Research Note 85-42

Job Skills Education Program: Cost Benefit Tradeoff Analysis

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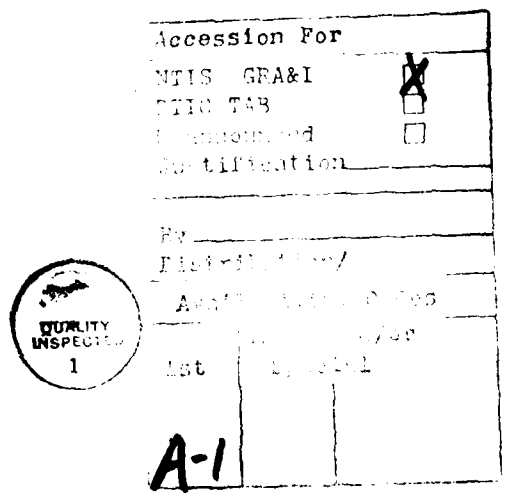

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Beatrice J. Farr, contracting officer's representative. This report, together with RNs 85-22, 85-37, 85-40, 85-41, 85-43, 85-44, 85-45, 85-46, and 85-47, forms part of a series on the Army's Job Skills Education Program (JSEP).

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Computer Based Instruction (CBI)
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Job Skills Education Program (JSEP) is designed to provide soldiers with the prerequisite knowledge and skills required for successfully learning their Military Occupational Specialties (MOS). When the JSEP is put into effect, it will replace the Army's current Basic Skills Education Program (BSEP) with a sophisticated, computer-based system.

This report presents descriptions of costs of two Computer-Based Instruction (CBI) systems (PLATO and MicroTICCIT). The advantages and (Continued)

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20. (Continued)

limitations of various options and features available with the two systems are discussed and, where applicable, priced. Options and features include video and/or audio capabilities, printers, color, and resolution among others.

FOREWORD

The Job Skills Education Program (JSEP) is a multi-phase program begun in Fiscal Year 1982, and designed to enhance enlisted career potential by improving soldier job performance. The sponsor, the Education Division, Office of the Deputy Chief of Staff for Personnel, expects JSEP to replace the Army's current Basic Skills Education Program when it is implemented.

The JSEP program, being developed by Florida State University (FSU) will result in a standardized curriculum for soldiers who demonstrate deficiencies in the knowledge and skills required to successfully learn their Military Occupational Specialty (MOS).

In accordance with current policy, JSEP will be an on-duty program. It will also use a computer-based management system to facilitate an open entry/open exit approach. At present, most of the lessons being developed will be computer delivered; however, the plan calls for using existing materials, and incorporating materials developed as part of other ARI efforts, whenever appropriate.

A unique aspect of JSEP is that it builds upon a very detailed front-end analysis of MOS Baseline Skills. The analysis covered tasks performed by soldiers in the 94 highest density MOSs, in addition to Common Tasks (the skills that all soldiers, regardless of their MOS, need to know). Although the Army has over 300 MOSs, the 94 covered in the analysis represent about 80% of all soldiers. Perhaps the most useful product developed for the analysis was a taxonomy listing more than 200 prerequisite competencies.(P.C.) for these MOSs. The competencies were derived from detailed reviews of Soldier Manuals, and from extensive interviews with subject-matter experts at Army schools. This effort produced a series of tests intended to diagnose deficiencies in the P.C.s. Modified versions of these tests will be used in JSEP.

The JSEP program will include a front-end learning strategies module designed to improve soldier skills in reading, studying, test taking, and problem solving. The curriculum will consist of this strategies-training, plus 180 diagnostic review lessons, and 120 skill development lessons, which are being developed for the PLATO and MicroTICCIT computer systems. The program is being tried out at two TRADOC sites and two FORSCOM sites, prior to an Army-wide phased implementation.

DEVELOP COST BENEFIT TRADEOFF ANALYSIS

EXECUTIVE SUMMARY

Requirement:

To develop a list of options available with computer based instruction (CBI), their advantages and limitations with respect to JSEP, and their costs for varying numbers of units or systems.

Procedure:

The contractor conducted a review of the literature relevant to CBI and consulted with educators, psychologists, instructional systems designers, and computer scientists in academia and private industry.

Findings:

The options applicable to JSEP are whether to incorporate an audio or video capability into the instruction, whether to make hard copy (printer/plotter) available, whether to use color, and some environmental considerations of the classroom.

There are certain features (adequate screen resolution and partitioning and comparable graphics, text, and student response facilities) on the systems studied.

The advantages and limitations of the options and features are discussed and, where applicable, cost estimates are provided. This report will enable US Army decision-makers to determine the configuration of JSEP.

Utilization of Findings:

The cost data will be used in models of possible configurations to compare costs of various systems.

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DEVELOP COST BENEFIT TRADEOFF ANALYSIS (CBTA)

OVERVIEW

Operational Problem

Soldiers must be trained so that each Army job is performed competently--regardless of differences in ability and background of new accessions. To accept a lower performance level would cause many mission elements to fail. Many Army jobs are increasingly dependent upon the soldier's ability to use high technology and to learn new technology as it develops. Soldiers, therefore, need more than training. They need enough education to learn subsequent jobs, to become eligible for promotion, and, ultimately, to provide leadership for tomorrow's Army.

The Job Skills Education Program (JSEP) is designed to teach soldiers basic educational skills (that is, reading, arithmetic) that are prerequisites for learning skill level 1 and 2 job tasks during first duty assignments. An extensive job analysis by RCA Educational Services of the 94 most populous Military Occupational Specialties (MOS), and tasks contained in the Soldiers' Manual of Common Tasks, identified MOS specific indicators of functional basic skills required in each MOS. These are the skills that will be taught in JSEP.

