs are reasonably straight-forward and easy to understand since they are usually described by a single, dollar value. Resource variables (the different types and kinds of resources) enter the training system model as either an input or as a process cost. The combined costs of the inputs and process resources determine the cost required to produce the output where a dollar value serves as a common denominator for the resources consumed in the system. Taken individually or in aggregate, the resource costs of a training system can be analyzed to determine the relative value of one resource variable to another, and the value of all resource variables to the output.

The output variables, on the other hand, are not as straight-forward to understand or determine as are the resource variables. Output variables can be any type of result, benefit, or outcome that is produced by the training system process. Two of the most common variables used to describe training system output are number of graduates and number of student man-years. These two variables denote a quantity or standard unit of output. Output variables are usually associated with some quantity or standard unit of the system's productive efforts.

Efficiency measures are usually ratios of the cost per graduate, cost per student man-year, or some other cost per quantity of product. Efficiency measures correlate with the quantity end of the quantity versus quality end of the decision spectrum. The training system produces a quantity of output while minimizing costs. Comparing the efficiency of a training system over a specific time interval will show changes in the efficiency of the system whenever the ratio between resource costs and output quantity change.

b. Problems with Efficiency Measures

The output variables used to determine an efficiency measure are susceptible to limitations which affect their use. For instance, cost per graduate and cost per student man-year are affected differently by training attrition rates and by course length. Cost per graduate computations tend to capture attrition and course length effects whereas cost per student man-year computations do not change for attrition or course length changes [Ref. 4: p. 12]. Costs and student man-years both increase/decrease whenever attrition rates or course lengths increase/decrease. One efficiency measure captures the effects of the changes while the other measure hides the effect.

Another problem of efficiency measures are their ability to differentiate in the resources needed for training. Different training courses require different amounts and types of resources. For example, to try and compare the efficiency of training an aviator pilot and training a galley cook is somewhat ludicrous. Both training systems may be equal in their ability to efficiently produce graduates, but they vary substantially in the costs required to obtain that objective. Efficiency measures cannot be realistically compared for course (training systems) which are heterogeneous. Different courses teach different skills which require different amounts of resources and therefore, restricts analysis of efficiency to single courses or groups of like courses [Ref. 4: p. 10]. Like courses should be from the same subcategory (type) of training, be of nearly equal length, and be of an unchanging curriculum. For instance, comparing the efficiency of apprenticeship training in two different time periods assumes that both groups were given the same duration of training, the graduation standards were the same, and the same material was taught. Changes in any of these factors may or may not be detected as a change in efficiency. In summary, efficiency measures must be cautiously interpreted. Changes in the cost and output variables may or may not be reflected as a change in efficiency.

2. Effectiveness

The opposite end of the decision spectrum is the effectiveness of the training system. Training system effectiveness can be defined as the system's ability to train graduates to perform the tasks that they will be required to perform in a future assignment [Ref. 4: p. 24]. Effectiveness is the relationship between the output (results, benefits, or outcome) of the training and a valid requirement for that output. In this sense, effectiveness is the quality of the output compared to what quality is required for the job. The skills and knowledge objectives of a specialty training system, if properly specified, reflect those required in a job. Achievement of these training objectives represents the effectiveness of the training system.

a. Effectiveness Measures

Effectiveness measures are not easily quantified. Placing a numerical value on an individual's ability to perform a specific set of job skills is highly subjective. In actuality, the individual either can or cannot perform the required skills. Most training courses have some leeway in the degree of perfection that is allowed and considered "satisfactory." The system is a pass-fail situation, within the leeway given, where successful performance on successive job skill tasks is required for an individual to continue in the training system until eventual graduation. If all performance tasks taught in the course can be performed, then it is reasonably assumed that the individual will be able to perform in a job situation and that the training was effective. Measuring the effectiveness of the training system can be carried one step further. The graduate can be evaluated as to how well he or she actually performs on the job. Here, the training system could be evaluated on how effectively it produced a qualified or proficient graduate.

Overall, effectiveness measures are highly arbitrary and subjective. A training system may meet its objectives of teaching a certain valid set (not all sets) of the skills and knowledge required in a job. At the time of graduation, the training system was effective. But, since all sets of job skills and knowledge were not taught, the training system was ineffective in achieving the proficiency level required for the job. Effectiveness is greatly influenced by the point where it is measured and by the requirements criteria used in the evaluation. Most frequently, effectiveness is measured at the time of graduation and evaluated against the skill and knowledge objectives of the course under the assumption that the objectives are a valid set of skills required by the job.

b. Problems with Effectiveness Measures

Effectiveness measures, being subjective and arbitrary, are difficult to determine. As mentioned in the previous section, determining the point where effectiveness of a training system is measured and the criteria against which the quality of the output is evaluated provide the two most significant difficulties in measuring effectiveness. Provided that the training strives to teach the student a certain, specific, valid subset of the skills and knowledge required for a job, then the level of proficiency demonstrated by the student during, upon completion of the course, or after training, is the effectiveness of the training system. Since most performance-based training systems do not require demonstrated performance to be without error, a passing criteria must be determined.

Determining the criterion for the permitted degree of error is another difficulty which may cause interpretive judgements of effectiveness to be inaccurate.

3. The Relationship Between Efficiency and Effectiveness

Taken individually, efficiency and effectiveness can be thought of as opposite ends of a decision-maker's spectrum of possibilities. Economic analysis provides a decision-maker with information where, on one end, an efficiency alternative can be selected or, on the other end, an effectiveness alternative can be selected. The efficiency alternative values the quantity or cost per standard unit of output whereas the effectiveness alternative values the quality of the output.

Taken together, efficiency and effectiveness can be thought of as the productivity of the training system. With efficiency describing the relationship between the cost of resources and the output and effectiveness describing the output and the requirements for the output, the productivity of the training system is the relationship between the cost of the resources consumed in the training process while producing a quantity and quality of output compared to the requirements for the output. This is the midpoint of the decision-maker's spectrum. It is the point that Navy training systems must endeavor to achieve. Training must be efficient and effective in order to optimize the resources used in training and maximize the attainable proficiency level of graduates.

V. A COST DETERMINATION MODEL

A. THE FOUNDATIONS FOR THE MODEL

The conceptual foundations used to develop this cost determination model are derived from the notions presented in the preceding chapter based on the systems analysis approach, economic analysis concepts, and the cybernetic model. Each of these three notions contributes separate aspects needed to develop a cost model. The systems analysis approach provides a means to define the system being analyzed to a single course of instruction. Economic analysis concepts provide the means for focusing the analysis on the cost value of the resources consumed by a course of instruction. The cybernetic model provides a description of the separate components of the course of instruction which must be analyzed for the resources used in the training system's process. All together, these notions form the foundation which allows a cost determination model to be developed which will compute the cost of the resources needed and consumed by a single course of instruction.

A cost model is a useful tool for a decision-maker who is confronted with resource allocation decisions among various allocation alternatives. In the analysis of Navy training, cost is a critical factor (although, not the only factor) that a decision-maker must consider when making resource allocations. The costs of the resources needed by a training system vary by the types, categories, and courses of instruction found within the whole Navy training system. Therefore, a cost determination model is needed which can determine the costs of all the resources consumed in a wide diversity of courses; be flexible enough to capture all relevant costs without being so complex that the model is extremely difficult to use; and provide the decision-maker/analyst with the cost information needed in allocation decisions. The information provided by the cost model, along with information provided from productivity (efficiency and effectiveness) analysis provide the decision-maker with what he or she needs in order to reach a decision.

The final aspect which contributes to the development of a cost determination model is an existing cost model used in a procedure for selecting instructional delivery systems known as the Training Effectiveness, Cost Effectiveness Prediction (TECEP) technique. TECEP uses a three step procedure where learning strategies are derived for the training objectives, instruction delivery systems to support the learning strategies are identified, and the costs associated with the delivery systems are determined. The TECEP cost model computes the costs of a majority of the resource variables which can be identified as input and process elements found in the cybernetic model. The procedures are repeated for each delivery system alternative. Once the costs are computed, comparisons are made between the alternatives and the delivery system which minimizes resource allocations is selected. [Ref. 19: pp. 1-3]

B. THE TECEP TECHNIQUE

The TECEP technique is a three step procedure which allows a training system designer/developer to select among alternative instructional delivery systems based on the costs and the estimated training effectiveness. Effectiveness, in this instance, is defined as the ability of the training system to achieve a set of pre-specified training objectives which are the basis for determining the delivery systems selected for comparison. This definition of effectiveness makes the TECEP technique specifically applicable to designing training systems that optimize resource allocations to accomplish a set of objectives. The situation facing the decision-maker differs from the situation the training system designer. For the decision-maker, the situation of resource allocation implicates the requirement for Navy training systems managers to analyze existing training systems to a degree where decisions to eliminate inefficient training methods, unnecessary training courses, outdated training technology can be made. The manager is concerned with the most efficient and effective means to conduct required training. Thus, the manager seeks to optimize resource allocations which minimize costs while maximizing the required level and quantity of training.

