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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report No. 7	2. GOVT ACCESSION NO. AD-A115 489	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Computer Instrumentation for Research on the Cognitive Structures and Processes Required to Execute Procedures Based on Instructions		5. TYPE OF REPORT & PERIOD COVERED Technical 2/1/82-5/31/82
		6. PERFORMING ORG. REPORT NUMBER Technical Report 8, Series B
7. AUTHOR(s) David E. Stone and Margaret L. McMinn, Hazeltine Corporation/Cornell University		8. CONTRACT OR GRANT NUMBER(s) N00014-80-C-0372
9. PERFORMING ORGANIZATION NAME AND ADDRESS Cornell University, Dept. of Education, N.Y. State College of Agriculture and Life Sciences: A Statutory College of the State University		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61153N(42) RR-42-06 RR0420602 NR157-452
11. CONTROLLING OFFICE NAME AND ADDRESS Personnel and Training Research Programs Office of Naval Research (Code 458) Arlington, VA 22217		12. REPORT DATE May 1982
		13. NUMBER OF PAGES 11
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for Public Release; Distribution Unlimited		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) No restrictions		
18. SUPPLEMENTARY NOTES This research was also supported by Hatch Funds Project #424, PRES. STRAT. IMP. COMP. PRINT TECH MAT, N.Y. State College of Agriculture and Life Sciences; a Statutory College of the State University		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Time-Shared Interactive Computer-Controlled Information Television (TICCIT) Device 4E7; Computer-Based Instruction (CBI); Computer-Assisted Instruction (CAI); Computer-Managed Instruction (CMI); Hypertext; Computer-based Job Aids; Video Disc; Authoring Languages; Procedural Text; Computer Graphics ²		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Research on the cognitive structures and processes required to execute procedures based on instructions has, until very recently, focused on the delivery of instructions in print. However, the advent of computer systems designed to deliver procedural training and job-aiding information has led us to conduct research on the use of computers for communicating procedures. The power of computers makes this type of presentation fundamentally different from print media and the growing use of computer-based training		

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S/N 0102-LF-014-6601

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In this report we describe a system for displaying interactive computer generated color text, graphics, and symbols and computer-controlled video and videodisc displays for use in our research.

The computer system selected for use in our research is the TICCIT system. This is a commercially available system now in widespread use in military, industrial, and civilian educational settings. TICCIT is an officially designated Navy device (Device 4E7).

This report is intended to provide a description of our instrumentation and thereby make our subsequent reports of experiments more understandable to the reader.

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Research on the cognitive structures and processes required to execute procedures based on instructions has, until very recently, focused on the delivery of instructions in print. However, the advent of computer systems designed to deliver procedural training and job-aiding information has led us to conduct research on the use of computers for communicating procedures. The power of computers makes this type of presentation fundamentally different from print media and the growing use of computer-based training and job-aiding systems in the military also makes them worthy of study.