The vast majority of soldiers have been exposed to basic skills instruction before entering the Army. However, according to reports promulgated by the General Accounting Office (1977, 1983), some recruits are unable to learn and perform their duties due to academic deficiencies. To help soldiers learn faster and remember more, JSEP combines straightforward instruction in job related educational skills with training in research-based learning strategies. Strategies training attempts to improve soldiers' learning skills and study habits.

Research Objectives

The product of Task 8 is a framework within which alternative configurations and various options and features of a computer based instruction (CBI) delivery system can be evaluated. That is, CBI can be delivered by different systems (for example, PLATO, MicroTICCIT) and the systems themselves permit various options and features (for example, audio capabilities or color). This report enumerates the components of PLATO and MicroTICCIT systems, the optional equipment and features available on each, as well as the costs and benefits of the various options and features.

PLATO was requested by the Army (which already owns, uses, and is familiar with the system and its capabilities). MicroTICCIT is a product of the Hazeltine Corporation to whom the subcontract was awarded because of their extensive experience with military training.

Most package or system components are not separately priced, but some peripherals, such as printers, audio output, and videodisc, are add-ons. Each

component of the JSEP system will be described, as will its advantages and limitations (both expected and research based). Where separately priced, its costs will be noted.

Each component of the JSEP system may contribute to instructional effectiveness, learning strategies improvement, or more efficient management when measured by itself. However, when all of the components are put together, the effects of some may be masked by the effects of others. Therefore, in describing the various options and features available, we note which complement one another, which are substitutes, and which are redundant with respect to the instruction, the learning strategies, and/or the management system.

Costs are given as current dollar manufacturers' listed prices for different numbers of units or systems. Placing an accurate dollar value on the improved job performance due to the selection of any single option is tenuous at best; therefore, benefits are described and evaluated subjectively rather than estimated in dollars.

Scope

The analysis of Task 8 assumes that JSEP instruction will be delivered by two systems: the Control Data Corporation's PLATO system and the Hazeltine Corporation's MicroTICCIT system. Both systems will deliver the same instruction. However, they differ with respect to the means of delivery. PLATO requires a single computer located at some central site with which student workstations are interfaced via telecommunications lines, whereas MicroTICCIT requires a host processor at each local post or site, to which varying numbers of workstations are linked via direct access.

PLATO and MicroTICCIT differ with respect to available features and options that will be described. Where the options are separately priced, this will be noted. In addition, the impacts of these options and features on JSEP will be described and evaluated. The evaluation will be in terms of impacts upon instructional effectiveness, the learning strategies program, and/or the management system.

The computer industry is developing rapidly. New products and options are being introduced continuously and existing ones are being improved. Furthermore, prices have been falling. Therefore, though the prices and costs stated in this report are as current as possible, there is a strong likelihood that they will have changed before full JSEP implementation. These prices then are more for purposes of comparison than as indicators of what might actually be charged at a future date.

Note on Costs and Present Values

It is noted in the text and tables which expenditures are one-time capital outlays and which are recurring expenses such as maintenance. For purposes of comparison, the present values of the recurring expenses have been computed. A seven-year life-cycle was assumed and expenses were discounted at 10% per year.

Note on Configurations

This report considers a single student workstation as its basic unit, and many options, features, and pieces of equipment correspond one-to-one with a workstation. For example, each workstation requires one terminal. Other options, features, and types of equipment (for example, printers), however, are relevant to the number of posts at which JSEP will be instituted and the number of workstations at each. Still others are relevant only to the system as a whole. The tables and text indicate which relationship is applicable.

DELIVERY SYSTEMS

The delivery system consists of the essential hardware or equipment necessary to deliver computer based instruction. The two delivery systems selected for JSEP, MicroTICCIT and PLATO, are described and costed, respectively.

PLATO

PLATO requires only one computer for an entire system of 500-600 terminals. A CYBER 825 (131K) may be purchased for $600,000 (plus $36,000 annual maintenance). An alternative is to lease or subscribe to a PLATO system, for example, the Florida State University Computer Center (FSUCC) or to tie into the Ft. Leavenworth system. Costs will vary depending upon which system is chosen. In particular, data circuit costs are based on the distance from the central computer to the various posts. However, PLATO cost estimates quoted in this report are based on FSUCC port charges and library fees and distances from FSUCC to various posts. The FSUCC charges are used as an example. Costs of using and availability of the Ft. Leavenworth system are not known at this time. However, the Joint Committee on Computer Based Instruction (JCCBI) estimates a charge of $6000 per terminal per year for the use of Army facilities (central computers and communications network).

PLATO port charges ($3000/terminal/year) permit consulting with PLATO personnel for various problems as well as allowing new or revised courseware to be entered centrally. Library access fees ($900/terminal/year) provide unlimited use of PLATO libraries A-H. However, JSEP instruction is intended to be related directly to academic prerequisite competencies required for learned MOS related skills, not general education. A schematic of the PLATO delivery system is shown in Figure 1.

