Best Available Copy

AD-770 884

SURVEY OF THE USE OF EDUCATIONAL TECHNOLOGY IN THE ARMED SERVICES. VOLUME I

Dean Brown, et al

Stanford Research Institute

Prepared for:

Advanced Research Projects Agency

November 1973

UNCLASSIFIED

Security Classification

AD-770 884

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Stanford Research Institute 333 Ravenswood Avenue Menlo Park, California 94025	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

Survey of the Use of Educational Technology in the Armed Services

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report, 1 March 1972 to 15 April 1973

5. AUTHOR(S) (First name, middle initial, last name)

Dean Brown, David H. Brandin, Phyllis Cole, Thomas H. Marshall, Sylvan Rubin, Abraham Waksman

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1973	152	29

8a. CONTRACT OR GRANT NO. DAHC15-72-C-0225, ARPA Order No. 2189 b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Final Report, Project 1775 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency 1400 Wilson Boulevard, Architect Building Arlington, Virginia 22209

13. ABSTRACT

This final report documents a research project that addresses the impact of instructional technology (I.T.) on the technical training of military personnel. The research was directed toward (1) measuring benefits that the Department of Defense might gain through increased utilization of I.T. and (2) postulating new research objectives and programs that would make possible the realization of these benefits. Potential savings in cost and manpower from I.T. were estimated using a large data base, consisting of actual military data on training costs for specific courses with known student loading in graduates per year (labeled throughput based upon number of students graduated). A simple mathematical model was used to estimate potential reductions in course time for samples drawn from the data base of over 4000 courses. Exemplary calculations for over 100 formal technical courses were performed.

The results indicate that the DoD can anticipate substantially reduced training costs by future utilization of innovations in I.T. The most significant variables contributing to cost savings are instructional strategies and methods. Courseware and equipment costs were determined to have less impact on cost savings than was previously considered. The research results suggest that the DoD should expand its use of I.T. to both nontechnical and on-the-job training.

Research in five areas is recommended: (1) instructional strategies, (2) curricula and courseware development, (3) course evaluation methods, (4) equipment and (5) benefit and cost analyses. These exploratory research findings indicate that a basic I.T. research center is desirable for the DoD.

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Computer-assisted instruction (CAI)						
Computer-based instruction (CBI)						
Computer-managed instruction (CMI)						
Educational technology						
Instructional technology (I. T.)						
Manpower						
Media						
Military training						

DD FORM 1 NOV 65 1473 (BACK)
(PAGE 2)

Unclassified
Security Classification

STANFORD RESEARCH INSTITUTE
Menlo Park, California 94025 · U.S.A.

November 1973

Final Report

Volume I

SURVEY OF THE USE OF EDUCATIONAL TECHNOLOGY IN THE ARMED SERVICES

By

DEAN BROWN, *Project Leader*
DAVID H. BRANDIN
PHYLLIS COLE
THOMAS H. MARSHALL
SYLVAN RUBIN
ABRAHAM WAKSMAN

Sponsored by:

ADVANCED RESEARCH PROJECTS AGENCY
ARPA Order No. 2189
Program Code No. P2D20
1 March 1972 to 15 April 1973
Contract No. DAHC15-72-C-0225
Contract Amount: $159,450

SRI Project ISU-1775

Prepared for:

DIRECTOR
ADVANCED RESEARCH PROJECTS AGENCY
1400 WILSON BOULEVARD
ARCHITECT BUILDING
ARLINGTON, VIRGINIA 22209
Attention: PROGRAM MANAGEMENT

Approved by:

DAVID R. BROWN, *Director*
Information Science Laboratory

BONNAR COX, *Executive Director*
Information Science and Engineering Division

ii.

ABSTRACT

This final report documents a research project that addresses the impact of instructional technology (I.T.) on the technical training of military personnel. The research was directed toward (1) measuring benefits that the Department of Defense might gain through increased utilization of I.T. and (2) postulating new research objectives and programs that would make possible the realization of these benefits. Potential savings in cost and manpower from applied I.T. were estimated using a large data base, consisting of actual military data on cost and school throughput. A simple mathematical model was used to estimate potential reductions in course time for samples drawn from the data base of over 4000 courses. Exemplary calculations for over 100 formal technical courses were performed.

The results indicate that the DoD can anticipate substantially reduced training costs by future utilization of innovations in I.T. The most significant variables contributing to cost savings are instructional strategies and methods. Courseware and equipment costs were determined to have less impact on cost savings than previously considered. The research results suggest that the DoD should expand its use of I.T. to both nontechnical and on-the-job training.

Research in five areas is recommended: (1) instructional strategies, (2) curricula and courseware development, (3) course evaluation methods, (4) equipment, and (5) benefit and cost analyses. These exploratory research findings indicate that a basic I.T. research center is desirable for the DoD.

CONTENTS

Preceding page blank

*Bound separately as Volume II.

ILLUSTRATIONS

Preceding page blank

TABLES

Preceding page blank

GLOSSARY

Symbol or Acronym	Title on Computer Printout	Definition
AFB		Air Force base
AFSC		Air Force specialty classification
ARPA		Advanced Research Projects Agency
ARPANET		ARPA Network (Computers and Communications)
CAI		Computer-assisted Instruction
CBI		Computer-based instruction
C_C		Courseware costs (dollars per courseware hour)
C_E		Equipment costs (dollars per terminal hour)
C_G		Cost per graduate
C_{IMP}	$COMP	Cost of implementing I.T. equipment
CMI		Computer-managed instruction
CONARC		Continental Army Command
CONUS		Continental United States
C_T	$TOT	Annual total cost of training
δ(CT)	CAT	Fractional reduction in course time
DoD		Department of Defense
GNP		Gross national product
HumRRO		Human Resources Research Organization
I.T.		Instructional technology
K		Kilo (1000)
MIT		Massachusetts Institute of Technology
MOS		Military occupational specialty
NEC		Naval enlisted classification
NIH		National Institutes of Health
NSIA		National Security and Industrial Association
OJT		On-the-job-training

Preceding page blank

GLOSSARY
(continued)

Symbol or Acronym	Title on Computer Printout	Definition
ONR		Office of Naval Research
O_T		On-line load factor
PLATO		Programmed logic applied to teaching operations
S_C	SSAV	Total dollar savings per year
S_M	MANSAV	Total man-years saved per year
SRI		Stanford Research Institute
t	CT	Course time (weeks)
TICCIT		Time-shared, interactive, computer-controlled information television
T_P	TP	Throughput (graduates per year)

PREFACE

This study was intended to provide data useful to the Defense Advanced Research Projects Agency in formulating its research program in Advanced Training Technology.

The work focused on the estimation of cost savings resulting from different assumptions about: the cost of delivering training per student contract hour; the cost of developing training courses using advanced training; and the amount of reduction in training time resulting from use of advanced training technology, variably paced and delivered in a form individualized to meet the needs of individual trainees.

The report points out that the reader should not interpret the estimated savings literally. The figures can only be taken as indications of trends in the field. The report qualifies the findings in a number of ways, including:

1. The course sample is several years old and the nature of the courses, number of students, and the course length have changed in a number of cases resulting in changes in potential savings.

2. The procedure for estimating the reduction in course time was applied consistently across the course sample and, therefore, gives relative values on savings, however the procedure relies heavily on the professional judgments of the project staff rather than direct measurement.

3. The measurement of course cost is handled in different ways by the Services of the Armed Forces.

4. Savings are dependent on shortening of course time which, in turn, is dependent on individualization of instruction resulting in a spread over time of course completion by trainees. The potential savings can only be achieved if post course assignment procedures can effectively put students into productive activity as they complete the course.

The report does identify important relationships between the key parameters of reduction in course time, cost of delivery, and cost of development. It is on these relationships that the report recommendations are based.

Thomas C. O'Sullivan
Project Director
Advanced Training Technology
Defense Advanced Research Projects Agency

I INTRODUCTION

Instructional technology (I.T.) is beginning to affect training within the U.S. military establishment. In fact, no single organization is likely to push instructional technology forward on a broad front faster than the U.S. military. This report describes the findings of a research program conducted by Stanford Research Institute (SRI) for the Advanced Research Projects Agency (ARPA) of the Department of Defense (DoD). The year-long study focused on (1) the role of I.T. in the U.S. military training programs and (2) the necessary research programs required for the DoD to benefit from I.T.

The analysis of this role required the cooperation of the three major military services. SRI wishes to thank the various offices within the services for their invaluable cooperation and contributions to this study.

This report is divided into six main sections and several appendices. Following this introduction (Section I), Section II summarizes the technical problem, methodology used, research results, and implications of these results. Section III identifies I.T. research programs and relevant data within the DoD. Section IV presents numerical estimates of potential savings from I.T. using a computational model based upon 1971 and 1972 cost and manpower data. Section V discusses inferences from the computational model, implied trends, and deductions about future research. Section VI suggests future research to enable the DoD to realize benefits from I.T. One of the important research alternatives is the implementation of I.T. research centers. The appendices cover a survey of reported I.T. applications, source documentation on training costs and number of trainees, a summary of the cost calculations, and representative experimental values of course time reductions used as calibration data for the calculations.

II SUMMARY

A. Technical Problem

This study focuses on the relationship of instructional technology (I.T.) to military training and the research that must be conducted to enable the military to realize the benefits inherent in this new technology.

I.T. has been defined as "a systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives, based on research in human learning and communication, and employing a combination of human and nonhuman resources to bring about more effective instruction."[1*] I.T. thus involves the combined use of modern technological devices and individual and group motivating techniques to improve the instructional process. These tools and techniques include individualized learning, peer instruction, group dynamics, audio-visual aids, programmed instruction, teaching machines, and the computer.

Experiments in both military and civilian educational institutions have suggested that I.T. offers both tangible cost-effective benefits and others less tangible. The measurement of these benefits is the first step toward proper identification of new channels for increased utilization of I.T. in the military.

The research objectives of this study were to establish criteria for measuring the tangible benefits of I.T., to study the development of I.T. within the services, to assess the present and potential commonality of these efforts, and to make recommendations to exploit the further benefits of I.T. In particular, the research program was specifically

---

*References are listed on page 83.

Preceding page blank

intended to postulate new research objectives and programs that would establish a foundation for obtaining these potential benefits from I.T.

B. Methodology

To achieve the research objectives, efforts were directed toward measuring potential cost and manpower savings from applied I.T. This was accomplished by:

- Establishing a data base consisting of training costs and throughputs (graduates per year) for approximately 4000 formal technical training courses, as actually recorded by the military.
- Identifying the meaningful parameters of I.T.
- Developing a simple mathematical model that determined potential cost and manpower savings.

Before the potential savings in dollars and manpower could be estimated, the reductions in course length resulting from the application of I.T. had to be estimated. Many socio-psychological variables can affect the amount of course time a given student needs to complete any single course successfully. Thirteen variables were identified as key contributors to the expected reductions in course time. Their individual effects were integrated into a single parameter, the fractional reduction in course time, δ(CT). Calculations were performed, based upon estimated values of δ(CT), that would likely be realized if I.T. were introduced into course curricula.

A sample comprised of about 120 courses from all three services was selected for the calculations. The courses were chosen to represent a diversity of curricula, subject to the constraint that complete data on each course was available. Three parameters were varied: (1) δ(CT), (2) I.T. equipment costs, and (3) courseware development costs. The estimated cost reductions (if any) were quantified.

Cost and manpower reductions were chosen as measures for providing quantitative indications of the principal factors involved in optimizing training effectiveness. To optimize in the short run, the savings potential was based on a 1971 "snapshot" of the formal military training schools and the potential for improvement. Since the implementation of that potential will likely require many years, it is expected that new requirements, new instructional strategies, and new technology will have to be considered as they arise in the future. Therefore, the recommendations reported herein describe programs that will facilitate appropriate evaluation of I.T. and instructional methods in this continuing evolution. Estimates of potential savings are to be interpreted as guidelines to the areas of most effective applications of new I.T. in 1974 to 1975 and to research opportunities. The estimates should not be considered as predictions of actual savings at a specific time.

C. Technical Results

The calculations suggest, that for samples of 30 Air Force, 39 Army, and 50 Navy courses, annual dollar savings of $14.4 million, $15.0 million, and $13.3 million, respectively, might accrue for the sampled courses through the application of I.T. These savings were calculated based upon assumed hardware costs of $0.50 per terminal hour and total courseware development costs of $2500 per courseware hour for each hour of the course adapted to I.T. It is not certain that these projected savings can be converted into actual savings because questions remain concerning reassignment practices, options for increased training, and other factors. However, the estimated savings will certainly contribute to increased effectiveness within each service.

The corresponding annual manpower savings for the sampled courses under the same assumptions would be 1150, 1280, and 2360 man-years, respectively.* Interpreting these figures as general indicators and not as specific course-dependent data, these results suggest that implementation of innovations in I.T. in the military can reduce total training costs.

By testing the sensitivity of the variables in the cost model, other important results were observed. Considerable sensitivity to the variations in δ(CT) is noted. The most significant variables are training strategies and instructional methods, which impact directly on δ(CT).

Common curricula indicate that the services already see the value of shared training activities. However, there are several advantages to increased commonality. These are discussed in Section V of the report. Although increased commonality is not necessary to gain benefits from I.T., the project team concluded that increasing commonality in applied I.T. will result in larger cost and manpower savings than would otherwise accrue.

D. Department of Defense Implications

In the DoD training system about half of the training occurs on the job, and the rest is formally organized as schooling. For all training, however, I.T. which uses training aids where the trainee is normally located, offers important and worthwhile savings. The minor redirection of training philosophy toward increased utilization of I.T. that is needed to realize these benefits is already underway. Examples include the basic electricity and electronics training at Keesler AFB, the Computerized Training System (CTS) at Ft. Monmouth, and the new techniques

*The selection of courses for the Army and Air Force samples was made on the basis of the available data. The Navy samples were biased toward those courses where large manpower savings might be effected. The larger sample size and the bias toward manpower savings were performed as part of a related study for ONR.

for training in mathematics and engineering at the Air Force Academy at Colorado Springs. A strong trend exists toward training in the field and on board ship or aircraft, and the idea is popular among field commanders. If the transition to greater use of I.T. in military training is made in a careful, continuous manner, time and experience will permit new procedures, policies, and equipment to come into orderly use without disrupting normal operations. Thus, SRI recommends that the DoD continue to improve allocations of training resources by utilizing I.T. throughout its formal and informal training programs.

E. Implications for Future Research

The potential gains in dollar and manpower savings are large compared to the small cost associated with the risk to the DoD of investing additional funds in future research in I.T. The potential gains to the DoD of the research suggested below lie in its commonality to all military services, in its fundamental nature (not operational or developmental), and in its ease of integration with projected I.T. systems. The recommended research reflects the present cost study, whose results demonstrate that, of the many variables and parameters studied, instructional strategies and methods have the greatest impact on cost savings. The purpose of the proposed new research is to guide and to clarify an optimum future development path for I.T. within the military.

Five domains of research are suggested:

(1) Theory of instructional strategies

(2) Curricula and courseware development for applied I.T.

(3) Course evaluation methods

(4) Equipment and software aspects of applied I.T.

(5) I.T. benefit and cost analysis.

Future funding should be applied to these categories on a priority basis according to the ranking in the above list.

I.T. research centers should be established by the DoD, or present educational facilities should be improved to coordinate research activities and to accelerate the application of research results from the I.T. laboratories to the field. It is recommended that a basic I.T research center be established and that it be accessible by each military service. Also, each military service should enhance its present operational centers. The basic I.T. research center should not be operated by any specific military service.

The basic research center should be organized with balanced participation of all three services in mind. Its objectives should be:

- To provide a foundation for nourishing basic I.T. research
- To monitor and validate the future benefits of I.T.
- To maintain an optimum path for the expansion of I.T. in the DoD.

The center should perform and support basic research and be cognizant of the present and projected state of the art in I.T. It should also make recommendations and facilitate research in "blue-sky" areas. While it is difficult to program "blue-sky" research effectively, the center should be responsible for identifying new research opportunities and for locating appropriate funding resources.

The center should be available as a breadboard facility for outside researchers, and it should provide the focal point for other I.T. workshops. Each military service should augment its existing facilities or functions in I.T. development, and each should designate one of its facilities as an I.T. workshop or communication center for interfacing with the basic center.

III BACKGROUND

A. Instructional Technology

As discussed in Section II-A, I.T. combines modern technological devices and student motivating techniques to improve the instructional process. One of the key nonhuman resource elements of I.T. may be the computer.

The role that the computer plays in I.T. is growing. Computer-based instruction (CBI) can be either computer-assisted instruction (CAI) or computer managed instruction (CMI). This report uses an expanded version of of the Army's definition[2] of CAI and CMI. CAI is a man-machine interaction in which most of the teaching functions are accomplished by using the computer in direct support of a training situation. Both training and tutorial logic are stored by the teacher or curriculum developer in the computer memory. The techniques used in CAI include individualized instruction and group dynamics for simulation and gaming, logic problem solving, computation, tutorial dialogue, drill and practice, and others. CMI is an overall instructional management system in which detailed student information, complete curriculum data, and information on available resources are integrated to facilitate the development of individualized programs, to revise curriculum content, to provide the necessary counseling and guidance, and thus, to bring about optimum instructional resources management.

1. Benefits

Benefits from I.T. vary considerably, and no simple common element identifies all potential benefits. Therefore, for the purposes of this study, these benefits have been divided into two categories of variables: tangible and intangible benefits. No value rankings are implied by the order in which the two classes of variables are listed below.

(1) Tangible benefit variables

- Cost reductions
- Reductions in training time
- Shortening of the time needed to revise curricula
- Manpower savings.

(2) Intangible benefit variables

- Increased comprehension and performance of the student
- Better student and teacher motivation
- More effective use of the military services as training institutions
- More reenlistments due to increased training effectiveness and student satisfaction
- More options for the training commands.

Tangible benefits can be translated directly to dollar savings. Intangible benefits are more difficult to quantify, but both classes of variables affect training requirements.

2. Training Effectiveness

The military services have a continuing need to improve the effectiveness of their training methods. Cost and manpower economies are sought at every level in the DoD. Although training is becoming increasingly complex, savings are still imperative. While the sophistication of equipment has dramatically increased,[3] the abilities of men coming into the service have remained constant. These problems will intensify as the services shift to an all-volunteer force.*

---

*The impact of this problem was accelerated by Secretary Laird's announcement of the early termination of the draft (January 1973).

The services are now beginning to shift the responsibility for training to smaller units, thus increasing the need for improved self-management and learning motivation. At the level of the small training unit, this means that training skills and aids must have greater transferability.

Having recognized some of the potential benefits and requirements of I.T., the services have revised their training programs and policies to some extent.[4-6] However, a unified, internally consistent program remains to be set forth to measure the benefits and effectiveness of operational programs that apply the results of I.T. research.

B. Research Objectives

Military training is always in a state of revision and modernization. Training requirements change; cost reductions are made. New training objectives and methods of evaluation are steadily being introduced. New techniques for training evolve. It is widely assumed and already observed in preliminary experiments that I.T. is an important factor in this dynamic field, but a clear role has not emerged. This study was undertaken to help place I.T. in a rational perspective. The research objectives were:

(1) To establish the criteria for measuring the benefits and effectiveness of I.T.

- To determine the parameters to be measured.
- To identify selected areas of training subjects where the application of I.T. would readily yield benefits.

(2) To study the development of I.T. training efforts within the services and to assess the commonality of these efforts.

- To relate advantages and disadvantages of joint training programs using I.T.
- To determine the impact of increased and/or decreased common efforts.

(3) <u>To make recommendations to exploit the further benefits of I.T.</u>

- To postulate the basis for training policies and future research programs.
- To provide new research objectives that will establish a foundation for realizing further benefits from I.T.

The recommendations derived from this study are given in Section VI, page 71.

C. Achieving the Objectives

To achieve the research objectives, efforts were directed primarily toward measuring potential cost and manpower savings from applied I.T. This was accomplished by identifying the meaningful parameters of I.T. and developing a mathematical model based upon payoff criteria. Present military training programs were examined, and a considerable data base was developed. The methodology used is discussed in Section IV.

D. The Use of Instructional Technology in Training

During the last two decades, each service has explored the possible contributions of I.T. in its training programs. In fact, the military pioneered most of the research in the use of film, videotape, television, and computers as instructional aids. Each of the services has established its own training objectives and pass/fail criteria, and each has also developed its own evaluation procedures for determining the extent to which training objectives have been satisfied.

Army goals are based on the following objectives:[4]

(1) Training will be performance based.

(2) Techniques of training will focus less on subject matter and more on functional context.

(3) Absolute rather than normative criteria will be used.

(4) Testing will be performance oriented and measurement will be on a go or no-go basis.

(5) Individualizing methods will be used to the greatest extent possible.

(6) Immediate feedback will be provided at the training site to the trainee, the trainer, and the training management.

(7) A rigorous quality control system will be used.

The Army instituted this system because of a conviction, based upon a good deal of evidence, that the lecture/ demonstration technique is not the most effective method to promote learning.[4]

The Air Force, using concepts of system analysis, evolved its own training procedure--instructional system development. As stated by an Air Force training representative:

> "It grew out of programmed learning which we [the Air Force] have applied extensively over the last decade to increase the job-relevancy of training and to reduce training time . . . . It calls for the creative use of those audio-visual devices that industry has been developing. This approach frees the instructor from his role as an animated public address system and makes him a problem-solving manager of instruction. This approach will also make training responsive to rapid changes in manpower requirements."[5]

These goals and objectives are similar to those of the Army. Courses are tailored to fit job performance objectives, and criterion-based tests are used. It is implied that every student will learn the necessary job skills. In fact, training is aimed at matching the man and the job more precisely than in the past.[6]

The Navy has the following objectives , which give special consideration to shipboard requirements:[7]

(1) To develop individualized training involving specific learning objectives and stringent performance evaluation.

(2) To promote simplification of the learning process through increasing hands-on experience, the involvement of the learner, and the use of counselors. This intensifies the need for well-integrated training aids, materials, and devices.

(3) To develop valid performance measures of individual and team proficiency to be used in training and in fleet operation.

(4) To promote shipboard training where it can be clearly demonstrated as the most productive site for a training program.

(5) To develop effective ways to use simple synthetic training devices and simulators to reduce training time and fleet training cost, and to increase standardization of performance throughout the Navy.

All three services emphasize the educational goals of individualized instruction and performance testing. As a result, the large lectures familiar in both military and nonmilitary classrooms are no longer so pervasive. The instructional strategies most frequently employed in realizing these revised training goals are self-paced instruction (including programmed instruction), peer instruction,* on-the-job training, and simulation.

Each of these innovative instructional strategies may be used with a variety of media. Often, one or more strategies are used in conjunction

---

*An example of peer instruction was developed by the HumRRo (Human Resources Research Organization), Division 3 and applied to the Army's Basic Combat Training.

with one or more types of media or equipment. Perhaps the most common combination used is the lecture and the programmed textbook. The lecture in combination with television is not uncommon, and CBI is used for self-paced instruction and simulation.

Although these identifiable separate efforts exist, there is no explicit policy for extensive common use of technology within the military establishment. However, statements of general training policies often refer to technological advances and their implied uses to support training.

Policies implicit in the studies initiated by the services demonstrate increased concern with I.T., particularly as it applies to technical training.[2,8-10] Some interservice conferences, such as the CAI "Shirtsleeve" Conference at Fort Bliss, Texas, in 1971 and the annual NSIA Application of Computers to Training (ACT) Conferences, are examples of cooperative efforts to achieve common instructional goals. All of the services are interested in exploring the use of computers as training devices. The increasing number of statements* advocating the use of computers for various instructional purposes suggest that military training administrators believe that the use of computers can upgrade training. Financial support is evident from the backing that is being extended to groups doing research in CBI.† In these research efforts, emphasis is often placed on reducing training costs.

---

*Examples include statements made by the Board of Dynamic Training, CONARC Task Group Report, "Shirtsleeve" Conference, and the NSIA ACT Conferences.