1. TECEP Limitations and Strengths

The TECEP technique has one major limitation to provide the analysis information a training system manager needs. The full analysis procedure prescribed by the technique (the three steps, comparisons, and selection of an alternative) determine the optimal delivery system that should be used before the training system is developed and implemented. The procedure requires user expertise where the user is familiar with learning strategies, available instructional technology, instructional mediums, and other such technical aspects of training. While the training system manager does not usually possess the level of expertise required to use the TECEP technique, he or she does possess a certain degree of specific knowledge concerning the strategies, technologies, mediums, and so forth that are contained in the existing systems. The procedural steps of deriving the learning strategies and identifying delivery systems are not applicable in the training system manager's analysis of training systems. The training objective, the strategies derived from those objectives, and the delivery system are given constraints over which the manager usually has little control. [Ref. 19: pp. 11, 19]

The major strength of the TECEP technique which is applicable in a manager's decision-making process is the cost model. The manager must have an overall perspective of all the elements comprising the training system being analyzed before a decision can be made. The cost model in the TECEP technique identifies a majority of resources consumed by a training system and computes a single, dollar value for those resources. Costs associated with a training system and the benefits, results, or outcomes provided by the system represent the information needed to make allocation decisions. [Ref. 19: pp. 19-20]

The TECEP cost model can be used in situations where the objectives of the analysis are selecting the most efficient alternative, determining the total absolute long-run cost of training, or determining the budget requirements for implementation and system operation. The efficient alternative selection eliminates resources common to all alternatives from the computations and analysis. Only the differences in resources used by the alternatives which achieve the same objectives are compared. To compute the total absolute long-run cost of training, all resources consumed by an alternative are included and evaluated at the cost incurred by its use. Using the model to determine budgeting requirements, the costs to purchase resources and cost of operating the system are included in the computation and analysis of each alternative. The first two uses of the cost model are beneficial to a decision-maker/analyst by providing a specific type of information. The cost of operating the training system now and in the future is an important aspect the decision-maker must consider. Although the

TECEP cost model determines future and not current costs, the decision-maker can use the model for that purpose. When the objectives of the analysis must change to fit a particular situation, the TECEP cost model has the strength to provide the specific cost information (without assessing the output) needed for allocations decisions. [Ref. 19: pp. 75-7]

2. Use of the TECEP Cost Model

The TECEP cost model provides the framework for constructing a cost determination model. A cost determination model should contain all of these same strength attributes in order to provide the manager/decision-maker/analyst a useful tool. The TECEP cost model provides another attribute beneficial for analyzing alternatives. Too many models attempt to be a panacea by providing the final decision instead of producing information the decision-maker can use. The model only computes the resource costs of a delivery system even though the technique seeks to minimize resource consumption. A cost determination model should likewise only compute the resource costs of existing training courses and leave the determination of course productivity to separate models or analytical techniques.

C. BUILDING FROM THE FOUNDATION

1. Training Resources

The training resources identified in the TECEP cost model fall into three major categories: (1) research and development, (2) implementation, and (3) operation and maintenance [Ref. 20: p. 17]. Although the TECEP technique and model are used to determine which instructional delivery system to develop and implement based on resources consumed from these categories, the three categories are equally applicable in a more general purpose cost determination model. If the manager is investigating possible course revisions which use state-of-the-art instructional technologies, he or she would need to know the cost required for developing the new instructional materials suited to the technology, costs required to acquire new or modify existing classroom facilities, and the cost required to operate and maintain the revised course in future years. Each of the three categories are applicable in a cost determination model and can be divided into six resource classes: instructional material development, facilities, equipment, expendable supplies, personnel, and students [Ref. 20: p. 17]. Within these six classes, the elements or variables contained in the training system's input and process components can be identified and their costs determined. The TECEP cost model includes a seventh resource class. The seventh class is comprised of miscellaneous variables which affect the cost of training such as attrition rates, rate of students repeating parts of the course, length of the course, and so forth.

One of the weakness found in most models is the inclusion of all relevant variables. In the case of a cost model, all relevant cost variables must be identified and considered even though, at some point, the variable may not be included in the analysis conducted. Inclusion of ALL relevant variables in a model appears to be a nearly impossible task, but an as complete as possible model provides more flexibility in the model's use. The TECEP cost model does exclude some variables from resource classes. This deficiency in the TECEP model is recognized and an attempt has been made to include all relevant variables in this cost determination model. The following section describes and defines the resource and miscellaneous variables which require data for use in the model's computations. (See Reference 19 for descriptions of the TECEP variables and for comparison of the two models.)

2. Resource Class Variables

This cost determination model contains all TECEP cost model variables. The descriptions of some input variables have been modified to more explicitly differentiate between resource variables used in this cost determination model. The seven resource classes follow.

a. Facilities Resources

The facilities resource class includes the buildings, land, and other real property assets associated with the training site. These variables depend on the type of course and instructional material used in the training.

VARIABLE	DESCRIPTION/DEFINITION
FACOST	The total cost to acquire new facilities for training course implementation.
LOFFA	Expected years of life of FACOST assets.
FARVL	The total remaining dollar value of existing facilities (greater of current market value, resale value, or original acquisition cost minus accumulated depreciation).
LORFA	Expected years of life of FARVL assests.
SQFTIN	Total square feet required for each instructor.
SQFTST	Total square feet required for each student.
SQFTAM	Total square feet required for administrative support and overhead.
CPSQFT(I)	Annual operation and maintenance cost for facilities per square foot (includes operation, maintenance, janitoral services, utilities, and so forth).

b. Equipment Resources

This resource class includes all non-real property capital assets such as classroom and laboratory equipment, instructional equipment, simulators, equipment for outfiting new facilities or adding to existing facilities, and so forth.

VARIABLE	DESCRIPTION/DEFINITION
EQCISP	The cost of equipment necessary for outfiting new facilities (does not include equipment uniquely associated with student positions or directly used in instruction).
LOFEQA	The expected years of life of equipment included in EQCISP.
EEQCIS	The cost of equipment necessary for adding to existing facilities (does not include equipment uniquely associated with student positions or directly used in instruction.
LOFEQB	The expected years of life of equipment included in EEQCIS.
CAQSP(I)	Total cost of equipment acquired in each year of the planning period. Includes cost of equipment which represents expansion or addition to the program plus replacement costs for facility, student position, and instructional equipment variables.
LOFEQ(I)	The expected years of life of equipment included in CAQSP(I).
RVLFEQ	The remaining dollar value of existing facility equipment in inventory (greater of current market value, resale value, replacement cost, or original acquisition cost minus accumulated depreciation to current year).
RLOPEQ	The expected remaining years of life of equipment included in RVLFEQ.
RVLSEQ	The remaining dollar value of existing student position equipment in inventory (greater of current market value, resale value, replacement cost, or original acquisition cost minus accumulated depreciation to present year).
RLOSEQ	The expected remaining years of life of equipment included in RVLSEQ.

RVLIEQ	The remaining dollar value of existing instructional equipment in inventory (greater of current market value, resale value, replacement cost, or original acquisition cost minus accumulated decreciation to present year).
RLLIEQ	The expected remaining years of life of equipment included in RVLIEQ.
OMFEQ(I)	Total annual operating and maintenance costs of equipment not uniquely related to student positions or instructional equipment. O&M costs of equipment included in EQCISP, EEQCIS, RVLFEQ, and CAQSP(I).
EQIMPC	The cost of new equipment (per student position) which must be acquired for implementation or added to existing student position equipment.
LOFEQ	The expected years of life of student position equipment included in EQIMPC.
EQIMIE	The cost of new equipment which must be acquired for implementation or added to existing instructional equipment.
LOFIEQ	The expected years of life of equipment included in EQIMIE.
COMPT(I)	Annual operation, maintenance, and replacement costs of equipment associated with student position and instructional equipment included in EQIMPC and EQIMIE.
TSPOSD	The percentage of operating time over the length of the course student position equipment is nonfunctional due to unplanned contingencies, i.e., failure, weather, etc.

(Note: accumulated depreciation is the straight-line depreciation value.)

c. Instructional Material Development Resources

The instructional material development resource variables represent one of the major training resource requirements [Ref. 20: p.17]. Included in this class are the variables which account for the costs to develop, revise, and update the master copy of the course instructional material. This resource class does not include the costs to produce the instructional material for classroom use.

VARIABLE	DESCRIPTION/DEFINITION
UIMD	The percentage of time the student (non-recycled students) spends in the training medium for which new or unique hours of instructional material must be developed.
REVISE	The percentage of time the student (non-recycled students) spends in the training medium for which existing instructional material must be revised.

(NOTE: UMID and REVISE total will not exceed 100%.)

VARIABLE	DESCRIPTION/DEFINITION
UIMDYR(I)	The number of unique hours of new instructional material to be developed in each year of the planning period. Does not include updating or revsions to the original course material.
UPDATE	Percentage of the original course material which must be revised each year to maintain the currency of the course material.
EVIM	The percentage of the original development and revision costs of the instructional material which remains at the end of the planning period.
CIMD	Average cost of developing the master copy of one hour of new or unique instructional material.

RIMD	Average cost of revising or updating the master copy of one hour of instructional material.

(NOTE: CIMD and RIMD exclude the cost of producing the instructional material for classroom use.)

d. Personnel Resources

The personnel resource class contains variables representing the staff required for instruction, instructional support, and administrative support. The salary and benefits paid facility and equipment maintenance personnel are included in CAQSP(I), OMFEQ(I), and COMPT(I).

VARIABLE	DESCRIPTION/DEFINITION
INTSPO	Student-to-Instructor ratio.
SALINR	Average annual salary and benefits for one instructor.
ADMRAT	Ratio of the number of students onboard to each administrative support persons.
SALADM	Average annual salary and benefits for one administrative support person.
ADMIN	Average annual administrative overhead for the course to cover instructor/administrative travel in conjunction with the course, salary for part-time employees, and so forth.

e. Supply Resources

The variables included in the supply resource class are the expendable materials which are consumed by students, instructors, and administrative support personnel. This class includes the costs for printing, publishing, and producing instructional materials for classroom use.

VARIABLE	DESCRIPTION/DEFINITION
SUPPLY	Average cost of expendable supplies other than instructional material per student while in the training medium.
PAPSUP(I)	Average annual cost of administrative and instructor supplies used directly in support of the course.
PPPIM(I)	Average annual cost required to prepare instructional material for classroom use from master copies.

f. Student Resources

This class of variables contains the costs associated with the students trained in the course. Unlike public education, the Navy must pay students while in training as well as the costs of transportation to and from the training site.

VARIABLE	DESCRIPTION/DEFINITION
STUDSL	Average annual salary and benefits for one student.
GRAD(I)	The required number of students who must be trained and graduate during each year of the planning period.
STCST1	Average student travel costs to and from the training site.

STCST2	Average student travel costs incurred as maybe required by the course.

g. Miscellaneous Variables

The seventh resource class contains a variety of relevant variables which affect the costs of training.