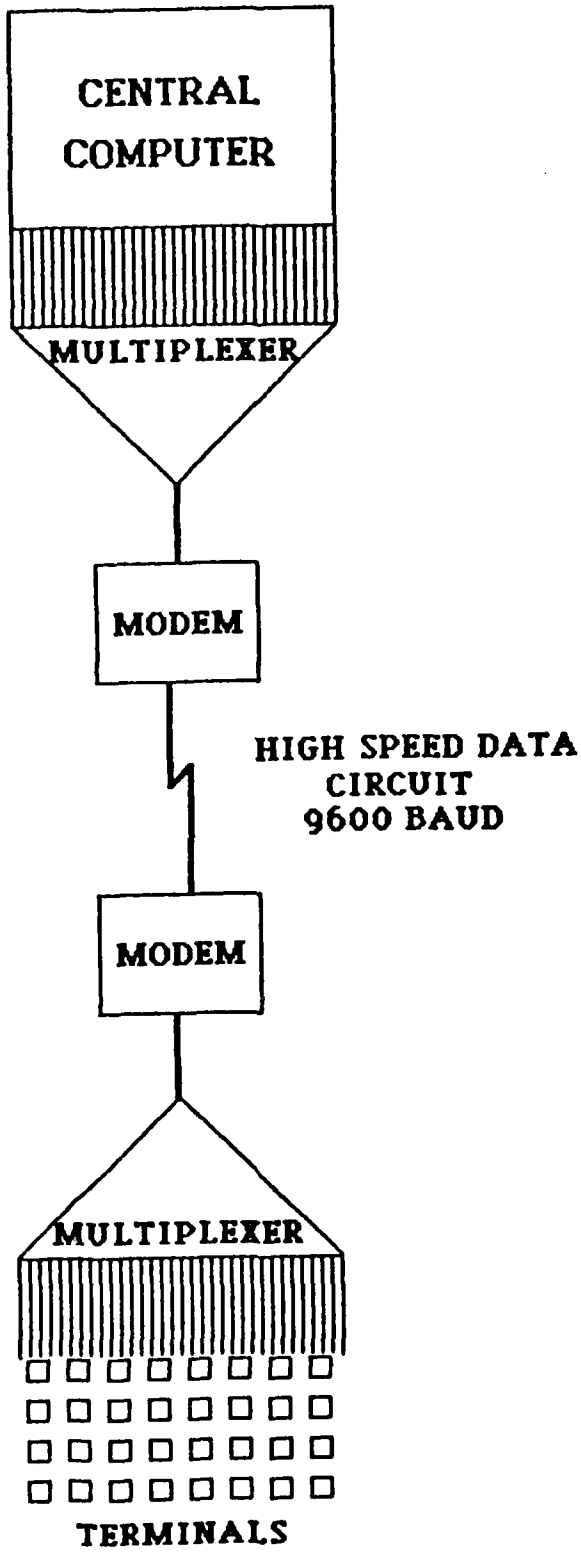

Figure 1. Schematic of the PLATO Delivery System

PLATO Terminals

CDC 110 VIKING. The VIKING, or Control Data Corporation (CDC) Model 110, is the only PLATO terminal presently being manufactured by Control Data Corporation (CDC) that is offered for sale. With a monochrome display (green on black), built in touch panel, and detachable keyboard assembly, it supports line drawings, text characters, custom characters, touch panel use, and all four PLATO standard presentation modes. The VIKING can execute programs written in PLATO Authoring Language or MicroPLATO Authoring Language. The VIKING can function as a conventional microprocessor and can use CP/M, BASIC, and Pascal/M. An output printer, second disc storage unit, RS232 coupled peripheral devices, and modem may be connected to a VIKING with suitable accessory hardware installed.

IBM Personal Computer and Zenith Z-100. CDC is presently offering an "Access Disk System" for the IBM Personal Computer and Zenith Z-100 personal computers. The access disk system enables these terminals to emulate a PLATO terminal. Either system may gain access to PLATO material through a modem system under PLATO subscription agreement provisions.

The minimum configuration of the IBM Personal Computer required as specified by CDC in August 1983 consists of:

- IBM Personal computer with at least 64K bytes of RAM
- At least one 5 1/4" disc drive
- PC DOS Operating System
- Color/Graphics Monitor Adapter (Monochrome Mode)
- Asynchronous communications adapter and RS232 cable
- 1200 Baud Bell 212A Modem or equivalent
- Monochrome Monitor (Not IBM Model 5151001)

The minimum configuration of the Zenith Z-100 consists of:

- One of the following Z-100 series microcomputers:
  - ZF121-22 All in One Z-100
  - ZF100-21 Low Profile Z-100
  - ZF110-22 Color Microcomputer (Note: the color capability of the ZF 110-22 is not supported by present PLATO courseware.)
- Monitor:
  - ZF120-22 includes monochrome monitor
  - For others add AVM-121 monochrome monitor or ZVM-143 Color Monitor
- Zenith Z-DOS Operating System
- 1200 Baud Bell 212A Modem or equivalent

The PLATO Access Disk Product is a 5 1/4" floppy disk containing the software which enables the IBM Personal Computer and Zenith Z-100 to operate as an emulation of a PLATO terminal. The cost of the disk, unique key labels required, and instruction manual is presently $29.95. In addition, users must establish their account for PLATO access. The estimated costs of PLATO terminals is shown in Table 1.

Table 1

Estimated Costs of PLATO Terminals

VIKING (CDC 110)	$ 2950
IBM PC	2670
ZENITH Z-100-22 (color)	2400

Statistical Multiplexers and Modems

Statistical multiplexers and modems are applicable only to PLATO since it requires long-distance telecommunications. Each cluster of terminals (up to 32) requires a pair of multiplexers and a pair of modems. In addition, statistical multiplexers must have a card for each terminal linked to it. Cards cost $100 apiece. The estimated costs of the statistical multiplexers and modems is shown in Table 2.

Table 2

Estimated Costs of Statistical Multiplexer and Modem Pairs

Number of Pairs	1	10	100
Statistical multiplexer (120R-1616)	$7,420	74,200	742,000
Modem (MP 96)	$7,348	73,480	734,800

Data Circuits

PLATO requires high-speed data circuits to link the various US Army posts with a central computer. Each data circuit can serve up to 32 terminals. Data circuits are installed and maintained by AT&T at a cost of $500 initially plus $10/mile/month. Table 3 shows estimated costs for such circuits from the FSUCC for 16 representative posts. The cost of circuits varies according to both the

number of circuits and the number of miles from the central computer. (Using existing autovon equipment and the Ft. Leavenworth computer would increase these costs to $6000 per terminal per year, according to the JCCBI.)