†ARPA, the four military services, and NSF have supported a broad range of research in CBI. The studies extend from large-scale delivery systems such as TICCIT and PLATO, to CBI languages such as LOGO, to the use of the ARPANET for supporting CBI research, to fundamental studies in artificial intelligence, to the exploration of fundamental pedagogical procedures such as confidence testing.

1. Training Costs

Training costs represent a large expenditure in the DoD, and they constitute an area in which I.T. benefits can be visibly demonstrated. For example, the DoD's total national expenditure on military training in 1975 is projected to range from $5 to $8 billion, or 8 to 9 percent of the estimated 1975 military budget. If advances in I.T. were to realize a 15 percent reduction in military training costs, the potential savings would amount to $0.75 to $1.2 billion, or approximately 1.25 percent of the total 1975 DoD budget.

Figure 1 shows possible trends in the estimated GNP, estimated DoD expenditures, and estimated DoD training expenditures. This figure is based upon a factual DoD cost history and an average annual growth rate of 4.2 percent for the GNP. The data sources are given in Table 1, which presents estimated DoD military training expenditures.

Present research results in I.T. in both the military and nonmilitary indicate wide variations in potential cost savings. However, most of the results imply significant cost reductions are possible. Appendix A summarizes some examples of recent I.T. research and cites author conclusions about changes in costs.

In measuring I.T. costs, there is considerable disagreement due to differing assumptions as to the appropriate components of such costs. This problem occurred repeatedly during the research program, and it is discussed in some detail in Section IV. Due to these disagreements, studies on the costs of I.T. usually yield large amounts of noncomparable cost data. This is most noticeable in studies comparing civilian and military costs, although similar problems exist in inter- and intraservice studies. Cited cost reductions resulting from the use of I.T. in civilian educational settings most often rely on the assumed combination of a volume of users and efficient use of I.T. to produce

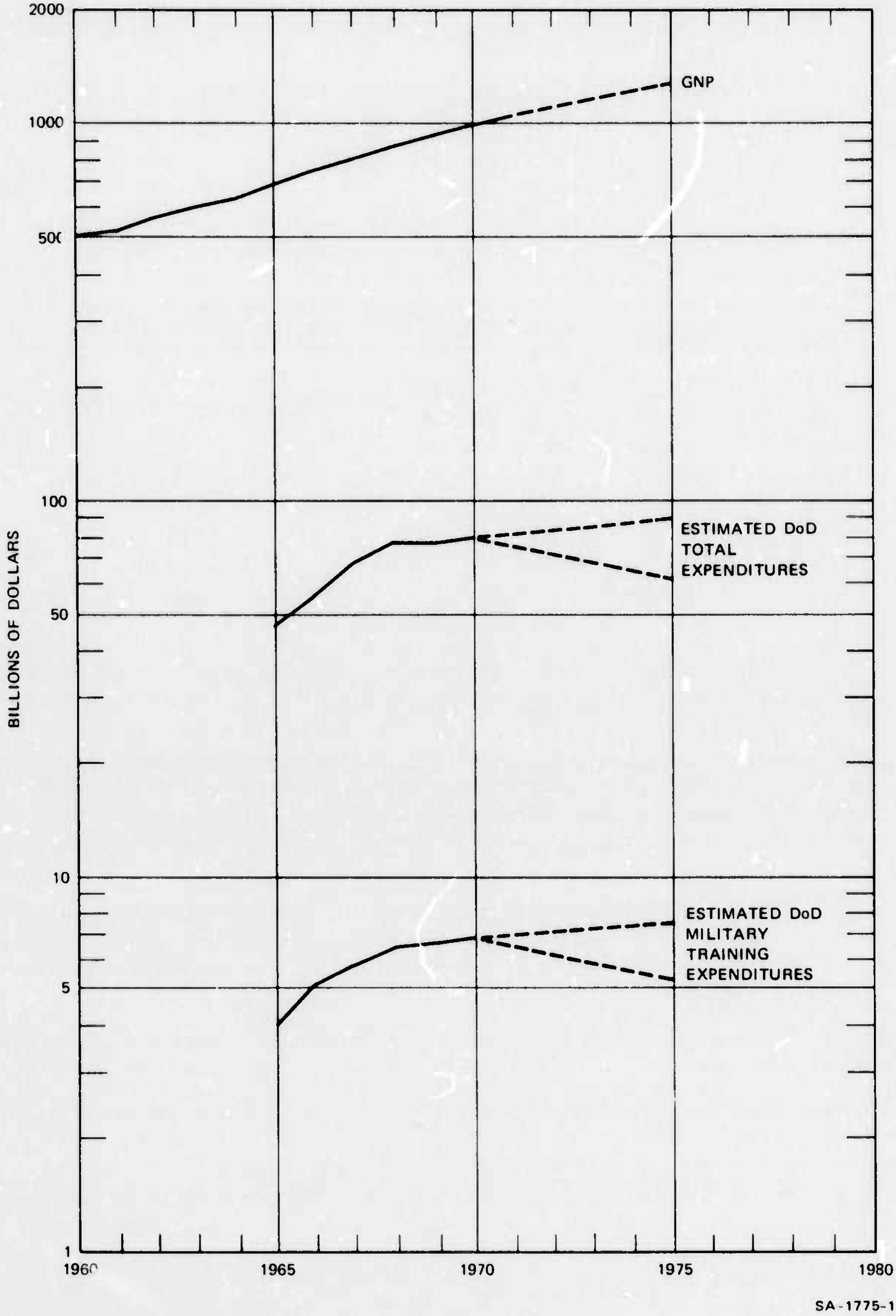


FIGURE 1 ESTIMATED DoD MILITARY TRAINING AND TOTAL EXPENDITURES COMPARED WITH THE GNP: 1965 TO 1975

Table 1

ESTIMATED DoD MILITARY TRAINING EXPENDITURES

1965-1975
(In Billions of Dollars)

Fiscal Year	DoD Outlays*	GNP+	DoD Outlays as percent of GNP	DoD Training, Medical, and Other General Personnel‡	DoD Military Training Activities§
1965	$47.4	$684.9	6.9%	$5.9	$4.0
1966	55.4	749.9	7.3	7.5	5.1
1967	68.3	793.9	8.6	8.5	5.8
1968	78.2	865.0	9.0	9.4	6.4
1969	78.4	931.4	8.4	9.8	6.7
1970	79.0	976.5	8.0		
1971		1046.8			
1972					
1973	68-85	1137	6.0-7.5	8.6-10.7**	5.9-7.3
1974					
1975	62-86	1234	5.0-7.0	7.8-10.8**	5.3-7.3

*Source for the 1965 to 1970 data, "The 1970 Budget and Defense Program FY 1970-74," Clark Clifford's statement to the House Armed Services Committee, p. 157 (15 January 1969). Data for 1973 and 1975 were estimated by assuming that DoD outlays in these years, relative to the estimated levels of the GNP, will be in the range of the 1965 percentage or less.

+Source: "National Income and Product Accounts, Survey of Current Business," Office of Business Economics, U. S. Department of Commerce. Data for 1973 and 1975 were estimated by assuming an average annual compound rate of growth of 4.2 percent after 1971.

‡Source: "The Fiscal Year 1969-1973 Defense Program," McNamara's statement before the House Armed Services Committee, p. 214 (22 January 1968).

§Source: Senate Hearings Before the Subcommittee of the Committee on Appropriations, FY 1972, p. 464. This is calculated by applying the factor 68 percent to the preceding column. The operation and maintenance appropriation for the U.S. Army (actual 1970 fiscal year experience) showed that 68 percent of the general personnel activities category was spent on military training.

**The 1973 and 1975 training, medical, and other general personnel expenditure data are estimated by applying a factor of 12.6 percent based on five years of data (1965 to 1969).

cost benefits. In the results for the military, shortening of training time usually accounts for the principal savings,[11-15] since the trainee receives a salary during his training period.

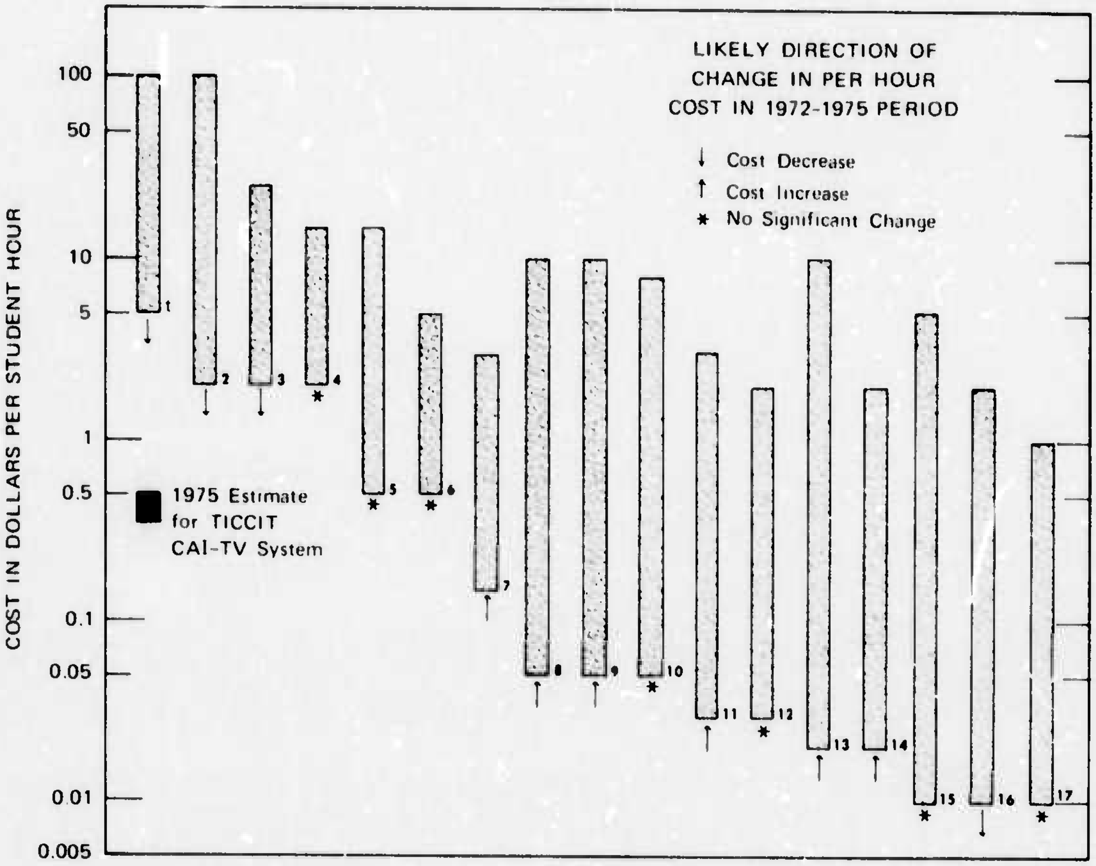
Even though there are wide cost disparities in experimental systems in the civil sector, it is possible to array cost ranges,[16] as shown in Figure 2. In this figure, cost data for 17 categories of instructional media are ranked from highest to lowest cost per student hour. (The direction of the arrows beneath each bar in Figure 2 indicates SRI's projection of the trend in cost per student hour during the 1973 to 1975 period.) Six of the 17 instructional techniques are expected to show increases in the cost per student hour, and four are expected to decrease. The left side of Figure 2 shows the estimate[17] for TV CAI in 1975. This system is expected to be cost competitive with all other instructional technologies.

By the time a study of costs in the CBI area has been published, enough time has usually elapsed to make the published cost per student hour an overstatement because costs are decreasing. For example, it is now possible to purchase or lease a CBI system using a minicomputer and 32 Teletype terminals within an estimated cost range of $0.45 to $1.84 per student hour.* This example is for rates available in February 1973 in the San Francisco Bay Area.

More detailed information on various systems needs to be established and the costing procedures analyzed for commonality before such systems will likely enjoy successful and wide implementation.

---

*Data from Computer Curriculum Corporation of Palo Alto, California. The costs depend on the assumptions made as to the number of years for amortization and the amount of student use per year. Costs include hardware, maintenance, three CAI tutorial packages (without audio), on-line individual and class reports, workshops for instructors, one teacher's manual per course, and unlimited use of the facility.



1 On-Line Computer (CAI)
2 Automated Storage and Retrieval of Written and Graphic Materials
3 Computerized Programmed Instruction
4 Facsimile Transmission of Documents by Electronic Circuits
5 Small Discussion Group
6 Dial Access Instructional TV
7 Class Lecture
8 Books and Journals
9 Printed Programmed Instruction
10 Standard Audio-Visual Aids
11 Closed-Circuit Live Instructional TV
12 Closed-Circuit Tape-Recorded Instructional TV
13 Broadcast Live Instructional TV
14 Closed-Circuit Lectures on Public Address System
15 Broadcast Tape-Recorded Instructional TV
16 Dial Access Audio Tape Recordings
17 Educational Radio

SOURCES: References 16 and 17

SA-1775-2

FIGURE 2 RANGE OF COST PER STUDENT HOUR FOR 17 INSTRUCTIONAL TECHNIQUES (1969 TO 1970) COMPARED WITH 1975 CAI ESTIMATE

The emphasis on a set of agreed definitions for costs is continually being stressed by all sectors using CBI,[2,18,19] but as yet no common procedures, such as those outlined by Tickton,[20] have been implemented.

2. Computer-Based Instruction

The extent of the development of CBI in the services is a function of available facilities, their present cost effectiveness, and the technical difficulties associated with implementing CBI methods. However, the use of CBI is growing nationwide in the areas of administrative data processing (e.g., scheduling), and educational operations depend upon the computer (CMI) in many school systems. CMI services are also available from commercial sources. In contrast, CAI has only recently emerged from experimental status. When the computer is not used in an interactive CAI mode, it may still serve to inform the student and teacher by CMI techniques which booklet, device, or equipment should be used in an individualized course of instruction. Thus, potential reductions in course time can be realized from either the CMI or CAI modes of CBI.

Reductions of 30 percent in course time as a result of using CBI are common. In the area of electronics, reductions of 87 percent have been reported using the Lincoln terminal system.[21] Other electronic courses experiments have reported reductions of 20 to 55 percent.[11-15,22] Significant reductions in instructor work loads and course overhead costs are also implied.

CBI also offers some valuable intangible benefits. It makes the transition from school training to field training possible on a large scale. When sophisticated equipment (e.g., radar, sonar) is involved, CBI offers several on-the-job training advantages, including the following:

- The trainee can learn in a realistic environment.

- He can learn on actual field equipment, which can be simulated by CBI for rare situations, as well as common ones.
- CBI exercises the field equipment in important modes and thus contributes to its continuing readiness.

Operational CBI programs (primarily CAI) can be found in 12 Army schools and colleges.*[3] At the Army Logistics Management Center at Fort Lee, Virginia, a Univac computer is used for both simulations and tutorial courses. Practical CAI courses are available through the Medical Field Service School. The Army War College supports a course involving such areas as individual research, a gross national product projection, a joint force budget model, and quantitative applications to international relations. The Army Security Agency Training Center and School offers a large, successful CBI course in Morse code. Since 1966 basic electronics courses have been offered via CBI at Fort Monmouth. Computer-supported instruction in an automated environment is used to train supply personnel at the U.S. Army Quartermaster School. Emphasis is placed on CAI drill and practice at the U.S. Army Infantry School. The Engineer School and Air Defense School mainly use CBI for problem solving.

The Navy supports CBI projects conducted by several civilian groups, as well as CBI in-service development.† [23-25] Dr. Richard Atkinson of Stanford University has developed a tutorial course to teach computer programming that focuses on the basics of learning techniques. The late Dr. Jaime Carbonnell of Bolt Beranek and Newman was performing research with a system enabling both the learner and the computer to take the

---

*Sources include conversations with Army personnel listed in Table 2 in Section IV.

†Sources include conversations with Naval personnel listed in Table 2.

initiative in a dialogue. Dr. Seymour Papert of MIT is supported by ARPA (work monitored by ONR) for the development of LOGO, a high-level programming language useful in teaching a variety of mathematical concepts. Dr. Joseph Rigney of the University of Southern California is focusing attention on performance in training programs involving the trouble-shooting of operating equipment. His research has found significant applications in CAI tutorial programs involving simulation in courses such as Radar Repeater (AN/SPA-66) or Radio Transceiver (AN/URC-32). A Florida State University contract involves on-line intelligence testing and evaluation and several studies of the interaction of CAI with various psychological states. Much of the CBI pioneering effort in the Navy has stemmed from the work of Dr. John Ford at the Naval Personnel and Training Research Laboratory in San Diego.

The Air Force has directed its CBI funding to four main projects.*26 The main operational system is the Computer-Directed Training System, which provides worldwide on-the-job training in a variety of management functions related to the operation and use of computers. The Lincoln Terminal System developed in prototype form at MIT provides both audio and complex pictorial capability; the prototype system is now undergoing developmental tests at Keesler AFB. This system is used in training for basic electricity and electronics. In addition, special provisions have been made for the preparation of training materials. The Advanced Instructional System, presently undergoing specification and bid reviews at Lowry AFB, involves computer control of a wide variety of media to allow for sophisticated individualized instruction. Initially, the system is intended to support research on computer-based training, as well as to offer three technical training courses for up to 2400 students. The undergraduate Pilot Training System, now being developed incrementally, will use CAI in the teaching of pilot skills. Advanced simulators and simulation techniques will be used in this program.

---

*Sources include conversations with Air Force personnel listed in Table 2.

IV COST ANALYSIS

This section identifies the data base used in the research, develops a mathematical model, and calculates the estimated dollar and manpower savings to be gained from the application of I.T. to military training.

A. Data Base

The data base consists of three principal segments:

(1) The estimated instructional cost per hour in both public and military instructional sectors. These per hour costs are based upon actual experimental implementation of various forms of I.T.

(2) The expected hardware, software, and courseware cost trends for I.T. systems.

(3) Actual annual data on the number of trainees graduated and the training costs in the three military services.

These three segments of data are the smallest set of inputs necessary to permit the calculation of dollar and manpower savings estimates from the mathematical model.

Together, these three segments constitute an extensive data base that can be used as a foundation for subsequent interpretations, although for this study it has not been tapped in depth. The military manpower and training cost data has been collected and coded; some of it is now stored in computerized form on disk files.

1. Data Survey

Literature searches and on-site interviews were conducted to initiate the data collection for Segment 1 of the data base. The I.T. group at SRI utilized its contacts with the civil I.T.

community and expanded these sources through direct contacts with military and other civilian officials to identify and gain access to current information. The survey identified in a very broad scope (not claimed as exhaustive) pertinent civilian and military cost elements associated with I.T. Table 2 lists some of the individuals contacted during the study.

Segment 2, equipment and courseware costs, is discussed in Section IV-B. This segment of data was used to develop parameters for the cost analysis and for testing the sensitivity of the cost model to changes in these parameters.

2. Data Collection

To obtain the Segment 3 information for representative costs on a course-by-course basis emphasis was placed on finding the original data as actually recorded by each of the military organizations. The level of detail sought was the individual technical military course with all of its associated cost, curriculum, and student loading characteristics, as actually pursued in a given time frame. The time period selected was the most recent for which both training costs and student throughput were available from the services. In all cases, the sources of data sought were the most recently available (i.e., latest publications) course descriptions and cost compilations. For examples, see Appendix B.

Sources of data included the formal school catalogs, the staffing data, and school throughput data (trainees graduated) as well as direct interviews with personnel involved in the training activities of each of the three military services. Data were sought at the headquarters and staff levels, and interviews were conducted with both training management and training clerical personnel responsible for preparing accounting data describing technical courses. For example,

Table 2

DATA SURVEY CONTACTS

Name	Organization	Location
Lt. Col. M. J. Ascencio	ROTC, Stanford University	Stanford, CA
Col. F. Atsif	Combat Arms Training Board	Ft. Benning, GA
CWO Brady	MOS Reference Library and Educational Testing Facility	San Francisco, CA
Col. H. Braunstein	Division of Plans and Training	Ft. Ord, CA
Dr. N. Brodsky	Office of the Secretary of Defense	Washington, D.C.
Dr. G. Bryan	Office of Naval Research	Arlington, VA
Mr. C. L. Buecker	Air Training Command	Randolph AFB, TX
Mr. R. Butman	Lincoln Laboratories	Lexington, MA
Mr. B. Cantor	Field Operations Cost Agency	Alexandria, VA
Dr. J. Carbonell	Bolt Beranek and Newman	Cambridge, MA
Mr. B. Carnahan	Field Operations Cost Agency	Alexandria, VA
Col. J. Carrol	Continental Army Command	Ft. Monroe, VA
Dr. J. Collins	Office of Chief of Naval Operations	Washington, D.C.
Sgt. Corrington	Air Training Command	Lackland AFB, TX
Mrs. J. Crane	Continental Army Command	Ft. Monroe, VA
Mr. G. Crawford	Naval Air Technical Training Command	Millington, TN
Mr. J. Cretura	Department of the Navy	Washington, D.C.
Mr. Cushing	U.S. Naval Schools Command	San Francisco, CA
Sgt. DeCesare	Air Training Command	Lackland AFB, TX
Mr. D. Delaune	Continental Army Command	Ft. Monroe, VA
Dr. W. Feurzeig	Bolt Beranek and Newman	Cambridge, MA
Dr. J. Ford	Naval Personnel and Training Research Laboratory	San Diego, CA
Mr. T. Gillespie	Continental Army Command	Ft. Monroe, VA
Mr. Goldfine	Training Office of the 6th Army	San Francisco, CA

Table 2 (continued)

Name	Organization	Location
Dr. J. Goodenough	Air Force Cambridge Research Laboratories	Hanscom Field, MA
Col. J. Handley	Continental Army Command	Ft. Monroe, VA
Col. G. B. Howard	Computerized Training System	Ft. Monmouth, NJ
Lt. Col. N. A. Howard, Jr.	Continental Army Command	Ft. Monroe, VA
Maj. Gen. I. Hunt	Continental Army Command	Ft. Monroe, VA
Dr. E. Jones	Naval Training Research Laboratory	San Diego, CA
Lt. Col. C.E. Kerwin	U.S. Army Reserve	Mt. View, CA
Dr. F. Kopstein	Human Resources Research Organization	Alexandria, VA
Comdr. Long	Naval Air Technical Training Command	Millington, TN
Mr. Al Longo	Signal Center and School	Ft. Monmouth, NJ
Mr. M. K. Mailhorn	Naval Training Command	Arlington, VA
Mrs. Maita	Training Office of the 6th Army	San Francisco, CA
Dr. S. P. Mansour	Naval Postgraduate Language Institute	Monterey, CA
Mr. McCabe	Continental Army Command	Ft. Monroe, VA
Dr. H. McFann	Human Resources Research Organization	Monterey, CA
Capt. A. McMichael	Naval Training Center	Pensacola, FL
Maj. D. Mead	Air Training Command	Randolph AFB, TX
Mr. R. Mercer	Naval Air Technical Training Command	Millington, TN
Mr. D. Meyer	Air Training Command	Randolph AFB, TX
Col. Mitchell	Air Training Command	Randolph AFB, TX
Mr. P. Morris	Office of Ass't Secretary for Defense Analysis	Washington, D.C.
Lt. Col. Mullins	Air Training Command	Lackland AFB, TX
Col. W. Murphy	Air Force Human Resources Laboratory	Lowry AFB, CO
Mr. C. Niblock	Air Training Command	Randolph AFB, TX
Sgt. G. Oldfield	Air Training Command	Lackland AFB, TX
Mr. T. O'Sullivan	Advanced Research Projects Agency	Washington, D.C.
Lt. Col. R. W. Otto	Office of the Chief of Staff	Washington, D.C.
Mrs. E. Potter	Department of the Navy	Arlington, VA
Mr. D. G. Price	Navy Personnel Requirements	Washington, D.C.