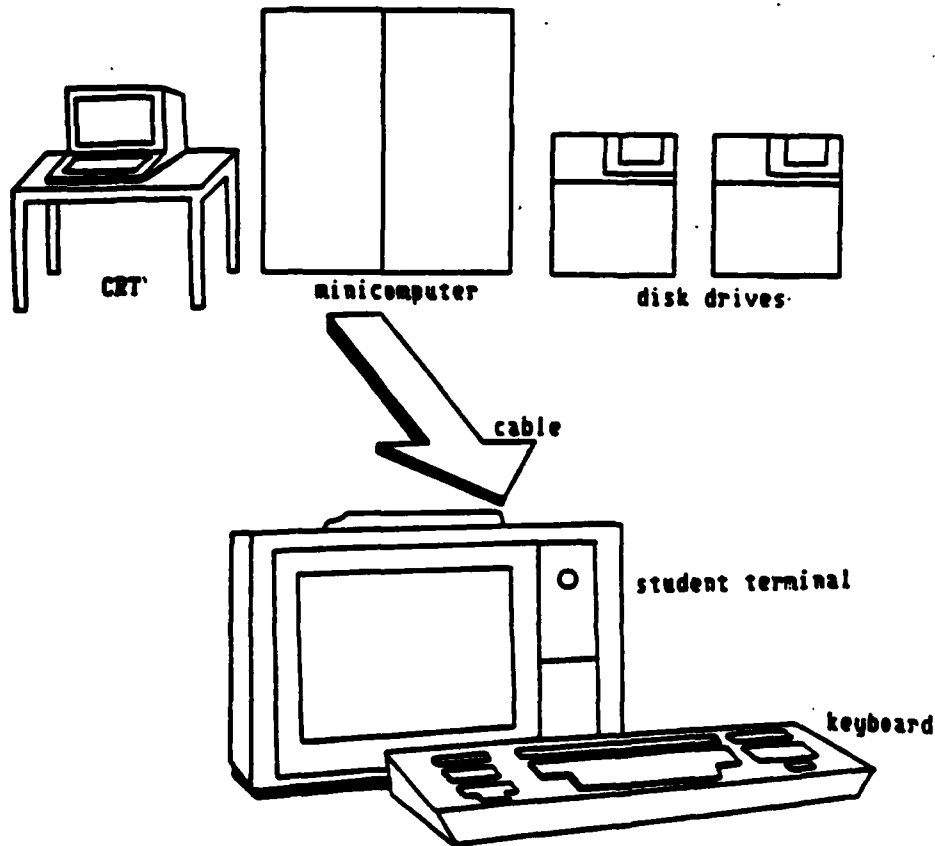
In this report we describe a system for displaying interactive computer generated color text, graphics, and symbols and computer-controlled video and videodisc displays for use in our research.

The computer system selected for use in our research is the TICCIT system. This is a commercially available system now in widespread use in military, industrial, and civilian educational settings. TICCIT is an officially designated Navy device (Device 4E7).

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SYSTEM HARDWARE

The TICCIT system is driven by Data General (DG) NOVA 4 minicomputers.

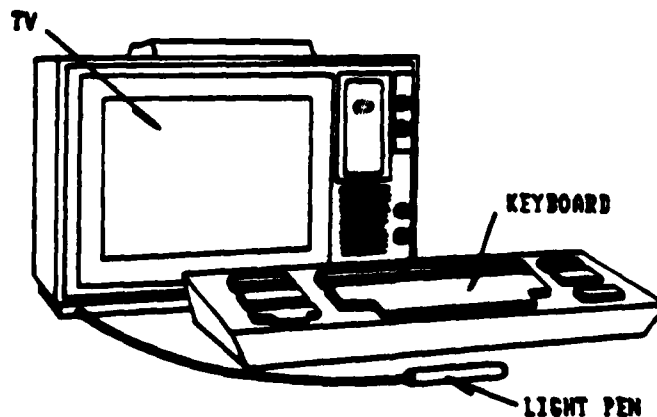


TICCIT uses color terminals and specially designed keyboards and light pens. The TICCIT system hardware is modularly designed to allow users to configure systems that best meet their individual training needs. The TICCIT systems now in the field have one, two, three or more processors configuring from two to over five hundred terminals. Storage capacity ranges from 25 megabytes to 1000 megabytes, all with the same courseware and software capabilities. A DBMS interface at two TICCIT sites allows an interface between the TICCIT systems' computer-managed instructional software packages and other OMI packages written in COBOL, AOS, etc.

In addition, each system will support a variety of peripheral devices, including: a fixed-head disk for rapid data swapping, magnetic tape units for dumping and loading data, a graphic digitizer (for automatic scanning and entry of line drawings, charts, maps, etc.) and Impact as well as electrostatic dot-matrix printers (for producing hard copy printouts, including copies of TICCIT screen images of both text and graphics). Other specialized peripherals can be added as options. They include optical mark readers, audio and/or videotape/videodisc systems, large-screen monitors for troubleshooting simulations, and specialized mock-ups of actual equipment used for part-task training and simulations. Therefore, each TICCIT system can be configured to meet the specific requirements of each individual user site.

The TICCIT system hardware and software have sophisticated "fail-soft" features built in to guard against data loss during unexpected fluctuations in power. The mini-computers and other standard peripherals were designed for wide-scale, industrial use in diverse training environments. They are extremely tolerant of normal variations in power.