VARIABLE	DESCRIPTION/DEFINITION
N	The number of years in the planning period. (I = 1, . . . , N.)
ARATE	The attrition rate as a percentage of the students who begin the course but do not complete the training.
DRATE	The discount rate. As directed by DOD, a rate of 10% is used [Ref. 21].
WSCHOP	The number of weeks a student position is available each year.
TLENGH	The average number of weeks spent in the training medium for nonrecycled students. (Average course length in weeks.)
TLEGTH	The average number of hours per week that a student spends in the training medium.
RCRATE	The recycle rate as a percentage of the students who begin training and repeat some portion of the course.
ARCYTM	The average number of weeks that recycled students spend repeating some or all parts of the course.
ESP	The percentage of the student positions above the computed number needed to provide for fluctuations in student input through the system.

3. The Time Value of Money

Several of the variables described in the cost determination model above imply that resource expenditures will be made in future years. In order to compare the resources from differing time periods, a procedure known as discounting must be applied to all future expenditures. Discounting involves the notions that a dollar tomorrow is worth less than a dollar today. The model's single dollar value output must be in the same type of dollars. Usually, future dollars are discounted to their present value (today's dollars). The present value represents the dollar amount (less than $1.00) that a person would be willing to take today if he or she could invest that amount in an interest bearing account at an interest rate which would produce a dollar at some future time. [Refs. 19,20: pp. 28, 25]

One other important aspects of the time value of money is the point in the future when the value of the money invested reaches its dollar value and is recognized. For instance, if a person had $0.75 and invested it in a savings account at 10% annual interest, it would take three years for the original amount to be worth a dollar. In other words, if a person with a 10% discount (interest) rate was offered one dollar three years in the future or $0.75 today, he or she would be indifferent. The money invested must be deposited for the full three years so that at the end of the third year/beginning of the fourth year is when the full dollar value is recognized. To preclude the problems caused by the time an interest payment is made, DOD has standardized the process. A mid-year discount rate is used. The mid-year discount rate is computed by averaging the end-of-the-year discount factors from two successive years. [Refs. 19,22: pp. 27, 46]

VI. USE AND ANALYSIS OF THE COST DETERMINATION MODEL

The cost determination model (hereafter referred to as COSTDEMO) was constructed using the 55 resource variables described in the previous chapter. COSTDEMO is capable of computing the present (dollar) value of the resource costs associated with a single course of instruction. As with the TECEP cost model, COSTDEMO only computes the cost and leaves the efficiency/effectiveness determination to other analytical techniques and models.

A. REQUIRED DATA

1. Data Sources

As with any model, COSTDEMO requires data for each of the 55 resource variables. Most all of these variables are such that gross information containing the required data is available from within the area of responsibility of the training manager conducting the analysis. If the training system manager does not have the information within his or her course, the information should be available within the manager's administrative chain of command. The available information is usually historical information and in a gross form where the data has been aggregated into categories which are not of the exact specification for individual resource variables in the model. Consequently, the manager may have to extract needed data from the context of the aggregate information.

Some of the data may not be held within the administrative organization. At present, there are DOD and Navy organizations who maintain training cost data bases (as well as other training course information). One source of data is the Defense Training Data and Analysis Center.[4] This center began operation in August of 1984 as a DOD organization whose mission is to function as a center for training related data. A major tasking for this organization is to integrate training data, presently held in multiple data bases, into a single data base. Although not used in this research, the center should be a single, easily accessible source for training cost data.

Within the Navy's organization, the primary sources for data are agencies within the Naval Education and Training Command. The two principle sources are the Course Costing System[5] and the Navy Integrated Training Resources Administration System (NITRAS).[6] Each of the data sources,

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[4]DTDAC, 3280 Progress Dr., Orlando, FL 32826. Phone: COM (305) 281-3600.

[5]Course Costing System: Chief of Naval Education and Training (Code 13), Bldg. 624, Naval Air Station, Pensacola, FL 32508; (AV) 922-3407/8.

[6]NITRAS primarily maintains training course information other than cost data. (AV) 922-1970.

DTDAC, CCS, and NITRAS, are able to produce tailored data sets if given adequate time (about three weeks) and if the requested data specifics are contained in their data base. One final source is the Course Curriculum Model Manager (CCMM) who has the overall cognizance for a group of courses using the same curriculum.

2. Handling Unavailable Data

In a number of instances, data for some resource variables will not be readily available or require inordinate effort to obtain. This presents a problem for the analyst. He or she must have some mechanisms to deal with unavailable data. COSTDEMO, largely inherited from the TECEP cost model, provides the analyst several options for using the model when resource variable have missing data. The options are:

- An estimated value may be substituted.
- Given assumptions concerning the structure of the costs at various points, assign a value of zero. For example, if no instructional material needs to be developed or revised during the planning period or if the instructional material has no remaining value at the end of the planning period, a value of zero is applicable.
- Resource costs common to all alternatives may be eliminated (only if the analysis objective is to determine the cost minimizing alternative).
- Future costs should be estimated based on past cost trends.

In each of these options, the analyst must make one or more assumption. The assumptions made must be considered when interpreting the model's output. For instance, if future cost estimates are not based on past trends, the cost figures outputted may vary substantially from empirically based guesses. In short, the assumptions can be made and unavailable data for resource variables can use substitute data, but the output must be interpreted with regard to the assumptions.

B. MODEL COMPUTATIONS

1. Model Layout

The TECEP model was designed to utilize a FORTRAN (Formula Translation) Program. FORTRAN requires some user expertise and a computer for utilization. Although computer sophistication today allows FORTRAN to operate in an interactive mode as opposed to the batch, punch-card mode of before, the data must exist in a separate storage disk location or within the program. Consequently, each alternative must be run separately before comparisons can be made. This can be very time consuming since they analyst/manager must either write a working program or use a programmer. Additionally, due to the data location, it is somewhat cumbersome to make changes to an individual variable. When there is an interest to examine the effects of marginal changes in variables such as attrition rate, instructor-to-student ratio, and so forth, the efforts required to change the data may render the output trivial in comparison.

COSTDEMO was designed with the inherent limitations of a manager's computer literacy and ease of manipulating the data required. With the surge in the availability of desk-top, mini-computers in the Navy, "user friendly" software, and the magnitude of computations required in the model, COSTDEMO was designer to be run on the LOTUS 1-2-3 Spreadsheet (Copyright, 1982, 1983 by LOTUS Development Corporation). Even though LOTUS does not have some of the computational powers of FORTRAN, it does have enough flexibility to perform the required COSTDEMO computations. LOTUS has more accessability than FORTRAN which allows specific variables to be quickly changed for examining marginal changes. Like the TECEP cost model, COSTDEMO must be used separately for each alternative, but, the LOTUS spreadsheet has sufficient size (2048 rows by 76 columns or 155,648 cells) to accommodate more than one COSTDEMO model. This allows the comparisons between alternative , as well as each alternative's relevant data, to be kept together on one spreadsheet. Appendix A contains an illustration representing the physical arrangement of the COSTDEMO spreadsheet and the cell ranges containing the input and computational variables.

Another aspect concerning the layout used for COSTDEMO is that of future year resource variables. Nearly every resource class has a variable that reflects future costs such as operation and maintenance, replacement of equipment, and so forth. These future cost variables are in the format of XXXX(I) where I = 1, . . . , N; N is the number of years in the planning period. A common, longer-ranged planning period used within the Navy is 10 years (See SECNAVINST 7000.14B for further guidance on setting the planning period). The COSTDEMO spreadsheet uses this 10 year planning period for all future cost variables where XXXX1, . . . , XXXX0 represent the ten years. Should the analyst desire a planning period less then 10 years, a zero value can be assigned for all XXXX(I) > N, i.e., if N = 5, the value for XXXX6, . . . , XXXX0 would be zero. One limitation in the COSTDEMO model is its ability to compute training costs for planning periods greater than ten years. This difficulty can be handled but it would require expanding the spreadsheet for that planning period length and changing several formulas.

Since LOTUS does not possess the computational power of FORTRAN such as computing powers of a number, some of the more complex formulas are solved using sequential calculations. The COSTDEMO model has 72 computational variables and 261 formulas. This seemingly enormous number of variables and formulas is not as unruly and unmanageable as it appears. In particular, the future year calculations involve 21 variables and 21 formula repetitions for the 10 year planning period skeleton. A full description of the computational variables and formulas used to determine the outputs can be found in Appendix A.

2. COSTDEMO Output

COSTDEMO provides the user more than one present dollar value output. Since the standard unit of the system's output is a student, the computations are based on the "student position." The number of students trained is an externally mandated constraint in the form of training requirements imposed on the training system mangers. The number of student positions influences the number that can be trained, outfiting costs, operation and maintenance costs, number of instructors required, and so forth. The training requirement (annual number of graduates) drives the number of student positions required which drives the variable costs of training. [Ref. 19: p. 77]

The COSTDEMO model provides the following cost output:

- Present valve cost for each year and the total planning period.
- Nondiscounted cost for each year in the planning period.
- Nondiscounted cost for the total planning period.
- Value remaining at the end of the planning period for facilities, equipment, and instructional material classes.
- Average discounted cost per student position for the total planning period.
- Average annual discounted cost per student position.
- Average nondiscounted cost per student position for the total planning period.
- Average annual nondiscounted cost per student position.

- Initial system acquisition costs for facilities, equipment, and instructional materials.

- Initial system acquisition costs for facilities, equipment, and instructional material per student position.

- Uniform annual cost.

C. TRAINING COURSE COST ANALYSIS

The objective of this thesis is to develop a cost determination model for computing the costs of the current BE/E courses and the FCT revision of BE/E. Since the current course recently changed from SP-BE/E to GP-BE/E, a cost analysis will be conducted on each of these training alternatives. Partial resource variable data for SP-BE/E and GP-BE/E was provided by the BE/E school at NAS Memphis.