Table 2 (concluded)

Name	Organization	Location
Col. Redman	Air Training Command	Randolph AFB, TX
Lt. Cmdr. Riggs	U.S. Naval Air Station	Moffett Field, CA
Dr. B. Rimland	Naval Personnel and Training Research Laboratory	San Diego, CA
Dr. M. Rockway	Air Force Human Resources Laboratory	Lowry AFB, CO
Mr. A. Ruebush	Naval Air Technical Training Command	Millington, TN
Lt. Col Savage	Air Training Command	Lackland AFB, TX
Mr. H. Schultz	Continental Army Command	Ft. Monroe, VA
Mrs. H. Scott	Air Training Command	Randolph AFB, TX
Dr. R. Seidel	Human Resources Research Laboratory	Alexandria, VA
Mr. Siegel	Office of Naval Education and Training	Arlington, VA
Dr. R. G. Smith	Human Resources Research Organization	Alexandria, VA
Mr. C. Smithfield	Air Training Command	Randolph AFB, TX
Miss C. Solomon	Massachusetts Institute of Technology	Cambridge, MA
Mr. K. Stetten	Mitre Corporation	McLean, VA
Capt. Stone	Office of Chief of Naval Training	Pensacola, FL
Mr. R. Stutz	Continental Army Command	Ft. Monroe, VA
Mr. Sullivan	Plans and Training Office	Ft. Ord, CA
Mr. F. J. Sullivan	Office of the Secretary of Defense	Washington, D.C.
Gen. Taxis	Human Resources Research Organization	Alexandria, VA
Dr. J. Taylor	Human Resources Research Organization	Monterey, CA
Mr. A. Usher	Office of Ass't Secretary for Defense Analysis	Washington, D.C.
Dr. R. Watson	Stanford Research Institute	Menlo Park, CA
CWO Webb	U.S. Naval Schools Command	San Francisco, CA
Col. P. Whitfield	Continental Army Command	Ft. Monroe, VA
Mr. R. Williams	Naval Training Center	Pensacola, FL
Dr. M. Wiscoff	Naval Personnel and Training Research Laboratory	San Diego, CA
Mr. Yergovitch	Office of Director of Naval Education and Training	Arlington, VA

supervisory instructors were queried by SRI professional staff on questions of curricula, student motivation, reasons for and frequency of changes in the curricula, and the mechanics and system for generating the raw data on school throughput (attendance, attrition, and trainees graduated) at the classroom level. The cost-per-trainee information was sought and found in the financial and controllers' offices of the three military services.

Pertinent special studies on costs that cover the presently used definitions and methods for estimating the total cost to train an inductee or volunteer to achieve a given skill level were identified, and in some cases, the raw data from these studies were used in the analysis.

Examples of the types of general cost information on training that are currently available are the "Military Occupational Specialty Training Cost Handbooks," Volumes I and II, published by the U.S. Army Field Operating Cost Agency in November and December 1972, respectively, "Annual Training Time and Costs for Navy Ratings and NECs," (fiscal 1972 edition), published by the Bureau of Naval Personnel, Department of the Navy, and "U.S. Air Force Program Technical Training," Volume I, published by the Headquarters of the Air Training Command, Randolph AFB, Texas, in March 1972.

Professional military and civilian personnel of the three service organizations who are concerned with the common curricula and joint cost problems were interviewed to ascertain their perceptions of trends toward commonalities in both areas.

3. <u>Summary of the Data Base</u>

The established data base was placed in machine readable form by keypunching directly from the source documents to cards. The data base includes the following approximate number of technical courses:

Service	No. of Courses
Army	2000
Navy	1200
Air Force	1000

This data base is now in a form amenable to computation using various mathematical models. Alternative assumptions from those discussed below may be postulated by various experts in the specialty fields of civil and military instructional methods. The data base is both open-ended and susceptible to rapid refinements and further iterations because of its computerized form.

4. Sufficiency and Comparability of Data

The following anomalies exist in the present data base:

- Cost accounting differences
- Catalog inconsistencies
- Variations in training methods among the three services (which need further examination)
- A lack of complete, detailed course curricula descriptions.

Where the anomalies were apparent, they were excluded from the data sample used in the calculations. For the purposes of this macroanalysis, it was concluded that the fine structure and detail in the complete course curricula would not significantly change the results.

Cost accounting varies from service to service, and, to some extent, within a given service. No adjustments were made in the data base to the total cost per graduate, and the definitions of the cost per trainee are those given by each military service. Thus, costs of equipment used in a given training course may or may not be reflected in the cost per graduate, depending on the specific service's accounting procedure. This will not degrade the computational results significantly, since the overall inferences from this study are not intended to have a specific course orientation.

Differences in military training catalogs constitute the second class of anomalies. Because of variations in interpretations of MOS (military occupational specialty), AFSC (Air Force specialty classification), and NEC (Naval enlisted classification), it is often difficult to determine when courses with similar descriptions designed to train an individual for a given specialty have enough commonality to permit their application service-wide with the aid of new I.T. This anomaly is of no concern to the cost results reported herein because all samples were specific to each service. Thus, this anomaly also impacts only the commonality aspect.

In some cases, courses may already be revised for programmed instructions, or they may include other aspects of I.T. without such effects being reflected in the catalog or in the cost and throughput data provided by the services. This implies that cost differentials projected in subsequent sections based upon 1971 data reflect, in some cases, savings estimated by the model that may have already been effected. Again, this anomaly is of little concern to the overall project, since the results are not intended to be dependent on single courses.

The third class of anomalies is due to variations in training methods. For example, in teaching mathematics, the Navy uses classical mathematical educational procedures, the Army prefers handbook techniques, and the Air Force uses a combination of both methods. These differences are not reflected in the military catalogs, and readers should be aware of this type of inconsistency in the data. Other variations in training--e.g., on-the-job training--also impact the net training budget and I.T. savings, but they are not reflected in this study, which is based only on formal technical training. These effects are discussed in Section V.

In cases where data for a given course were incomplete, the course was excluded from the data sample used in the calculation. Nontechnical courses were not included in the data base, but evidence* suggests that the yield from newly applied I.T. for these courses can also be substantial.

5. Sample Data for Calculations

The logistic problems associated with analyzing data on over 4,000 military courses are substantial. The method used in this project was to select sample courses from each of three training commands. The courses are representative of the general field of military training, as described in the formal school catalog. Courses selected represented a diversity of curricula.

Restrictive requirements affecting these selections were that the cost and manpower data base be complete for the chosen course and that a description of the course content be available. The latter requirement, though not directly related to cost, is necessary to the assessment of whether the application of I.T. will be appropriate for the given course. It allows the determination of present levels of I.T. (in some cases) and provides for determining which I.T. media would be most appropriate. With this knowledge, an estimate of the form of instructional strategies, technical equipment, and other I.T. parameters can be compared with known conclusions from experimental or prototype courses.

---

*Reports by Richard Atkinson, Donald Bitzer, Duncan Hanson, Seymour Papert, Patrick Suppes, and others. CONARC's Task Group Report on CAI recommends extension of I.T. application to nontechnical courses, as does the "Shirtsleeve" Conference. Also see "Instructional Technology in the Armed Forces," by Lt. Col. H. B. Hitchens (Ref. 23).

Courses with zero throughput were rejected from the sample used in the calculations. Courses that had an estimate for $\delta(CT)$--the fractional reduction in course time--equal to zero were also excluded since there would be no rationale for introducing I.T. in such courses.

The total number of courses actually used in the calculations was 119, drawn from each of the services as follows:

Service	No. of Courses
Air Force	30
Army	39
Navy	50
Total	119

The Navy data sample is somewhat larger than that of the Army and Air Force because the data sample from a separate manpower study (sponsored by ONR) was also used as an input to the analysis for this report.

B. Mathematical Model and Payoff Criteria

The mathematical model used considers estimated costs for developing I.T. programs; for obtaining, maintaining, and operating equipment; and for creating and distributing training materials. A single payoff criterion, a reduction in course time that yields cost and manpower savings, is the payoff function that integrates the effects of 13 critical I.T. variables.

1. Overview

The project team was concerned with developing useful models and identifying significant parameters. Of particular concern was the identification of a value function that would be quantifiable and self-converging, so that each iteration of the model would tend to improve the resolution of the benefit evaluation. From a qualitative point of view, the study team searched for models that would generate ranges of values for the given parameters and that would establish cost levels above which the application of I.T. would yield benefits.

The data analysis is not rigorous in a mathematical or statistical sense. Random samples were not selected, and the size of the sample was small compared to the total population. Course selection for the sample calculations was based instead upon completeness of data. Relevant I.T. variables were identified, and attempts were made to integrate their individual effects in a single payoff function. Given the selected payoff value (fractional reduction in course time), exemplary calculations for cost and manpower savings were performed. The benefit was quantified in terms of annual military cost and manpower savings.

The size of the sample courses selected is a minor restriction on the results of the analysis; it simply means that the data base has not been exhausted. The sample is of sufficient size to recognize trends, to identify cost differentials, to relate the effects of different types of cost factors on net cost, and to compare the results of different types of I.T. innovations as reflected by the significant variables.

Although the present study does not extend the quantitative implications of these results to the entire field of training in the military services, it provides the model and the mechanism for a more comprehensive analysis that would provide estimates of the dollar and manpower savings expected for each of the three military services. The results make it possible to determine quantitative differences in the adaptability of military training courses to I.T. and to determine where further analysis and innovation are justified and where they are not. The calculations were primarily intended to serve as background for identifying future research goals in addition to demonstrating a method to quantify potential cost and manpower savings from applied I.T.

2. <u>The Payoff Criterion</u>

A single parameter, defined as the fractional reduction in course time, and expressed symbolically as δ(CT), was selected as the basic criterion upon which to base cost and manpower savings. The cost calculations were based upon values of δ(CT) that could be achieved by the introduction of I.T. while maintaining the stated course objectives and pass/fail criteria. The calculations were based upon estimated values of δ(CT) for each course sampled. These estimated values were, in turn, determined by relating a set of 13 significant I.T. variables to each course studied. For each course studied, an optimal mixture of the I.T. variables was postulated. The model assumes a maximum value of δ(CT) of 0.5. The procedures used for estimating δ(CT) are discussed in subsequent sections.

3. <u>Significant Variables</u>

The 13 variables identified that contribute to savings in training time achieved by the application of I.T. emerged from a study of a wide range of courses to which I.T. has been applied, as well as technical training courses presently offered in the services. The list was continually modified and refined as new data were examined. Additional refinements or modified interpretations may be needed in the future to cover such situations as a second application of I.T. to a given course.

The 13 variables were divided into four general categories:

- Instructional strategies
- Course content

- Course structure
- Course conditions.

a. Instructional Strategies

The four variables related to instructional strategies are individualization, inefficiencies, immediate feedback, and evaluation. They are briefly described below.

- Individualization--Many courses are written to allow the individual student to proceed through the material at his own pace. Some courses also individualize the content of a course, e.g., additional background material may be provided for selected students, students may be given varying amounts of practice when learning a new skill, and advanced material may be provided for certain students.

- Inefficiencies--Each time a course is revised, it is likely to produce savings in course time by culling out repetitive material, by clarifying explanations that proved difficult for students, and by removing outright errors. Application of certain forms of I.T. (e.g., CBI) is exceptionally valuable when removing such inefficiencies. For example, the nature of CBI forces the curriculum designer to be explicit about the goals of the course and any performance measures involved.

- Immediate Feedback--This is defined as a prompt response to the student that gives him an assessment and evaluation of his input. When course curricula can exploit immediate feedback to benefit the student, the amount of time saved by implementing I.T. (CBI, in particular) can be significant. For most courses, immediate feedback to the student is extremely important. Its major benefit to the student is that it provides the basis for on-the-spot, ongoing self-evaluation. The choice of the type of I.T. to be used is affected by the perceived desirability of immediate feedback.

- Evaluation--Ongoing evaluation saves testing time, helps pinpoint and clarify misunderstandings that could lead to the need for remedial instruction, and shortens course time by enabling a trainee to finish the course as soon as he demonstrates the desired performance. Evaluation results can also aid the curriculum designer in course revisions.

b. Course Content

The four variables most closely associated with course content are commonality, nonverbal representation, teaching algorithm, and stability. They are described below.

- Commonality--Time savings in the preparation and revision of curricula exist if commonality can be found in one or more courses. The degrees of commonality vary greatly. For example, courses may be identical, at least in part; they may use the same teaching or instructional logic; or they may use the same equipment, such as, visual displays.
- Nonverbal Representation--Potential savings are found in the application of I.T. to largely nonverbal

courses that deal with motor, graphic, or symbol manipulation rather than linguistic manipulation. It is difficult to adapt nonverbal technical training to the traditional lecture, and much on-the-job training retains a high verbal component. Applying selected forms of I.T. to nonverbal training reinforces the desired visual/nonverbal component while allowing student participation and interaction with the teaching strategies.

- Teaching Algorithm--Some courses have sufficient logical structure and content to enable them to be expressed in algorithmic form. Such courses will facilitate the use of certain forms of I.T., such as CBI.

- Stability--A course is defined as stable if it is relatively immune to changes in its basic curriculum and structure. Courses with low stability are usually more easily changed in an I.T. than a traditional setting. Well-designed, modular CBI courses can be easily revised to reflect modified goals or a change in the instructor's viewpoint, and such revisions are less costly than those for traditional courses. The distribution of revisions can be facilitated by mailing cassette tapes or by using a computer network.

c. Course Structures

Three types of training course structures are simulation, problem solving, and on-the-job training:

- Simulation--Simulation approaches may involve a wide variety of media, and they may be designed for use by an individual or a group or both. For example, the trainee pilot can practice landing in a safe situation, without the possible loss of valuable equipment. Strategies can be examined through the use of simulated war games. Weapons can be tested in a variety of hypothetical situations before field use. Computers are being used to "stimulate" equipment to perform in an unlikely fashion so that trainees can practice troubleshooting using simulated malfunctions. Computers are well adapted to simulation techniques because programmed situations can be easily duplicated, updated, and calibrated.

- Problem Solving--Certain courses deal with the acquisition of problem-solving skills rather than the acquisition of factual information. I.T. in the form of CBI offers several advantages over traditional approaches to problem solving. The computer's problem-solving capabilities can serve the student on an ongoing basis, and the computer can be used to generate problems suitable for each student. Most CBI courses involving problem solving show significant time savings over courses using a traditional classroom approach, primarily because of the ability of CBI to analyze portions of the problem-solving processes.

- On-the-Job Training--The amount of on-the-job training (OJT) that is desirable in a course affects possible savings in course time. OJT is closely related to simulation, insofar as simulation may be viewed as an attempt to replicate an OJT situation. Some OJT procedures strongly interact with a number of other variables, such as individualization.

d. Course Conditions

The final two variables--proximity and heterogeneity--are best described in relation to course conditions.

- Proximity--Proximity is defined as the proportion of a course that meets in the classroom rather than on the training field. Proximity influences (1) the amount of time saved through the application of I.T. and (2) what type of I.T., if any, would be most useful.

- Heterogeneity--In a traditional classroom, an instructor usually finds it extremely difficult to provide relevant instruction for a class whose preparation and abilities vary widely. In most well-developed I.T. courses, the trainee has the total attention of the "instructor" in a course geared to his individual needs.

e. Interrelationships Among the Variables

Table 3 indicates some perceived areas of interaction among the variables. Most such interrelationships are highly complex and course-dependent. For example, individualization will usually save course time, but if a course already uses extensive methods of self-paced instruction, further possible savings through the use of CAI may be marginal. However, if the self-paced course yields immediate

Table 3

INTERRELATIONSHIPS AMONG THE VARIABLES

	Teaching Strategies				Course Content				Course Structure			Course Conditions	
	Individualization	Inefficiencies	Immediate Feedback	Evaluation	Commonality	Nonverbal Representation	Teaching Algorithm	Stability	Simulation	Problem Solving	On-the-Job Training	Proximity	Heterogeneity
Teaching strategies													
Individualization		X	X			X			X	X	X		X
Inefficiencies											X		X
Immediate feedback				X						X			
Evaluation										X	X		X
Course content													
Commonality								X					
Nonverbal representation													
Teaching algorithm									X	X			
Stability													X
Course structure													
Simulation										X	X		
Problem solving											X		
On-the-job training												X	
Course conditions													
Proximity													
Heterogeneity													

feedback, adding both individualization and feedback may create additional time savings.

The interaction between OJT and simulation is similarly complex, and the decision to use one or the other depends on the specific goals of a given course. Stability and commonality also interact; suppose two courses have identical content, but one is highly stable and one is unstable. The stability factor strongly influences any interpretation of commonality.

4. Estimation of δ(CT)

During this research, the 13 variables served as a checklist in the judgmental assignment of adaptability of a given course to further applications of I.T.

Ranges for δ(CT) from actual experimental results demonstrate course time savings of 20 to 70 percent. The average is approximately 40 percent. Examples of δ(CT) from the literature served to relate the course under study to a set of calibration data.* In each case, a best mix of I.T. strategies was postulated for estimating the reduced time in training expected for a trainee to reach a level of achievement identical to that before the new technology was applied.

Fifty percent or more of advanced technical training in the military services is OJT, for which no curricula descriptions are available. Therefore, savings derived from estimates of δ(CT) (based only on existing written curricula) are lower than the total savings expected if the proposed applications of I.T. were implemented both for formal schooling and OJT courses.

---

*Representative experimental values of δ(CT) used as calibration data in this study are described in Appendix D.

Ranges of values were established for δ(CT). They are commensurate with the resolution of the input data. They permit the classification of a known course description into a category of adaptability to I.T. Although the use of wide ranges for δ(CT) at the microlevel or course level could benefit from greater quantitative precision, at macrolevel (estimating total savings in dollars and manpower for the DoD), it was not found necessary. Table 4 lists each category for δ(CT) in Roman numerals, the corresponding range of values, and the actual values used in the calculations.

Categories of δ(CT) for each course analyzed were determined by first estimating an appropriate value of δ(CT). If, for a specific course, a value of 0.32 was selected, the I.T. Adaptability Category would be III and the actual value used in the calculation would be 0.3.

Table 4

CATEGORIES OF δ(CT)

I.T. Adaptability Category	Range of Values	Value Used in Calculation
I	0.00 - 0.15	0.1
II	0.15 - 0.25	0.2
III	0.25 - 0.35	0.3
IV	0.35 - 0.45	0.4
V	0.45 - 1.0	0.5 (maximum)

Analytic formulation of the 13 variables relating to δ (CT) is premature now. However, the thought behind each estimation of δ(CT) as it relates to each of the 13 variables can be exemplified in some detail, as shown in the two examples discussed below.

a. Example 1

Perhaps one of the best-known series of military CAI experiments is the one conducted in the late 1960s and early 1970s by the Naval Personnel and Training Research Laboratory at the Basic Electricity/Electronics "P" School in San Diego.[11,12,22] As an example of the SRI approach used to estimate δ(CT), consider the inductance module of the curriculum, discussed by Hurlock.[12]

Prior to applying CAI to the course, the module on inductance comprised 17 hours of instruction, consisting "primarily of lectures, question and answer discussion periods, drill and practice sessions, assignment sheets, demonstrations, and short laboratory exercises."[12] Presentation of the course content was appropriate for introducing the student with little background to standard concepts involved in inductance. The following evaluation relates the module to the 13 variables:

- Teaching strategies
  - Individualization is seen as very important in such a course, where there is likely to be a great diversity of ability and interests.
  - Inefficiencies in such a course are likely to be high, since lectures and verbal discussions are relied upon to teach many concepts having a high nonverbal component.
  - Immediate feedback is applicable in several important areas in this course, mainly recognition and definition of terms and problem solving.

- Evaluation is particularly useful in such a course, when detailed information can further individualize the course and prevent the need for remediation.

- Course content

  - Commonality of a topic, such as inductance, is high. It is found in a number of specialities in all three services.

  - Nonverbal Representation is common in this subject area, since much of the content is easily presented in diagrams or symbolic form.

  - Teaching algorithms are standard conventions for teaching basic electronics theory.

  - Stability of such a course is high, since few changes in content, goals, or equipment occur.

- Course structure

  - Simulation is easily and usefully done using "real" laboratory equipment that is both inexpensive and easily managed.

  - Problem solving is a very important part of the course, since it is a major route to a good grasp of the subject.

  - OJT is low for such an introductory course in electronics. However, the use of "real" equipment in a sense partially simulates OJT.

- Course conditions

  - Proximity to the classroom is high for such a course. No field experience is needed at such an elementary level.

  - Heterogeneity is probably high. Students can be expected to vary widely in background, ability, and interests.

The above considerations lead to the conclusion that the application of I.T. to this course--in a form that promotes individualization, immediate feedback, simulation, problem solving, and ongoing evaluation--would result in significant savings in course time. Thus, the estimated value of $\delta(CT)$ is 0.5 (Category V). This value of $\delta(CT)$ corresponds well with the experimental results of 48.5% reduction in course time as reported by Hurlock[12] in 1971.

b. Example 2

The second example is the Navy's current Basic Electricity and Electronics Course, identified as Course A-100-0010. This course was developed as a result of such I.T. experiments as Hurlock[12] applied to the inductance module. This course already incorporates an individualized learning system. It is assumed that a second application of I.T. to the course will result in lower time savings than the original application.

The inductance module discussed in Example 1 is a subset of Course A-100-0010, and the majority of considerations regarding the relationship between the course and the $\delta(CT)$ variables remain the same. However, those relating to individualization, inefficiencies, and immediate feedback are somewhat different. In particular, the individualization variable contributes less to time savings, since the course has already been adapted to meet an individual's needs. Some additional individualization is assumed to be possible, however, because of new technology and/or research results on instructional strategies. Similarly, since I.T. has been applied to the course, it is assumed that inefficiencies have been greatly reduced in the course. Immediate feedback remains an important factor in the course to enhance the student's control over his rate of progress in this highly individualized course.

These considerations led to an estimate of $\delta(CT)$ as 0.1 (Category I) for this individualized basic electricity and electronics course.

C. Cost and Manpower Savings Calculations

1. Variables and Parameters

Cost and manpower savings for the sample courses were calculated using the estimated $\delta(CT)$s as independent variables. Other significant variables, their mathematical representation, and their source, are indicated in Table 5.

Table 5

VARIABLES USED IN THE CALCULATIONS

Variable Description	Symbol	Units	Source
Fractional reduction in course time	$\delta(CT)$	None	Estimated
Throughput	T_p	Graduates per year	Data base
Course time	t	Weeks	Data base
Cost per graduate	C_G	Dollars per graduate	Data base

The model also assumed two additional parameters: (1) equipment costs, represented symbolically as C_E and expressed in terms of dollars per terminal hour, and (2) courseware costs, represented as C_C and expressed in dollars per courseware hour. Both C_C and C_E are represented in the mathematical model in terms of amortized annual costs. This is consistent with common practice with respect to C_E; however, it may be confusing with respect to courseware costs. The following example should clarify the terms.

Assume, for example, that the total cost incurred in preparing one hour of I.T. courseware material is \$2000. Assume further that this material must be completely replaced in five years and that it has no residual value. Amortizing this cost over five years yields an annual courseware cost of \$400 (\$2000/5) per hour. The mathematical model uses the amortized annual cost, \$400 per hour, rather than the total cost of \$2000 per hour, and the results are calculated on an annual basis.

In estimating total I.T. costs for each course, it was necessary to estimate the on-line factor, O_T, the proportion of course time during which equipment and courseware would be in use. For courses with a large involvement of I.T. and a large estimated $\delta(CT)$, there is a relatively heavy use of equipment and courseware, and O_T would be large. On the other hand, where I.T. is of little use, both $\delta(CT)$ and O_T would be low. For this study, O_T and $\delta(CT)$ were assumed to be linearly related:

$$O_T = \delta(CT) + 0.25 \quad .$$

O_T is a fractional, dimensionless term. This formula allows O_T to range from a minimum of 0.25 when the addition of I.T. has very little benefit, to 0.75 which corresponds to the upper limit of I.T. that is considered to be desirable. Refer to Table 4 and its associated discussion, where the range of $\delta(CT)$ is presented.

O_T has a major impact on the calculation of the cost of implementing I.T. in a course because it determines both the number of class hours that are devoted to equipment and the required number of lecture hours that must be converted to courseware hours. This is discussed in greater detail below.

2. <u>Equations</u>

The four principal equations are those for:

- Total cost.
- Cost of implementing I.T., as measured in equipment and courseware.
- Cost savings.
- Manpower savings.