TICCIT TERMINAL CHARACTERISTICS

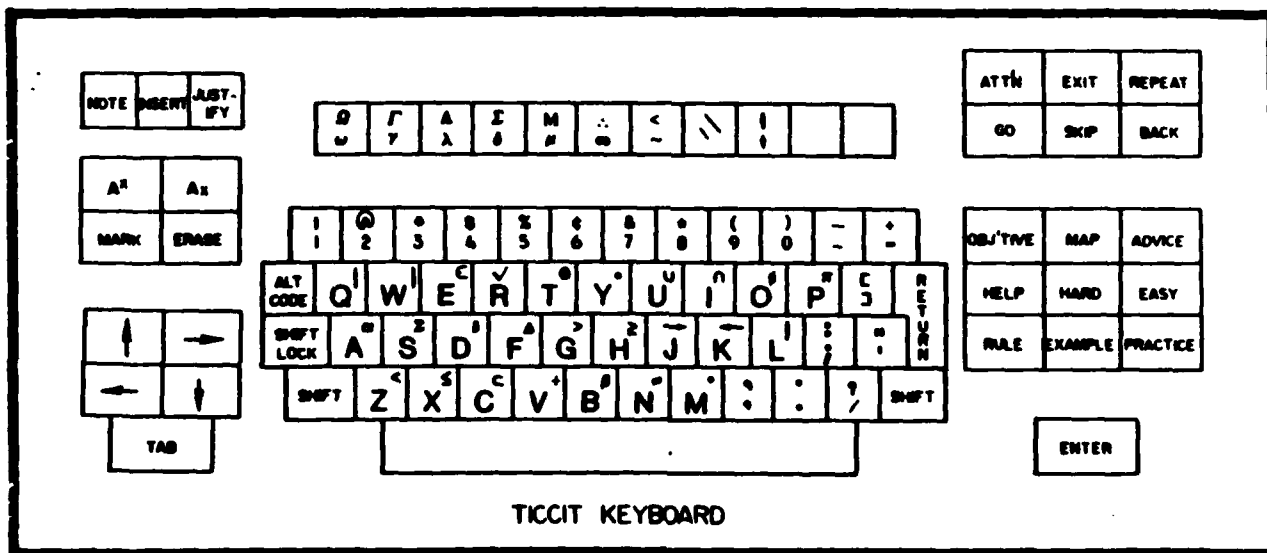


The TICCIT terminal utilizes a raster display of 17 rows by 43 columns. Each character space is made up of a 10 x 12 dot matrix. Thus, the screen resolution is 430 x 204 picture elements.

The TICCIT terminal has two modes of operation: It functions as a color CRT when supporting computer-generated displays of text and graphics; It functions as a color television monitor when supporting full color/sound videotape and videodisc presentations. Since the TICCIT terminal is totally compatible with NTSC broadcast video, video materials can be utilized on TICCIT without any modification to the existing system hardware.

THE TICCIT KEYBOARD

The TICCIT keyboard is comprised of three keypads.



Center Keypad -- Typing Keypad

The center keypad is for typing alphanumeric characters and for selecting color. Color is chosen by simultaneously depressing the ALT CODE key and any one of the numeric keys 1 through 7. The user can select "blink" mode by simultaneously depressing the ALT CODE key and numeric key 8. Having enabled the blink function, the user can then type blinking text or graphics. To turn off the blink function, the user simply repeats the ALT/CODE 8 key presses.

Left Keypad -- Cursor Control

The left keypad is for editing and cursor control functions. North, south, east, and west arrows are available for positioning the cursor to any desired location on the screen. In addition, each TICCIT terminal includes a light pen for one-step cursor positioning. The user simply touches the light pen to the TICCIT screen at the desired cursor location and the cursor automatically moves to that location. The left keypad also contains editing keys that allow the user to modify text being displayed on the TICCIT screen. The ERASE key allows the user to delete up to one entire line of text automatically. The INSERT key allows the user to insert additional spaces within existing text. The JUSTIFY key can be used to close up unnecessary spaces within existing text. The TAB key allows the user to move to predefined response boxes on the display.