The following general assumptions governing missing data variables apply in the analysis of each alternative:

- Each course is in operation, requiring no investment in facilities, equipment, and instructional material acquisition.

- No additions to existing facilities or equipment are needed for implementation.

- Instructional material was developed in the past and is considered to be a sunk cost.

- Existing facilities had an original life expectancy of 25 years; the facilities are 15 years old.

- Existing facilities equipment has 10 years life remaining.

- Half of the student position and instructional equipment will require replacement every six years.

In each analysis other estimates and assumptions made for individual resource variables are stated. Each of the next three sections will describe the values used for each variable and assumptions made. Comparisons of the separate results are provided in the final section.

1. SP-BE/E

This particular version of BE/E training has been used for a number of years. There is a good deal of historical data to support the 55 resource variables. Since there is limited data for the other alternatives, several variables where more than one year's data existed were averaged. Below is a listing of the resource variables, the initial value used, units for each value, and an annotation as to the source of the data and any assumptions made.

VARIABLE	VALUE	UNITS	DATA SOURCE	NOTES
FACILITIES RESOURCES				
FACOST	0	$	G/A	
LOFFA	0	YEARS	G/A	
FARVL	500,000	$	E	1
LORFA	10	YEARS	G/A	
SQFTIN	11.20	SQ FT	D	
SQFTST	20.45	SQ FT	D	
SQFTAM	2700.00	SQ FT	D	
CPSQFT(I)	VARIOUS	SQ FT	E	2
EQUIPMENT RESOURCES				
EQCISP	0	$	G/A	
LOFEQA	0	YEARS	G/A	
EEQCIS	0	$	A	1
LOFEQB	0	YEARS	A	1
CAQSP(I)	5000	$	E	3
LOFEQ(I)	6	YEARS	G/A	
RVLFEQ	175,000	$	E	1
RLOPEQ	10	YEARS	G/A	
RVLSEQ	25,000	$	E	1
RLOSEQ	6	YEARS	G/A	

RVLIEQ	10,000	$	E	1
RLLIEQ	6	YEARS	G/A	
OMFEQ(I)	10,000	$/YR	E	4
EQIMPC	0	$	G/A	
LOFEQ	6	YEARS	G/A	
EQIMIE	0	$	G/A	
LOFIEQ	6	YEARS	G/A	
COMPT(I)	2,000	$/YR	E	4
TSPOSD	2.0	%	E	5

INSTRUCTIONAL MATERIALS RESOURCES

UIMD	0	%	G/A	
REVISE	0	%	G/A	
UIMDYR(I)	10	HRS/YR	E	6
UPDATE	2.0	%	E	6
EVIM	0	%	A	7
CIMD	1000	$	E	6
RIMD	500	$	E	6

PERSONNEL RESOURCES

INTSPO	25	#STU/INST	D	
SALINR	17,000	$	D	
ADMRAT	60	# STU/ADMIN	E	1
SALADM	16,000	$	D	
ADMIN	0	$	D	

SUPPLY RESOURCES

SUPPLY	3.39	$	D	AVG 82-84
PAPSUP(I)	7289.00	$	D	AVG 82-84
PPPIM(I)	1000.00	$	E	1

STUDENT RESOURCES

STUDSL	9717.94	$	D	AVG 82-84
GRAD(I)	560	# STU/YR	D	8
STCST1	0	$	D	
STCST2	0	$	D	

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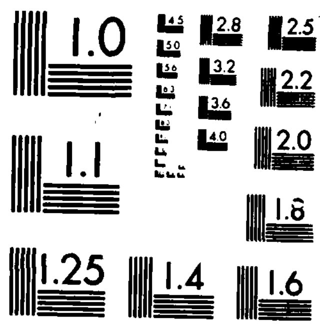

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

MISCELLANEOUS RESOURCES

N	10	YEARS	G/A	
ARATE	9.1	%	D	AVG 82-84
DRATE	10.0	%	D	
WSCHOP	50.0	WEEKS	D	
TLENGH	5.02	WEEKS	D	
TLEGTH	30	HOURS	D	
RCRATE	0	%	D	
ARCYTM	0	WEEKS	D	
ESP	8.3	%	D	

Key for Source Data Codes:

A	Assumption
D	From data provided by school
E	Estimate
G/A	Given as a general assumption

The following specific assumptions were made:

1. Arbitrary value used for illustrative purposes.
2. Estimates were made beginning at $3.00 and increased by $0.15 a year to $4.35 in year 10.
3. As given in the general assumptions, the replacement of equipment cost occurred in years 2, 5, and 8.
4. Total of OMFEQ and COMPT equals what a general maintenance person could be salaried. Maintenance not done at on course equipment full-time.
5. Student position equipment limited and very little downtime occurs.
6. Annual curriculum reviews do occur. Some material will revised as estimated. Logically, new material being developed from scratch should cost more than revisions.
7. Instructional material at the end of the period will have no value as the course will no longer be taught.
8. Computed from BE/E training load (FY78-84) and divided equally among the 41 courses conducting BE/E training.

2. GP-BE/E

Data for the GP-BE/E version was limited to one year. Since the SP-BE/E data was averaged and the same value used in all years, the available GP-BE/E data was considered to be the average of several years. This assumption is quite broad since implementation and start-up costs are usually higher than average costs later in the planning period. The value for PAPSUP provided by the school was $11,455 and a considerable increase over the previous year. The value used is an average of the SP-BE/E average PAPSUP and the GP-BE/E PAPSUP ($7289 + 11,455 divided by 2 = $9372). Below is a listing of the resource variables, the value used, the units for the value, and an annotation as to the source of the data and any additional assumptions.

VARIABLE	VALUE	UNITS	DATA SOURCE	NOTES
FACILITIES RESOURCES				
FACOST	0	$	G/A	
LOFFA	0	YEARS	G/A	
FARVL	500,000	$	E	1
LORFA	10	YEARS	G/A	
SQFTIN	11.20	SQ FT	D	
SQFTST	20.45	SQ FT	D	
SQFTAM	2700.00	SQ FT	D	
CPSQFT(I)	VARIOUS	SQ FT	E	2
EQUIPMENT RESOURCES				
EQCISP	0	$	G/A	
LOFEQA	0	YEARS	G/A	
EEQCIS	0	$	A	1
LOFEQB	0	YEARS	A	1
[illegible]AQSP(I)	5000	$	E	3
LOFEQ(I)	6	YEARS	G/A	

RVLFEQ	175,000	$	E	1
RLOPEQ	10	YEARS	G/A	
RVLSEQ	25,000	$	E	1
RLOSEQ	6	YEARS	G/A	
RVLIEQ	10,000	$	E	1
RLLIEQ	6	YEARS	G/A	
OMFEQ(I)	10,000	$/YR	E	4
EQIMPC	0	$	G/A	
LOFEQ	6	YEARS	G/A	
EQIMIE	0	$	G/A	
LOFIEQ	6	YEARS	G/A	
COMPT(I)	2,000	$/YR	E	4
TSPOSD	2.0	%	E	5

<u>INSTRUCTIONAL MATERIALS RESOURCES</u>

UIMD	0	%	G/A	
REVISE	0	%	G/A	
UIMDYR(I)	10	HRS/YR	E	6
UPDATE	2.0	%	E	6
EVIM	0	%	A	7
CIMD	1000	$	E	6
RIMD	500	$	E	6

<u>PERSONNEL RESOURCES</u>

INTSPO	25	#STU/INST	D	
SALINR	17,000	$	D	
ADMRAT	60	# STU/ADMIN	E	1
SALADM	16,000	$	D	
ADMIN	0	$	D	

<u>SUPPLY RESOURCES</u>

SUPPLY	4.20	$	D	
PAPSUP(I)	9372.00	$	D	
PPPIM(I)	1500.00	$	E	8

<u>STUDENT RESOURCES</u>

STUDSL	9717.94	$	D	9
GRAD(I)	560	# STU/YR	D	10
STCST1	0	$	D	
STCST2	0	$	D	

MISCELLANEOUS RESOURCES

N	10	YEARS	G/A
ARATE	12.0	%	D
DRATE	10.0	%	D
WSCHOP	50.0	WEEKS	D
TLENGH	5.73	WEEKS	D
TLEGTH	40	HOURS	D
RCRATE	0	%	D
ARCYTM	0	WEEKS	D
ESP	8.3	%	D

Key for Source Data Codes:

A	Assumption
D	From data provided by school
E	Estimate
G/A	Given as a general assumption

The following specific assumptions were made:

1. Arbitrary value used for illustrative purposes.
2. Estimates were made beginning at $3.00 and increased by $0.15 a year to $4.35 in year 10.
3. As given in the general assumptions, the replacement of equipment cost occurred in years 2, 5, and 8.
4. Total of OMFEQ and COMPT equals what a general maintenance person could be salaried. Maintenance not done at on course equipment full-time.
5. Student position equipment limited and very little downtime occurs.
6. Annual curriculum reviews do occur. Some material will revised as estimated. Logically, new material being developed from scratch should cost more than revisions.
7. Instructional material at the end of the period will have no value as the course will no longer be taught.
8. The classroom environment will require more paper and student materials, hence a higher cost.
9. Used same salary value as SP-BE/E.
10. Computed from BE/E training load (FY78-84) and divided equally among the 41 courses conducting BE/E training.

3. FCT-BE/E

The FCT-BE/E revision is expected to be taught in a classroom type of setting much similar to the GP-BE/E version. Consequently, due to the lack of substantiated data and similarity to the GP-BE/E version, the costs for the two courses are assumed to be the same. The analysis in the next section will show why there is a significant cost difference between these two alternatives using the same resource costs except for one. Below is a listing of the resource variables, the values used, units for the values, and an annotation as to the source of the data and any assumptions.