The <u>annual total cost</u>, C_T, is determined by multiplying the throughput T_P (number of graduates) by the cost per graduate C_G, i.e.,

$$C_T = T_P \times C_G \quad . \tag{1}$$

The <u>annual cost of implementing I.T.</u>, C_{IMP}, is a function of equipment costs, course time, courseware costs, on-line factor, and throughput:

$$C_{IMP} = 40 \times t \times \left[1 - \delta\,(CT)\right] \times O_T \left(C_E \times T_P + C_C\right) \quad . \tag{2}$$

In Eq. (2) the first three factors represent total hours per year devoted to I.T. training, and the expression in parentheses represents the annual cost per hour of I.T. equipment and courseware. A machine loading of one trainee per terminal is assumed. A dimensional analysis may help clarify the equation:

$$C_{IMP} = \frac{\text{hours}}{\text{week}} \times \text{weeks} \times \left(\frac{\text{equipment cost}}{\text{terminal-hour}} \times \text{annual terminal loading}\right.$$

$$\left. + \frac{\text{annual courseware cost}}{\text{hour}}\right) \quad . \tag{2a}$$

This reduces to:

$$C_{IMP} = \text{total classroom hours} \times \left(\frac{\text{annual equipment cost}}{\text{hour}}\right.$$

$$\left. + \frac{\text{annual courseware cost}}{\text{hour}}\right) \quad . \tag{2b}$$

The <u>annual cost savings</u>, S_C, are determined by applying the fractional reduction $\delta(CT)$ to total costs and then subtracting the cost of implementing I.T., i.e.,

$$S_C = \delta(CT) \times C_T - C_{IMP} \quad . \tag{3}$$

The <u>annual manpower savings</u>, S_M, are determined by applying the fractional reduction in course time, $\delta(CT)$, to course throughput:

$$S_M = 1.1 \times T_P \times \delta(CT) \times t/52 \quad . \tag{4}$$

The coefficient 1.1 used in Eq. (4) reflects estimated instructor manpower savings and assumes an instructor-to-trainee ratio of 1:10.*

3. Parameters and Variations

To determine the sensitivity of the results to the variables in the savings model, three parameters were varied: $\delta(CT)$, equipment costs, and courseware costs. Each was varied discretely over a range, as

---

*SRI estimate.

summarized in Table 6. The effects of varying δ(CT) are shown in Figures 3, 4, and 5. The effects of varying C_E and C_C with savings delineated in both value ($) and real (manpower) terms are shown in Figures 6, 7, and 8.

Table 6

PARAMETER VARIATION VALUES

Parameter	Range
Equipment costs (I.T. Delivery Cost/Hour)	$0.50-$4.00 per terminal hour
Total courseware production costs	$0-$10,000 per course hour*
δ(CT)	Estimated value of δ(CT), δ(CT)-0.1, δ(CT)-0.2

*Corresponds to annual courseware production costs of 0-$2,000 based upon a five-year amortization.

In the selection of the range of equipment costs, the cost of computer hardware was assumed to be larger than that of any other type of I.T. equipment. Thus, the selected equipment cost range reflects CBI hardware costs. For courses that use other types of I.T. hardware (e.g., audio-visual devices), the calculations are somewhat conservative.

In the assignment of categories of δ(CT), a 1:1 ratio of students per terminal was assumed, using alphanumeric terminals. This assumption impacts only on equipment costs. As shown below, savings that can be realized through the use of I.T. are less sensitive to hardware costs than other parameters.

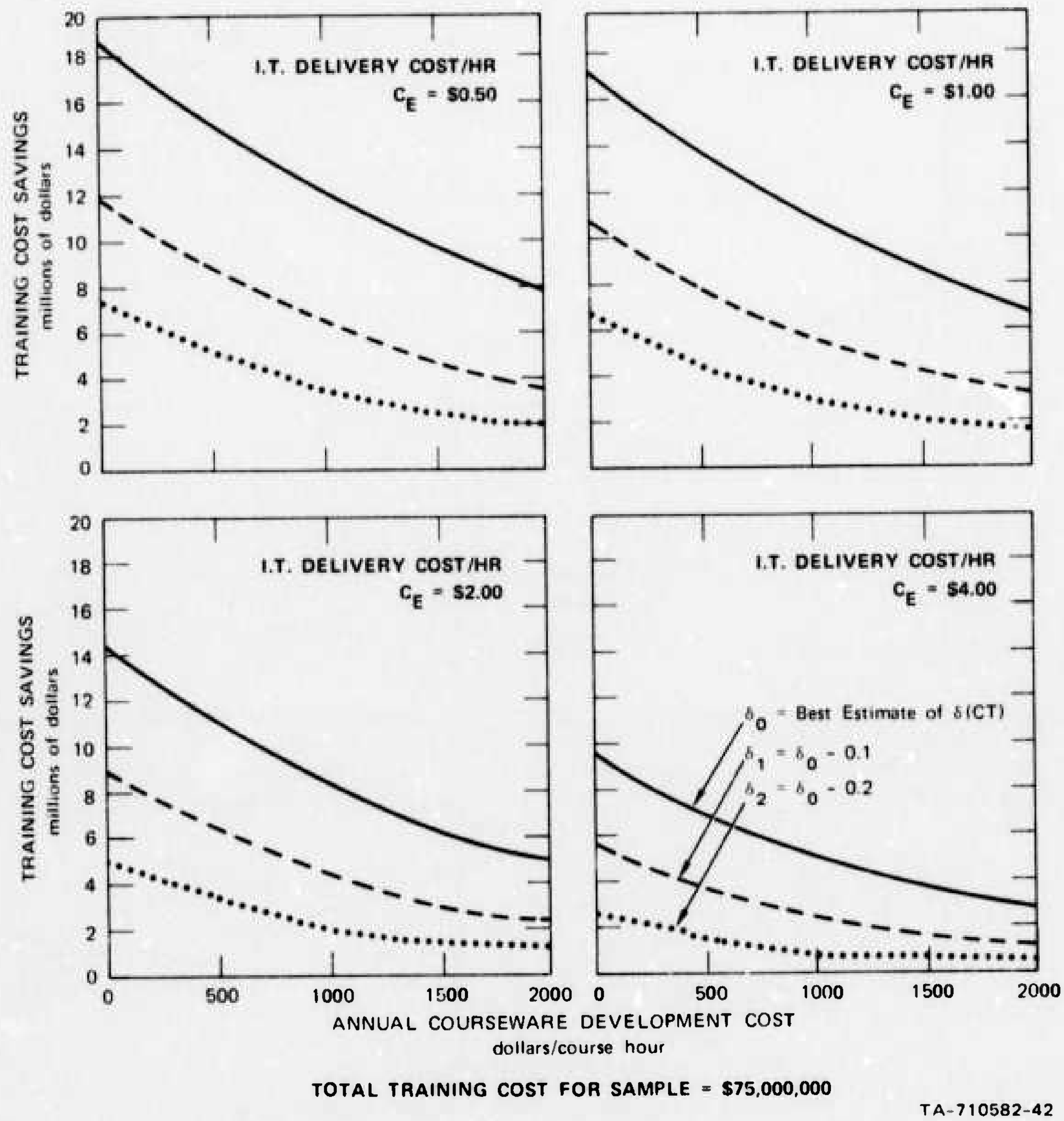


FIGURE 3 EFFECTS ON DOLLAR SAVINGS (TRAINING COSTS) FOR SAMPLED U.S. ARMY TRAINING COURSES FROM VARYING THE VALUE OF δ(CT) FOR 4 I.T. DELIVERY COSTS (C_E)

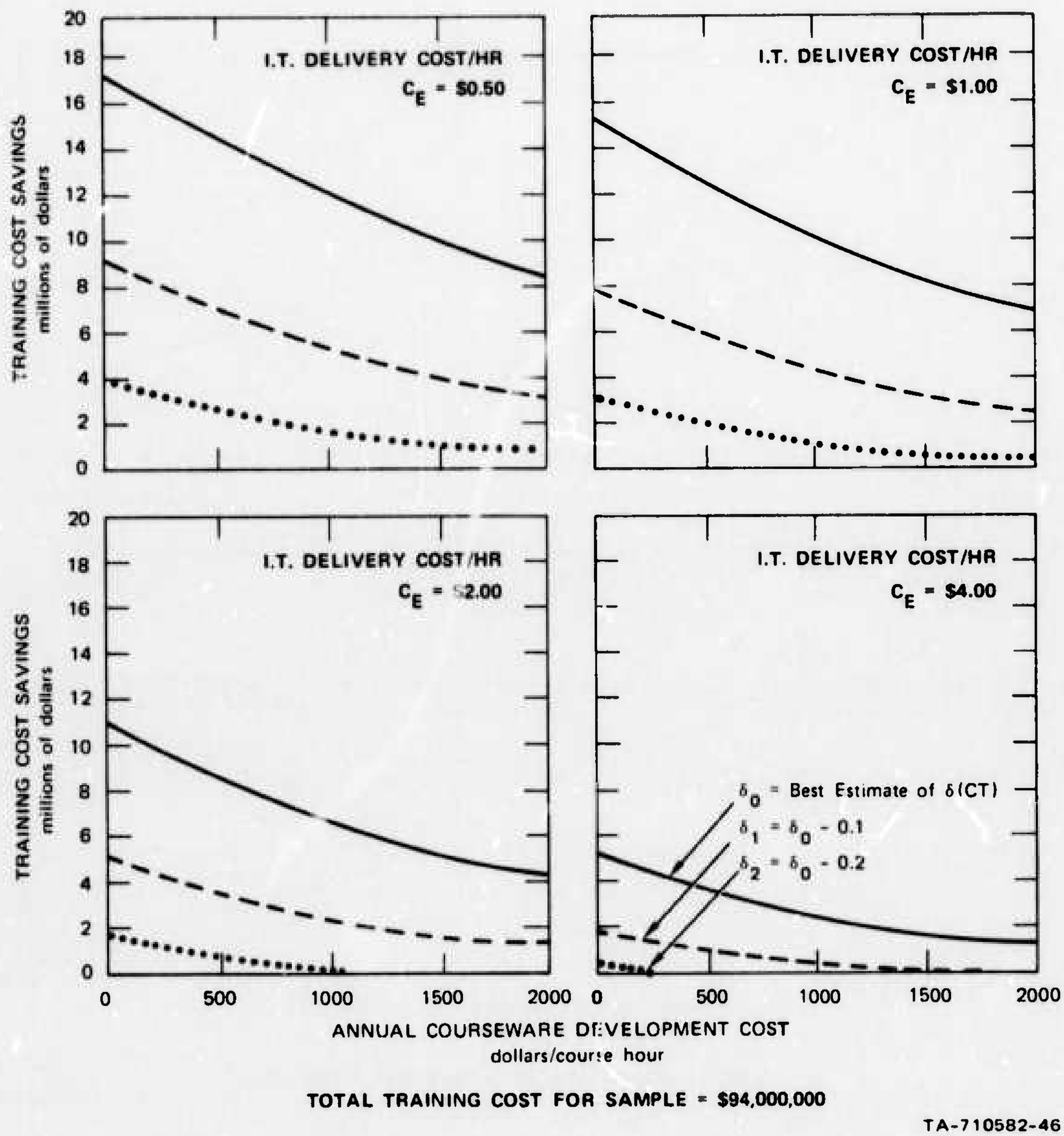


FIGURE 4 EFFECTS ON DOLLAR SAVINGS (TRAINING COSTS) FOR SAMPLED U.S. AIR FORCE TRAINING COURSES FROM VARYING THE VALUE OF δ(CT) FOR 4 I.T. DELIVERY COSTS (C_E)

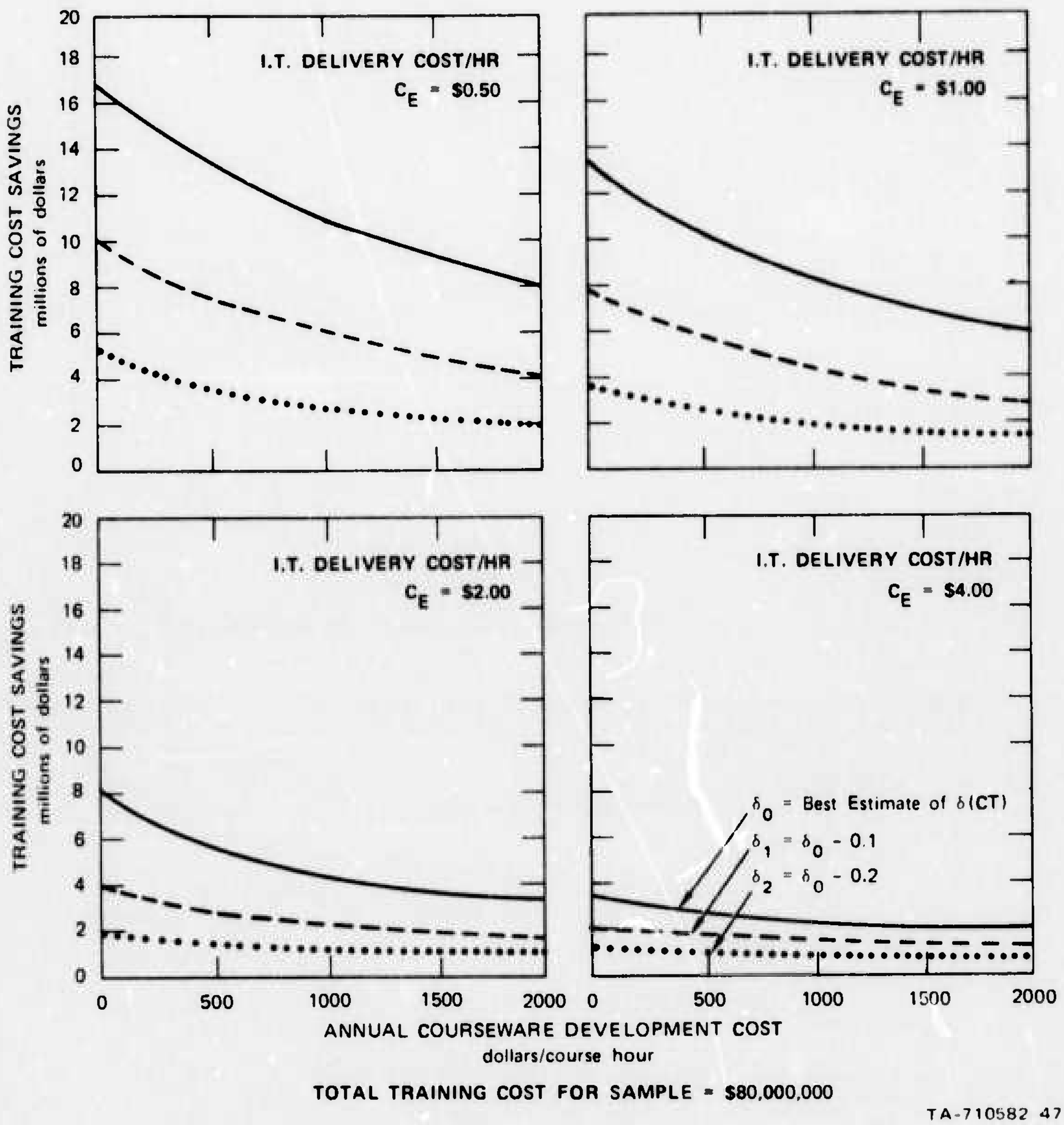


FIGURE 5 EFFECTS ON DOLLAR SAVINGS (TRAINING COSTS) FOR SAMPLED U.S. NAVY TRAINING COURSES FROM VARYING THE VALUE OF δ(CT) FOR 4 I.T. DELIVERY COSTS (C_E)

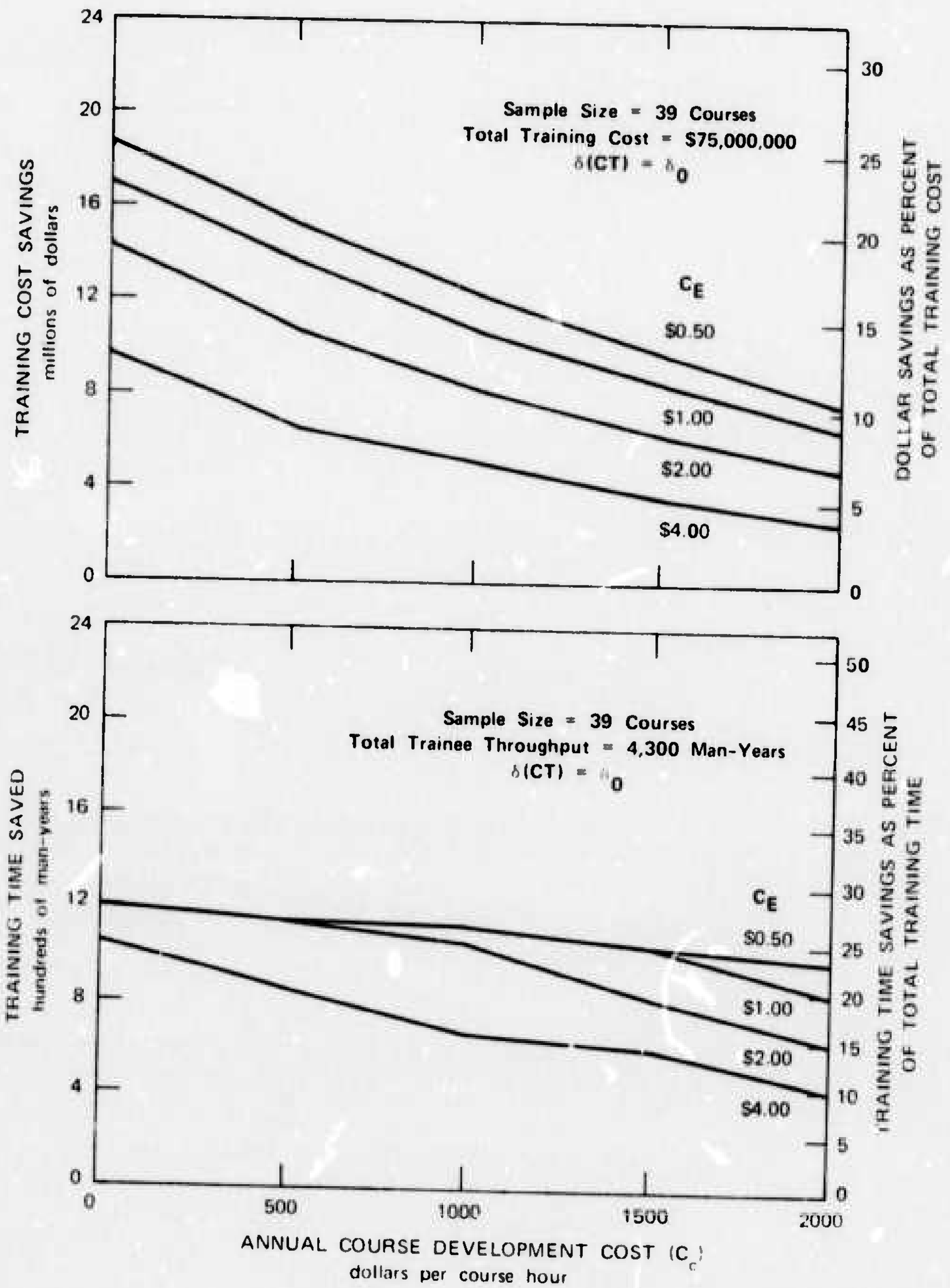


FIGURE 6 EFFECTS ON DOLLAR AND MANPOWER SAVINGS FOR SAMPLED U.S. ARMY TRAINING COURSES FROM VARYING I.T. DELIVERY COST (C_E) AND COURSE DEVELOPMENT COST (C_c) FOR CONSTANT $\delta(CT)$

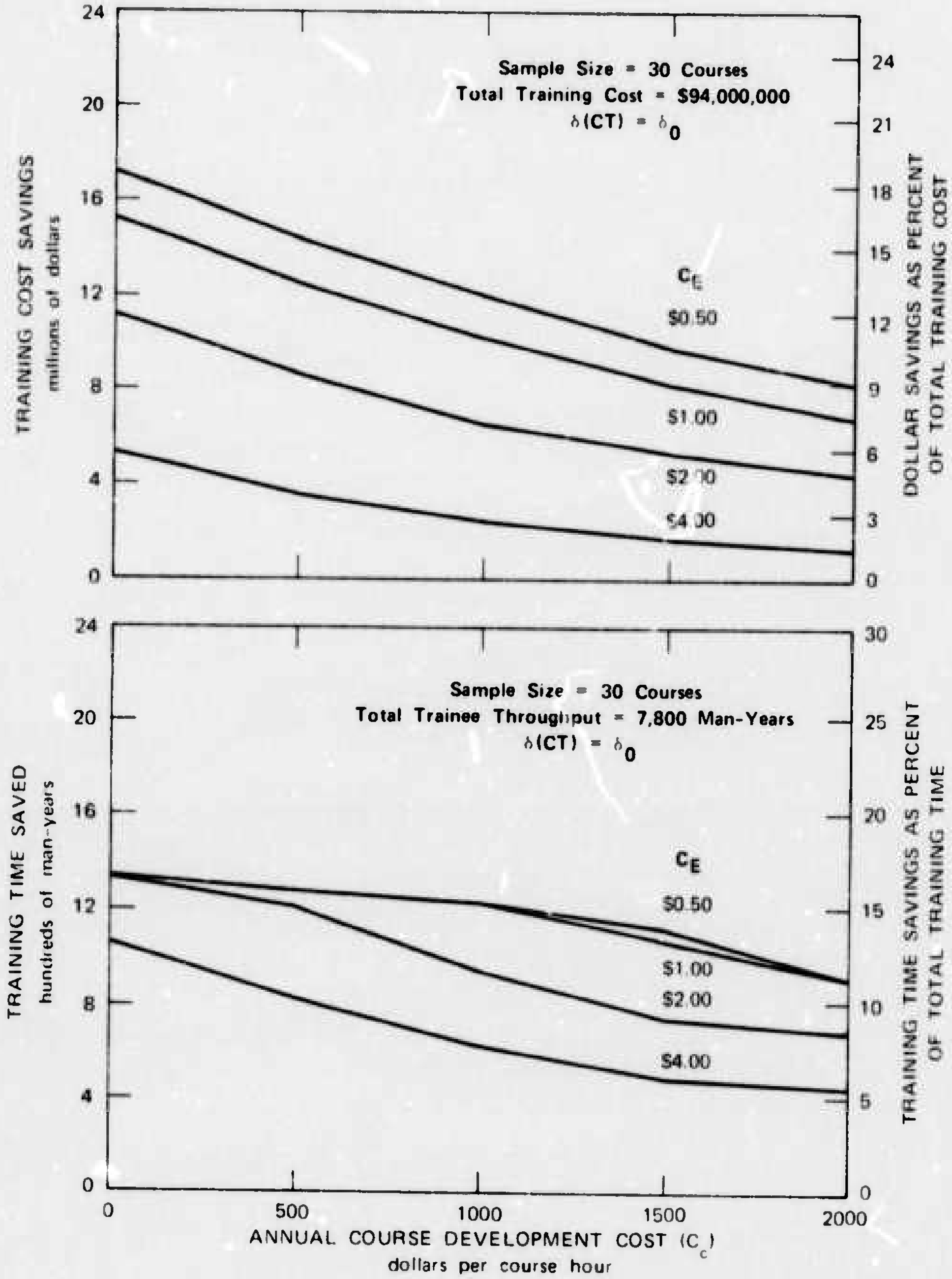


FIGURE 7 EFFECTS ON DOLLAR AND MANPOWER SAVINGS FOR SAMPLED U.S. AIR FORCE TRAINING COURSES FROM VARYING I.T. DELIVERY COST (C_E) AND COURSE DEVELOPMENT COST (C_c) FOR CONSTANT δ(CT)

