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MICROCOMPUTER ASSISTED INSTRUCTION IN GRAPHICS

by

Philip Edward Callahan

A Thesis Submitted to the Faculty of the

DEPARTMENT OF ART

In Partial Fulfillment of the Requirements
For the Degree of

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WITH A MAJOR IN ART EDUCATION

In the Graduate College

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1982
STATEMENT BY AUTHOR

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This thesis has been approved on the date shown below:

Jean Rush
Associate Professor of Art

Date
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ABSTRACT

A computer aided instructional program was designed to provide analysis of user drawn graphics. The menu driven program addresses rhythm and repetition, positive-negative space, and balance. Students of an undergraduate art education class evaluated the graphics program and associated operational documentation. As a result of the student evaluation, an upgraded graphics program was produced. The graphics program is written in Microsoft Basic and designed to operate on the Tandy TRS-80 Model III microcomputer. The graphics program is directed at secondary, vocational, and college level students.
CHAPTER I

INTRODUCTION

The availability of low cost microcomputers over the past few years suggests tremendous possibilities for computer assisted instruction (CAI). Hirschmann, Clausing, and Purcell (1977) aptly state that instead of the outlay of hundreds of thousands of dollars for a large computer system, a microcomputer may be purchased for several thousand dollars, and these costs are continually declining. The low cost microcomputers eliminate the need of many users competing for a large computer's resources, thereby minimizing slow responses, resulting in spirited interactive (conversation) communication between the user and computer. Because each terminal (communication unit) is a small independent computer, microcomputer based CAI (MCAI) offers extensive flexibility for adapting to a wide variety of applications.

Downing (1982) categorizes CAI as the use of the computer for drill and practice as a tutor and for providing simulations as a problem solving tool. Typically, effective CAI applications are designed to teach specific topics that represent learning problem areas. To change the characteristics of a CAI application, be it a specific lesson or course, a new program file on a memory storage disk (floppy disk) is inserted into the microcomputer.

Squires (1980) states that although art education is a field in which automation has been late in arriving, automatic control is
available and necessary for better education in the arts. The question of feasibility and efficacy of computer assisted design instruction becomes an important issue in the wake of declining school budgets and what States describes as the real need of "improvement of productivity and reduction of training time and/or reduction in training costs without sacrifice of desired training outcomes" (p. 208).

**Thesis Purpose**

The purpose of this thesis was to develop an interactive (conversational) microcomputer based system for developing design skills of secondary, vocational, and college level students. Although a number of sources were utilized, this MCAI system is largely modeled after *Art Fundamentals Theory and Practice* by Bone, Ocvirk, Stinson, and Wigg (1981).

The completed system was evaluated in a hands-on manner by 13 students using a TRS-80 Model III microcomputer. The students, from a University of Arizona introductory basic design course for non-art majors, provided written evaluations based on individual impressions, understanding, and ease of use. As a result of the evaluation, the MCAI graphics program was rewritten reflecting the suggestions and observations of the 13 subjects.
Background

"Although the teaching machines that often went with programmed instructional materials have virtually disappeared, computer assisted instruction (CAI) continues to be the basis of a vigorous research and development movement" (Gage & Berliner, 1979, p. 541). Gage and Berliner also go on to state that, in general, CAI appears to be an effective tool for drill and practice – particularly with the slower students.

Northern Illinois University Art Department has utilized a large IBM system 360/65 computer as an aid for teaching basic design principles. Truckenbrod (1977) relates that:

The programs provide examples of the principles involved, and serve as a tool for students to use to explore numerous alternative solutions to design problems. These computer aided graphics are not meant to replace hand-executed projects, but to supplement the class projects, and to provide an additional means of exploration and experimentation for the students. This exploration and experimentation is based on the theory and principles presented in class. As a result, the computer has become a successful teaching aid in these beginning design classes. (p. 181)

Truckenbrod also notes that the computer usage aids the students in understanding the procedures necessary for computer graphics programs. He states that regardless of how effective CAI is, its users are
learning computational skills that could turn out to be even more important. The student is being taught how to teach himself (1977).

Uthe (1981) states "interfacing (communication), whether between man and machine or between machines, will become increasingly important in the 1980's and 1990's. Artists and educators must learn to adapt to the computer, for the future will be decided by how creatively we utilize the fruits of technology" (p. 12).
CHAPTER 2

METHODS AND PROCEDURES

The MCAI graphics program was designed for the TRS-80 Model III microcomputer using Microsoft Basic. Although the graphics functions of the TRS-80 Model III microcomputer are not as comprehensive as some currently marketed microcomputers, the Model III is a commonly used microcomputer in many educational institutions.

The student evaluation of the MCAI graphics program was performed within a classroom equipped with microcomputer stations. Several days prior to the testing, each student evaluator was presented with graphics documentation (see P. 5 - describing documentation). Subjects evaluated the MCAI graphics program simultaneously without time limitation.