Right Keypad -- "Learner Control"

The right keypad is called the "Learner Control" keypad. It contains keys which allow the user to access the individual instructional components available on TICCIT. These keys are also author definable so that they can be used as end-of-message keys to be used to branch to other displays as the author desires.

CHARACTER SETS

The TICCIT system contains fourteen pre-programmed character sets, including Scripts, Computer, and Backlite. In addition, TICCIT users are able to define new character sets as desired. As many as 512 character definitions can be active on TICCIT at any one time. For our research, we have used this capability to store graphics representing the parts of a model indexed by keys on the keyboard. This has been of great help in allowing the rapid and cost effective production of the large quantity of graphics used in our research.

COLOR CAPABILITY

TICCIT displays can be in up to seven colors--red, green, yellow, blue, black, cyan, and white--and blink mode which provide authors with a capability to highlight specific areas of display text.

GRAPHICS CAPABILITY

In addition, the design of the TICCIT system software permits the use of graphics, artwork, drawings, cartoons, charts, sketches, etc. as an integral part of courseware displays.

These graphics can be constructed either using the graphics editor on any TICCIT terminal or through use of a graphics digitizer. The graphics digitizer consists of a Hamamatsu document camera that can be used to scan graphics drawn by artists off-line and then store them as consecutive bits in computer memory. Graphics (whether constructed or digitized) can be called up on any TICCIT terminal and can be modified as desired. Modifications may include enlargement or reduction in size of all or part of the graphic, rotation of all or part of the graphic, coloring of all or part of the graphic, integration of a digitizer graphic or integration of text with the graphic. These completed object graphics can then be incorporated into specific screen displays for student viewing.

VIDEODISC CAPABILITY

The TICCIT system's video technology also permits users to access full color video through the student terminal. This provides courseware developers and instructors with the capability of incorporating motion video into instructional sequences. The TICCIT keyboard and specialized software give the student full control over the positioning of videotape while viewing it (i.e. fast-forward, rewind, "freeze-frame"). TICCIT can also access videodiscs on a random access basis and display single video frames of video or motion video sequences under computer control.

AUDIO CAPABILITY

The TICCIT system also supports a sophisticated audio input and delivery system. Digitally-stored audio messages can be linked to any particular output display, so that textual material can be enhanced with an associated audio message.

SYSTEM SOFTWARE

TICCIT software is based on a general purpose time-sharing operating system, written totally in assembly language to minimize core requirements and maximize throughput.

The operating system has been designed to support interfacing with and controlling a variety of auxiliary terminal devices, including:

- Video tape players (standard and controllable)
- Videodisc players
- Video cameras
- Teletype/telephone
- Asynchronous interface with other computers
- Remote line printers
- Interactive computer control over television tuning

In addition to supporting the simultaneous delivery of instructional material to over 500 terminals, the operating system has also been designed to support on-line software and courseware development and revision, as well as a number of other on-line capabilities such as inter-terminal communications.

AUTHORING LANGUAGES

TICCIT supports two authoring systems. The first, Authoring Procedure for TICCIT (APT) is the original TICCIT authoring system (although revised) which reflects a particular instructional design strategy.

The second, TICCIT Authoring Language (TAL) is a general purpose language. TAL permits the author to define the function of TICCIT's learner control keys in any way desired. The author, therefore, is not restricted to commands developed for instructional applications or by a particular predefined model of the instructional or learning process.

TAL EDITING

TAL provides the author with up to four specialized editor packages for each page the subject sees. This authoring system is the one that we have used in our research.

Base Page

The first editor the author sees is called a base page, upon which text is formatted and colored exactly as it will be presented to the subject. Here, the author simply types the display as the student should see it. An example of a base page is shown below.

```

04/09/02 12:30 AA.1.2.1.S/1/1
Mark each step with your light pen when
you have completed it. Press GO to see
the next page.

■ 1. To form column one:           Completed

    a. Assemble three large       ■
       blocks end to end.

    b. Attach a small block       ■
       to the tab end of
       the column just assembled.

C( )L($P1 )T(C, )           AA.1.2.1.S/1/1

```

Display Specifications Page

The second editor that the author may use is called the display specifications page. Here, the author may enter commands used to display additional text when specified conditions have been met or may identify a graphic and give its coordinates to display to the subject. This page may also be used to define windows that make use of the light pen possible. The following is an example of a display specifications page.