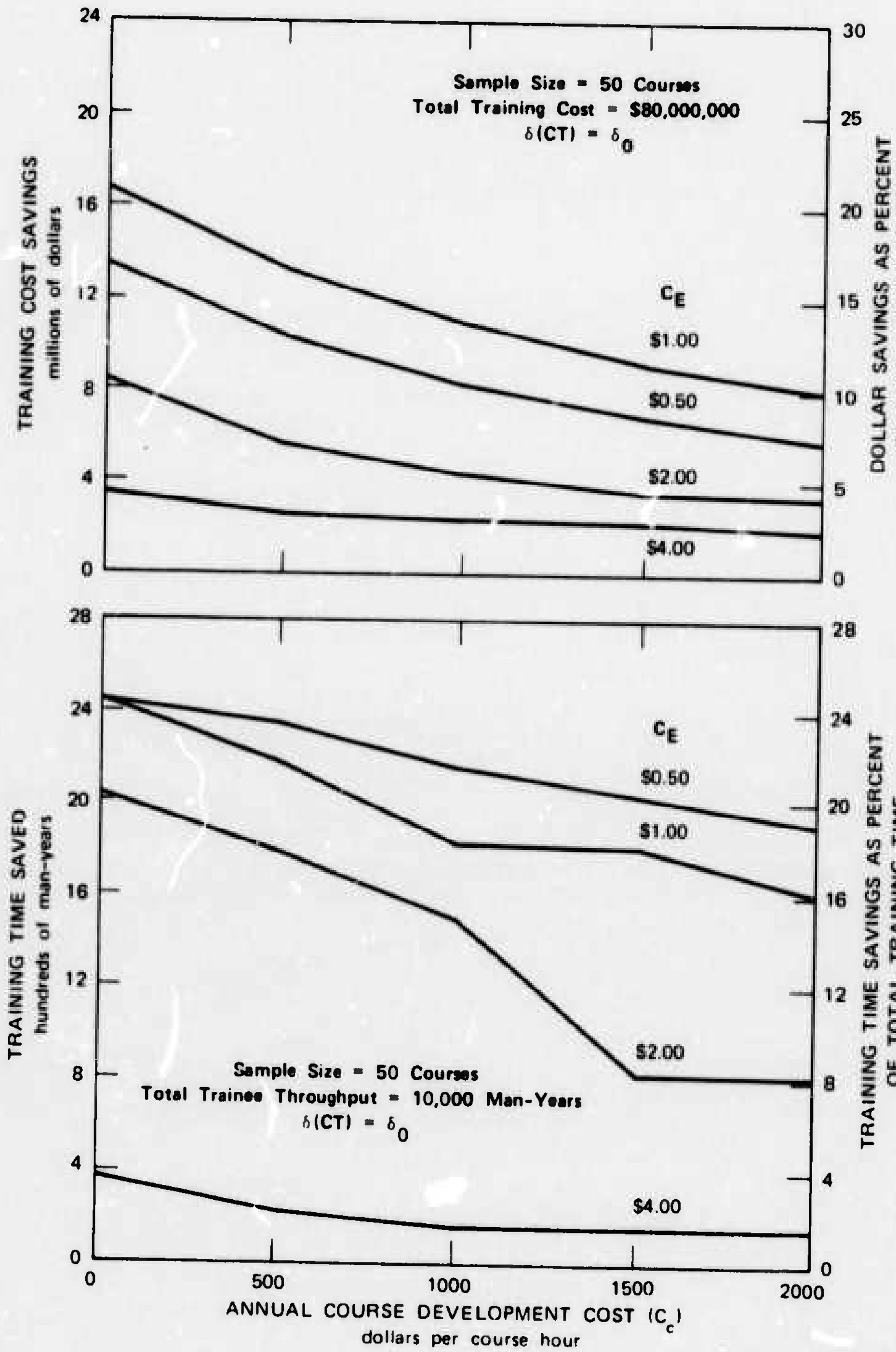


FIGURE 8 EFFECTS ON DOLLAR AND MANPOWER SAVINGS FOR SAMPLED U.S. NAVY TRAINING COURSES FROM VARYING I.T. DELIVERY COST (C_E) AND COURSE DEVELOPMENT COST (C_c) FOR CONSTANT $\delta(CT)$

A systematic shift in the values of $\delta(CT)$, which can be considered a major variation in learning strategy, produces considerable variation in the behavior of the savings curves. Figures 3, 4, and 5 display these effects on savings as $\delta(CT)$ is systematically decremented first by one and then by two categories, referred to symbolically as δ_1 and δ_2, respectively. The δ_0 value represents the best estimate of all the $\delta(CT)$'s. Under δ_1 conditions, all courses in Category V would be reduced to Category IV; Category III courses would be classified as Category II, and so on. In the δ_2 curves, all courses that were Category V would be reduced to Category III; courses in Category IV to Category II, and so on. The solid-line curves show the results based upon estimated values of $\delta(CT)$ and fixed hardware costs of $0.50, $1.00, $2.00, and $4.00 per terminal hour. The dashed and dotted curves reflect savings based upon the decremented values of $\delta(CT)$ and the same hardware cost ranges.

The variations in $\delta(CT)$ yield tremendous variations in savings. As an example, consider the case of the Air Force sample (Figure 4). For a hardware cost of $0.50 per terminal hour and a total courseware cost of $2500 per course hour, the savings increase from $2.5 million to $14.4 million when δ_2 is changed to δ_0. This is an increase of more than 500 percent. This reflects the considerable impact of learning strategies--the major components of $\delta(CT)$--on savings.

The estimated annual dollar and manpower savings for the sample sets of courses selected from each military service are summarized in dollars, in training time saved, and in percentages of the total manpower and the total training cost. The results, taken from the computer runs, are shown graphically in Figures 6, 7, and 8. For example, the upper graph in Figure 6 shows total annual dollar savings for the 39 sampled Army courses. Each curve represents a different assumption for hardware cost. The abscissas common to both sets of curves show annual course development cost (C_C). Savings in millions of dollars and in hundreds of man-years can be read directly from the left hand vertical axis. On the right hand vertical axis the savings may be read directly in terms of percent of training time or cost saved.

Assuming hardware costs of $1.00 per terminal hour and $2500 total cost per course development hour, the savings amount to $13.6 million, or 18 percent of present costs, for the sampled Army courses. There are, of course, some additional questions, not addressed in this study, as to how these savings would be actually realized.

To realize these savings, it would be necessary for the services to institute immediate reassignment of graduated personnel to productive jobs. There is also the possibility of giving such personnel additional training. Such questions impact on military policy and cannot be discussed here. Thus, these estimated savings should be viewed as potential increases in "effectiveness."

In computing the totals shown by the curves, savings for each course that yielded negative savings through the introduction of I.T. were set to zero. Negative savings imply that the cost of implementing I.T. exceeds the projected savings, and there would be no rationale for making such changes.

The following considerations determined the range of hardware costs. A PDP-11, NOVA, or Hewlett-Packard minicomputer system with 20 Teletype terminals costs approximately $50,000. Amortization over five years* and use of 2000 hours per terminal yields a cost of $0.25

---

*Both hardware and courseware costs were amortized over five years to an assumed salvage value for equipment and courseware of zero; i.e., it is assumed that both hardware and courseware must be completely replaced every five years.

per terminal hour. Assuming maintenance costs of one percent per month and capital costs of 5 percent, the present cost per terminal hour approaches $0.50. In comparison, a Datapoint 2200 stand-alone system with alphanumeric display, tape cassettes, and 8K (byte) memory costs $8,000. Assuming the same usage and amortization, this system has a hardware cost of $0.80 per terminal hour. Generally, costs of large scale systems and commercially available services range from $0.40 to $1.60 per terminal hour, including software and maintenance. Public schools in the San Francisco Bay Area are presently obtaining CBI services for $250 per month for unlimited usage, including maintenance, one Teletype rental, and local communications charges. This corresponds to a cost of $1.40 per terminal hour. These costs cover the range of presently quoted prices--or exceed those prices--for nearly all I.T.-CBI systems under consideration. An extended range of representative hardware costs per terminal hour were used in this study: 0.50, $1.00, $2.00, and $4.00. The lower figure reflects the assumption that hardware costs are expected to decrease.

In addition, the following values of total courseware costs per hour were used in the study to determine their effect on I.T. savings: 0, $2500, $5000, $7500, and $10,000. The corresponding amortized annual costs were 0, $500, $1000, $1500, and $2000, respectively. A total cost of $2500/course hour corresponds to 200 hours of authoring time at the rate of $12.50 per hour.

The graphs in Figures 3 through 8 were compiled from the larger set of course-by-course detailed results shown in the printouts presented in Appendix C. The printouts display typical profiles of dollar and manpower savings, which can be used as standards of comparison for other courses of interest.

Figure 9 is an illustrative example of the printouts contained in Appendix C. The column headings are:

Abbreviation	Explanation
TP	Throughput (graduates per year)
CT	Course time (weeks)
$TOT	Total cost (dollars per year)
CAT	Estimated category of δ(CT)--see Table 5, page 48
$COMP	Cost of computerizing (equipment)
$SAV	Total dollar savings per year
MANSAV	Total man-years saved per year
REF	Reference number for identifying source documentation--see Appendix C

TP	CT	STOT	CAT	%COMP	ESAV	%ANSAV	REF
158.	15	2126048.	IV	198120.	652299.	70.	B 078
78.	28	1608960.	V	359520.	444933.	43.	B 088
113.	12	1148645.	IV	144456.	315002.	50.	B 092
154.	37	4016936.	IV	484848.	1121926.	65.	B 096
110.	4	314161.	III	42480.	53768.	36.	B 098
1105.	9	5111730.	V	392856.	2163015.	608.	C 028
111.	12	938505.	II	99576.	83125.	24.	C 030
422.	6	1624820.	I	64666.	95802.	46.	C 036
76.	16	1222280.	IV	177215.	311616.	33.	D 064
2632.	8	11688712.	I	333984.	834837.	290.	D 092
449.	5	969842.	V	119852.	365070.	247.	D 098
1021.	4	1191537.	I	76776.	42375.	112.	F 010
467.	10	1873137.	I	114380.	72934.	51.	G 040
127.	12	758698.	II	103732.	45728.	28.	G 042
63.	8	261891.	II	59472.	-7094.	14.	K 066
32.	20	372864.	V	229200.	-42768.	18.	K 074
162.	19	1379754.	II	175104.	103847.	36.	K 090
97.	9	515361.	III	56556.	66102.	32.	L 054
152.	10	589152.	I	76284.	-11365.	17.	L 058
172.	10	638808.	I	73064.	-9199.	19.	L 064
134.	11	569634.	I	74536.	-17573.	15.	L 070
9.	15	52833.	I	75390.	-73110.	1.	L 084
3263.	7	7139444.	I	354274.	359874.	359.	L 090
1737.	3	1745685.	I	87654.	86914.	191.	L 092
121.	5	436205.	III	51510.	79052.	42.	L 094

FIGURE 9 ILLUSTRATIVE SAMPLE PRINTOUT

V MAJOR FINDINGS

The impact of I.T. on DoD activities can be inferred from the results presented in Section IV. The results suggest that if innovations in I.T. are implemented in the military services, the DoD will benefit from reduced total training costs. This section discusses the major findings of this research program. Discussion of the findings responds directly to the categories (1) and (2) of the research objectives discussed in Section III. Recommendations, category (3), are discussed in Section VI.

A. Measurement of Benefits

Present experimental data on training innovations relates to the DoD training picture as a whole through a quantifiable parameter defined as δ(CT). Because most experiments are reported in terms of reductions in time to meet course objectives, δ(CT) was selected as the central parameter for the calculations. The cost calculations can be considered as a simple extension from estimated δ(CT)s to cost and manpower savings.

Each military service minimizes training costs within the constraints of military readiness, availability of resources, and the levels of competence required to carry out explicit tasks. Within budget and resources limitations, tradeoffs are made that give due consideration to all of the variables. When new policies are adopted, when research programs are undertaken, or when training innovations are made, the cost model permits rapid reassessment of the implications.

The total cost variations shown in Figures 3 through 8 have considerable sensitivity to δ(CT) but less sensitivity to variations in hardware and courseware costs. Although hardware and courseware cost variations have a large relative effect, this effect is dominated by the effect of δ(CT) variations. For the Army sample, an increase in the total development cost from \$2500 to \$5000 per course hour (holding delivery cost at \$2.00 per terminal-hour and δ(CT) at δ_0) reduces the cost

Preceding page blank

saving by 24 percent. A decrease in delivery cost from $2.00 to $1.00 per terminal-hour (at constant $2500 per course hour and δ_0) increases the cost saving by 25 percent. A decrease in δ(CT) by 0.1 from δ_0 to δ_1 (at $2500 per course hour and $2.00 per terminal-hour) decreases the cost saving by 43 percent. A change from δ_0 to δ_2 (at $2500 per course hour and $2.00 per terminal-hour) decreases the cost saving by 70 percent. Similar tradeoffs hold for the Navy and Air Force samples. Thus changes in δ(CT) have strong effects on cost and manpower savings, whereas the cost of hardware and courseware have a lesser effect.

The results suggest that considerable cost and manpower savings can be realized by introducing I.T. and that these savings are, to some extent, independent of equipment and courseware costs. Economies of scale are not necessary to achieve cost and manpower savings. The most influential variable is training strategy. Thus, proposed I.T. systems should be analyzed on the basis of their instructional methods; less emphasis should be placed on their equipment or courseware costs.

This principal relationship of savings to δ(CT) depends on large values of δ(CT) that ield large reductions in training time and corresponding large reductions in expenditures in student salaries while in training. Since salaries are major training costs, these results are not surprising.

A quick scan of Figure 9, for example, demonstrates that despite variations in δ(CT), the "CAT" variable, there are courses in the area of technical training where it is well worthwhile to introduce I.T. In other cases, the net savings are negative, indicating that the cost of adopting I.T. exceeds the projected benefits. Several factors may be responsible for the negative savings: low throughput, low conventional training costs, or the inappropriateness of I.T. for that particular course.

There are several reasons why I.T. can be expected to yield greater benefits than those presented. This project investigated only technical courses. Enough evidence has been accumulated to indicate that the introduction of I.T. in nontechnical courses would offer benefits of similar magnitude. Also, overseas and other commands were not covered, and OJT courses were excluded. In the case of the Army, only CONARC data were used.*

The Army, as well as the Navy, and Air Force, does not explicitly account for all training costs, in particular OJT. For example, after basic training, the trainee in CONARC takes either OJT or advanced technical training to qualify in a more advanced military occupational specialty (MOS). The technical training courses for the advanced, technical MOSs vary in length from 5 to 35 weeks and are given at a number of different schools. Although advanced individualized training, support training, and advanced technical courses all have formal schools courses associated with them, the trainee may bypass them and gain his MOS through OJT. No method presently exists to separate the portion of a soldier's time that involves learning a skill from the portion spent qualifying for an MOS while attached to an operational unit. With the application of new I.T. within the operational units (general purpose and strategic forces), potential savings would be gained not only from formal training courses (those for which statistical savings can be calculated), but also from many OJT courses as well. This would increase any savings calculated on the basis of available cost statistics, which focus only on the costs of formal training courses and thus underestimate the actual amount of training required to reach a given MOS.

The Navy course called "Basic Electricity and Electronics," discussed in Section IV, is another example of how I.T. benefits can be easily underestimated. The I.T. used in this course is self-paced learning, and the catalog reflects a possible completion time of one to eight weeks.

---

*The Army has recognized the usefulness of I.T. in training other than that conducted in formal schools. It is now experimenting with the use of audiovisual divices in selected Army divisions in CONUS and Europe. Courses are being redesigned along the lines described by the Board of Dynamic Training.[27]

The stated average completion time was four weeks at San Diego and six weeks at Great Lakes. The Navy has found that the introduction of I.T. is an iterative process in which further reductions in course time occur as new I.T. techniques are implemented. Thus, the course time averages may still have the potential for further reduction.

B. Commonality

The services already share a portion of their training activities. Some specialty courses taught by one service are given to trainees from other branches. This is particularly true where machinery, such as aviation equipment, is common to the services. In other cases, courses involving similar training areas are taught separately because of the different objectives of each service. Increased commonality would have the advantages listed below.

- By jointly sponsoring I.T. research, the services could reduce their individual costs and gain the benefits of multisponsored research.
- By sharing operating experiences in I.T., the services could reduce the redundancy of potential errors made in introducing new I.T.
- By pooling their training, the services could achieve:
  - Increased teacher proficiency.
  - Reductions in the number of schools.
  - Simplified development and revision of curricula and exchange of courseware modules.
  - Centralized logistic and scheduling controls.
- By working together in common areas, the services could improve the standardization of languages and communications schemes.

These commonalities can evolve in a practical way with time and experience, especially if the training commands are aware of the potential benefits they would receive when procuring new I.T. equipment and sponsoring new research and development. If conflicts should arise from differing training objectives and philosophies, scheduling incompatibilities, variations in curriculum planning, and divergent equipment requirements, training managers could minimize them through joint participation in the activities and projects recommended in Section VI.

Although commonality can help to maximize the benefits from I.T., increased commonality is not necessary to gain benefits from I.T. Benefits can be realized from I.T. in each service without a pooling of resources and activities. In fact, some advantage might be gained from independent approaches to similar problems.

C. Training Philosophies

In the DoD training system about half of the training occurs on the job; the rest is formally organized as schooling. For all training, however, I.T. characterized by training aids wherever the trainee is located offers important potential savings. This complements a policy trend toward more training in the field under realistic circumstances away from artificial school environments. The full range of didactic material, deemed necessary to attain course objectives can be conveyed through minicomputers and video devices on site for a given course. A trainee working toward qualification for operating new equipment or achievement of a higher rating can take his course in situ, supplied by course materials prepared at the school.

Potential benefits from implementing training philosophies through I.T. are significant:

- Reduced pay, allowances, and relocation costs when trainee transits to the school are eliminated.
- More efficient training as a result of using more realistic training environments.

- Improved readiness of equipment due to its systematic exercise through didactic modes.
- Shorter learning times because instruction is individualized and personalized.
- Reductions in school overhead costs due to reductions in school loadings.
- Easier revision of course material to reflect changes in policy or equipment. (For example, new courseware can be recorded on cassettes at the course center and mailed out to those training terminals where the course is currently supported.)

The minor redirection of training philosophy necessary to realize these benefits is underway. A strong trend toward training in the field already exists, and the idea is popular among field commanders who believe that training is more effective when conducted under actual field conditions. If the transition to I.T.-implemented training is made slowly and continuously, time and experience will permit procedures, policies, and equipment to be introduced in an orderly manner without disrupting normal operations. This will allow sufficient time for feedback from the field experience to make equipment and courseware modifications.

VI RECOMMENDATIONS

The DoD should establish I.T. research centers or improve present educational facilities to coordinate research activities and to accelerate the application of research results from the laboratory to the field.

A. DoD Research on Instructional Technology

The financial risk to the DoD of undertaking future research on I.T. is small compared with the potential gains in dollar and manpower savings. Flexibility in mission readiness and preparedness has been shown to be a corollary benefit from I.T., and the military should continue to consider these requirements when establishing its research budgets. However, reliable manpower and dollar savings alone justify further I.T. research programs.

The potential gains to the military of the research programs suggested below lie in their commonality to military services, in their research nature--as opposed to operational or developmental programs--and in their ease of integration with projected I.T. systems. Their purpose is to guide and to clarify an optimum future development path for I.T. within the military.

Five domains of research are pertinent:

- Theory of instructional strategies
- Curricula and courseware development
- Course evaluation methods
- Hardware and software aspects of applied I.T.
- Benefit and cost analysis of I.T.

The results of this study indicate that future funding should be assigned to these categories of research on a priority basis according to the ranking in the above list. Learning, for example, definitely has a first-order effect on δ(CT), and it is a function of the instructional strategies and evaluation.

The courseware, hardware, and software effects were shown in Section IV to have less influence on savings and should therefore be assigned lower priorities. Benefit and cost analysis research should be continued to keep the I.T. costs in line with the projected and realized benefits and to improve the chances of benefitting from future research results.

1. The Theory of Instructional Strategies

Research on learning processes is necessary to the successful expansion of I.T. The major component of savings that can be realized through the application of I.T. to training lies in this category. Further research is needed to answer the following questions:

- What are the appropriate instructional strategies?
- How can I.T. improve motivation and achieve the corresponding inherent benefits of increased learning and retention, reduced training time, and more reenlistments?
- What is the effect of feedback?
- What is the role of the teacher using I.T.?
- How does the Hawthorne effect* impact on I.T.?
- What is the importance of interstudent discussion?
- What is the psychology of the student-machine interface?

Research should be conducted to improve understanding of the relationships between instructional strategies and (1) course content, (2) student population characteristics, (3) instructor training, and (4) CBI apprenticeship techniques. Improved techniques are needed for interpreting student

---

*The Hawthorne effect refers to initial interest in and good performance as a result of an innovation. A reversion to original performance occurs when the novelty has passed.

responses, soliciting desired responses, and increasing student satisfaction.

Research on the response of low-aptitude personnel to various types of self-pacing and individualized training should be accelerated. In addition, research should be conducted to determine improved combinations of peer training, self-pacing, hands-on learning, and conventional lecture study with books and manuals. Relationships between instructional strategies and cognitive development, attitude changes, motor skills, and group/team performance should also be studied.

Research is necessary to improve identification and measurement of the relative effectiveness of motivational factors. The role of the instructor as a motivational model should be studied, and improved methods for fostering practical attitudes in instructors toward I.T. innovations should be developed. This may require the establishment of courseware development as a professional discipline. Research is needed on the effective use of available materials and games to teach skills and concepts and to provide practice in applying concepts. Motivation is closely linked with student strategies, as the student's strategy varies in response to the instructional strategy.

Research on the psychology of the student-machine interface is recommended for the purposes of developing more effective modes of display, improving the mechanical processes for student responses, and establishing more efficient methods of structuring machine dialog. The study of this nonverbal dialog should include research on more efficient man-machine interaction.

2. Curricula and Courseware Development

Guidelines should be developed for increasing commonality in curricula and courseware (languages and software). Some of the main impediments to dissemination of I.T. courseware and CBI programs are incompatibilities in author languages, hardware, and software. For example, two bases may teach the same course, but the CBI used for that course at one base may not be easily transferable to the other base because of software differences.

Courseware development should be established as a separate discipline, fundamentally independent of course content and service. Research is needed on training authors and instructors on a large scale. Although courseware costs impact in a second-order sense on I.T., some research should be addressed toward the more efficient preparation of courseware, in particular, programming languages and formal processes for creating teaching algorithms. The wide range of parameter values for courseware costs used in the cost analysis in Section IV are due to widely varying estimates of the cost of producing courseware. The lower figures (see Section IV) for courseware preparation costs are both reasonable and conservative, especially when viewed from the perspective of future advances in programming languages, such as the development of automatic courseware generators.

Courseware costs can be expected to be reduced in the future for several additional reasons:

- Improved author experience and establishment of a courseware discipline.
- Use of advanced students as authors of course segments.
- Appropriate modularizations of course materials.

In conducting research in this area, special consideration should be given to a systematic exploitation of research results on courseware organization, since this is one area where research results are not adequately disseminated.

3. <u>Evaluation</u>

I.T., and CBI in particular, is still at too early a stage in its development to have established accepted standards of evaluation. Research is necessary to develop models for comparing varieties of I.T. systems on a common basis. Course evaluation methods must be determined that meet the following objectives:

- To assure attainment of course training objectives
- To meet go/no-go testing criteria
- To provide feedback on the student's progress
- To measure the trainee's performance
- To measure the trainee's confidence
- To provide processes for identifying learning deficits and for applying appropriate remedial action.

4. <u>Hardware and Software</u>

Research in I.T. hardware (computer and other) and software should be considered, even though its impact on savings is less than that attainable through improved instructional strategies. The term "hardware" is used here to refer to the collective media and equipment, although computing equipment has been emphasized. The principal objectives of any research on hardware should be first, to improve the training mechanism, and second, to improve cost effectiveness.

In the past, hardware and software availability have often determined the constraints of CBI courseware. This relationship is not appropriate for the emerging technology. With appropriate research, the process can be reversed, and learning processes and I.T. requirements can be used as a basis for selecting and/or developing the appropriate hardware and software. Such an approach requires research in several areas:

- The application of special purpose central processing units and peripheral equipment in I.T. environments.
- Relationships between training objectives, instructional strategies, and different hardware configurations.