Table 3

Estimated Annual Cost of Data Circuits

Post	Number of Terminals	Number of Circuits	Total Annual Cost of Data Circuits (using FSUCC)
Belvoir	47	2	33,600
Bliss	155	5	82,800
Benning	140	5	24,000
Dix	39	2	27,600
Eustis	25	1	11,400
Gordon	67	3	18,000
Harrison	25	1	10,500
Jackson	10	1*	3,300
Knox	79	3	30,600
Lee	10	1*	4,200
Lenard Wood	35	2	24,000
Leavenworth	8	1*	3,600
McClellan	9	1*	3,840
Monroe	3	1	11,400
Rucker	15	1	5,400
Sill	49	2	25,680

* 2-wire circuit (Jackson-Gordon, Leavenworth-Lenard Wood, Lee-Monroe, McClellan-Benning).

Cables

Cable requirements depend on the number of posts and the number of terminals at each. Each PLATO terminal requires a cable ($75 each) linking it to a statistical multiplexer. Two cables are required to link the statistical multiplexer and modem pairs ($50 each). In addition, if there is a printer (see Optional Equipment), at least one terminal must be linked to it ($50 each).

Equipment Cabinets

Each post requires an equipment cabinet or rack for the statistical multiplexer. Such furniture costs approximately $160.

System Costs

There are both capital and annual expenditures for the hardware components. One way to look at the combinations of initial and recurring costs is to calculate present value. For the PLATO system, present values were calculated on the assumption that the equipment had a 7-year life cycle with no salvage value at the end of that time and a 10% discount rate. The 7-year life cycle was assumed to reflect the rapidly changing and developing computer industry, that is, it is assumed that the equipment will be technologically obsolete by the end of 7 years. The 10% discount rate is appropriate as an approximation of current interest rates. The estimated total PLATO costs summary is shown in Table 4. (The formulas used for the calculations are shown in Appendix A.)

Table 4

Estimated Total PLATO Costs Summary

Capital Expenditures per Terminal:	
Terminal	$2,950
Card	100
Cable	75
	$3,125
Capital Expenditures per post for each 32 (or fewer) terminal system:	
Statistical multiplexer pair	$7,420
Modem pair	7,348
Cables	100
Data circuit	500
Cabinet	160
	$15,528

Annual Expenditures:	
Port charges and libraries/terminal	$ 3,900
Data circuit/post	12,000 (est. average)
Maintenance (terminals, statistical multiplexer, modems)	2,000 (est. average)

Calculations

TCE	Total capital expenditures
T	Number of terminals
F*	Number of 32-(or fewer) terminal systems
AE	Annual expenditures
PVAE	Present value of annual expenditures (assuming a 7-year life cycle and a discount rate of 10%)

PVS Present value of the system

TCE = $3,125 T + $15,528 F*

AE = $4,400 T + $13,500 F*

PVAE = $21,421 T + $65,724 F*

PVS = $24,546 T + $81,252 F*

For example, for a system of 3 posts with 20, 35, and 60 terminals respectively, the costs would be:

TCE = $3,125 (115) + $15,528 (5)
TCE = $437,015

AE = $4,400 (115) + $13,500 (5)
AE = $573,500

PVAE = $21,421 (115) + $65,724 (5)
PVAE = $2,792,035

PVS = $24,546 (115) + $81,252 (5)
PVS = $3,229,050

*In posts having more than 32 terminals, each cluster of 32 terminals and any remaining fraction over 32 as a multiple thereof should be treated as a separate post.

TICCIT and MicroTICCIT

In August, 1983, Hazeltine Corporation announced the availability of a new TICCIT delivery and authoring system called "MicroTICCIT." This product line is supported by a revised authoring system and instructional management system. The system is capable of supporting two to 64 student workstations in distributed networks.

MicroTICCIT is based on a proprietary use of an IBM personal computer with 128K random access memory interfaced with the Hazeltine digital display system driving SONY color video monitors. The IBM Personal Computer serves as the workstation computer. When not used for instructional purposes, it may be used as a personal computer, supporting most IBM Personal Computer compatible software for the 64K and 128K memory configuration.

All standard MicroTICCIT configurations consist of a host processor supporting a cluster of student workstations. Schematics of the MicroTICCIT delivery systems are shown in Figure 2. Table 5 contains some pertinent specifications and prices of MicroTICCIT.