VARIABLE	VALUE	UNITS	DATA SOURCE	NOTES
FACILITIES RESOURCES				
FACOST	0	$	G/A	
LOFFA	0	YEARS	G/A	
FARVL	500,000	$	E	1
LORFA	10	YEARS	G/A	
SQFTIN	11.20	SQ FT	D	
SQFTST	20.45	SQ FT	D	
SQFTAM	2700.00	SQ FT	D	
CPSQFT(I)	VARIOUS	SQ FT	E	2
EQUIPMENT RESOURCES				
EQCISP	0	$	G/A	
LOFEQA	0	YEARS	G/A	
EEQCIS	0	$	A	1
LOFEQB	0	YEARS	A	1
CAQSP(I)	5000	$	E	3
LOFEQ(I)	6	YEARS	G/A	
RVLFEQ	175,000	$	E	1
RLOPEQ	10	YEARS	G/A	
RVLSEQ	25,000	$	E	1
RLOSEQ	6	YEARS	G/A	

RVLIEQ	10,000	$	E	1
RLLIEQ	6	YEARS	G/A	
OMFEQ(I)	10,000	$/YR	E	4
EQIMPC	0	$	G/A	
LOFEQ	6	YEARS	G/A	
EQIMIE	0	$	G/A	
LOFIEQ	6	YEARS	G/A	
COMPT(I)	2,000	$/YR	E	4
TSPOSD	2.0	%	E	5

INSTRUCTIONAL MATERIALS RESOURCES

UIMD	0	%	G/A	
REVISE	0	%	G/A	
UIMDYR(I)	10	HRS/YR	E	6
UPDATE	2.0	%	E	6
EVIM	0	%	A	7
CIMD	1000	$	E	6
RIMD	500	$	E	6

PERSONNEL RESOURCES

INTSPO	25	#STU/INST	D	
SALINR	17,000	$	D	
ADMRAT	60	# STU/ADMIN	E	1
SALADM	16,000	$	D	
ADMIN	0	$	D	

SUPPLY RESOURCES

SUPPLY	4.20	$	D	
PAPSUP(I)	9372.00	$	D	
PPPIM(I)	1500.00	$	E	8

STUDENT RESOURCES

STUDSL	9717.94	$	D	9
GRAD(I)	560	# STU/YR	D	10
STCST1	0	$	D	
STCST2	0	$	D	

MISCELLANEOUS RESOURCES

N	10	YEARS	G/A	
ARATE	6.7	%	E	11
DRATE	10.0	%	D	
WSCHOP	50.0	WEEKS	D	
TLENGH	5.73	WEEKS	D	
TLEGTH	40	HOURS	D	
RCRATE	0	%	D	
ARCYTM	0	WEEKS	D	
ESP	8.3	%	D	

Key for Source Data Codes:

A	Assumption
D	From data provided by school
E	Estimate
G/A	Given as a general assumption

The following specific assumptions were made:

1. Arbitrary value used for illustrative purposes.
2. Estimates were made beginning at $3.00 and increased by $0.15 a year to $4.35 in year 10.
3. As given in the general assumptions, the replacement of equipment cost occurred in years 2, 5, and 8.
4. Total of OMFEQ and COMPT equals what a general maintenance person could be salaried. Maintenance not done at on course equipment full-time.
5. Student position equipment limited and very little downtime occurs.
6. Annual curriculum reviews do occur. Some material will revised as estimated. Logically, new material being developed from scratch should cost more than revisions.
7. Instructional material at the end of the period will have no value as the course will no longer be taught.
8. The classroom environment will require more paper and student materials, hence a higher cost.
9. Used same salary value as SP-BE/E.
10. Computed from BE/E training load (FY78-84) and divided equally among the 41 courses conducting BE/E training.
11. Equal to the 1984 attrition rate of initial skill training and lower than either other alternative.

4. Cost Analysis and Conclusions

As should be obvious in the data presented for each alternative, there are only a few variables whose dollar values would make one alternative more favorable than the other, all other things equal. The predominant variables among these three versions where there are differences are: (1) Attrition Rate, (2) Course Length, and (3) Time in Medium. As stated in the introduction to the FCT-BE/E data, the most significant difference between the FCT-BE/E and GP-BE/E versions is the attrition rate. Since the attrition rate, course length, and time in medium variables are considered to influence the variable costs of training, analysis was conducted by changing these three variables in the GP-BE/E and FCT-BE/E versions. SP-BE/E had the lowest costs for the input variables and was expected to be the low cost alternative. As such SP-BE/E will be used as the base for comparisons.

Rather than comparing all of the COSTDEMO output costs for each alternative, only three of the cost output will be used for comparisons: (1) the uniform annual cost, (2) present value, and (3) average annual nondiscounted cost per student position. Since these cost outputs are a function of the number of students, three computational variables related to the number of students are provided in the comparisons. The three variables are planned student positions, annual average number of students on board, and required number of instructors (a function of the required number of students and student-to-instructor ratio). In Table 3, the cost data results for the initial input values described in previous sections are presented.

TABLE 3

COST ANALYSIS - RESULTS OF INITIAL INPUT DATA

ALTERNATIVE	SP-BE/E	GP-BE/E	FCT-BE/E
INITIAL INPUTS:			
Attrition Rate	9.1%	12.0%	6.7%
Course Length (Weeks)	5.02	5.73	5.73
Hours Per Week	30	40	40
VARIABLE (Units)			
PSP(# Stud.)	65.20	75.69	73.40
INSTR (# Instr.)	2.61	3.03	2.94
AAOB (Avg. #/Yr.)	59.00	68.49	66.42
ANCSP ($)	12,025.81	11,991.86	12,005.78
UAC ($)	780,289.32	903,850.29	877,450.97
PV ($)	5,034,267.07	5,831,457.20	5,661,134.20

Abbreviations:

AAOB	Average Annual Onboard
ANCSP	Average Annual Nondiscounted Cost Per Student Position
INSTR	Number of Required Instructors
PSP	Planned Number of Student Positions
PV	Present Value of Alternative
UAC	Uniform Annual Cost

As the data in Table 3 shows, the SP-BE/E alternative is the minimum cost alternative with FCT-BE/E next and GP-BE/E as the most costly. The initial input values indicate that the costs are affected by the length and numbers of hours per week in the medium. It appears that attrition rates could affect the cost more than the other two factors. To investigate this possibility, the attrition rates of the GP-BE/E and FCT-BE/E versions were changed to that of the SP-BE/E. It is recognized that there will be differences in the output costs since there a cost differences in the supply resource class. Table 4 displays the cost results when attrition rates are equal.

TABLE 4

COST ANALYSIS - EQUAL ATTRITION RATES

ALTERNATIVE	SP-BE/E	GP-BE/E	FCT-BE/E
INITIAL INPUTS:			
Attrition Rate	9.1%	9.1%	6.7%
Course Length (Weeks)	5.02	5.73	5.73
Hours Per Week	30	40	40
VARIABLE (Units)			
PSP(# Stud.)	65.20	74.41	73.40
INSTR (# Instr.)	2.61	2.98	2.94
AAOB (Avg. #/Yr.)	59.00	67.33	66.42
ANCSP ($)	12,025.81	11,999.57	12,005.78
UAC ($)	780,289.32	889,024.00	877,450.97
PV ($)	5,034,267.07	5,735,800.98	5,661.134.20

NOTE: Actual FCT-BE/E results would be identical to GP-BE/E results shown above. FCT-BE/E results above are from initial input settings.

Abbreviations:

- AAOB Average Annual Onboard
- ANCSP Average Annual Nondiscounted Cost Per Student Position
- INSTR Number of Required Instructors
- PSP Planned Number of Student Positions
- PV Present Value of Alternative
- UAC Uniform Annual Cost

It may seem unusual that the average annual nondiscounted cost per student position increases when the number of student positions decreases. The inverse relationship is due the fact that PSP is the divisor in the formula used to compute the ANCSP cost; the smaller the divisor, the larger the product. Referring back to Table 3, this inverse relationship is confirmed. SP-BE/E will continue to have the highest ANCSP cost.

The next series of Tables will display the manipulation of the independent variables to examine the changes in costs of the dependent variables. The changes in the independent variable will be for one alternative at a time to allow comparisons. Table 5 will initialize the attrition rate for GP-BE/E and change the length of the course. One assumptions made in the following analysis is that the course length and hours per week are simultaneously changed to minimize the differential in the course lengths. If this assumption were not made, the increase in costs would be substantial and complicate comparisons. Under this assumption, the differences in course length equals to 0.72 weeks or 3.5 days. In Table 6, the course length is changed for FCT-BE/E to examine the affects of equality in course lengths among alternatives.

The results show that in this situation, FCT-BE/E becomes the low cost alternative with the highest ANCSP costs (lowest PSP and AAOB). One final comparison will be

TABLE 5

COST ANALYSIS - ATTRITION RATE VS. LENGTH

ALTERNATIVE	SP-BE/E	GP-BE/E	FCT-BE/E
INITIAL INPUTS:			
Attrition Rate	9.1%	12.0%	6.7%
Course Length (Weeks)	5.02	5.02	5.73
Hours Per Week	30	30	40
VARIABLE (Units)			
PSP(# Stud.)	65.20	66.33	73.40
INSTR (# Instr.)	2.61	2.65	2.94
AAOB (Avg. #/Yr.)	59.00	60.02	66.42
ANCSP ($)	12,025.81	12,064.29	12,005.78
UAC ($)	780,289.32	796,373.77	877,450.97
PV ($)	5,034,267.07	5,138,040.66	5,661,134.20

NOTE: The actual results for FCT-BE/E under the same circumstances would be the same as the result shown above for GP-BE/E.

Abbreviations:

- AAOB Average Annual Onboard
- ANCSP Average Annual Nondiscounted Cost Per Student Position
- INSTR Number of Required Instructors
- PSP Planned Number of Student Positions
- PV Present Value of Alternative
- UAC Uniform Annual Cost

made by changing GP-BE/E attrition rate and course length equal to that of SP-BE/E. Table 7 below displays the results.