To benefit from research on hardware/media conducted in the industrial sector, additional economic research is recommended to determine means of fostering and accelerating the response of the private industrial sectors to the requirements of I.T. Justifications--based on sound business principles--for the development of competitive sources of I.T. hardware need to be presented.

SRI recommends that software research concentrate on establishing criteria for the selection of author languages, based on training objectives and instructional procedures. More research on (1) software techniques for data collection and evaluation in real time and (2) basic software components--e.g., metacompilers and translators--would also be useful.

In particular, note that the number of CBI languages can only proliferate with increasing time. Thus, emphasis must be placed on developing metacompiler generators for languages that concentrate on the language aspects rather than the software considerations.

5. Benefit and Cost Analyses

Most of the benefit appraisals of I.T. conducted in the last few years have been evaluated using cost as the principal parameter of interest (see Appendix A). In each of these cases, appraisals were complicated by a lack of comparable bases for cost comparisons. Research is required for the development of a uniform approach in which cost variables can be fixed and varied systematically to provide a controlled context for evaluation.

Tickton and Kohn delineated many of the criteria needed for such an analysis.[20,28] If their plans are adopted by national agencies, then all grants from such agencies will require the grantee to provide the specified information needed by the costing methods. Such a procedure, if also adopted by the military, would enable the military to test its programs against a standard and to compare its programs with programs used in the civilian and industrial sectors. SRI recommends additional research in this area to facilitate the use of such costing methods in the military. The experience gained during this research project demonstrated that the absence of standardized costing procedures imposes a handicap on researchers studying I.T. in the military. The recommended research is intended to eliminate this handicap.

A systematic, course-by-course analysis based on the data base and an automated mathematical model could be useful to each of the services. However, such research should incorporate all up-to-date information on courses that have already been modified for I.T. (e.g., programmed instruction).

Research on data base methodology for CBI systems is recommended. Considerable disagreement exists about the appropriate data requirements for CBI systems (in such areas as data logging and the size of the data base). Research should be conducted to determine the necessary data base requirements. Assumptions that large data bases are necessary should be studied carefully, since there is no generally accepted evidence that sizeable portions of CBI data bases are useful. The result of such assumptions may turn out to be large, costly, inflexible systems.

Software costs can easily dominate the total computing system costs of CBI. Thus, research on computing software should have the same priority level as the hardware research in CBI systems.

A systematic analysis would also aid in the development of an analytical tool. The main purpose of perfecting an analytical tool is to enable a paraprofessional to use it in evaluating courses. At present, this is strictly the job of a highly skilled professional. Thus, SRI recommends additional research to continue the study of the relationship between δ(CT) and the independent variables of I.T. Such information would be especially useful in planning curriculum modification and development in operational I.T. research centers. It would provide a systematic basis for relating the capabilities of the instructional techniques to the instructor's detailed knowledge of course content and objectives. Such research should be directed toward investigating functional relationships between δ(CT) and the variables, determining domains of values for the variables, and validating the functional form using the existing data base.

B. Instruction Technology Research Centers

To improve coordination of activities, expenditures, and research among the services, it is necessary to establish a basic I.T. research center and to enhance the present operational I.T. efforts within the services. Both classes of I.T. centers are important because the services are obligated under mission requirements to concentrate their principal resources on operational programs, and because it is necessary in this long lead time technology to support basic research via another mechanism. The high commonality of this technology strongly argues for an independent activity capable of supporting all three services.

The concept of the I.T. research center (either basic or operational) has been presented by several other researchers. For example, a comprehensive design was completed in 1967 by the Office of Naval Research.[10] The Navy design sets forth a rationale similar to the one presented in this report. However, due to the evolution of technology in the last five years, the procedures recommended here are somewhat different.

1. <u>The Basic Instructional Technology Research Center</u>

The I.T. research center should be structured as an autonomous organization with well-established lines of communication to the services. It should be administered contractually under either ARPA or joint services management. The center should be organized with balanced participation of all three services in mind. Imbalance in favor of any particular service would only interfere and degrade the cooperation that is a necessary ingredient to the success of the center's program.

The objectives of the basic I.T. research center should be the following:

- To provide a foundation for nourishing basic research in I.T.
- To monitor and validate the future benefits of I.T. in the DoD.
- To maintain an optimum path for the expansion of the use of I.T. in the DoD.

The center must perform and support research to be cognizant of the present and projected state of the art in I.T., and it must also take responsibility for research in "blue-sky" areas that the individual services would have difficulty justifying. The center should also be available as a breadboard facility for outside researchers to use in conducting their experiments.

The center should serve as a focal point for centralizing documentation, communications, and research efforts. For example, many laboratory research results on learning processes are rarely applied at the actual training site, or they are only partially implemented. The center could strengthen the feedback loop between research sites and field sites, and it could assure some continuity in the filtering process between the laboratory and the classroom by monitoring the technology.

The proposed center can be similar to present coordinating centers operated by the Office of Education, Atomic Energy Commission, National Institutes of Health, and National Bureau of Standards. However, the activities of the basic I.T. research center could be dispersed in location, possibly along the nodes of the ARPANET. The facilities, for the most part, already exist. Since the center must serve as a timely distribution and communication center, the ARPANET can serve admirably. The center must be responsible for establishing some level of standards for research and programs, without restricting present efforts. It must accept alternative approaches; in fact, it should support them with a balanced perspective. Thus the center should be responsible for relating the efforts of the individual services and, thereby, for preventing unnecessary redundancy.

The center must be organized to compare components and techniques in relation to training effectiveness and compatibility with equipment. Training strategies should be optimized to make use of variations in equipment.

One of the most important functions of the center should be to assure the availability of competitive sources in industry for hardware, software, and courseware. The industrial sectors of the economy are usually very responsive to DoD technical requirements, and some centralization of specifications for this type of technology would aid the cost effectiveness of industry's research and development in this technology.

The ARPANET and the Network Information Center could be used as a means for communication and as a research facility to coordinate I.T. and CBI research funded by the basic I.T. research center. The network would permit, for example, experimental techniques in one laboratory to be linked to another. Or, courseware created at one node could be exercised at another node to be evaluated on different equipment and in line with varying objectives.

The I.T. research center could also serve an invaluable role by acting as a catalyst in instituting workshop concepts and providing workshop facilities. There has been considerable interest[29] in establishing I.T. workshops where participation could be dispersed and easily available to many researchers. Again, the ARPANET can serve as a valuable adjunct to this concept.

Workshops provide an efficient process for developing opinions and coordinating information. Assertions can be proposed, discussed, and modified in a matter of minutes or hours, rather than in a period of months. In I.T., a number of research activities are carried on all over the country. These researchers could convene on the ARPANET, say, once a month. Geographically they would be at home, using their own computers and instructional programs. Functionally, however, these programs would be exercised by the entire community. Revisions could be tried and discussed on line. The ability to try alternatives in a group and to iterate toward new concepts in a short time adds a qualitatively different research dimension.

To fulfill the objectives proposed above, the research center must have personnel skilled in all of the technical and administrative categories that relate to the use of I.T. This includes but is not limited to:

- Mathematicians and statisticians
- Psychologists

- Economists
- Courseware authors
- Software experts
- Hardware experts
- Educators
- Administrators.

Such technical and administrative skills are necessary both to perform and to monitor research programs and to keep the center headed toward its principal objective: optimizing the benefits that can be achieved by the introduction of advanced technology in the military training establishment.

2. The Operational I.T. Research Centers

Although basic research in I.T. should be supported or coordinated through a joint service organization, the individual services will use the results of such research to meet their individual objectives. The services already have established I.T. research facilities* and the suggestions below are intended to augment the function of these existing facilities.

First, SRI recommends that each service designate one of its facilities as an I.T. operational communication center for interfacing with the basic I.T. research center. Although the center located at a Navy installation might serve as the main center for Naval courses, all bases could be informed on a day-to-day basis of I.T. activities in the other services. Part of the communication role of the operational centers would

---

*Keesler AFB; Chanute AFB; Navy Training Devices Center, Orlando; Naval Training Research Institute, San Diego; Fort Monmouth.

be to provide a variety of I.T. demonstrations for those interested in initiating or expanding the use of I.T. at their bases. The availability of a single facility with information on all I.T. courses in the service would facilitate implementation of I.T. and remove the problem of on-site course demonstrations.

Second, the operational centers should be responsible for training instructors in the use of I.T., particularly CBI. Instructors might well be trained at these centers to return to their bases to instruct others in the new role of CBI monitor/instructor. Feedback to the centers from instructors in the field could optimize the training of instructors who will be using CBI in such diverse ways as drill and practice, tutorial, and simulation modes.

Third, the centers should train instructors to prepare I.T. curricula in a variety of modes. In the course of such training, some courses will be produced at the centers, but in the long run, it is assumed that most courses will evolve in a decentralized fashion from local instructors.

Fourth, the centers should disseminate courses written at these centers and at the basic I.T. research center. The operational centers also offer an ideal location to collect information on I.T. courses. Feedback from the users of such courses could be used in revising the material, as well as in developing techniques for revision.

Fifth, the centers should serve as a vital link in reformulating basic research results to be of use in the field.

Interservice staffing should provide ongoing communication and stimulation to I.T. users/producers. The staff of each center should include experts on hardware, software, and courseware. Courseware experts should be familiar with the preparation of a variety of I.T. modes and with research in learning applicable to I.T. Software and hardware experts should be familiar not only with equipment at the laboratory, but also with equipment likely to be found at bases using the laboratory. Service personnel using the facilities of the laboratory should be experts in the area for which they will be producing curricula.

The present study covered the role of I.T. in the military services as a whole. Since existing military educational centers were not exhaustively studied, no recommendations are made concerning experiments to be conducted in these existing centers, scales of operation, research investments, staffings, or other considerations. Such topics would benefit from further study.

REFERENCES

1. "A Report by the Commission on Industrial Technology," in To Improve Learning, Part I, S.G. Tickton, ed. (R. R. Bowker Company, New York, New York, 1971).

2. "Computer Assisted Instruction," Vol. 1, CONARC Task Group Basic Report, U.S. Army Signal School Fort Monmouth, New Jersey (April 1972).

3. T. J. Gillespie, "Computer Applications to Military Training," Proc. of the NSIA ACT Conference, 1972, pp. 45-55 (1972).

4. "Revision of Training Programs within the Army Training Centers," via personal communication from H. McFann, Human Resources Research Organization, Presidio, Monterey, California (1971).

5. Maj. Gen. F. M. Rogers, Deputy Chief of Staff for Technical Training, Headquarters, Air Training Command, from "Applications of Computers to Training," pp. 29-30, USAF Technical Training Center, Biloxi, Mississippi (5 April 1972).

6. Conversations with Lt. Col. R. Gerry, USAF Retired, University of Texas, Austin, Texas, April 1972.

7. From conversations with Mr. R. Williams and Capt. A. McMichael at the Naval Training Center, Pensacola, Florida.

8. "Report of the Board of Dynamic Training," Army document (17 December 1971).

9. W. E. Rhode et al., "Analysis and Approach to the Development of an Advanced Multimedia Instructional System," (a study sponsored by the Air Force) Westinghouse Learning Corporation, Bladensburg, Maryland (1970).

10. D. V. Torr et al., "A Plan for the Establishment of a Computer Aided Instruction Research and Development Center," General Learning Corporation, Washington, D. C. (July 1967).

11. J. D. Ford, Jr. and D. A. Slough, "Development and Evaluation of Computer Assisted Instruction," AD 706728* (1970).

12. R. E. Hurlock, "Development and Evaluation of Computer Assisted Instruction," AD 720309* (1971).

13. A. A. Longo, "The Implementation of Computer Assisted Instruction in U.S. Army Basic Electronics Training. Follow-up of a Feasibility Study," ED 038021† (1969).

14. K. A. Johnson et al., "Comparison of Conventional and Programmed Instruction in Teaching Communications Procedures," AD 656894* (1967).

15. Dr. M. Rockway, Technical Director, Lowry Air Force Base, Denver, Colorado, correspondence with T. Marshall of Stanford Research Institute. Included as Appendix D.

16. J. G. Miller, "Deciding Whether and How to Use Education Technology in the Light of Cost Effectiveness Evaluation," Academy of Education Development, Incorporated, Washington, D. C., ED 039728† (1970).

17. T. D. Profitt, "CAI and Then Some," <u>College Management</u> (April 1972).

18. Examples are the following statements from the <u>Proc. of the NSIA ACT Conferences</u>:

    (a) W. McDowell, p. XXIV-4 (1971).

    (b) R. Williams, p. XXV-5 to XXV-6 (1971).

    (c) Capt. A. McMichael, p. 41 (1972).

    (d) T. Gillespie, p. 53 (1972).

    (e) S. Mayer, p. 69 (1972).

19. Papers from <u>To Improve Learning</u>, S. G. Tickton, ed. (R. R. Bowker Company, New York, New York, 1971):

---

* AD numbers refer to Clearinghouse for Federal Scientific and Technical Information identification.

† ED numbers refer to Educational Resources Information Center identification.

(a) H. J. Keisling, "On the Economic Analysis of Educational Technology," pp. 977-997.

(b) H. M. Levin, "Cost Effectiveness Evaluation of Instructional Technology: The Problems," pp. 999-1005.

(c) J. G. Miller, "Deciding Whether and How to Use Educational Technology in the Light of Cost-Effectiveness Evaluation," pp. 1007-1027.

(d) R. E. Speagle, "The Cost of Instructional Technology," pp. 1061-1074.

20. S. G. Tickton and S. D. Kohn, "The New Technologies: Are They Worth It?" Report to the President's Committee on School Finance (September 1971).

21. F. C. Frick, "The Lincoln Terminal System," MIT Lincoln Laboratory, Lexington, Massachusetts (1972).

22. J. D. Ford, Jr., D. A. Slough, and R. E. Hurlock, "Computer Assisted Instruction in Navy Technical Training Using a Small Dedicated Computer System: Final Report," Navy Training Research Laboratory San Diego, California (November 1972).

23. Lt. Col. Hitchens, "Instructional Technology in the Armed Forces," in To Improve Learning, S. G. Tickton, ed. (R. R. Bowker Company, New York, New York, 1971).

24. M. Farr, "Computer Assisted Instruction," in "Naval Research Reviews," Office of Naval Research document (September 1972).

25. J. W. Rigney and D. M. Towne, "Final Report: Research in Computer-Aided Instruction Training," Department of Psychology, University of Southern California, Los Angeles, California (October 1972).

26. S. Mayer, "Computers in Training: Positives, Probables, and Possibles," Proc. of the NSIA ACT Conference, 1972, pp. 57-70 (1972).

27. From conversations with Lt. Col. Hilsman and Maj. D. Parrish, Combat Arms Training Borad, Fort Benning, Georgia (16 February 1973).

28. Papers from To Improve Learning, S. G. Tickton, ed. (R. R. Bowker Company, New York, New York, 1971):

(a) F. C. Johnson and J. E. Dietrich, "Cost Analysis of Instructional Technology."

(b) J. G. Miller, "Deciding Whether and How to Use Educational Technology in the Light of Cost-Effectiveness Evaluation."

(c) J. G. Miller and G. J. Rath, "Planning-Programming-Budgeting and Cost-Effectiveness Analysis in Educational Systems."

(d) R. E. Speagle, "The Cost of Instructional Technology," and "Cost Benefits: A Buyer's Guide for Instructional Technology."

29. T. O'Sullivan, ARPA Network Working Group, Request for Comment No. 313, ARPA Network Information Center 9343 (March 1972).

Appendix A

REPORTED INSTRUCTIONAL TECHNOLOGY APPLICATIONS

SELECTED FROM LITERATURE SURVEY

Appendix A

REPORTED INSTRUCTIONAL TECHNOLOGY APPLICATIONS SELECTED FROM LITERATURE SURVEY

Course	Class of System and Cost Variables Discussed	Criteria Assumed for Successful Implementation	Successes, Failures, and Author's Conclusions	Notes	Source
A six-week course in skills. Dial-a-drill home math lessons.	Computer-aided instruction cost per terminal hour = $2.60, reducible to $2.20 with new equipment.	(1) Acceptance of CAI by staff and pupils. (2) Lower cost per pupil. (3) Student achievement.	SUCCESS: For grades 2-5, the City University Evaluation Study concluded "CAI students earned higher gains in most grades." Differences were significant for all students: girls, boys, black and Puerto Rican. CONCLUSIONS: (1) CAI places little burden on the administration of an urban school system. (2) CAI provides an attractive learning environment. (3) CAI significantly enhances student performance. (4) CAI can be implemented with existing technology at costs that make it a reasonable instructional alternative.	Largest CAI operation in a public school system. First year operation ended June 1969. Average daily number of lessons = 3600, at 10 minutes per lesson. Cost reduction measures included: (1) Clustering terminals instead of one per classroom. (2) Eliminating communication lines by multiplexing and concentrating.	C. F. Butler, "CAI in New York City: Report on First Year's Operations," Educational Technology Vols. 9, 10, pp. 84-87 (October 1969).
LCI F-111A weapons control system mechanical technician course.	Learner-centered instruction (LCI) compared with conventional instruction. Hours and costs of various aspects of mechanical technician training course. Man-hour cost of LCI = 60% of conventional cost. Dollar cost of LCI = 25% of conventional cost.	(1) Man-hour and dollar costs. (2) Job performance (a) Job performance test. (b) Air Force practical test. (c) Supervisor ratings. (d) Substitute job knowledge test. (3) Student acceptability.	SUCCESS: High-aptitude trainees did better when trained by LCI. Medium-aptitude trainees performed at the same level when trained by LCI and by conventional methods. More students rated the course as outstanding rather than just satisfactory.	A 14-week course training 80 students in a self-paced environment. Test results held up after 5 months in the field.	W. J. Pieper, et al., Learner Centered Instruction (LCI), Vol. 7 (Applied Science Associates, June 1970).
College freshman mathematics--a semester course worth three credits.	Initial development and production costs for mainline programs for CAI. A mainline program is a complete system for teaching an entire course. The present cost is $5,000 to $10,000 per student hour, reducible to $3,000 per student hour.	Assumes the existence of languages, systems, and authoring techniques still under develop.	SUCCESS: Model of a course in college freshman mathematics has been shown to work at less cost than traditional instruction.	Makes extensive use of program design and help from teaching assistants. Adjunct programs support the mainline program.	C. V. Bunderson, Justifying CAI in Mainline Instruction, paper presented at University of Iowa conference on computers (June 1970).

Preceding page blank

Course	Class of System and Cost Variables Discussed	Criteria Assumed for Successful Implementation	Successes, Failures, and Author's Conclusions	Notes	Source
Not related to specific subject material	Audio-visual teaching machine (AVTM). Cost less than $100 not including the program format.	Programmed audio and visual materials will allow machine to proceed with a lesson under linear or branching logic.	CONCLUSION: Technology readily available, and AVTM costs less than CAI; however, little acceptance of this type of device to date.	Computer-controlled AVTM considered to be another option.	L. G. Dorsett, <u>Audio Visual Teaching Machines</u> (Educational Technology Publications, Englewood Cliffs, New Jersey).
General education physics courses.	Computer-aided instruction and computer-managed instruction. Used both IBM 1440 and IBM 1500 systems.	(1) Student must pass diagnostic test before getting next assignment (2) Final grades.	SUCCESSES: (1) Grades improved with CAI. (2) Evidence that increasing involvement with CAI produces better grades. CONCLUSION: CMI along with CAI provides a very cost-effective approach.	A self-paced program of test reading, taped lectures, and films of experiments. Covered 23 students in 1967 and 37 students in 1968.	O. M. Kromhout, et al, "Conference on Computers in Undergraduate Science Education: CAI and CMI Course in Physical Sciences," Florida State University (1970).
Flight training, helicopter instrument training phase.	Simulation: Simulated hourly flight training cost only one sixth of actual flight training at time of experiment (1968).	Lower training cost.	SUCCESS: Synthetic flight training already considered successful, as reported in Isely, Caro, and Jolley, "Evaluation of Synthetic Instrument Flight Training in the Officer/Warrant Officer Rotary Wing Aviator Course."	Report describes treatment of data and major assumptions used in allocation of costs.	O. B. Jolley and P.W. Caro, "Determination of Selected Costs of Flight and Synthetic Flight Training," Human Resources Research Organization, Alexandria, Virginia (April 1970).
Sciences, humanities, social sciences, and languages.	Televised instruction--cost per enrolled student.	Achievement test data in controlled experiments.	SUCCESSES: (1) Achievement test data of three-year experiment demonstrated that televised instruction was superior to conventional classroom instruction for certain subjects and audiences. (2) Cost per enrolled student was slightly higher than that for classroom teaching, but it can be reduced to levels below that of conventional teaching by expanded enrollment.	1,261 students in Chicago Junior College participated over three-year period.	Erickson and Chausow, "Chicago's TV Colleges," Final Report of Three-Year Experiment, Chicago City College, Illinois (1960).
Wide range of classroom courses.	Joint cost of using telecommunication network to make EDP, administrative, audio and instructional services widely available through northern and central Michigan schools.		CONCLUSION: Feasibility and projections of typical costs for the number of broadcast stations needed, communication services required, and shared use of computers.		Report to Central Michigan Educational Resources Council, Mount Pleasant, Michigan (1967).

Course	Class of System and Cost Variables Discussed	Criteria Assumed for Successful Implementation	Successes, Failures, and Author's Conclusions	Notes	Source
Graduate engineering education.	Educational TV total cost per student.	Cost.	CONCLUSION: Total cost per student semester hour are approximately the same for campus and off-campus students.	Monitor and two-way audio system allows students to ask questions and hear responses.	W. E. Foreman, "Graduate Engineering Education via TV," paper presented to 1968 IEEE convention.
Educational extension courses, literature, and teacher training.	Comparative costs of instructional technologies (television, radio, filmstrips and correspondence studies) on nationwide scale.	Attitudes of participating teachers, impressions of visitors, and proportion of students passing literary examinations.	CONCLUSIONS: (1) New media entailing higher initial cost can bring down unit cost, depending on the number of students reached. (2) In Columbia costs as low as $0.05 per hour per pupil have been achieved for instructional TV. (3) Reaction and comment from participating teachers and visitors are largely favorable.	Other case studies in developed and undeveloped countries. Countries include Italy, Niger, New Zealand, Honduras, Nigeria, and USA.	"New Educational Media in Action," UNESCO, 3 volumes (1967).
Reading to sixth grade level.	Talking typewriter. Cost per student and cost per month for equipment of $6 per student hour, not including preparation of materials.	Grade level advancement in reading ability, as shown by: (1) Stanford achievement test. (2) Sullivan placement. (3) Progress in PI.	SUCCESSES: (1) 93 students tested showed advancement of two grade levels in 250 hours on the machine. (2) Student attitude improvement. (3) Total cost per student for two-grade-level improvement could fall from $729 to $263 under maximum utilization of facilities.	An evaluation of "Operation Wordpower" involved 372 students at four different sites.	"Initial Evaluation of Operation Wordpower," Instructional Dynamics, Inc., Chicago, Illinois (1970).
No specific courses. An evaluation of new resources available in education.	Cost effectiveness of major media of educational technology available in 1970. Educational TV as low as $0.94 per student hour. CAI about $9 per terminal hour. Videotape costs cited as prohibitive.		SUCCESS with CAI: Learning rate cited as 20% faster than that achieved with human tutors. However, the administration found it necessary to tutor 200 students with CAI to keep the average cost per student down to acceptable levels.	A suggested approach to decision making for new instructional media at various educational levels is made.	J. G. Miller, "Deciding Whether and How to Use Educational Technology in the Light of Cost Effectiveness Evaluation," Academy for Educational Development, Inc., Washington, D. C.
U.S. Army cockpit procedures.	Simulation--comparison of low cost and high cost methods for aircraft cockpit procedures.	Degree of transfer of training from simulator to actual flight environment.	CONCLUSION: No significant differences in the transfer of training were found between an expensive computerized trainer and a low cost mockup of the aircraft cockpit.	Ten additional references and 18 figures are included in the report.	W. W. Prophet and H. A. Boyd, Human Resources Research Organization, Alexandria, Virginia (July 1970).