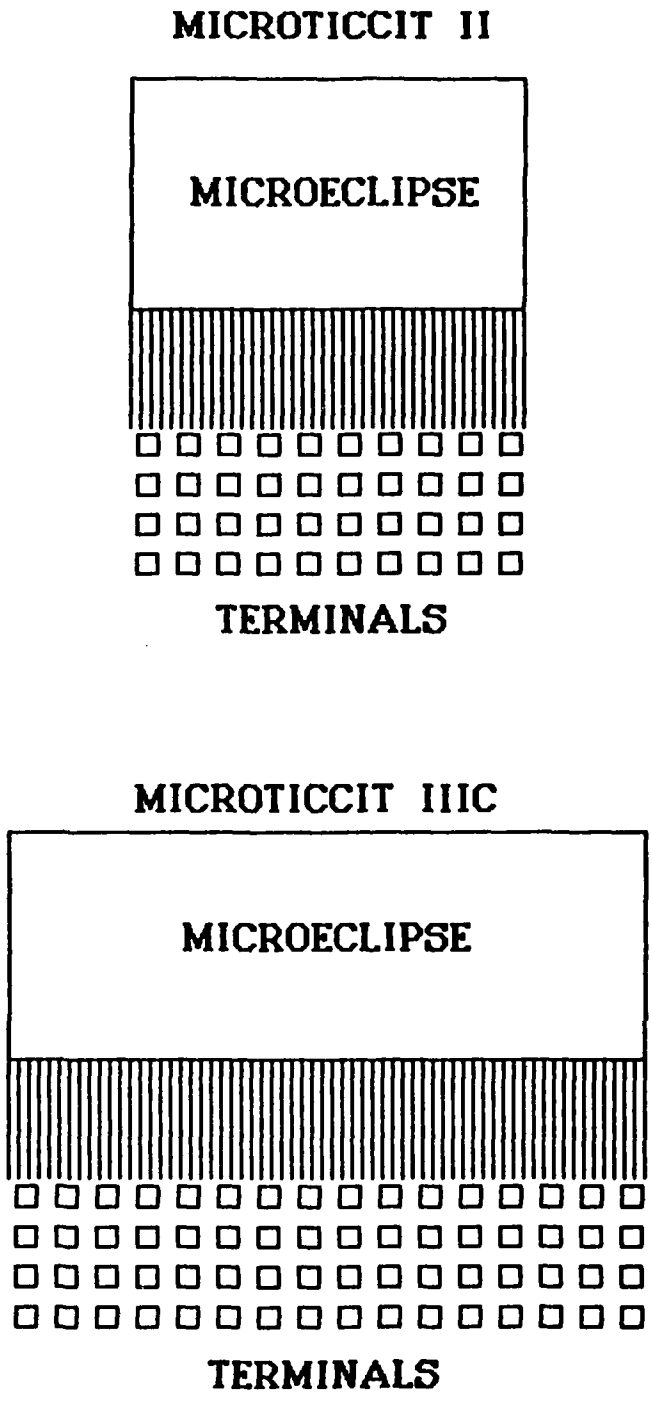

Figure 2. Schematics of the MicroTICCIT Delivery System

Table 5

Total MicroTICCIT Costs (Standard Systems)

System	Capacity: Workstations	Capacity: Hours on-line courseware	Price of Host Processor
II	up to 40	50	$60,700
III C*	up to 64	160	$97,300

Workstation (including keyboard, light pen, IBM personal computer and color display video monitor) $ 6,500

Annual Maintenance 20% of initial hardware costs after the first year

* The disk storage of system III consists of a 15MB fixed disk plus an additional 50, 73, or 146 MB fixed disk. The systems are designated System III A, III B, and III C respectively. Whether a standard System IIIC is capable of storing the 420 hours of instruction contracted for under JSEP cannot be determined at this time. The quantity of instructional material capable of being stored depends on whether the instruction is in text or graphic form in addition to the size of the source and object codes. It is essentially a programming problem with respect to how compactly the lessons can be programmed. Since JSEP lessons are still in the development and programming stages, it cannot yet be determined how much disk storage will be required.

The price of the host processor also includes the full software package with the software license, a one-year maintenance warranty, all associated cabling, and authoring and operations training.

MicroTICCIT costs are primarily one-time capital expenditures. Electric power costs are relatively insignificant (the system runs off common household current) and will vary according to the pricing policy of the local utility that supplies it.

MicroTICCIT maintenance is provided by Hazeltine, free of charge, on all hardware components for the first year. There are numerous types of maintenance arrangements that can be made for subsequent years (for example, repair times of 4-hours, 1-day, or 1-week can be contracted). Since MicroTICCIT has Sony, IBM, and Data General components, the service networks of these companies are available, in addition to Hazeltine. Maintenance arrangements are discussed in detail in Task Report 4.

For purposes of comparison, however, CET has estimated maintenance of its MicroTICCIT system for $21,140 per year. The present values of the MicroTICCIT

systems II and IIIC (PVS-II and PVS-IIIC, respectively) are given below. These calculations assume a 7-year life cycle and a discount rate of 10% per annum.

$$\text{PVS-II} = \$8{,}545\ T + \$99{,}802\ F,$$

$$\text{PVS-III} = \$8{,}545\ T + \$129{,}402\ F,$$

where T is the number of terminals and F is the number of posts (F is also the number of host processors).

In addition, total capital expenditures (TCE), annual expenditures (AE), and the present values of those annual expenditures (PVAE) for the two systems (II and IIIC) are given below.

$$\text{TCE (II)} = \$6{,}500\ T + \$60{,}700\ F,$$
$$\text{TCE (IIIC)} = \$6{,}500\ T + \$90{,}300\ F,$$

$$\text{AE (II)} = \text{AE (IIIC)} = \$517\ T + \$9{,}876\ F,$$

$$\text{PVAE (II)} = \text{PVAE (IIIC)} = \$2{,}045\ T + \$39{,}102\ F.$$

Note--AE (II) = AE (IIIC) and PVAE (II) = PVAE (IIIC) because both systems have identical terminals and both have DG microECLIPSE host processors which, in estimating maintenance expenses, were assumed to be covered by on-call service agreements with DG.

MicroTICCIT is flexible in that the smaller systems can be upgraded to the larger ones. All courseware developed on any system is compatible with other systems. In addition, MicroTICCIT is available as a custom designed special system when, for example, more than 64 workstations are desired, or when the courseware database is large. This latter possibility is immediately relevant to JSEP since JSEP will consist of approximately 420 hours of specialized courseware.

Courseware

JSEP will ultimately consist of 420 hours of courseware which will cost approximately $3,000,000 to produce. It is not anticipated that up-date or revision costs will be significant due to the basic nature of JSEP; that is, JSEP teaches fundamentals and they are not expected to change significantly. Furthermore, as noted below (see Authoring), FORSCOM, TRADOC, and other using commands will be able to author courseware.