It appears that the attrition rate and course length/hours in the medium per week combination have substantial impacts on the costs of training. The five Tables illustrate the possible combinations of comparisons using three independent variables to determine the cost

TABLE 6

COST ANALYSIS - EQUAL COURSE LENGTHS

ALTERNATIVE	SP-BE/E	GP-BE/E	FCT-BE/E
INITIAL INPUTS:			
Attrition Rate	9.1%	12.0%	6.7%
Course Length (Weeks)	5.02	5.02	5.02
Hours Per Week	30	30	30
VARIABLE (Units)			
PSP(# Stud.)	65.20	66.33	64.32
INSTR (# Instr.)	2.61	2.65	2.57
AAOB (Avg. #/Yr.)	59.00	60.02	58.20
ANCSP ($)	12,025.81	12,064.29	12,080.16
UAC ($)	780,289.32	796,373.77	773,221.96
PV ($)	5,034,267.07	5,138,040.66	4,988,669.90

Abbreviations:

AAOB	Average Annual Onboard
ANCSP	Average Annual Nondiscounted Cost Per Student Position
INSTR	Number of Required Instructors
PSP	Planned Number of Student Positions
PV	Present Value of Alternative
UAC	Uniform Annual Cost

minimizing alternative. Tables 6 and 7 clearly show that FCT-BE/E should provide cost savings once implemented so long as the results of past research using FCT methods hold. If FCT does reduce the attrition rate below the rates found in the current versions of BE/E training and the are no differences in the course length, then there should be cost savings. One final possibility suggested by the data and past research is even greater cost savings by using FCT methods. Past research infers that by using FCT for an

TABLE 7

COST ANALYSIS - GP-BE/E VS. SP-BE/E

ALTERNATIVE	SP-BE/E	GP-BE/E	FCT-BE/E
INITIAL INPUTS:			
Attrition Rate	9.1%	9.1%	6.7%
Course Length (Weeks)	5.02	5.02	5.02
Hours Per Week	30	30	30
VARIABLE (Units)			
PSP(# Stud.)	65.20	65.20	64.32
INSTR (# Instr.)	2.61	2.61	2.57
AAOB (Avg. #/Yr.)	59.00	60.02	58.20
ANCSP ($)	12,025.81	12,073.08	12,080.16
UAC ($)	780,289.32	783,371.33	773,221.96
PV ($)	5,034,267.07	5,054,151.37	4,988,669,90

Abbreviations:

- AAOB Average Annual Onboard
- ANCSP Average Annual Nondiscounted Cost Per Student Position
- INSTR Number of Required Instructors
- PSP Planned Number of Student Positions
- PV Present Value of Alternative
- UAC Uniform Annual Cost

entire training pipeline may reduce the time of training and thereby reduce the training costs even more. Indeed, FCT may be the solution to the Navy's technical training dilemma of minimizing training costs while producing graduates with the applicable level of job skill proficiency required by the operational units.

VII. DISCUSSION AND RECOMMENDATIONS

Results from the original research studies conducted using the functional context principles and approach in developing and designing instructional systems are quite promising in the strengths that functional context methods possess over conventional instructional methods. The FCT project will further investigate a possible instructional method to resolve some of the perceived weaknesses of the Navy's specialty skill training. Using a pilot course for teaching basic electricity and electronics knowledge and skills to students, the project will evaluate the instructional system's output to determine how well the student is prepared for follow-on training.

A. FCT EXPECTATIONS

The project has explicit expectations which have been derived from the results of past research and are:

- Increase the meaningfulness of the subject matter to the student,
- Increase the student's retention of the subject matter, and
- Improve the student's ability to transfer and apply the learning to job-related situations.

These three expectations are the focus of the evaluation of the project which will determine the success of FCT. Two other expectations are objectives of the project--reducing training time and lowering course-entry aptitude requirements. If the FCT project is successful in meeting these expectations, the implications of the methodology are promising as a means to maintain the quality of the training system's output. The remaining factor which must be determined in the project evaluation is the cost of the resources consumed for the training conducted.

At some future point, a decision will be made and one of the three alternatives will be selected as the "optimal" instructional method for BE/E training. The cost of each alternative will weigh heavily in the decision and selection process. The magnitude and variety of resources required by a single instructional course need to be gathered and aggregated into a single, dollar cost figure.

This study has developed a cost determination model that has the capability to compute the costs of training. The model, COSTDEMO, can provide several different, aggregated, course-cost outputs. Individually the cost outputs are useful information for a decision-maker since cost information is a critical factor needed to make resource allocation decisions.

B. COMPARISON OF THE PROJECT ALTERNATIVES

The COSTDEMO model was used to perform cost analysis of the three instructional methods being compared in the FCT project. Using BE/E historical cost and training data and assumptions regarding missing variable data, separate analyses were performed by the model. The differences in training costs of the three alternatives were compared under a variety of situations where the course attrition rate and length of the course/weekly hours of instruction were varied.

As shown previously in Table 3, the self-paced version has the lowest cost based on the initial data settings. The costs of the other two versions of instruction were then compared to the "low-base" of the self-paced version. It was felt that, even though the FCT version has not been implemented, the FCT and group-paced versions were considered to have equal costs and differ only in their attrition rates. It was found in the analysis that, once the FCT version's course length was equal to the self-paced version, the FCT version would cost the least, even though the FCT version contained higher costs in one resource class.

C. CONCLUSIONS

Although the analysis of the three BE/E versions had incomplete data, the COSTDEMO model appears to be a useful tool for computing the training costs for alternative courses. Coupled with the results from the evaluation of the training course graduate quality, the COSTDEMO model provides information to the system manager where the optimality of alternatives can be assessed. Since a manager is frequently concerned with cost minimization considerations, the model can compute the changes in training costs due the effects of policy changes.

The construction of the COSTDEMO spreadsheet model is very time consuming. The effort expended is worth the benefit it provides--cost information. In a spreadsheet format, the manager can quickly assess the effects of training policy changes, changes in acquisition and purchase costs, and so forth. The spreadsheet is of sufficient size to accommodate more than one model. Each alternative can occupy a separate model and be accessed without having to change all data elements for analysis of each alternative.

D. RECOMMENDATIONS

The FCT project focuses on a very narrow segment of a much broader training system. If the project is successful and cost efficient/effective, the methodology should be applied over a larger segment or over an entire training pipeline. This recommendation has other benefits that are connected with the expectations held for the method. By expanding the scope of application for the FCT method, courses could be eliminated from the training system altogether since the follow-on school could absorb the prerequisite course as part of its training. This could also reduce the length of the overall training pipeline and eliminate the difficulties encountered in sheduling follow-on courses. Cost savings could be realized in reducing student idle time costs while awaiting instruction; reduce costs involved in retraining students for knowledge retention losses while awaiting instruction; and reduce costs of the overall training pipeline. If successful, the course entry aptitude requirements could be lowered and result in decreased recruiting costs and subsequent retention costs. Therefore, the FCT method, if expanded, could create substantial cost savings and the COSTDEMO model could be used to determined the costs associated with this option.

The COSTDEMO model appears to have the potential for being applied to systems other than training course. Within the conceptual structure, the model could be applied to are¬s such as recruiting to develop cost determination models of these pipeline segments. A series of "COSTDEMO" models could compute the costs of all the resources required to recruit, train, and employ an individual in an operational billet. Manpower policy changes could be quickly and easily be assesed for the cost implications that could result. Further research is required in this area.

Contained in A Primer for Economic Analysis in for Naval Training Systems [Ref. 20], there is a section that deals with several opportunities for improvements in productivity and addresses the reduction of training costs. The COSTDEMO can be used to provide the cost information required when considering improvements in the four major areas listed--management efficiency, resource cost reduction, adoption of advanced technology, and reorganization to capture economies of scale. Training managers need to assess the training courses in their area of responsibility using this guidance and COSTDEMO to reduce training resource allocations required.

APPENDIX A

COSTDEMO COMPUTATIONAL VARIABLES AND FORMULAS

An earlier chapter defined and described the resource cost variables used by COSTDEMO to calculate several output cost values. Of significance to the 55 input variables are the 72 computational variables and 261 formulas (210 formulas are iterative formulas to compute costs for different years in the planning period). A physical representation of the COSTDEMO spreadsheet layout is important for understanding how a spreadsheet is oriented. In Figure A.1 below, the layout of the spreadsheet is shown. The LOTUS 1-2-3 Spreadsheet uses alphabetic letters for the columns and numbers for the rows. Each letter-number combination is a cell address. A grouping of cells is called a range. In the section following the spreadsheet layout diagrams, each computational variable will be described/defined. In the location column is the cell address of the variable with the related formula and its address listed beneath each variable. The address of a multiple year variable will be indicated by the range of cells containing the ten yearly data elements. Figures A.2 and A.3 illustrate the general format of the cell range blocks used in the COSTDEMO spreadsheet.

The primary differences between Figures A.2 and A.3 is the addition of the year column in Figure A.3 LOTUS 1-2-3 has an option in one of its RANGE sub-menus for a column-width adjustment. It is recommended to use this feature to proportionally space the area for the value entries. The column-widths used in COSTDEMO were: columns A, E, J, O, T, Y, AD, and AI have three spaces, columns titled "Variable" and "Units" have eleven spaces, columns titled "Year" five spaces, and Columns titled "Value" have fifteen spaces.