Appendix A (Continued)

Course	Class of System and Cost Variables Discussed	Criteria Assumed for Successful Implementation	Successes, Failures, and Author's Conclusions	Notes	Source
Boolean algebra and logic design.	CAI used to help deficient college and graduate students.	Cost and student retention of conceptual material.	CONCLUSIONS: (1) High costs for hardware and software and poor software support from IBM. (2) Control group's retention of conceptual material better than CAI group. (3) The implication that CAI is unsuitable for engineering education was caused by experimental conditions.	Early attempt at overcoming some problems in hardware and software development in CAI.	R. Roy, "Computer-Aided Instruction for a Course in Boolean Algebra and Logic Design," Rensselaer Polytechnic Institute, Troy, New York (1968).
Pilot training course, 102 instructional hours.	Systems approach using programmed instruction. Savings in time over present (1969) methods to train military pilots ranges from 20% to 60%.	Percentage of total training time saved.	CONCLUSIONS: (1) Total time savings were: pilots 50%, copilots 60%. (2) Present average cost per student to complete training ranges from $10,000 to $16,000.	Estimates of reduced cost result from comparison of military and private airline training programs.	J. B. Shaw, et al., "C-130 Phase I Pilot Training Program," Tactical Airlift Center, Pope AFB, North Carolina (1969).
General study of costs of TV courses	Instructional TV--average unit cost for televised film lectures at university level.	Meaningful cost comparison possible only when all costs are compared with conventional instruction.	CONCLUSIONS: (1) Major expense of televised instruction is the cost of instructional staff. (2) Cost reductions possible only if the number of senior staff used is reduced. (3) Unit costs decrease with higher student enrollments; therefore, a large class size is necessary to attain efficiency.		G. Jones, et al., Unit Costs Provide Basis for Meaningful Evaluation of Efficiency of TV Courses, McGraw Hill Publications, New York (1969).
General Study covering CAI trends in the Midwest.	Computer usage trends in education. Range of costs in total cost per pupil per year.		CONCLUSION: Computers used primarily for administrative needs. In 1967-1968 only about 5% of applications were for instructional and personnel purposes. Computers were used mostly for administration, testing, grading, and scheduling--thus, their educational value was questionable.	Total costs per pupil per school year in the central midwestern region of the United States ranged from $0.04 to over $12 in 1967-1969.	H. Ohlman, "Educational Computer Trends in the CEMREL Region: Analysis and Recommendations," Central Midwestern Regional Education Laboratory (May 1969).

Appendix A (Concluded)

Course	Class of System and Cost Variables Discussed	Criteria Assumed for Successful Implementation	Successes, Failures, and Author's Conclusions	Notes	Sources
Junior college and college.	CIA cost per student hour and savings in educational time.	CAI can be superior to traditional instruction. CAI will allow the under prepared student to approach the same levels of achievement as better qualified students.	CONCLUSIONS: (1) Time savings of 40% or more are not uncommon. (2) Average cost for delivering junior college and higher education by traditional methods ranges from $3 to $8 per student hour. A conservative estimate for a complete CAI system for a junior college amortized over eight years will range from $0.35 to $0.50 per student hour. (3) Learning enhancement is expected in addition to time and monetary savings.	Testing of the TICCIT system to occur at Brigham Young University in 1973-1974. By 1975 extensive development of new non-traditional modes of education expected; schools without walls and learning in living and working environments.	T. D. Profitt, "CAI and Then Some," College Management (April 1972).
Four full semesters of community college English and mathematics are planned.	CAI cost per student hour.	Low cost development of courseware (educational materials).	Goal of the program for 1973-1974 is to demonstrate that CAI can provide better instruction at lower cost than traditional instruction in community colleges. Prorated cost per contact hour for courseware is expected to be about $0.15 (based on 20 schools X 1000 hours use per year X 100 terminals over a five-year period).	As experience is gained in developing courseware, costs should decrease. If more than 1% of the schools adopt CAI, the anticipated courseware cost is $0.05.	J. L. Volk, "Toward A Market Success for CAI," First USA-Japan Computer Conference Proceedings, October 3-5, 1972, Tokyo.

Appendix B

SOURCES OF TRAINING COSTS AND THE NUMBER OF TRAINEES

Preceding page blank

Appendix B

SOURCES OF TRAINING COSTS AND THE NUMBER OF TRAINEES

This appendix presents descriptions and examples of the source documents from which the data used for this study were collected.

1. U.S. Air Force

The U.S. Air Force compiles summary cost data on training and maintains them in a computerized data bank. This data bank is updated each year and was designed by the Management Analysis Office of the Financial Division Comptroller's Office at the Headquarters of the Air Training Command. Data are compiled on total cost per graduate at the individual training course level. Cost data used in this study are based upon Air Force experience in fiscal 1972.

Another source document necessary to this study is the programmed technical training plan of the U.S. Air Force. It is used to obtain the number of programmed students to graduate from each course in 1972. Both the cost and the training plan data were compiled by the Headquarters of the Air Training Command, located at Randolph Air Force Base, Texas.

A multipage computer printout maintained at ATC headquarters shows the cost breakdown, as well as the total cost per trainee graduated, adjusted for the attrition rate. This information was made available, on a course-by-course basis, for all students involved in technical training command courses for fiscal 1972. Courses are identified by course number and title in this data bank. The cost definitions used for the various accounts, as defined by the comptroller in the Management Analysis Office of the Financial Division, are given below.

- Direct Costs--Those costs directly attributable to training i.e., pay and allowances of all personnel in the school, contracted and purchased services (such as maintenance and

Preceding page blank

repair of training equipment and instruction), supplies and training aids, maintenance, POL, and other miscellaneous costs.

- Support Costs--The costs for those activities normally considered to be base support and not directly engaged in training; i.e., military and civilian pay, maintenance, supplies, materials, utilities, rent, commercial transportation and communications, printing, reproduction, and others.

- Student Pay--This cost is computed using a standard rate for each rank; e.g., a captain's pay is based on an average of all Air Force captains' pay (including pay, allowances, and benefits).

- Command Overhead--This cost includes the operating costs of the command headquarters (i.e., ATC) and also that portion of the support costs of the host base (i.e., Randolph) allocated to the headquarters.

2. U.S. Army

Within the Continental Army Command (CONARC),* the U.S. Army has a standard methodology to analyze the cost of training for all schools. It is the basis for providing the Comptroller of the Army with detailed cost analyses and costs per graduate for each course taught at CONARC schools.

Using these raw cost data (fiscal 1971 costs per graduated trainee) collected by CONARC, inferences were drawn about Army cost and manpower savings resulting from the introduction of new I.T. Forms used by the Army Training Command to report these costs for each course identify the

---

*See the annex to this appendix.

specific course by title and number. Raw data were taken from a sample of the source documents and then keypunched and stored for use in the analysis.

Five fields of data were used: course title, course number, course length in weeks, throughput in terms of normalized graduates, and total cost per normalized graduate. The course description corresponding to the given course number is obtained from the Army Schools Catalog.

3. U.S. Navy

In 1971 the U.S. Navy had 13 separate commands, each conducting training courses for its particular needs. Each of the 13 commands maintained its own schools and published its own course catalogs for the training offered. The 13 commands were:

(1) A--Bureau of Naval Personnel

(2) B--Bureau of Medicine and Surgery

(3) C--Naval Air Training Command

(4) D--Naval Air Force, Atlantic

(5) E--Naval Air Force, Pacific

(6) F--Submarine Force, Atlantic

(7) G--Amphibious Force, Atlantic

(8) H--Amphibious Force, Pacific

(9) J--Training Command, Atlantic

(10) K--Training Command, Pacific

(11) L--Submarine Force, Pacific

(12) M--Naval Air Systems Command Representative, Atlantic

(13) N--Naval Air Systems Command Representative, Pacific.

The upper case letter designator is the first element of a training course alphanumeric descriptor that identifies the sponsoring command for the particular course.

In 1972 the Office of the Chief of Naval Training began to consolidate reports on Naval training data. Training within the 13 commands was regrouped into a fewer number of subcommands, including the Chief of Naval Technical Training and the Chief of Naval Aviation Training.

It is estimated that there are some 6000 training courses given in the U.S. Navy and that under the new training command organization, some 50 percent of these are to be given by the Naval Technical Training Command. They include most of the basic skills courses; the courses with the "B" designator, originated by the Bureau of Medicine and Surgery, are the exception.

For this report, the information on training time, cost, number of trainees, and related course descriptions is data derived from several Navy sources. All of the courses analyzed in this report for potential application of I.T. have either an "A" or "C" preceding the numerical digits of the course number. Their course descriptions were taken from school catalogs published by the Bureau of Naval Personnel and the Naval Air Training Command.

The data on trainees graduated from the courses were taken from the Naval Technical Training Command computer printout headed "Basic Level Training Data." For example, for the basic technical training course for electronic technicians for Course A-100-0012, the same course curricula, content, and length are given at the Service Schools Commands at Great Lakes and San Diego. At San Diego the course identifier is A-100-0013. For the purposes of the present study, Courses A-100-0012 and A-100-0013 are treated as separate data entries. The actual number of trainees graduated from both courses is taken from the first quarterly reports of fiscal year 1972-1973. This number is multiplied by four to obtain the total year's estimated throughput for the two courses.

These printouts, made available by the Naval Technical Training Command, are summaries of information that originates at the classroom level. Figure 10 is an example of the source document from which these summarized data are compiled. This form is the basic report prepared at the school level.

From the Bureau of Naval Personnel Formal Schools Catalog, the course descriptions of these same two courses--A-100-0012 and A-100-0013--given at two locations are obtained. For courses with a "C" designation, an example would be C-000-2012, which was selected from the school catalog of the Naval Air Training Command. It is an example of a short course, (3 weeks) that has a high throughput. The estimated number of fiscal 1972-1973 graduates is calculated as four times the cumulative graduates shown for the first quarter (available data at this time), or about 6500.

To assign costs for the above "A" and "C" courses, the researcher must refer to another Navy publication, since costs are not typically reported and summarized on a course-by-course basis in the various commands where training is given. However, an annual cost study performed by the Bureau of Naval Personnel makes possible the assignment of some selected raw cost data on a course-by-course basis. As an example of the procedure used for the Navy data under the ET-1501 rating, a 13-week course in the ET-A school for the E-2 phase shows a total cost per student (including school, military pay, and leave costs) of $1,588, or $1,588/13 = $122 per week. This cost per week is multiplied by the course length, in weeks, to yield the estimated training cost for the course.

The second sample course is entitled "Aviation Mechanical Fundamentals Course," C-000-2012. During the first quarter of 1972, 1626

NTECHTRACOM SCHOOL/COURSE REPORT
CNTECHTRA 1500-6

LOCATION	UIC	SCHOOL	TPC
TYPE COURSE	COURSE IDENT A-100-0017	DATE M/Y 0772	DIR/IND

SERVICE GROUP

		USN		USNR		USCG		USMC/R		FOR/NAT	OTHER
		OFF	ENL	OFF	ENL	OFF	ENL	OFF	ENL		
STUDENT	PLANNED INPUT		97								
	ACTUAL INPUT		113		4					9	
	BLOCK INPUT	0									
	GRADUATED		102							5	
	ACADEMIC DROPS		6								
	NON ACAD DROPS		10								
	ACADEMIC SETBACKS	0									
	NON ACAD SETBACKS		33								
	UNDER INSTRUCTION		254		15					16	
	AWAITING INSTRUCTION	0									
	AWAITING TRANSFER	0									

			USN/R		USCG		USMC/R		OTHER ← (Civ. Inst.)
SUPPORT	INSTRUCTOR	REQUIREMENT		27					3
		ALLOWANCE		34					8
		ON BOARD		27					7
	ADMINST	ALLOWANCE	0						
		ON BOARD		1					

		USN	USMC	OTHER
AWAITING INSTRUCTION	MESS COOKS	0		
	COMPARTMENT CLEANERS	0		
	BACKLOGGED	0		
	ALL OTHER	0		
AVERAGE U/I		285	1	

REMARKS

CNTECHTRA GEN 1500/6 (5-72)

SA-1775-7

FIGURE 10 SAMPLE NAVY SCHOOL COURSE REPORT trainees graduated. Some 6500 are expected to graduate if the first quarter rate is maintained for a year. The per week cost for the AMFU course assigned to these 6500 trainees for the purpose of an annual estimated cost is $429/3, or $143 per week.

Annex to Appendix B

STANDARD METHODOLOGY USED TO DETERMINE THE COST PER GRADUATE

FOR ALL CONARC SCHOOLS AND ARMY TRAINING CENTERS

Preceding page blank

Annex to Appendix B

STANDARD METHODOLOGY USED TO DETERMINE THE COST PER GRADUATE
FOR ALL CONARC SCHOOLS AND ARMY TRAINING CENTERS

1. Purpose.

a. To provide CONARC School Commandants with detailed cost analyses and costs per graduate for each course taught in their respective schools.

b. To provide ATC, installation and CONUSA commanders with detailed cost analyses and costs per graduate for each ATP conducted at USATC's under their command.

c. To furnish the Comptroller of the Army and DCSPER, DA costs relative to individual training conducted throughout CONARC.

2. Data Sources.

a. Direct OMA and MPA cost data, ammunition expenditures, student/trainee input-output data, attrition, POI hours per course and other pertinent data related to the various training activities is furnished this headquarters by the respective Schools and USATC's in accordance with instructions contained in letter, this headquarters, 21 July 1971, subject: CONARC Cost Analysis Requirements (RCS ATCOM-159).

b. Expense, workload, workforce, population and other data used in the development of indirect (base operations and support) costs is furnished to this headquarters by the installations upon which training activities are located in accordance with letter, this headquarters, 21 July 1971, subject: CONARC Cost Analysis Requirements (RCS ATCOM-159).

c. Installation and activity mechanized Prior Year Reports.

3. Methods of Computing Costs per Graduate.

a. Computation of direct costs.

(1) Student pay and allowances. Course length in weeks X weekly rate for modal grade of student (AR 37-29) = per graduate cost. NOTE: In computing ATC costs consideration must be given to time spent by trainee in awaiting start of training and time between completion of training and shipment.

(2) Travel pay to course. Average one-way mileage (determined from sample of student records) X $.06 = travel pay per graduate.

NOTE: Travel from course is picked up in costing of units or next place of recruit training.

Preceding page blank

(3) Per diem at course (TDY courses only).

(a) Officer. Course length in weeks X $35.00 = cost per graduate (if quarters are available, if not, per diem rate must be obtained).

(b) EM. Course length in weeks X $14.00 = cost per graduate.

(4) Instructional departmental costs and ATC direct instructional costs.

(a) MPA - Compute total military pay cost of each Instructional Dept, including instructors, departmental overhead, command control, etc.

NOTE: Information is furnished in school/ATC reports in the form of yearly military pay costs or by average assigned strength by grade for the FY.

1 Compute number of classes for each course taught. Number of classes = ½ classes started in FY + ½ classes completed in FY.

2 Compute total POI hours per course. Total POI hours = POI hours per course X number of classes.

3 Compute POI hours per graduate. POI hours per graduate = total POI hours ÷ number of normalized graduates. Normalized graduates per course = actual graduates - ½ in training at beginning of FY + ½ in training at end of FY.

4 Complete steps (1) through (3) for each course.

5 Add total POI hours per course for each instructional department that expends any effort into a course.

6 Divide the total departmental MPA cost by the total POI hours of effort expended by that department to obtain the MPA cost per POI hour. Multiply the MPA cost per POI hour times the POI hours per graduate to obtain departmental cost per graduate for each department. Add the per graduate cost for each department to obtain total MPA instructional department cost per graduate.

(b) Repeat the same process to obtain the instructional department cost per graduate in categories of civilian pay, supplies and equipment and other OMA.

(5) School overhead and school support command or brigade.

(a) Determine total school overhead MPA, civilian pay, supplies and equipment and other. Includes Commandant, Office of the Secretary, DOI, supply and maintenance elements, administrative support, ETV, etc.

(b) Determine total manweeks of training per course and manweeks per graduate per course.

Total manweeks training per course = (normalized graduates + ½ attritions) X course length in weeks.

Total manweeks per graduate = total training manweeks per course ÷ normalized graduates per course.

(c) Divide each cost element for total school overhead by the grand total of training manweeks for the entire school to arrive at a school overhead cost per training manweek.

(d) Multiply the results times the manweeks per graduate for each course, and divide by the number of normalized graduates in each course to arrive at a cost per graduate by cost element.

(e) Repeat the same process for the cost elements for the school support command or school brigade.

(6) Ammunition - Total cost of ammunition expended per course ÷ normalized graduates per course = ammunition cost per graduate.

(7) Major PEMA item depreciation.

(a) Using acquisition costs for all PEMA items issued to each instructional dept, determine yearly amortization costs. Tanks, trucks, artillery pieces, etc. amortized over a 12 year period; tactical radios, small arms and other small items amortized in 5 years.

(b) Add yearly amortization costs for each dept to arrive at total equipment depreciation costs per dept.

(c) Divide department depreciation cost by total department POI hours to arrive at cost per POI hour.

(d) Multiply the cost per POI hou times the POI hours per graduate per course to arrive at department cost per graduate for each department.

(e) Add cost per graduate for each department to arrive at cost per graduate per course.

b. Computation of indirect costs.

(1) Indirect costs consist of a pro rata share of base operations, medical, training aids, family housing admin, and TOE support of training.

(2) To compute costs per graduate the following steps will be taken:

(a) Determine school/ATC share of base overhead in the following manner:

B0000, G0000, H0000, J0000 and N0000 - average population of school/ATC (including students, trainees, overhead, staff and faculty, etc.) ÷ total post population (assigned, attached, tenant units, TOE units, trainees, students, etc. minus those assigned to base operations accounts) = school/ATC percentage share of these accounts. NOTE: Rationale for this computation is that base overhead personnel and services are provided for tenants, schools, TOE units, etc., and that if these activities were not present, there would be no need for the base overhead. Therefore, base overhead is distributed to all activities on the installation other than the base overhead itself. Part of base administration is not distributed to maintenance and vice versa.

C0000 - End items processed for school/ATC ÷ (divided by total end items processed - those processed for base operations accts) = school/ATC percentage share of C0000.

K0000, L0000 and M0000 - square footage of bldgs and facilities assigned to school/ATC ÷ (total installation square footage - square footage assigned to base operations accts) = school/ATC percentage share of K0000, L0000 and M0000.

1900,720000, 840000, 390000, and 818097.2 use population calculations as indicated for B0000, G0000, etc., except in 840000 account include retirees and dependents in determining total installation population.

(b) Multiply percentages derived in paragraph 1 above times total installation civilian pay, supplies and equipment, other OMA, and MPA costs in the appropriate base operations accounts to arrive at school dollar share in each account.

(c) Divide school share of each account by total school/ATC manweeks of training to arrive at cost per manweek for each account.

(d) Multiply the cost per manweek for each account by the manweeks per graduate for each course to arrive at the cost per graduate.

(e) Add MPA costs and OMA costs for B0000 through N0000 to determine base operations cost per graduate in MPA, civilian pay, supplies and equipment, and other.

(f) Installation mission costs are displayed separately in OMA and MPA for each account.

(3) TOE Support Costs.

(a) Personnel.

1 Compute mandays by grade devoted to each course.

2 Multiply by number of classes.

3 Multiply result obtained in 2 above by daily pay rate to arrive at cost by grade.

4 Sum costs for all grades of TOE personnel supporting courses.

5 Divide result by number of normalized graduates to arrive at TOE, MPA support cost per graduate.

6 Repeat for each course that receives TOE support.

(b) Equipment.

1 Determine equipment days by type utilized by TOE units in support of each course.

2 Multiply by number of classes.

3 Compute daily depreciation costs for each piece of equipment. (Acquisition cost ÷ amortization period in years ÷ 365 = daily depreciation.)

4 Multiply results obtained in 2 by 3 to obtain total depreciation cost by equipment type.

5 Sum costs for all equipments used in support of course.

6 Divide by number of normalized graduates to arrive at PEMA equipment cost per student.

7 Repeat for each course.

c. Total and variable direct (mission) and indirect (base operations).

(1) Mission costs.

(a) Using student manyears (average yearly student load) as the independent variable and OMA mission costs for each school and training center as the dependent variable, perform a 2 variable linear regression with 5 years of data available in the CONARC data bank. (NOTE: This has already been accomplished for OMA, utilizing 4 years of data in the development of budget cost factors.) Determine the fixed OMA cost and the variable cost per student/trainee year.

(b) The slope of the regression line (b in the equation $Y = a + bx$) will represent the variable cost per student year.

(c) Using the same technique as described in (a) and (b) above, determine the fixed cost and variable MPA cost per student manyear. Total MPA for the school or training center will be used as the dependent variable. NOTE: Student pay and allowances and per diem, when authorized, will be added to the variable MPA cost per student/trainee.

(d) Using the fixed OMA and MPA costs developed for each school and ATC by the 2 variable regression directed in c, (1) (a) and (c) above, compute the variable cost per student per course in the following manner:

Total fixed cost for school or ATC	= $2,500,000
Total student manyears for entire school or ATC	= 3,000
Student manyears for course X	= 120
Percent of fixed cost attributable to course X	$= \frac{120}{3000}$ = .4 percent

Fixed Cost for Course X = $ 10,000
Total cost for Course X (determined in para 5b) = $120,000
Variable cost for Course X = $120,000 - $10,000 = $110,000
Normalized graduates Course X = 250
Variable cost per graduate for Course X = $\frac{\$110,000}{250}$ = $440

(e) The accuracy and validity of the fixed and variable breakout will be tested in the following manner:

Fixed cost per student per course X number of normalized graduates = fixed cost per course.

Summation of fixed cost per course for all courses = total fixed cost for school/ATC.

Variable cost per student per course X number of normalized graduates = variable cost per course.

Summation of variable costs per course = total variable cost for school/ATC.

Total fixed cost for school or ATC + total variable cost for school or ATC = total computed cost.

Total computed cost = total reported cost for school or ATC.

(f) PEMA costs per student will not be broken out into fixed and variable segments. PEMA costs attributable to a student/trainee are those generated by expenditure of ammunition and depreciation of major items of equipment used in training. Ammunition is normally used by the student/trainee and no portions of it can reasonably be allocated to the "fixed" element of a school, training center or department. Therefore, it will all be considered as a total cost directly chargeable to the student/trainee and the amount expended per course or ATP will depend on the student/trainee input. PEMA equipment issued to a school or training center depreciates at a rate that is dependent upon its expected usable life and its intensity of use, however, many items of equipment become obsolete prior to "wear out" from use by students and trainees. Under these conditions, that is when the equipment is depreciating at some unknown rate merely because it has been issued to a school or training center regardless of its use by students/trainees, there is no known accurate method for determining that portion of depreciation costs which are fixed and that portion which vary with student/trainee load and hence, intensity of use. Therefore, costs related to depreciation of equipment used in training will be computed in total only.

(2) Base operations costs.

(a) Fixed and variable base operations OMA cost factors developed during the Maroun Study, and which are to be refined and updated in accordance with DA letter, ACAA COMPT-SP, 2 Apr 71, subject: Analysis of CONARC Base Operations Funding (Maroun Study) will be used as a base point for determining the variable portion of base operations costs attributable to each student/trainee in each course or ATP. The following specific methodology will be employed:

Total base operations OMA cost per graduate per course/ATP = derived from Cost Analysis Studies of Schools and Training Centers (para 5b).

Variable base operations OMA cost per graduate per course - variable cost is obtained from slope of regression line for base operations of installation upon which school or ATC is located.

Variable cost per student per course will be computed as indicated in the following manner:

Variable OMA Base Opns Cost per MMY = \$400
Course Length for Course X = 20 weeks
Military Manyear = 52 weeks
Variable Cost per Student for Course X = $\frac{20}{52}$ x \$400 = \$153.85

(b) The methodology outlined in (a) above will also be employed in determining the total and variable base operations MPA cost per student/trainee per course/ATP.