FEATURES

PLATO and MicroTICCIT have the same or equivalent features with the exception that PLATO does not have a color capability. The equivalent features are included in the base prices of both systems and are discussed below.

Screen Delivery Capabilities

The screen displays vary in terms of resolution, text, graphics capabilities, and screen partitioning. These capabilities are included in the basic systems.

Screen Resolution

Various resolution capabilities are possible, ranging from RF-modulator driven standard television, through high resolution bit-mapped graphics systems. PLATO has 512 horizontal x 512 vertical display resolution. MicroTICCIT has 860 horizontal x 238 vertical display resolution. Both are adequate for JSEP graphics. The 512 x 512 pixel screen is included in the basic cost of PLATO. The 860 x 238 pixel screen is included in the basic cost of the MicroTICCIT.

Text

Most JSEP instruction will consist of text and graphic displays to which the student will respond by either electronically "turning the page" or by inputting responses. JSEP materials may include the requirement for special military symbols or superscripts (for electronics, for example). A variety of text sizes and placement options on the screen are available on both PLATO and MicroTICCIT which are adequate for JSEP purposes.

Graphics

Graphics break up the reading task, add interest, and present information in a variety of ways. Research conducted in recent years on the use of graphics in instruction (Stone & Glock, 1981) has consistently found that appropriately designed graphics improve the comprehension of text. Graphics have been found to be effective in helping readers grasp the organizational structure of the content presented. Graphics also can convey certain types of information more effectively than can text. This is particularly true, for example, for procedural information where the spatial location and orientation of parts and surfaces of parts must be clearly communicated.

Graphics are called for in the lessons designed for almost all PCs. Some are intended simply to maintain student interest, but most are essential to the instruction. The embedded learning strategies are heavily dependent on using symbols or imagery to prompt the students to use appropriate strategies when they have difficulties with the lessons.

Screen Partitioning

Screen partitioning is a display method where particular segments of the screen are used to display one text message or media display and other sectors are used to display other text messages or media displays. A screen may be divided, for example, into two horizontal zones at the middle of the screen, two vertical zones at the middle of the screen, or into four zones by combining

both capabilities. Any number of partitioning schemes are possible up to a practical limit set by screen size, resolution and cost.

Saloman (1974), in his discussion of media attributes, points out that mental processes of information manipulation are cued by certain media attributes. He states that "putting two visual displays side by side tends to activate comparison and discrimination." He elaborates from an earlier article (Saloman, 1972) which cites a series of experiments which indicated "that learners became better visualizers of transformations in space, better analyzers of complex displays, and less field-dependent after they were exposed to films that overtly and explicitly specified the relevant operations." Although his citations concern film, they can probably be generalized to the attributes of any media. Computerized presentations can, with new advancements, model many of these mental processes (such as split screen), as well as compare and contrast functions.

Student Response Capabilities

Students must interact with the computer in order to work through a lesson as well as to be tested on it. This interaction can be done with a variety of devices: Keyboard, touch panel, light pen, or external control devices. Keyboards are standard and included in the base prices of both systems. A touch panel is included in the base price of PLATO; a light pen is included in the base price of TICCIT.

Student interaction can be two types: (1) selecting the correct answer to a question (such as with multiple choice and true-false questions) and (2) typing an answer (as in a fill-in-the-blank statement or number answer). Light pens and touch panels are especially suited to the first type of interaction.

Testing experts (e.g., Fredrickson, 1984) argue that well-designed multiple choice questions test recognition more precisely than recall statements (that is, fill-in-the-blanks). This precision is achieved through the use of distractors such that unless the student thoroughly understands the material, he will be unable to discern the correct answer.

Multiple choice questions are inadequate as tests of recall or memorization. However, for tests of recall or memorization, both PLATO and MicroTICCIT have spelling algorithms which permit correct, though misspelled, answers.

Screen inputs provided by devices such as light pens and touch panels give JSEP students the ability to respond to displays without using the more cumbersome keyboard, mouse, or other mechanical input devices. For students who are not expected to be familiar with such devices, screen inputs make possible an important mode of interaction with the CBI system.

Table 6

Summary of PLATO and MicroTICCIT Features

Feature	PLATO	MicroTICCIT
Screen Resolution	512H X 512V	860H X 238V
Student Response Capability	touch-panel	light pen
Text	Both systems adequate	
Graphics	Both systems adequate	
Screen Partitioning	Both systems adequate	

OPTIONS

Options consist of peripheral units of equipment that can be added onto the delivery system. Options themselves, their technologies, specifications, and features are experiencing rapid development which is reflected in their costs. Therefore, though costs are quoted as accurately as possible, there may have been substantial changes by the time this report is published. The criteria for evaluating options are their impact with respect to the instruction, the learning strategies, and the management system.

Printers and Plotters

Hard copy (that is, paper output) is required for about 15 Prerequisite Competencies. In addition, hard copy offers all JSEP students a choice of on- or off-line completion of assignments as well as providing practice exercises, copies of graphics, maps, text, and tests. Instructors would be likely to find such a capability helpful in managing courses, record keeping, and evaluating students.

Each post or site would require at least one printer or plotter; the larger sites might be able to use several efficiently. Printers and plotters vary in several features, most importantly with respect to price and printing speed (characters per second or cps). Costs of several printers compatible with the two systems are shown in Table 7.

Table 7

PLATO-compatible printers:		
		Characters per Second
CDC PLATO Printer	$ 3,500	253
Epson MX 80 Printer	$ 446	100
Epson FX 80 Printer	$ 595	160
MicroTICCIT-compatible printers:		
IBM Graphics Printer	$ 595	80
Epson FX 80 Printer	$ 595	160

Each printer would have to be linked by a cable to a terminal by cable ($50) and, for multiple terminal per printer configurations switches ($100) would be required.