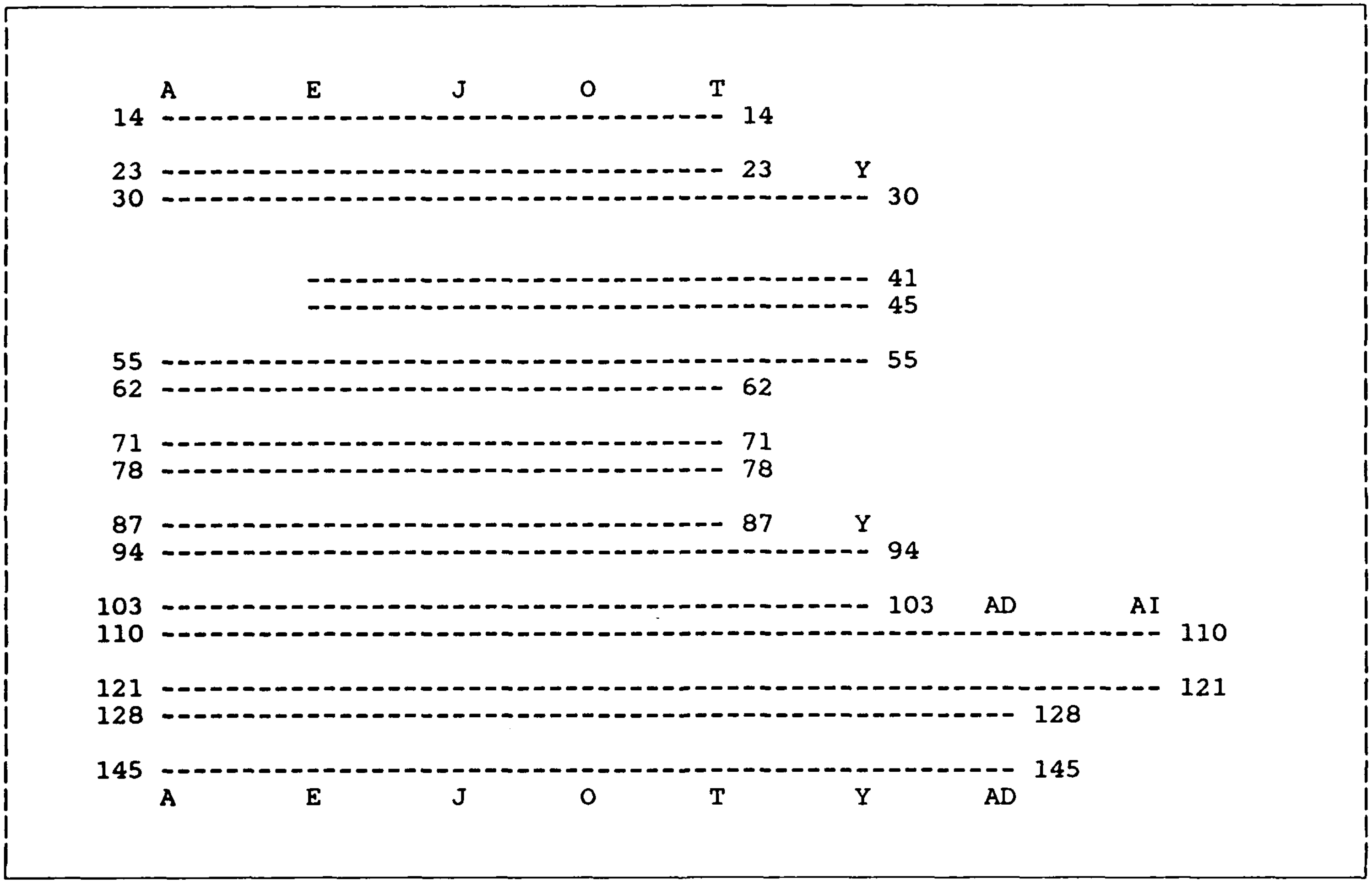

Figure A.1 COSTDEMO Spreadsheet Layout Diagram

```
                      <-- COLUMNS --->

            A    B                C            D      E
            ----------------------------------------|-
               VARIABLE         VALUE        UNITS  |
            ----------------------------------------|-
        14                                          |
        15                                          |
        16                                          |
   R    17                                          |
   O    18                                          |
   W    19                                          |
   S    20                                          |
        21                                          |
        22                                          |
        23                                          |
            ----------------------------------------|-
```

Figure A.2 COSTDEMO Spreadsheet Cell Layout

Columns A - E

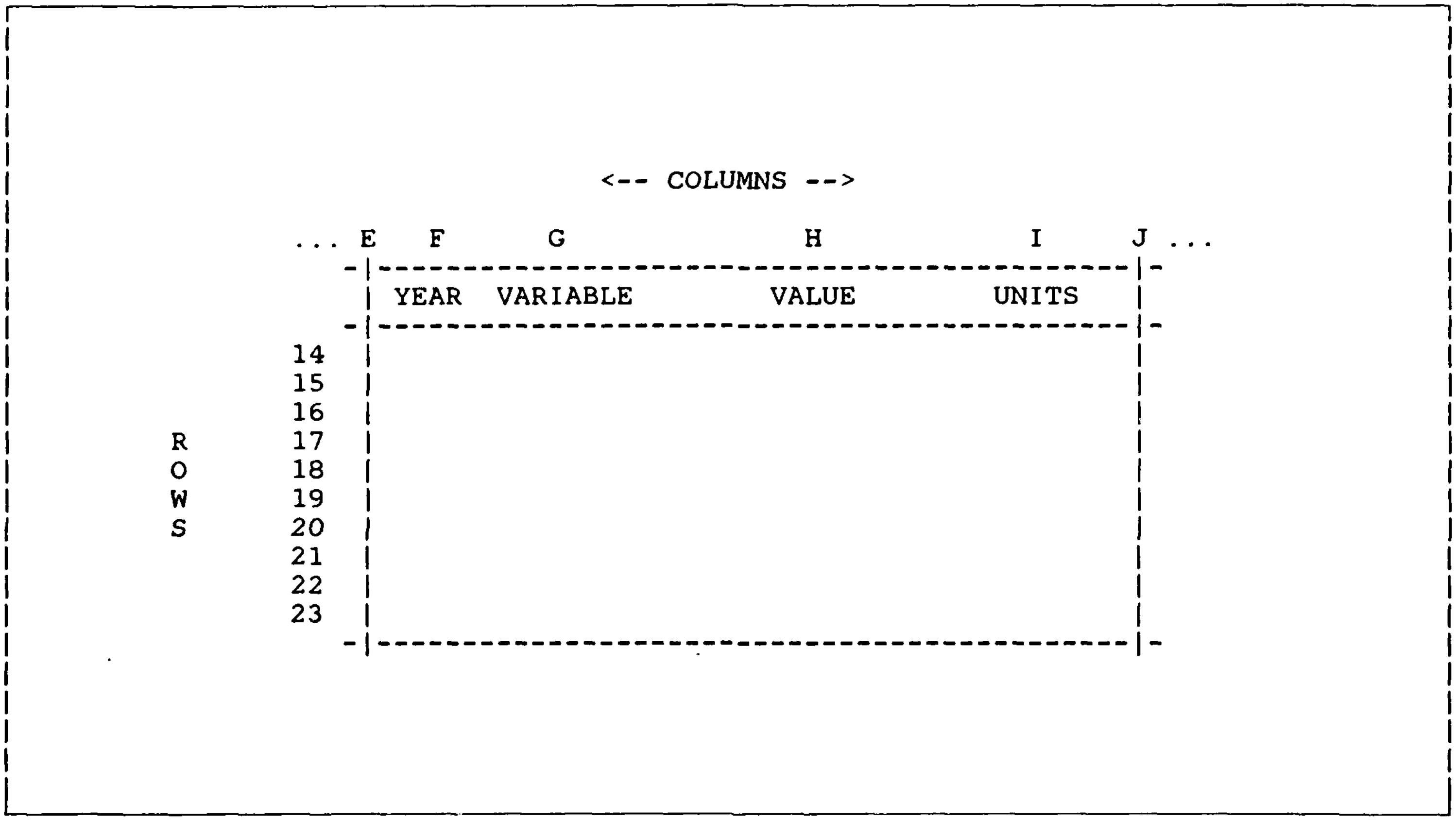

Figure A.3 COSTDEMO Spreadsheet Cell Layout

Columns E-AI

INPUT RESOURCE VARIABLES

LOCATION	VARIABLE	LOCATION	VARIABLE
FACILITIES RESOURCES			
B14	FACOST	B19	SQFTIN
B15	LOFFA	B20	SQFTST
B17	FARVL	B21	SQFTAM
B18	LORFA	G14..G23	CPSQFT(I)
EQUIPMENT RESOURCES			
B30	EQCISP	B38	RVLIEQ
B31	LOFEQA	B39	RLLIEQ
B32	EEQCIS	L45..L54	OMFEQ(I)
B33	LOFEQB	B40	EQIMPC
G30..G39	CAQSP(I)	B41	LOFEQ
L30..L39	LOFEQ(I)	B42	EQIMIE
B34	RVLFEQ	B43	LOFIEQ
B35	RLOPEQ	G45..G54	COMPT(I)
B36	RVLSEQ	B44	TSPOSD
B37	RLOSEQ		
INSTRUCTIONAL MATERIALS RESOURCES			
B62	UIMD	B65	EVIM
B63	REVISE	B66	CIMD
G62..G71	UIMDYR(I)	B67	RIMD
B64	UPDATE		

PERSONNEL RESOURCES

B78	INTSPO	B82	SALADM
B79	SALINR	B84	ADMIN
B81	ADMRAT		

SUPPLY RESOURCES

B94	SUPPLY	L94..N93	PPPIM(I)
G94..I93	PAPSUP(I)		

STUDENT RESOURCES

B110	STUDSL	B111	STCST1
G110..G119	GRAD(I)	B112	STCST2

MISCELLANEOUS RESOURCES

B128	N	B133	TLEGTH
B129	ARATE	B134	RCRATE
B130	DRATE	B135	ARCYTM
B131	WSCHOP	B136	ESP
B132	TLENGH		

COMPUTATIONAL VARIABLES AND FORMULAS

LOCATION	VARIABLE	DESCRIPTION/DEFINITION
B16	RVFA	The remaining value of facilities at the end of the planning period.
C16		= RVFAN + RVFAE
B22	TSQFT	Total square feet of facilities required.
C22		= (PSP * SQFTST) + (SQFTIN * (INTSPO / PSP) + SQFTAM
L14..L23	FCOST(I)	Total cost of facilities for each year of the planning period.
M14..M23		= TSQFT * CPSQFT(I)
Q14	RVFAN	Logical statement for computing the remaining value of new facilities at the end of the planning period.
R14		= @IF(LOFFA=0,0, (LOFFA-N) / (FACOST/LOFFA))
Q15	RFVAE	Logical statement for computing the remaining value of existing facilities at the end of the planning period
R15		= @IF(LORFA=0,0 (LORFA-N) / (EEQCIS/LORFA))
B45	MNSP	Mean number of student positions for the planning period.
C45		= NSPRS / N