The 13 subjects were completing a course in basic design for education majors (non-art majors). All 13 student evaluators were undergraduates and had had minimal art training prior to the current course of study.

**Documentation**

The following documentation describes the MCAI graphics program. Similar documentation was provided the subjects evaluating the program.

The documentation assumes the reader has minimal or no computer background. An introduction to the microcomputer and
procedures for operating the MCAI graphics program attempt to dispel
the fears of computer operation.

Introduction to Microcomputer Aided Instruction in Graphics

In spite of its apparent complexity, the microcomputer may be
easily operated. This documentation provides an introduction to the
microcomputer and procedures for operating a microcomputer assisted
instructional graphics program. The graphics program is intended to
supplement basic design courses for secondary, vocational, and college
level students.

The graphics program is menu driven (instructional modules
may be selected in any order) and segmented into instructional
modules covering rhythm and repetition, positive-negative space, and
balance.

The help module can be viewed initially as it provides basic
definitions and presents the template for electronically drawing on
the video screen. By familiarizing oneself with the process
definitions in this module, one may fully concentrate on the more
demanding requirements of subsequent modules.

The rhythm and repetition module dispenses design examples
and requests that the user draw a design having rhythmic and
repetitive concepts. Should the resulting completed composition
fail computer analysis, the user is provided additional examples
and encouraged to try again.

The positive-negative space module, like the prior module,
dispenses random designs, requests a drawing emphasizing positive-
negative space, and analyzes the completed drawing. Recursive
programming, as in the prior module, encourages the user to retry
the drawing when the drawing fails analysis.

The balance module, the most demanding, provides additional
tutoring before requesting a drawing. The resultant drawing is
analyzed with respect to balance as well as positive-negative space.

This documentation provides instruction for using the art
program on a TRS-80 Model III microcomputer with TRSDOS and 32K of
RAM. A single 5½ inch floppy disk accommodates the graphics program.

Although a number of sources were utilized, the graphics
program is largely modeled after Art Fundamentals Theory and Practice
(Bone, Ocvirk, Stinson, & Wigg, 1981).

The Microcomputer System

This section provides background information on basic
computer concepts. Those already familiar with computers may skip
this material.

Basics of Computer Systems. Computers are electronic
switching devices designed to execute a sequence of instructions
collectively termed a program. A program generally consists of all
the necessary steps to solve a specific problem, such as "search
through my data and find all the people whose last name begins with
'C'."

The same computer can solve a variety of problems simply by
executing different programs. The programs and data (statistical
information from which conclusions may be drawn) are stored in the computer's memory and recalled when needed.

All computers share a basic arrangement of six components (see Figure 1):

- input unit
- output unit
- memory unit
- control unit
- arithmetic/logical unit
- registers

Collectively, the registers, control, and arithmetic/logical units form the computer's "brain" called the Central Processing Unit (CPU). The input and output devices may be located miles from the CPU or, as in the case of most microcomputers, share the same cabinet enclosure.

Figure 1. Computer Basics
The input unit transfers information, such as typed commands, from a video display terminal to the computer. The information, both instructions and data, is stored in specific locations (cells) in the computer's memory. Each cell has a unique name for identifying its position so the CPU can rapidly access any information in memory.

The control unit of the CPU maintains the orderly processing of a sequence of events. Once an instruction is retrieved and decoded, the control unit issues messages to units, internal and external to the CPU, for the appropriate processing action, such as activating the output unit when a program instruction requires that data be written out.

The arithmetic/logic unit of the CPU performs all arithmetic functions, such as addition, subtraction, multiplication and division. Logical contrasts, such as alphabetical comparisons of names, are implemented through Boolean Algebra (a binary numbering system based on the digits 0 and 1).

The registers are temporary storage areas within the CPU aiding the arithmetic/logic and control units. The registers minimize the "shuffling" of information between the CPU and memory, thereby enhancing processing efficiency.

The output unit transfers the contents of a memory location to some output device, such as the screen of the video display terminal or a printer. The output unit, like the input unit, serves as the communications link between the computer and the operator.
Interactive Computer Systems. Many computers support interactive or conversational computing. Integral to interactive processing is the video display terminal, a device capable of displaying messages on a cathode ray tube (similar to a television screen) and equipped with a keyboard for transmitting messages to the computer. Because of its ability to send and receive messages from the computer, the video display terminal functions as both an input and output unit.

The communication link between the computer and video display terminal can be wired directly (hardwired) or may be a telephone link. In order to initiate communications via the telephone, the computer user dials the computer center's number and places the telephone receiver into a modem (telephone translating device) attached to the video display terminal. Many microcomputers share the same cabinet enclosure for both video display terminal and computer, forming a very compact unit.