Color

Display colors range from three to over 4000 colors of varying hue, brightness, and intensity. Recent instructional research is informative as to the effectiveness of this variable.

Dwyer (1978), in his book on strategies for improving visual learning, cites studies designed to evaluate the effectiveness of the realism continuum in visual illustration. He found that color versions were more effective for specific educational objectives, presumably those that dealt with learning of colors as identification on variable condition cues. Several Prerequisite Competencies involve color (for example, PC 41d "Matching objects by size, shape, color").

Color has also been consistently found to be an effective attention gaining and an attention sustaining device. Color is also strongly preferred when students have a choice (French, 1952; Katzman & Nyenhuis, 1972 as cited in Dwyer).

Research has yet to produce effective guidelines for the uses of color nor is there evidence that more colors contribute to greater effectiveness. Color is not currently an option for PLATO; it is included in the base price for MicroTICCIT.

Audio

Audio is considered essential for learning several PCs. For example, PC 41g, "Determine direction, duration, and intensity of sounds," requires an audio capability. Audio possibilities are numerous and varied, ranging from simple "arcade" sounds (beeps and buzzes) to recitations of entire lessons.

There is evidence that random arcade sounds increase student attention and interest, particularly over prolonged periods of concentration (Schneider, 1983). On another level, audio may consist of only a few words or phrases, such as "good" or "try again." However, students have turned such audio off when possible, apparently for reasons of privacy. Earphones would eliminate this problem. The most sophisticated audio presentation is to have entire lessons recited to the student. With this capability, students with little or no reading skills could benefit from JSEP.

There are many technologies for providing an audio capability: for example, audiotape, and digitized audio. Audiotape might be unwieldy since coordinating tapes and lessons could be time consuming as could inventorying tapes (which are easily damaged, lost, or stolen).

Digitized audio, in contrast, eliminates the problems intrinsic to audiotapes. Digitized audio is programmed onto the same disks as the rest of the instruction. Therefore, there is no problem coordinating lessons with their audio component nor is there an inventory problem.

MicroTICCIT's IBM Personal Computer and the Sony Monitor both have built-in speakers. However, due to the individualized nature of JSEP instruction, the use of earphones should be considered in evaluating this option. PLATO does not have a jack to connect earphones; that is, earphones are feasible technologically but a jack would have to be installed specially at undetermined extra cost. Table 8 shows cost estimates for audio capabilities. The audiotape option can be provided using medium fidelity cassette players ($50 each). Earphones cost approximately $15 per set.

Table 8

Estimated Costs of Digitized Audio

No. Units	1	10	40
MicroTICCIT Digitized Audio	$ 645	$ 6,450	$25,800
PLATO (VOTRAX)	$3,421	$22,110	88,440

Video

Motion and still color pictures are recommended for 15 Prerequisite Competencies, most involving the learning of motor skills. Videotape, videodisc, and film are three means of providing this capability directly. Graphics are an indirect means of providing this option; that is, most color and motion sequences can be simulated with graphics. However, of the three

direct means of providing still and motion pictures, film is considered least compatible with CBI because it is slow and awkward, due in part to the necessity of rewinding. Therefore, film will not be discussed in detail nor priced.

Videotape

Videotape is relatively slow since the student must wait for the tape to wind to the proper position with respect to the lesson. In addition, coordinating videotape cassettes with lessons, inventorying, and managing them may be time-consuming for the instructor, and the cassettes may be easily misplaced. Betamax and VHS systems are most common types; prices vary depending on the features selected, (for example, fast forward). All workstations will not require a videotape system; instead a few per learning center will be sufficient. Estimated costs per unit are shown in Table 9.

Table 9

Estimated Costs for Videotape

	COST/Unit
Betamax	$400-600
VHS	$400-600
Monitor* (color)	$395

* Additional Monitor is not needed for MicroTICCIT.

Videodisc

There are three levels of integrating videodisc with CBI. Some are available for one system and some for the other. The first level is the addition of a second videodisc display under JSEP computer control. The separate display requirement prevents overlay of computer graphics on the video image, and the additional monitor takes up space. The second level uses a single display, with the capability of displaying either videodisc material or computer generated displays, but not both at the same time. The third level has the capability to overlay computer generated text or graphics on the videodisc image. Implicit in this capability are highlighting, outlining, and pointing with graphic symbols, text, and feedback messages. Videodisc sequences are programmed directly into the lesson and, because they are read by laser, can be accessed much more quickly than videotape sequences. Estimated unit costs for videodisc for PLATO and MicroTICCIT are shown in Table 10.

Table 10

Estimated Costs for Videodisc

COST	1 Unit
PLATO	
Interface	$3,000
Discplayer	$1,975
Monitor*	$ 395
TOTAL	$5,370
Videodisc overlay	$4,300
TOTAL	$4,300

* Additional monitor is not needed for MicroTICCIT.

Optional Student Response Capabilities

In addition to the standard student response capabilities, keyboard, touch panel on PLATO, and light pen on MicroTICCIT, there are optional external control devices, such as joysticks and "mouses."

Joysticks and "mouses" are means of easily moving the cursor around the screen. Neither is standard on either PLATO or MicroTICCIT, although a mouse is available for the IBM Personal Computer. However, there is no unique instructional use for external control devices. The estimated costs for the external option student response capabilities are shown in Table 11.