B46	PSP	Planned number of student positions.
C46		= MNSP + (MNSP * ESP)
B47	EAQCI	Equipment acquisition costs necessary for implementation.
C47		= (EQIMPC * PSP) + EQCISP + EEQCIS + EQIMIE
B48	EEE	Annual depreciation of student position equipment.
C48		= DNSE + DOSE
B49	EEEE	Annual depreciation of instructional equipment.
C49		= DNIE + DOIE
B50	EEEEE	Annual depreciation of facilities equipment.
C50		= DNFE + DOFE
B51	REVQ	Remaining value of student position equipment at the end of the planning period.
C51		= R + R1
B52	REVQ1	Remaining value of instructional equipment at the end of the planning period.
C52		= R2 + R3
B53	REVQ2	Remainig value of equipment purchased in each year of the planning period.
C53		= @SUM (SREVQ21..SREVQ20)

B54	REVQ3	Remaining value for equipment purchased for implementation.
C54		= R4 + R5
B55	TRVEQ	Total remaining value of all equipment at the end of the planning period.
C55		= REVQ + REVQ1 + REVQ2 + REVQ3
Q30..Q39	NSPR(I)	Number of student positions required for the system.
R30..R39		= ((SMWRCC + STUDMW) / WSCHOP) /(1 - TSOPSD)
Q41	NSPRS	The summation of all NSPR(I) values.
R41		= @SUM (NSPR1..NSPRO)
V30	DNSE	Logical statement for computing the annual depreciation of new student position equipment.
W30		= @IF(LOFEQ=0,0,(EQIMPC * PSP)/LOFEQ)
V31	DOSE	Logical statement for computing the annual deprecation of existing student position equipment.
W31		= @IF(RLOSEQ=0,0, RVLSEQ / RLOSEQ)
V32	DNIE	Logical statement for computing the annual deprecation of new instructional equipment.
W32		= @IF(LOFIEQ=0,0, EQIMIE / LOFIEQ)

V33	DOIE	Logical statement for computing the annual deprecation of existing instructional equipment.
W33		= @IF(RLLIEQ=0,0, RVLIEQ / RLLIEQ)
V34	DNFE	Logical statement for computing the annual deprecation new facilities equipment.
W34		= @IF(LOFEQA=0,0, EQCISP /LOFEQA)
V35	DOFE	Logical statement for computing the annual deprecation of existing facilities equipment.
W35		= @IF(LOFEQB=0,0,EEQCIS / LOFEQB)
V36	R	Logical statement for computing the depreciation value remaining at the end of the planning period for new student position equipment.
W36		= @IF(LOFEQ-N<=0,0,(LOFEQ-N) * DNSE)
V37	R1	Logical statement for computing the depreciation value remaining at the end of the planning period for existing student position equipment.
W37		= @IF(RLOSEQ-N<=0,0, (RLOSEQ-N) * DOSE)
V38	R2	Logical statement for computing the depreciation value remaining at the end of the planning period for new instructional equipment.
W38		= @IF(LOFIEQ-N<=0,0, (LOFIEQ-N) * DNIE)

V39	R3	Logical statement for computing the depreciation value remaining at the end of the planning period for existing instructional equipment.
W39		= @IF(RLLIEQ-N<=0,0, (RLLIEQ-N) * DOIE)
V40	R4	Logical statement for computing the depreciation value remaining at the end of the planning period for new facilities equipment.
W40		= @IF(LOFEQA-N<=0,0, (LOFEQA-N) * DNFE)
V41	R5	Logical statement for computing the depreciation value remaining at the end of the planning period for existing facilities equipment.
W41		= @IF(LOFEQB-N<=0,0, (LOFEQB-N) * DOFE)
Q45..Q54	TAEQC(I)	Total annual operation, maintenance, and acquisition costs for each year of the planning period.
R45..R54		= (COMPT(I) * PSP) + CAQSP(I) + OMFEQ(I)
V45..V54	SREVQ2(I)	Logical statement for computing the remaining value at the end of the end of the planning period for equipment purchased during the planning period.
W45..W54		= @IF(LOFEQ(I)=0,0, ((LOFEQ(I)-N) * (CAQSP(I) / (LOFEQ(I)) * (-1))

B68	ACIMD	Instructional development cost for implementation.
C68		= ((UIMD * CIMD) + (REVISE * RIMD)) * TLENGH * TLEGTH
B69	RVIM	Remaining value of instructional material at the end of the planning period.
C69		= ACIMD * EVIM
L62..L71	CUIMD(I)	Total cost of developing instructional material for each year of the planning period.
M62..M71		= CIMD * UIMDYR(I)
Q62..Q71	AIMMC(I)	Maintenance costs of instructional material for each year of the planning period.
R62..R71		= CUIMD(I) + (ACIMD * UPDATE)
B80	RINSTR	Required number of instructors.
C80		= @IF(RINR<=1,1, PSP / INSTPO)
B83	RADMIN	Required number of administrative support personnel.
C83		= @IF(RADMN<=1,1, PSP / ADMRAT)
Q20	RINR	Logical statement for computing the required number of instructors
R20		= PSP / INSTPO

Q21	RADMN	Logical statement for computing the required number of administrative support personnel.
R21		= PSP / ADAMRAT
G78..G87	CINSTR(I)	Total costs of salary and benefits for all instructors for each year of the planning period.
H78..H87		= SALINR * RINSTR
L78..L87	CSADMN(I)	Total costs and salary and benefits for administrative support personnel for each year of the planning period.
M78..M87		= RADMIN * SALADM
Q78..Q87	PERCOST(I)	Total personnel costs for each year of the planning period.
R78..R87		= CINSTR(I) + CSADMN(I) + ADMIN
Q94..Q103	SUPPY(I)	Total cost of student supplies for each year in the planning period (excludes instructional material).
R94..R103		= STUD(I) * SUPPLY
V94..V104	COSSUP(I)	Total cost of supplies for each year of the planning period.
W94..W104		= SUPPY(I) + PAPSUP(I) + PPPIM(I)

B113	AASIN	Average annual student inputs required to provide the number of graduates specified in each year.
C113		= STUDS / N
B114	AAOB	Mean number of students on board for the entire planning period.
C114		= AOBS / N
B115	TRAVEL	Total annual travel costs for all students.
C115		= (AASIN * (STCST1 + STCST2)) * (1 - (0.5 * ARATE)
L110..L119	STUD(I)	Student input necessary in each year to provide the required number of graduates.
M110..M119		= GRAD(I) / (1 - ARATE)
L121	STUDS	Summation of STUD(I).
M121		= @SUM (STUD1..STUDO)
Q110..Q119	STUDMW(I)	Total time required in training for all students in each year of the planning period to train the required number of students (does not include recycle time).
R110..R119		= (TLENGH * STUD(I)) *(1 - (0.5 * ARATE))
V110..V119	SMWRRC(I)	Total time required for recycling for all students in each year of the planninng period.
W110..W119		= RCRATE * STUD(I) * ARCYTM

AA110..AA119	AOB(I)	Average number of students on board for entire planning period.
AB110..AB119		= (STUDMW(I) + SMWRRC(I)) / WSCHOP
AA121	AOBS	Summation of AOB(I).
AB121		= @SUM (AOB1..AOBO)
AF110..AF119	SSALRY(I)	Total costs of student salary and benefits for all students for each year of the planning period.
AG110..AG119		= ((SMWRRC(I) + STUDMW(I)) / 52) * STUDSL
B137	HHHH	Total nondiscounted cost of training course.
C137		= HHHHS
B138	RVAS	Remaining value of facilities, equipment, and instructional material at the end of the planning period.
C138		= RVFA + TRVEQ + RVIM
B139	CCC	Average discounted cost per student position.
C139		= PVALUES / PSP
B140	CCU	Average nondiscounted cost per student position.
C140		= HHHH / PSP
B141	CINT	Initial acquisition costs for facilities, equipment, and instructional development.
C141		= FACOST + EQACI + ACIMD

B142	ANCSP	Average annual nondiscounted cost per student position.
C142		= HHHH / (N * PSP)
B143	ADCSP	Average annual discounted cost per student position.
C143		= PVALUES / (N * PSP)
B144	ACSP	Initial acqusition costs for facilities, equipment, and instructional material development per student position.
C144		= CINT / PSP
B145	UAC	Uniform annual cost.
C145		= PVALUES / MYRDRS
G128..G137	UDACST(I)	Total nondiscounted costs fro each year of the planning period.
H128..H137		= FCOST(I) + TAEQC(I) + AIMMC(I) + PERCOST(I) + COSSUP(I) + TRAVEL
L128..L137	PVALUE(I)	Present value of training course for each year of the planning period.
M128..M137		= ((UDACST(I) * MYRDR(I)) + CINT - (RVAS / DR(I))
L139	PVALUES	Present value of the training course.
M139		= @SUM (PVALUE1..PVALUE0)

Q128..Q137	HHHH(I)	Total nondiscounted cost of the training course for each year of the planning period.
R128..R137		= UDACST(I) + CINT - (RVAS / DR(I))
Q139	HHHHS	Total nondiscounted cost of the training course.
R139		= @SUM (HHHH1..HHHH0)
V128..V137	MYRDR(I)	Mid-year discount rate for each year of the planning period.
W128..W137		= (2 + DRATE) / (2 * DR(I))
V139	MYDRS	Summation of MYRDR(I).
W139		= @SUM (MYRDR1..MYRDR0)
AA128..AA137	DR(I)	Computation for raising the discount rate to the Nth power.
AB128		= 1 + DRATE
AB129		= (1 + DRATE) * DR1
AB130		= (1 + DRATE) * DR2
...		
AB137		= (1 + DRATE) * DR9

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