Once the computer is engaged, the computer user can pursue a conversational dialogue with the computer. Responses will be virtually instantaneous due to high transmission rates and computing speeds. The modern computer operates at speeds measured in nanoseconds (one nanosecond is to one second as one second is to 32 years), and is capable of executing one to 200 million instructions per second.
Operating Instructions

This section will acquaint you with the video display terminal and microcomputer disk system. Specifically, this section describes the various functions of the terminal keyboard and provides instructions for log-in and log-off (steps required to initiate and terminate communication with the art instruction programs).

**Microcomputer Controls.** The video display terminal is an electronic communications device which displays messages from the computer on a cathode ray tube (similar to a television screen) and sends messages to the computer on a typewriter-like keyboard. Because of its ability to both receive and transmit messages to the computer, the video display terminal operates as an input and output device. Many microcomputers house the video display terminal and other computer components in a common cabinet.

To converse with the computer, the operator performs a log-in procedure. Messages appear on the screen in conversational English followed by a blinking underscored area for the operator's response. The underscore or cursor indicates the operator's exact position on the screen. The response is typed on the keyboard and appears directly above the cursor. Once the information is inserted, transmission to the computer is initiated by depressing the (enter) key (see Figure 2). The cursor is repositioned by the computer for the next response.
Figure 2. Keyboard Layout

Figure 3. Microcomputer Architecture
Depressing the (<) key permits the operator to backspace the cursor. Misspellings may be corrected by backspacing and retyping the correct character(s).

**Disk System.** The disk system serves as an extended memory or library for storing program instructions and data. The disk system operates in much the same manner as a tape recorder. Information is magnetically reproduced on interchangeable "floppy" disks or diskettes. Each diskette is capable of storing in excess of 100,000 bytes or characters of information (see Figure 4).

The diskette utilized for art instruction contains all programs and computer instructions for controlling the TRS-80 Model III microcomputer.

---

*Figure 4. Diskette*
Log-In or Starting Operations

Summary. The log-in procedure activates the microcomputer. Log-in is a simple process of turning on the microcomputer, inserting the diskette, and entering the proper command sequence on the keyboard.

Caution. Diskettes are fragile; handle by the jacket only. Do not touch or wipe any of the exposed surfaces.

Note. The disk drive led (light emitting diode) glows red when the diskette is accessed by the microcomputer.

Instructions.
1. Turn the microcomputer on (see Figure 3).
2. Wait until all disk drive motors stop.
3. Insert the diskette into drive 0 with the label side facing up and the read/write window pointed into the drive slot (see Figure 3 and 4). Caution - Diskettes are fragile; handle by the jacket only. Do not touch or wipe any of the exposed surfaces.
4. Close the disk drive door once the diskette is inserted.
5. Depress the "R" key (see Figure 3). Note - The disk operating system will display operating parameters and prompt for additional information.
6. Enter the date in the form MM/DD/YY and depress the (enter) key. Note - For example, enter 01/02/83 for January 2, 1983.
7. Depress the (enter) key after the microcomputer prompts for time. Note - The microcomputer responds with "DOS READY".
8. Finally, enter DO ARTS and depress the (enter) key. Note - The microcomputer responds with a menu describing the art program sequence (see Graphics Instruction Program).

Log-Off or Termination Instructions

Summary. The log-off procedure terminates microcomputer operation. Log-off is a simple process of aborting the art program sequence, removing the diskette, and turning off the microcomputer.

Caution. Diskettes are fragile; handle by the jacket only. Do not touch or wipe any of the exposed surfaces.

Instructions.
1. Enter selection five (log-off finished) from the art program menu.
2. Wait until all disk drive motors stop.
3. Remove the diskette. Caution - Do not touch or wipe any of the exposed surfaces.
4. Place the diskette in its storage envelope.
5. Finally, turn the power switch off (see Figure 3).

Graphics Instruction Program

Once the log-in sequence is completed, the computer will respond by displaying a menu of subprograms or modules on the video screen. The modules provide basic drill problems and recursive tutoring aid.

Module one, HELP, provides a description of the video screen area (picture plane), as well as an opportunity to practice
electronic drawing on the computer. There is no analysis of the
drawn image so the HELP module is an excellent review and "warm-up"
area.

Modules two through four, rhythm and repetition, positive-
negative space, and balance, provide computer analysis of drawn
compositions and tutoring when drawings fail to meet minimum guide-
lines.

Module five, log-off finished, is the quit procedure once the
desired modules are completed. The graphics program may also be
terminated (forced log-off) from within the modules by depressing
the break key.

A module is selected by entering the module number and
depressing the enter key.

Module One: HELP. The HELP module visually defines the
picture plane and provides a framed screen area for electronic
drawing. Drawing is easily accommodated on the numeric keypad (see
Figure 5).