Table 11

Estimated Costs for Optional Student Response Capabilities

	10 Units	40 Units	64 Units	100 Units
Mouse with serial interface	$1,950	$7,800	$11,500	$17,500
Joysticks	$ 600	$2,400	$ 3,000	$ 4,500

To facilitate a comparison of the two systems's costs, table 12 is provided below. Table 12 is meant only for a preliminary comparison and no totals are provided because some items refer to the number of terminals, others to the number of systems, and others to both terminals and systems. Totals in this context would be meaningless and, furthermore, for several items, there are several types of that item at different cost available. The reader can refer to the appropriate table and discussion for details.

Table 12

Summary Comparison of Systems' Costs

	PLATO	MicroTICCIT
Capital Equipment:		
Terminal	$2950	$6500
Stat. multiplexer (pair)	7420	N.A.
Modem (pair)	7348	N.A.
Computer*	600,000	97,300
Cables	175	N.A.
Cabinets	160	N.A.
Annual Expenditures:		
Maintenance	2,000	21,140
Data circuits*	6,000	N.A.
Optional Equipment:		
Printer	595	595
Digitized audio	3,421	645
Videotape	500	500
Videodisc	5,370	4,300
Mouse	195	195

* A PLATO computer can be leased rather than purchased; such a leasing arrangement is reflected in the estimated cost of data circuits.

INSTRUCTOR FACILITIES

Both PLATO and MicroTICCIT were developed with the instructor as well as the student in mind. This section describes the features and options of the systems as they pertain to the instructor rather than the student.

Management

Both PLATO and MicroTICCIT include management systems in their base prices. These systems will be essential to evaluate JSEP in such terms as courseware effectiveness and system utilization. The management systems have the ability to collect, store, and analyze data.

More immediately though, the management systems enable instructors to manage students; that is, their records, grades, and progress can be displayed or printed out.

Authoring

Both PLATO and MicroTICCIT allow for the authoring and incorporation into JSEP of new, up-dated, or site specific materials. Department of the Army Education Division will have to set authoring policy; however, for authorized individuals manuals are provided explaining how to author instruction. In addition, Hazeltine offers a 3-module training course in the MicroTICCIT system, included in its base price. These modules instruct system operators in system start-up, shut-down, and maintenance as well as in authoring courseware for MicroTICCIT. Should the Army not take the training course option, Hazeltine will credit the Army $7,100 per system.

Security

Both PLATO and MicroTICCIT lessons are "read only" which ensures that students cannot accidentally erase them. PLATO is protected in that courseware additions and alterations are entered at the site of the central computer. MicroTICCIT is protected in that certain codes and procedures must be known in order to change courseware. These codes and procedures are described in the system instruction manuals provided to instructors and authors.

GLOSSARY

BASIC: Computer programming language

CBI: Computer based instruction

CBTA: Cost benefit tradeoff analysis

CDC: Control Data Corporation

CP/M: Digital Research, Inc.'s operating system for microcomputers

FSU: Florida State University

FSUCC: FSU Computer Center

IBM: International Business Machines Corp.

IBM PC: IBM Personal Computer

JCCBI: Joint Committee on Computer Based Instruction

JSEP: Job Skills Education Program

MicroTICCIT: Hazeltine Corp.'s Microcomputer based instructional system

Modem: Device for transmitting computer data on telephone lines

MOS: Military Occupational Specialty

PASCAL/M: Sorcim's computer programming language for microprocessors

PC DOS: Operating system for IBM PC microcomputer

PC: Prerequisite Competency

PLATO: CDC's CBI system

TICCIT: Hazeltine Corp.'s CBI system

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APPENDIX A

Present Values Formula

APPENDIX A

Present values were calculated by the formula:

$$PV = \sum_{i=1}^{n} \frac{E}{(1+r)^1}$$

where PV = present value,

E = annual expenditure

r = discount rate

$\sum$ = summation

n = number of years

i = index indicating year.

For example, PVAE = \$18,987

$$= \frac{\$3900}{(1.10)} + \frac{\$3900}{(1.10)^2} + \ldots + \frac{\$3900}{(1.10)^7}$$

APPENDIX B

JSEP PLATO Communications Cost Estimate

APPENDIX B

JSEP PLATO Communications Cost Estimate

Post	Number of Terms	Number of Circuits	Unit Cost/Circuit	Total Cost/Circuit	Multiplexer (Pairs)	Modem (Pairs)	Rack	Total Monthly
Belvoir	47	2	1,400	2,800	800	500	10	4,110
Bliss	155	5	1,380	6,900	2000	1250	20	10,170
Benning	140	5	400	2,000	2000	1250	10	5,270
Dix	39	2	1,150	2,300	800	250	10	3,610
Eustis	25	1	950	950	400	250	10	1,610
Gordon	67	3	500	1,500	1200	750	10	3,460
Harrison	25	1	875	875	400	250	10	1,535
Jackson	10	1*	275	275	400	250	10	935
Knox	79	3	850	2,550	1200	750	10	4,510
Lee	10	1*	350	350	400	250	10	1,010
Lenard Wood	35	2	1,000	2,000	800	500	10	3,310
Leavenworth	8	1*	300	300	400	250	10	1,000
McClellan	9	1*	320	320	400	250	10	980
Monroe	3	1	950	950	400	250	10	1,610
Rucker	15	1	450	450	400	250	10	1,110
Sill	49	2	1,070	2,140	800	500	10	3,450

* 2-wire circuit (Jackson->Gordon, Leavenworth->Lenard Wood, Lee->Monroe, McClellan->Benning)

Assumptions:

Statistical multiplexers are 120R-1616's at $7,000 over 20 months = $350 Lease, $50 Maintain
Modem pair MP96 = $200 L/P, $50 Maintain
Equipment rack = $10
No cable costs included. 1 cable/terminal, 1 cable/multiplexer, 1 cable/modem @ $20 each
Concentration of terminals to multiplexer = 32 minimum

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