(c) Upon completion of the current Program 8M cost study, a methodology will be developed which will provide for the allocation of total and variable medical costs to each student/trainee graduated from CONARC schools and training centers. The methodology developed will be appended to this plan.

4. Fixed and Variable Cost Data Display. Mission and base operations fixed costs and variable costs will be summed so that there will be 5 cost elements for each course or ATP as follows: Fixed OMA cost, variable OMA cost, fixed MPA cost, variable MPA cost and PEMA cost.

5. Data Adjustments.

a. Where properly and adequately identified data has been adjusted to insure that to the maximum extent possible only those costs that contributed directly to resident instruction have been allocated to courses. Examples of adjustments are:

(1) Exclusion of OMA and MPA costs incurred by non-resident instruction departments.

(2) Exclusion of personnel, supply and travel costs incurred by an instructional department in setting up new courses to be taught in subsequent FY's but not taught in year being analyzed.

(3) Allocations of contract maintenance or instruction costs only to those courses receiving benefits from same.

b. All dollars used in this analysis have been inflated to the FY 72 level.

6. Attached at Inclosure 1 are costs per graduate/trainee for each course taught during FY 71, broken out by direct and indirect in the three appropriations of OMA, MPA and PEMA, and further broken out by total fixed and variable in OMA and PEMA.

Appendix C

COMPUTER PRINTOUTS

(This appendix is bound separately as Volume II.)

Appendix D

EXPERIMENTAL VALUES OF δ(CT)

Preceding page blank

DEPARTMENT OF THE AIR FORCE
AFHRL TECHNICAL TRAINING DIVISION (AFSC)
LOWRY AIR FORCE BASE, COLORADO 80230

20 October 1972

Thomas Marshall
Stanford Research Institute
Menlo Park, CA 94025

Dear Tom:

As indicated in our telecon, I am sending along some material to assist you in your effort to document cost savings made through the application of instructional technology.

Four separate studies are covered in this letter, two of which are in the final stages of completion just before publication, while the other two are already documented as Technical Reports. Let me begin by describing the former two in some detail.

These two contracts have been completed in the Precision Measurement Equipment (PME) course and the Inventory Management (IM) course here at Lowry. Each contract dealt with only selected units of instruction in each course. The first completed contract resulted in the individualization of one block of instruction in the PME course. The work was done by Logos, Inc. The second contract resulted in the individualization of selected lessons in Blocks I and III and all of Block IV in the IM course. This work was done by the System Development Corporation.

The block of instruction individualized in the PME course covered two major skills-precision soldering and troubleshooting electronic test devices. The main purpose of the contracted effort was to determine feasibility of individualizing the particular class of materials found in the selected block of instruction and not with trying to compare group with individualized instruction. Logos developed a highly mediated set of lesson materials to teach the task of precision soldering. Their approach involved the use of tape cassettes, 8mm film loops, and picture books in addition to the normal technical equipment needed to perform this type of task. The instructional strategy for teaching precision soldering centered on the use of an imitative mastery model. Implementation of the developed materials showed that all students were able to achieve the stated objectives with an average 40% savings in time. Since criterion testing was utilized, no direct performance comparison can be made to the group instruction. With criterion testing, a student was not allowed to proceed until he achieved a stated objective; thus, for all students, a 100% level of achievement was recorded. An important measure under criterion testing is the number of times it takes a student to reach the objective(s). For the precision soldering lessons, the minimum total trials to criterion is 14. The average total trials to criterion attained was 18.6. A further breakdown of this information is provided in attachment 1.

Preceding page blank

Logos used an instructional strategy based on the use of algorithms to teach troubleshooting of precision test equipment. This methodology resulted in a 38% savings in instructional time with all students achieving the stated criterion objectives. The algorithmic method relied heavily on the use of printed materials and required frequent involvement of instructors to set up training equipment for the student's use. Instead of the instructor setting up equipment once for a group of students, the individualization of instruction required an instructor to inject a malfunction in a piece of test equipment for each student. The management burden resulting from this situation tended to negate the efficiency gains on the part of the students. Attachment 2 gives the times to mastery for troubleshooting.

In the Inventory Management (IM) course, the last block of instruction (Block IV) and a total of five lessons in Blocks I and III were individualized. Except for one lesson that dealt with the use of a teletype terminal, the material taught in the selected IM lessons was conceptual in nature and involved procedural learning tasks. The main body of all lessons was taught through the use of programmed texts which allowed branching within themselves. Selected lessons also had a sound/slide presentation which served as both an advance organizer and as a review item. The results of the SDC contract are summarized in attachment 3-6.

Attachments 3 and 4 give the results for the small group validation of the IM instructional materials. Attachments 5 and 6 give the results for the large group operational tryout of the materials and, in addition, allow comparison of the small group results with the large group results. Large group, operational tryout of instructional materials only occurred for Block IV. The results of the operational tryout showed a 47% savings in time with a 91% average achievement score. The conclusion that can be drawn from the work done in the PME and IM courses is that individualization of instruction can reduce or eliminate inefficiencies that are inherent in group instruction resulting in considerable reduction of training time without any loss in achievement.

The second pair of studies will be discussed only briefly. Abstracts and summaries of these studies are included as attachments 7 and 8. Attachment 7 deals with the training of Medical helpers at Sheppard AFB. Note that only a very small portion of the course was altered via the introduction of audio-visual techniques; namely, a single chapter from a programmed text. The major benefit was time saved through elimination of redundancy. With respect to the two training methods, there were nonsignificant differences in performance on a test covering the material taught. The 75% time savings claimed here can be generalized only with caution.

Attachment 8 is included to point up a problem of which I am sure you are aware. Here there was no time saved (in fact, on the average, the amount of time spent reading the material doubled), but statistically significant gains in performance were registered. How to evaluate gains in performance using a dollar criterion remains a major obstacle to assessing the overall cost effectiveness of introducing instructional innovation.

Incidentally, during my visit to Randolph earlier this week, I alerted Chet Bueker and Don Meyer that you might be contacting them. If you have any questions regarding the attached material, or we can be of assistance in any other way, feel free to give me a call.

Most cordially,

Marty R. Rockway

MARTY R. ROCKWAY
Technical Director

8 Atch

TABLE VI

TRIALS TO MASTER

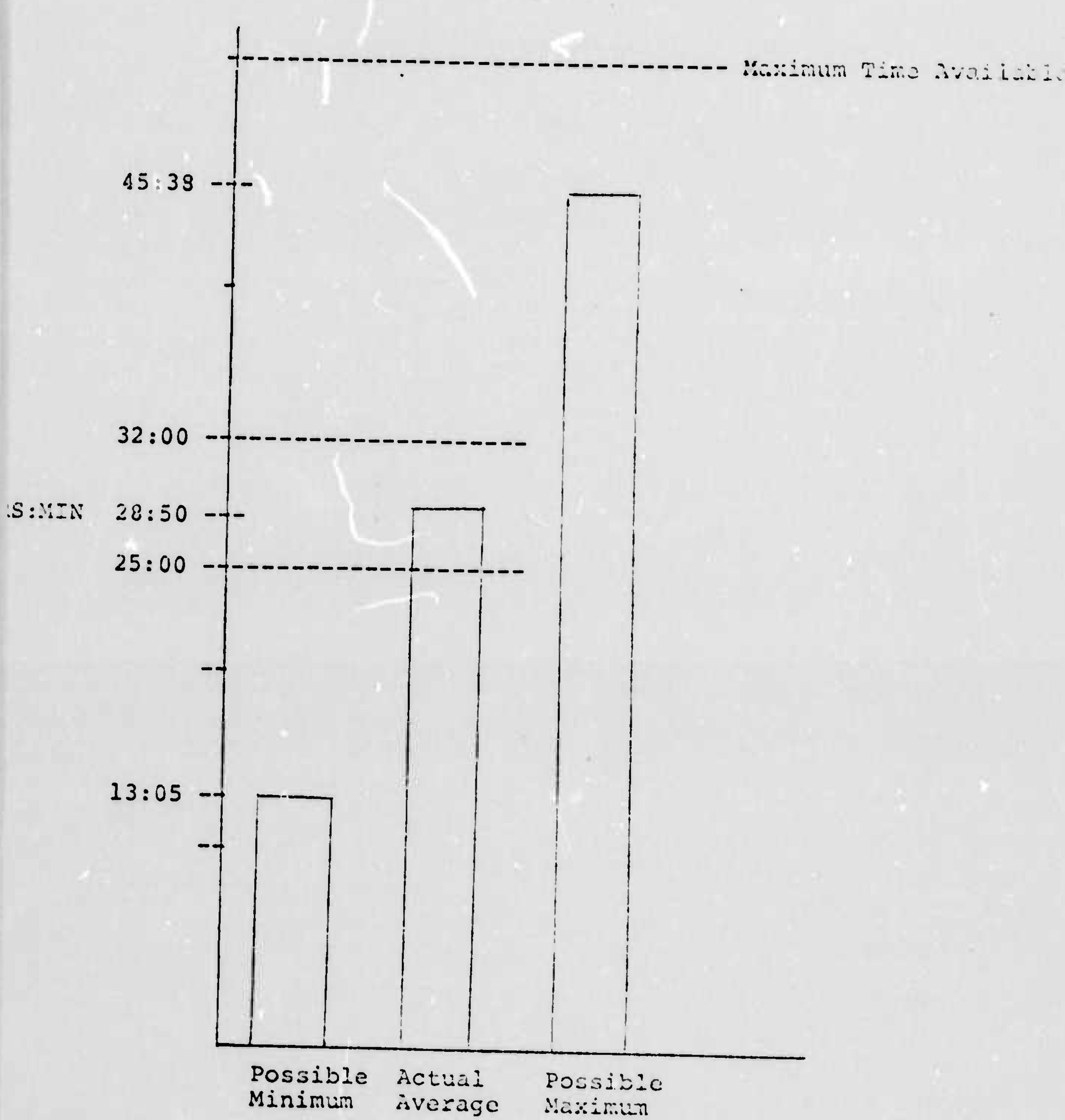
Soldering Criteria	Classes					Total N=62	[illegible] Criter[illegible]
	N=12	N=13	N=13	N=13	N=11		
Tinning Leads	15	27	13	17	26	98	1.580[illegible]
45° Tip	14	19	13	21	15	82	1.322[illegible]
Single Hook	16	22	13	41	16	108	1.741[illegible]
Double Hook	15	20	13	23	19	90	1.45[illegible]
Single Turret	12	22	13	21	13	81	1.306[illegible]
Double Turret	13	15	13	26	16	83	1.3387
Resistor 1W	15	19	13	13	15	75	1.20[illegible]
Resistor 1/2W	14	25	13	15	13	80	1.290[illegible]
Resistor 1/4W	12	21	13	13	13	72	1.161[illegible]
Buss Wires	12	24	13	13	14	76	1.22[illegible]
Transistor	14	25	13	15	16	83	[illegible].33[illegible]
Conical Tip	16	19	13	15	14	77	1.2419
Flat Pack	17	19	13	13	15	77	1.2419
Connector(s)	16	18	13	13	13	73	1.1774
TOTAL TRIALS	201	295	182	259	218	1155	18.6265

Minimum Trials Possible (N x 14)	168	182	182	182	154	868

Average Trials to Criterion	1.196	1.621	1.000	1.423	1.416	1.33[illegible]

ATTACHMENT 1

TIMES TO MASTERY--TROUBLESHOOTING



ATTACHMENT 2

Figure 4-6

Table III-10. Stage 2 Validation Student Performance Data Summary

Block I-III Lesson	Student	Total Wrong	Total % Correct	Lesson Item N	Lesson Mean Score
A	1	3	90		
	2	2	93		
	3	4	88	31	87
	4	5*	71*		
B	5	22	73		
	6	13	84		
	7	7	91	82	87
	8	2	98		
C	9	1	97		
	10	0	100	29	89
	11	11	62		
	12	1	97		
D	13	12	83	71	88
	14	5	93		
	15	12	83		
	16	4	94.5		
E	17	1	96		
	18	0	100	25	97
	19	1	96		
	20	1	96		

*Incomplete data, based on N of 17 enabling items.

Block IV Lesson	Student	Total Wrong	Total % Correct	Lesson Item N	Lesson Mean Score
1	1	6	71		
	2	6	70		
	3	2	90	21	77
	4	5	76		
2	1	21	66		
	2	19	69	62	72
	3	8	87		
	4	21	66		
3	5	4	92.5		
	6	8	85	53	[illegible]
	7	11	79		
	8	9	83		
4	5	6	85		
	6	3	93	41	[illegible]
	7	4	90		
	8	6	85		
5	5	4	93		
	6	7	87	55	[illegible]
	7	8	85		
	8	5	91		
6	5	15	80		
	6	12	84	75	[illegible]
	7	17	77		
	8	20	73		
7	5	8	74		
	6	9	71	31	70
	7	10	68		
	8	10	68		
8	5	4	79		
	6	2	89.5	19	87
	7	0	100		
	8	4	79		

ATTACH 3

Table III-11. Stage 2 Validation Student Learning Time Data Summary

BLOCK I-III TOTALS

Lesson	Student	Intro.	Material	Tests	Class Hrs.	% Saved	M % Saved
A	1	15	1:17	16	3	57	49
	2	9	1:14	21		59	
	3	16	2:19	16		23	
	4	16	1:20	14		56	
B	5	6	3:48	1:39	12	68	70
	6	6	3:44	1:10		69	
	7	6	3:34	1:03		70	
	8	7	3:06	52		74	
C	9	7	1:54	18	3	37	34
	10	8	2:04	11		31	
	11	12	2:18	14		23	
	12	8	1:38	13		40	
D	13	10	5:00	53	8	38	39
	14	7	4:32	53		45	
	15	10	4:44	1:05		41	
	16	7	5:26	1:01		32	
E	17	9	1:31	14	4	38	39.5
	18	3	1:37	18		40	
	19	9	1:35	11		40	
	20	6	1:35	14		40	

BLOCK IV TOTALS

Lesson	Student	Intro.	Material	Tests	Class Hrs.	% Saved	M % Saved
1	1	18	1:14	13	3	63	59
	2	12	1:36	17		47	
	3	3	1:19	16		56	
	4	5	53	17		70	
2	1	13	5:04	57	9	41	43
	2	14	3:34	1:29		58	
	3	15	5:23	1:17		37	
	4	18	5:26	1:27		36	
3	5	16	2:39	37	9	71	71
	6	12	2:29	30		72	
	7	13	2:49	35		69	
	8	20	2:36	48		71	
4	5	3	2:27	21	6	59	66.5
	6	2	1:49	23		70	
	7	2	2:04	32		66	
	8	1	2:19	35		61	
5	5	0	2:07	30	6	65	66
	6	3	1:47	23		70	
	7	1	1:55	23		62	
	8	2	2:04	26		66	
6	5	0	1:50	35	6	69	71
	6	1	1:28	22		76	
	7	0	1:51	30		69	
	8	0	1:53	46		69	
7	5	-	46	21	3	72	67
	6	-	54	18		70	
	7	-	1:07	26		63	
	8	-	1:11	18		62	
8	5	-	17	10	3	91	89.5
	6	-	21	7		88	
	7	-	18	10		90	
	8	-	19	8		89	

Table III-15. Small/Large Group Performance Comparison

Block IV Lesson	Small Group Tryout (Stage 2)			Large Group Tryout (Stage 3)			Improvement in Performance in Stage 3
	Number of Students	Lesson Item Number	Lesson Mean Score	Number of Students	Lesson Item Number	Lesson Mean Score	
1	4	21	77	20	21	93	+ 16%
2	4	61	72	20	60	89	+ 17%
3	4	53	85	20	53	92	+ 7%
4	4	41	88	20	46	93	+ 5%
5	4	55	89	20	56	90	+ 1%
6	4	75	79	20	76	91	+ 12%
7	4	31	70	20	41	85	+ 15%
8	4	19	87	20	19	96	+ 9%
Grand Mean Score			81			91	+ 10%

Table III-16 presents summary learning time data for the eight Block IV lessons. Raw learning time data for each student are located in Appendix C of this report.

Table III-16. Stage 3 Validation Student Learning Time Data Summary

Block IV Lesson	Mean Learning Time (N=20)	Current Class Hours	Mean % Saved
1	1:23	3	54
2	7:06	9	21
3	4:24	9	53
4	3:01	6	50
5	2:40	6	56
6	3:13	6	46
7	1:38	3	46
8	0:33	3	82
	23:58	45	47

ATTACH 5

Table III-17 compares time savings occurring in the Stage 2 validation with those in the Stage 3 validation.

Table III-17. Small/Large Group Time Savings Comparison

Block IV Lesson	Small Group (Stage 2) Time Savings Mean %	Large Group (Stage 3) Time Savings Mean %	Difference Stage 3 Minus Stage 2 %
1	59	54	- 5
2	43	21	- 22
3	71	53	- 18
4	665	50	-165
5	66	56	- 10
6	71	46	- 35
7	67	46	- 21
8	89.5	82	- 7.5
	66	47	- 19

As shown in the table, time savings in the large group trials were not nearly so dramatic as those in the small group trials, although the savings for the large group trials more than meet the criterion established, which was 30%. The Stage 3 time savings are more realistic predictors of lesson times in the course as it will be given, since conditions in the Stage 3 trials more nearly approximate actual course conditions.

Student attitude data are summarized in Table III-18.

Attach 6

ABSTRACT

This study evaluated the learning efficiency and effectiveness of teaching an anatomical and physiological system to Air Force enlisted trainees utilizing an experimental audio-visual programmed module and a commercial linear programmed text. It was demonstrated that the audio-visual programmed approach to training was more efficient than and equally as effective as the programmed text approach to training. It was determined that trainees of different learning abilities acquired as much knowledge about the digestive system from viewing the 20-minute audio-visual module as from interacting for 80 to 120 minutes with the programmed text. It was established that students who differed in their mastery of the rudiments of anatomy, physiology, and medical terminology performed equally well after audio-visual instruction or after written programmed instruction. It was found that trainees reported more positive reactions to the audio-visual program than to the written program. It was recommended that within the Medical Service Fundamentals Course audio-visual programmed instruction be emphasized and written linear programmed instruction be de-emphasized.

ATTACHMENT 7

SUMMARY

Federico, P.A. *Evaluating an experimental audio-visual module programmed to teach a basic anatomical and physiological system.* AFHRL-TR-71-37. Lowry AFB Colorado: Technical Training Division, Air Force Human Resources Laboratory, July 1971.

Problem

Air Force enlisted medical and dental personnel begin their training with the Medical Service Fundamentals Course at the Medical Service School (MSS), Sheppard Air Force Base, Texas. Included in the core curriculum are units of instruction planned to teach rudiments of medical terminology, anatomy, and physiology. Currently, MSS is using a linear programmed text to teach these subjects which are needed as a basis for understanding structures and functions of major mechanical and chemical systems of the human body. Despite precautions taken by the author of this text, training managers at the MSS were concerned that some of their less literate trainees were having difficulty following the programmed text. It was thought that students were not given sufficient exposure to audio-visuals to enable them to view subject matter in an integrated way, or to understand its overall organization. The primary purpose of this study was to determine whether a newly developed audio-visual programmed module was more effective and efficient than the currently used programmed text for teaching an instructional segment on the digestive system in the course. A secondary purpose was to estimate student opinions and reactions to this audio-visual programmed approach of teaching this system, as opposed to the written programmed approach.

Approach

An audio-visual programmed module was developed to teach the rudiments of the digestive system. It consisted of synchronized 35mm color slides and an audio-visual tape; and it covered the same enabling objectives as the corresponding chapter from a linear programmed text. However, the script was not as redundant as the written programmed material. Air Force enlisted trainees had been randomly and previously placed into four classes; and educational media were randomly assigned to these classes according to a Solomon four-group experimental design. Statistical comparisons of the groups were made in terms of posttest performance. Also, a theme analysis was conducted of student reactions and opinions toward the audio-visual program and written program.

Results

It was demonstrated that the audio-visual programmed approach to training was more efficient than and equally as effective as the programmed text approach. It was possible to reduce the duration of a lesson as much as 75 to 83 percent while still maintaining its effectiveness by using a minimally redundant audio-visual instructional module. Trainees of different intellectual abilities acquired as much knowledge about the digestive system from viewing the 20-minute audio-visual module as from interacting for 80 to 120 minutes with the programmed text. Students who differed in their mastery of the rudiments of anatomy, physiology, and medical terminology performed equally well after audio-visual instruction or after written programmed instruction. Trainees reported more positive reaction to the audio-visual program than to the written program.

Conclusions

In view of the findings, it was recommended that within the Medical Service Fundamentals Course the utilization of audio-visual programs be maximized and the utilization of written programs be minimized.

This summary was prepared by Pat-Anthony Federico, Technical Training Division, Air Force Human Resources Laboratory.

ABSTRACT

The present study was designed to determine if modifying career development course (CDC) format through the simplification of the written materials, the inclusion of more illustrations, and the addition of audio supplementation could improve the CDC as a training device designed to teach basic job information, especially to airmen possessing minimum verbal skills. High, middle, and low aptitude personnel studied three versions of the CDC for the 57130, Fire Protection, career ladder. In brief, the versions included a conventional CDC, a less verbal CDC with more pictorial materials, and a less verbal CDC with more pictorial materials accompanied by a tape recording of information complementary to that contained in the written text of the CDC. Data were collected on learning performance, reading speeds, and attitudes toward the CDCs. The analyses revealed that the modified CDC with the audio supplementation produced significantly increased learning scores. High and middle aptitude groups consistently outperformed the low aptitude groups across all CDCs.

ATTACHMENT 8

SUMMARY

Sellman, Wayne S. *Effectiveness of experimental training materials for low ability airmen.* AFHRL-TR-70-16. Lowry AFB, Colo.: Technical Training Division, Air Force Human Resources Laboratory, June 1970.

Problem

With the influx of New Mental Standards airmen, many Air Force training experts have expressed concern that existing career development courses (CDCs) are written at a level which is too difficult to be a satisfactory training device. Recognizing the need for training materials appropriate for use by low aptitude personnel, CDC writers at Chanute Technical Training Center developed a new CDC format expressly designed to reduce some of the learning skill requirements imposed by conventional CDCs. The present study was designed to determine if modifying CDC format through the simplification of written materials and addition of audio supplementation could improve the CDC as a training device. The experimental CDC was especially designed as an aid to teach basic job information to airmen possessing minimal verbal skills.

Approach

One hundred eighty technical school students at Lowry Air Force Base, Colorado, subdivided into high, middle, and low aptitude groupings, served as experimental subjects. Mental category status of each airman was defined in terms of his score on the Armed Forces Qualification Test (AFQT), the measuring instrument used to determine whether or not an individual meets acceptable mental standards for induction or enlistment. Three versions of the CDC for the 57130, Fire Protection, career ladder were used in the study: (*a*) a conventional CDC as published by the Extension Course Institute and used Air Force-wide for on-the-job training, (*b*) an experimental CDC with lowered reading requirements, additional illustrations, and a double-spaced, single column format, and (*c*) the same experimental CDC with an accompanying tape recording which reiterated material presented in the CDC. Criterion measures included a fire protection achievement test, the length of time required to read the CDC, and a questionnaire concerning subject attitude toward the CDC. Twenty subjects from each mental ability category were asked to study each CDC and respond to the test and attitude questionnaire.

Results

The results indicated that modifying the conventional CDC by reducing the reading level, augmenting the number of illustrations, and changing the format to a single column, double-spaced page produced statistically significant differences in learning scores. Middle and low aptitude personnel showed greatest learning using the CDC with audio supplementation. High ability personnel showed only slight differences across all CDCs. High and middle aptitude personnel consistently outperformed the low aptitude group across all CDCs, and they demonstrated faster reading times as well.

Conclusions

CDCs should be written at a reading level appropriate for the majority of airmen in the career ladder. Additional illustrations and pictorial materials also seem necessary. The comparisons of CDCs indicated that most personnel learned more when using the CDC with audio supplementation. However, more definitive research and analyses must be completed to determine if this will be a continuing trend across all aptitude ranges and career ladders.

This summary was prepared by Wayne S. Sellman, Technical Training Division, Air Force Human Resources Laboratory.