A rectangular dot, or cursor, in the upper left corner of the
picture plane border indicates the initial drawing position (see
Figure 6). Numeric keys eight, two, four, and six move the cursor to
any desired screen position. Key five prints the cursor permanently
at the current screen position. Erasing a printed dot requires the
"Φ" key. Key seven causes the cursor to blink and may be especially
helpful when filling-in drawn areas on the screen. Depress the "Q"
key to terminate the drawing sequence. The "Q" key will also erase
the cursor's last position if it has not been printed (key five).
The table summarizes the drawing keys:

<table>
<thead>
<tr>
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<th>FUNCTION</th>
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<tr>
<td>2</td>
<td>Moves the cursor down one unit.</td>
</tr>
<tr>
<td>4</td>
<td>Moves the cursor left one unit.</td>
</tr>
<tr>
<td>6</td>
<td>Moves the cursor right one unit.</td>
</tr>
<tr>
<td>8</td>
<td>Moves the cursor up one unit.</td>
</tr>
<tr>
<td>5</td>
<td>Prints the current cursor position on the screen.</td>
</tr>
<tr>
<td>Ø</td>
<td>Erases the current cursor position on the screen.</td>
</tr>
<tr>
<td>7</td>
<td>Blinks cursor – depress to blink or stop blinking.</td>
</tr>
<tr>
<td>D</td>
<td>Finished drawing – analyze.</td>
</tr>
<tr>
<td>P</td>
<td>Print the drawing and then analyze.</td>
</tr>
</tbody>
</table>

The HELP module does not analyze the completed drawing; the intent is to provide a learning area for subsequent drawing exercises.

**Module Two: Rhythm and Repetition.** The rhythm and repetition module offers a variety of computer generated designs. The design example sequence may be bypassed for the drawing exercise stressing rhythm and repetition. Computer analysis of the completed drawing is based upon balance along the horizontal and vertical axes and evidence of data in all four quadrants of the picture plane. Individuals requiring additional assistance, based on drawing analysis, are provided rhythm and design examples and requested to attempt another drawing.

**Module Three: Positive-Negative Space.** The positive-negative space module provides computer generated design examples and requests a drawing (using the procedure outlined in module one – HELP) emphasizing positive-negative space. Computer analysis of the
completed composition is based upon the presence of distributed data and a comparison of positive space (artist drawn areas) and negative space (dark remaining areas within the picture plane). Results are presented in a percentage format; for example, positive space exceeds negative space by 20%.

Recursive programming causes the module to repeat should the drawing under analysis lack a distribution of data. As in other modules, initial tutoring may be bypassed for immediate access to the drawing exercises.

Module Four: Balance. The balance module indicates a bypassable tutoring sequence, and a request for a drawing emphasizing balance and positive-negative space.

Horizontal, vertical and radial balance are presented in the tutoring sequence as well as a comparison of a design employing dynamic balance and another utilizing rhythm and repetition as a balancing tool.

Once the tutoring sequence is complete, the module requests a drawing which considers both positive-negative space and a sensitivity towards balance. The resulting computer analysis of the completed drawing presents a positive-negative comparison as described in the previous module and a balance comparison of the left, right, top, and bottom segments of the picture plane. The balance results are presented in a numeric format as a basis for comparison; for example, left = 20, right = 22, top = 25, and bottom = 23. The relative difference between the numbers expresses the difference in weighting from a central point within the picture plane.
<table>
<thead>
<tr>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLINK</td>
<td>UP</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>LEFT</td>
<td>PRINT</td>
<td>RIGHT</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>0</td>
<td>ERASE</td>
<td>ENTER</td>
</tr>
</tbody>
</table>

NOTE: GREYED KEYS ARE THOSE UTILIZED FOR MANIPULATING THE CURSOR OR DRAWING DOT

**Figure 5.** Numeric Keypad for Drawing

![Figure 5. Numeric Keypad for Drawing](image)

**Figure 6.** Picture Plane (Drawing Area)

![Figure 6. Picture Plane (Drawing Area)](image)
Recursive programming causes the module to repeat should the drawing under computer analysis lack a distribution of data (artist has not drawn in the left-right or top-bottom portions of the framed picture plane).

Computer Analysis of Drawn Images

The extrinsic and intrinsic elements combining to form a drawing can hardly be defined by a few quantitative algorithms; however, due to the limitation of the classroom microcomputer, several coarse algorithms were developed for analysis of the student drawn images of the rhythm and repetition, positive-negative space, and balance modules.

All drawing is displayed on a picture plane circumscribed by an illuminated frame (see Figure 6). This picture plane is composed of a matrix of discrete addressable locations within the microcomputer (see Figure 7). Each matrix location corresponds to a particular cursor location on the picture plane. Printing a cursor location on the screen initializes the corresponding location within the matrix thereby denoting a "drawn dot position." Once the drawing is completed, the student "quits" the drawing routine and the initialized matrix is analyzed.