Commands for Display Construction		
Command	Mod	Data
RBOX	CALC	PM-FALSE
	WINDOW	1 1,16 36
COLOR	IF	P1B1-TRUE
	WINDOW	7 35,7 36
	COLOR	GREEN
COLOR	IF	P1B2-TRUE
	WINDOW	10 35,10 36
	COLOR	GREEN
INPUT	SPEC	SINGLE

Branch Table

The third editor available to the author contains the branch table. This table is used to define direct branching by the TICCIT keyboard's learner control keys, which allow the student to branch to any other TAL page in the program, as the author specifies. An example branch table is shown below.

Log? <input checked="" type="checkbox"/>	ATTN Functions to Inhibit +				
Branch Specification Table					
Code	Label	Code	Label	Code	Label
OFF	+	EXIT	+RETUR	ON	+
GO	\$P2	SKIP	+	BACK	+
OBJ	+	HAP	+RETUR	ADV	\$CHAR
HELP	+	HARD	+	EASY	+
RULE	+	EXAMP	+	FRAC	+
ENTER	+	TIMER	+	NEXT	+
CA	+	WA	+	UN	+

Response Analysis Page

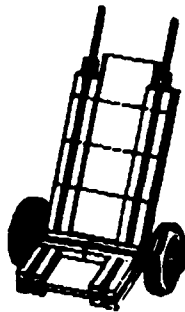
The fourth editor available to TAL authors is the response analysis page. This page is used to specify how the TICCIT system will respond to student input, whether it takes the form of the touch of the light pen, a typed word or phrase, an algebraic expression, etc. It also allows the author to compute, display or store any variables needed for scoring, simulations, or other conditional functions. An example of a response analysis page is shown below.

Commands for Response Analysis		
Command	Mod	Data
COMPARE	AREAS	INPUT=7 35,7 36 5 completed step 1
	CALC	P1B1+TRUE
	TO	SAMEPAGE
COMPARE	AREAS	INPUT=10 35,10 36 5 completed step 2
	CALC	P1B2+TRUE
	TO	\$P2
GO	TO	SAMEPAGE

Graphics

The authoring illustrations shown in the above paragraphs were all taken from the subject study. The figure below is an example of a graphic used in this study.

AA.1.2.1.5/7/27



APPLICATIONS FOR BASIC RESEARCH

In our explorations of the cognitive structures and processes that come into play as adults perform procedures based on instructions, we have come to use many of the capabilities of the computer system described here. One application has been to implement the idea of hypertext in the procedural instructions used in our research. Hypertext in this particular application consists of a set of directions for putting together a small model. These directions have no illustrations and are written at the fourth grade level. On each page of the directions, in addition to text, there are green squares.

Persons reading the directions need only touch any word in the directions to see another display designed to explain more fully what that word means or what the operation described looks like. For example, if the word is "assemble", the branch might lead to a page that shows the parts of the model to be assembled and includes arrows and text designed to make the meaning of the word "assemble" unmistakably clear in its application at this stage of assembling the model.

If readers want to view the completed model, they need only touch the green box on each page of the directions. A graphic illustration of the completed model is then displayed. At this point readers have even more options. They can touch a part of the graphic of the completed model and then be shown a blown-up graphic of that part of the model. Touching this graphic reveals an illustration of the parts which are used to put it together and how they are assembled.

Subjects also have the ability to request different views of the model, its subassemblies and their parts in the graphics only mode. A touch of a key will show readers how the component looks from any of six different angles.

Although the hypertext research we are conducting is still in its early stages, some preliminary findings are of interest. For example, when the directions for this task are presented to people on paper (both text and graphics) about two thirds of the people make mistakes in doing the task which they never recognize to be mistakes. However, when people are asked to do the assembly task using the hypertext, they don't seem to make mistakes. In fact, no subjects in our research have made any mistakes on this task when hypertext was available. Even though this is a preliminary finding, we are encouraged to believe that this approach will be of particular value for presenting instructions for tasks that are extremely dangerous, such as working with equipment which carries high voltage.

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