The picture plane matrix is examined on the basis of a distribution of drawn dots and a comparison of drawn dots (initialized locations) to non-drawn dot locations. Positive-negative space is realized by summing the number of initialized locations and expressing this as a percentage of the non-drawn (non-initialized) locations. Balance is considered through acceptance of a neutral
Figure 7. Addressable Picture Plane Locations

Figure 8. Dot Weighting
horizontal and vertical axis -- an area of absolute symmetry. From the horizontal axis all drawn dots appearing above are summed based on their integral distance from the axis. This presumes that a point further from the reference axis is "weighted" more heavily than one closer in to the reference axis (see Figure 8). The amount of weighting is described as equal to one-half times the distance in units from the reference axis. This summation of drawn dots is also performed for the area appearing below the horizontal axis and again for all drawn dots appearing to the left and right of the vertical axis. The top, bottom, left, and right drawn area summations are then displayed to the student as a basis of comparison for the "weighting" or balance of the drawn image. The closer the sums, the more evenly balanced the drawing.

The rhythm and repetition module utilizes the above described balance methodology along with a check for drawn dots in all quadrants (top, bottom, left, right areas). Quantitatively speaking, a well executed rhythmic-repetitive drawing would have less than a ten percent discrepancy in any of the summed areas (balance methodology) and have drawn information in all quadrants.

The positive-negative space module compares the number of drawn to non-drawn locations and displays this as a percentage.

The balance module displays both positive-negative space calculations and balance calculations.

While the algorithms are coarse, they provide an adequate basis for analysis within the confines of the picture plane with the graphics provided on the TRS-80 Model III microcomputer.
Each of the 13 students was asked for a written evaluation of the supplied documentation and analysis of the graphics program as presented on the Radio Shack (Tandy) TRS-80 Model III microcomputer.

Results of the 13 student evaluators were as follows: Unanimous acceptance of the graphics system as an aid for teachers; valuable tool for computer literacy; and complete approval of the approach and methodology of the supplied documentation.

The students offered the following recommendations and criticisms: Desire for a hardcopy (printed) version of completed graphics drawings; difficulty in drawing circles and curves; cursor movement was too slow inhibiting rapid drawing; and a desire for speedier analysis of the completed drawing.
CHAPTER 4

DISCUSSION

The student evaluation results suggest enthusiasm for microcomputer aided instruction in art. This is particularly noteworthy since none of the participants had any formal training in computer science; in addition, the electronic drawing methodology was completely foreign.

The TRS-80 Model III microcomputer is a commonly utilized microcomputer in many educational institutions and, for this reason, was the focus for the graphics program. Unfortunately, the TRS-80 Model III, is not as graphics orientated as some other currently marketed microcomputers -- especially the new color microcomputers. This graphics limitation becomes apparent when drawing a curved or circular line. The resultant line is saw-toothed or jagged due to the large pixel size (addressable dot or point of light on the screen). Several student evaluators found this aspect cumbersome although surmountable.

Also addressed by several student evaluators was a desire to speed up the drawing process. This modification has been incorporated in the revised graphics program (Appendix A).

Lastly, a provision for printing the drawn image was suggested by several student evaluators. The graphics program was designed for immediate quantitative analysis of roughly imaged student drawings. Due to the aforementioned limitation of pixel size, the
student drawings would be expectedly coarse and, therefore, generally only suitable for learning the mechanics of design. However, a dependance upon the permanency of the completed drawing was very important to several subjects and therefore incorporated into the revised graphics program (Appendix A).

The revised program reflects the recommendations of the student evaluators insofar as the limitations of the microcomputer permit.

The microcomputer assisted graphics program provides an introduction to computer graphics, a quantitative analysis of student drawn designs, and a step towards computer literacy and its applications in art education. Results suggested that creativity was not inhibited by the limitations of a typical classroom microcomputer but provided a new and exciting approach to the study of design. Future programming endeavors require development of more sophisticated graphics programs which not only provide analysis, but yield to the full creative potentials of the student artist.
APPENDIX A

GRAPHICS PROGRAM LISTING

10 REM ART PROGRAM COPYRIGHT P.E.CALLAHAN 1982
20 DIM A1(23,23)
70 REM DISPLAY MENU AND ENTER MAIN LOOP
80 CLS
90 PRINT:PRINT:PRINTTAB(22):"ROUTINE SELECTION*
100 PRINT:PRINTTAB(4):"1 Help!
2 Rhythm and Repetition":PRINT
TAB(4):"3 Positive/Negative Space 4 Balance":PRINTTAB(4):"5 Log off - finished"
140 ON S1 GOSUB 200:1050,1650,2060,150
150 REM DETERMINE IF LOG OFF
160 IF S1=5 THEN CLS:PRINT":...Goodbye...":END ELSE IF S1<1 THEN GOTO 70 ELSE IF S1>4 THEN GOTO 70 ELSE GOTO 90
170 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
200 REM XXX SHAPE ROUTINE XXX
230 CLS:PRINT0385:"...The picture plane is the area on which you electronically
draw an image...";FOR T1=1TO1000:NEXT T1CLS
250 REM DEFINE PICTURE PLANE
270 FOR C1=1TO10:XL=XL-4:XR=XR+4:YL=YL-2:YD=YD+2:SET(XL,24):SET(XR,24)
280 :SET(YL,YD):SET(48,YL):SET(48,YD):NEXT C1:FOR T1=1TO500:NEXT T1
300CLS:PRINT0957:"...The picture plane stops at":PRINT0255:"the defined border...
..":GOSUB 500:FOR T1=1TO1000:NEXT T1
330 REM DRAW A FORM
400 CLS:PRINT0385:"...Try drawing a shape within the picture plane borders...":F
OR T1=1TO1000:NEXT T1:CLS:GOSUB 500:GOSUB 550:GOSUB 650:GOSUB 1350
40 REM INKEYS:<" THEN GOTO 450
470 CLS:PRINT":Help! Section Completed":.480 RETURN
490 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
500 REM XXX PICTURE FRAME BORDER XXX
530 RETURN
540 REM XXX PICTURE DRAWING INSTRUCTIONS XXX
550 REM PICTURE DRAWING INSTRUCTIONS
560 PRINT@50,0:"---------":;PRINT@114:"DRAWING INFO":;PRINT@178,:---------":
570 PRINT@306:"Move Up =8":;PRINT@379:"Move Down =2":;PRINT@434:"Move Left =4"
580 ;PRINT@498:"Move Right =6":
590 PRINT@562,"Print Dot =5":;PRINT@626,"Erase Dot =0":;PRINT@690,"Blink Dot =7"
590 ;PRINT@754,"Done =D":;PRINT@818,"Printer =P":
600 RETURN
610 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
650 REM XXX PICTURE DRAWING XXX
660 REM LOCATE CURSOR ON PICTURE PLANE
670 R=1:C=1:L1=0:FOR Y2=1TO2:FOR X2=1TO5:SET(X2,Y2):X1=X2:Y1=Y2:NEXT X2:NEXT Y2
690 REM LOOP FOR USER INPUT
80 IF IS="D" THEN GOSUB 950:GOTO 900
70 REM CHECK FOR USER INPUT
720 IF IS="P" THEN GOSUB 950:GOSUB 3500:GOTO 900
730 REM CHECK FOR PRINT SWITCH
740 IF IS="S" THEN L1=1

26
270 REM CHECK FOR ERASE SWITCH
271 IF IS='0' THEN L1=0:R1=0:GOSUB 990
270 REM CHECK FOR DOWN SWITCH
272 IF IS='2' AND Y1<45 THEN GOSUB 950:R1=R1+1:FOR X2=X1-3 TO X1:FOR Y2=Y1-1 TO Y1:IF Y2<0 THEN GOTO 690
273 REM CHECK FOR UP SWITCH
274 IF IS='6' AND Y1>2 THEN GOSUB 950:R1=R1-1:FOR X2=X1-3 TO X1:FOR Y2=Y1+1 TO Y1:IF Y2>60 THEN GOTO 690
275 REM CHECK FOR LEFT SWITCH
276 IF IS='4' AND X1<90 THEN GOSUB 950:R2=R2-1:FOR X2=X1+1 TO X1+4:FOR Y2=Y1-1 TO Y1:IF Y2<0 THEN GOTO 690
277 REM CHECK FOR RIGHT SWITCH
278 IF IS='8' AND X1>90 THEN GOSUB 950:R2=R2+1:FOR X2=X1+1 TO X1+4:FOR Y2=Y1-1 TO Y1:IF Y2>60 THEN GOTO 690
279 REM CHECK FOR SIZE CHANGE
280 IF IS='7' THEN IF L2=0 THEN L2=1 ELSE L2=0
281 GOTO 690
282 RETURN

900 REM
901 REM xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
902 REM xxx RHYTHM AND REPETITION xxx
903 REM
904 PRINT R3B5....Would you like to see an example of rhythm and repetition?
905 IF INPUT "...Enter Y or N;"="Y" THEN GOTO 1190 ELSE GOSUB 1350:GOSUB 1300
906 REM CHECK FOR CONTINUE-RETURN FOR EXAMPLE
907 IF INKEYS<" " THEN GOTO 1170
908 GOTO 1190
909 REM USER DRAMS DESIGN
910 PRINT R3B5.Try drawing a repetitive and rhythmic design......
911 FOR X2=X1 TO X1-3 STEP 1:FOR Y2=Y1 TO Y1-3 STEP 1:IF Y2<0 THEN GOTO 690
912 FOR X2=X1 TO X1-3 STEP 1:FOR Y2=Y1 TO Y1-3 STEP 1:RESET (X2,Y2)
913 RETURN
914 REM xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
915 REM xxx TRY AGAIN ROUTINE xxx
916 IF INPUT "...Try filling in the picture...Press Space Bar to plane more..."<" " THEN GOTO 1265:FOR T1=1 TO 2500 NEXT T1
917 IF INKEYS<" " THEN GOTO 1270
918 REM CLS:PRINT R3B5.Explanation completed.
919 RETURN
920 REM xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
921 REM xxx xxxxxx TRY AGAIN ROUTINE xxx
922 IF INPUT "...Try filling in the picture...Press Space Bar to plane more..."=" " THEN GOTO 1265:FOR T1=0 TO 2100 NEXT T1
923 IF INKEYS<" " THEN GOTO 1370
924 REM CLS:PRINT R3B5.Explanation completed.
925 RETURN
926 REM xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
927 REM xxx xxxxxx EXPLANATION FOR EXAMPLE QUIT ROUTINE xxx
928 PRINT R3B5.Once Work Is Done, Press Space Bar to
• PRINTB562 * PRINTB562 * PRINTB562 *
• PRINTB754 * PRINTB754 * PRINTB754 *
• PRINTB816 * PRINTB816 * PRINTB816 *

1380 RETURN
1385 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
1390 REM XXX CLEAR SCREEN VERBAL AREA XXX
1392 PRINTB50 * PRINTB114 * PRINTB178 *
• PRINTB370 * PRINTB434 * PRINTB498 *
1394 PRINTB562 * PRINTB626 *
• PRINTB690 * PRINTB754 *
1395 RETURN
1396 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
1400 REM XXX BALANCE ROUTINE XXX
1410 XP=0:XM=0:YP=0:YM=0:PS=0:NS=0
1413 PRINTB1010 " I'm thinking;"
1420 REM CALCULATE LEFT SUM
1430 CW=12:FOR CI=1TO11:CW=CW-1:FOR R1=1TO23:GOSUB 1540:NEXT R1:NEXT CI
1435 PRINTB1010 " Hmmmmmmm"
1440 REM CALCULATE RIGHT SUM
1450 CW=0:FOR CI=13TO23:CW=CW+1:FOR R1=1TO23:GOSUB 1560:NEXT R1:NEXT CI
1455 PRINTB1010 " Hmmmmmmm"
1460 REM CALCULATE TOP SUM
1470 RH=12:FOR R1=1TO11:RH=RH-1:FOR CI=1TO23:GOSUB 1580:NEXT CI:NEXT R1
1475 PRINTB1010 " Almoast Done!"
1480 REM CALCULATE BOTTOM SUM
1490 RH=0:FOR R1=13TO23:RH=RH+1:FOR CI=13TO23:GOSUB 1600:NEXT CI:NEXT R1
1492 IF PS<0 AND NS<0 THEN IF PS>NS THEN PD=NS/PS ELSE PD=PS/NS
1495 PRINTB1010 ";"
1500 RETURN
1520 REM XXX BALANCE CALCS XXX
1540 IF A1(R1,C1)=1 THEN XM=INT(XM+(CW*.5)+1):PS=PS+1 ELSE NS=NS+1
1550 RETURN
1560 IF A1(R1,C1)=1 THEN XP=INT(XP+(CW*.5)+1):PS=PS+1 ELSE NS=NS+1
1570 RETURN
1580 IF A1(R1,C1)=1 THEN YP=INT(YP+(RH*.5)+1):A1(R1,C1)=0
1590 RETURN
1600 IF A1(R1,C1)=1 THEN YM=INT(YM+(RH*.5)+1):A1(R1,C1)=0
1610 RETURN
1620 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
1650 REM XXX POSITIVE/NEGATIVE SPACE XXX
1660 CLS:PRINTB50 * ... Would you like to see an example of positive/negative space? INPUT ... Enter Y or N * SS2
1700 IF S2<"Y" THEN GOTO 1770 ELSE CLS:GOSUB 500:GOSUB 1350:R1=RND(8):R2=RND(8)
1720 IF I=1TO(99) STEP (R1+R1):FOR J=1TO(46) STEP (R2+R2):FOR K=1TO(1910):NEXT L:NEXT K:NEXT J:NEXT I
1740 REM CHECK FOR CONTINUE - RETURN FOR ANOTHER EXAMPLE
1750 IF INKEY$="*" THEN GOTO 1750
1760 GOTO 1680
1770 REM USER DRAWS POS/NEG EXAMPLE
1779 CLS:PRINTB50 * ... Try drawing a design emphasizing Positive/Negative space.
1800 FOR Ti=1TO700:NEXT Ti:CLS:GOSUB 500:GOSUB 550:GOSUB 650
1820 REM PERFORM POS/NEG SPACE CHECK
1895 GOSUB 1290:GOSUB 1400:IF PS<0 AND NS<0 THEN GOSUB 1390:GOSUB 2050:GOSUB 2
1896 GOSUB 1350 ELSE GOSUB 1390:GOSUB 2030:GOSUB 1310:GOTO 1680
1870 IF INKEY$="*" THEN GOTO 1870
1890 CLS:PRINT* " Positive/Negative Space Completed"
1900 RETURN
1905 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
1910 REM XXX DESIGN POS/NEG CHECK XXX
1920 IF L>46 THEN GOTO 1930 ELSE IF K>93 THEN GOTO 1930 ELSE IF POINT(K,L) THEN
1930 GOTO 1930 ELSE SET(K,L)
1935 REM XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
2030 REM XXX SCREEN ARRAY CLEAR XXX
2032 FOR CI=1TO23:FOR R1=1TO23:A1(R1,C1)=0:NEXT R1:NEXT CI
2034 RETURN
2040 REM xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
2050 REM xxx POS/NEG RESULTS EXPLANATION xxx
2051 PRINT05O » • * ; ! PRXNT0114 r ' PQS/NEC * » tPRINTS178p ' '
2052 PW=INT<(l.OO-PD)xiOO)tIF PH<10 THEN PRINT03O6»•..Positive* J J PRINT037O r
2053 PRINTS434»' Negative * •tPRINTB498F'space HI'JtGOTO 2057
2055 IF PS>NS THEN PRINT03O6r'...Positive*ftpRINT0434»'Negative by"»tPRINTB501»PWJ
2057 FOR T1 = 1T02500NEXT T1
2058 RETURN
2059 REM xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
2060 REM xxx BALANCE xxx
2090 REM EXAMPLES OF DYNAMIC BALANCE
2095 CLS!PRINTB390t .Mould you like visual instruction in balance't INPUT"...
2096 PRINTS
2097 FOR T1=1T01800 tNEXT T1
2098 FOR T1=1T01500 tNEXT T1
2099 REM INTRODUCE VERTICAL AND RADIAL BALANCE
2100 PRINTB387?'...The same design modified for Horizontal Balance...'tFOR T1=1T01800NEXT T1
2101 PRINTS
2102 FOR T1=1T06500NEXT T1
2103 IF INKEYS<> ' THEN GOTO 2100
2104 CLS!PRINTB391»...Try drawing a design emphasizing Balance...";PRINT0114 r ' BALANCE '
2105 PRINTB498F ' BALANCE ' ;PRINT0178r;"```
2770 PRINT8306,"Left half....":PRINT8372,XH":PRINT8434,"Right half....":PRINT8500
  »XP":PRINT8562,"Top half....":PRINT8628;YP":PRINT8690,"Bottom half....":PRINT8756
  »YM:
2780 RETURN
2790 REM xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
2800 REM xxx DYNAMIC BALANCE DESIGN xxx
2810 FOR R1=1T05:FOR C1=32T065:SET(C1,R1):NEXT C1:NEXT R1
2820 C2=31:FOR R1=6T013:C2=C2+2:FOR C1=C2T065:SET(C1,R1):NEXT C1:NEXT R1
2830 C2=12:C3=35:FOR R1=14T019:C2=C2-2:C3=C3+3:FOR C1=C2T065:SET(C1,R1):NEXT C1:
  NEXT R1
2840 C2=0:C3=53:FOR R1=20T023:C2=C2+3:C3=C3-3:FOR C1=C2T065:SET(C1,R1):NEXT C1:
  NEXT R1
2850 C2=12:C3=47:FOR R1=24T030:C2=C2+3:C3=C3-2:FOR C1=C2T065:SET(C1,R1):NEXT C1:
  NEXT R1
2870 C3=52:FOR R1=31T035:C3=C3-2:FOR C1=33T065:SET(C1,R1):NEXT C1:NEXT R1
2880 FOR R1=36T046:FOR C1=31T093:SET(C1,R1):NEXT C1:NEXT R1
2890 FOR R1=20T026:FOR C1=72T088:SET(C1,R1):NEXT C1:NEXT R1
2900 RETURN
2990 REM xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
3000 REM xxx HORIZONTAL BALANCE TERMINOLOGY xxx
3010 PRINT850,"This design:'":PRINT8114,"is now":PRINT8178,"horizontally":PRINT8242,"balanced":";
3020 RETURN
3030 REM xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
3050 REM xxx HORIZONTAL WEIGHT SCALE xxx
3070 RETURN
3080 REM xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
3090 REM xxx BASIC DESIGN EXAMPLE xxx
3100 FOR I=16TO31:FOR J=18TO23:SET(I,J):NEXT J:NEXT I
3110 RETURN
3120 REM xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
3150 REM xxx PRINT CONTROL xxx
3160 ST%=PEEK(14312) AND 24:IF ST% <= 48 THEN CLS:PRINT8390,"PRINTER NOT AVAILA
3170 BLE*RETURN ELSE FOR R1=1TO23:LPRINT* "*FOR C1=1TO23:GOSUB 3600:NEXT C1:NEXT R1
3180 RETURN
3190 REM xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
3200 IF A1(R1,C1)=1 THEN LPRINT*X *ELSE LPRINT" ";
3210 RETURN
3220 REM xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
REFERENCES


