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A Case Study of a Prototype Computer-Aided Architectural Design System

by
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In this investigation an attempt was made to identify the elements and procedures in the design process that occur most frequently among the varying design methods and that can be defined well enough to be implemented on a computer-aided design system. A prototype system was developed which addressed the preliminary design stages of adjacency diagrams, bubble diagrams, and block layout diagrams.

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FOREWORD

This investigation was performed for the Headquarters, U.S. Army Corps of Engineers (HQUSACE), under Project 4A161102AT23, "Basic Research in Military Construction"; Task A, "Base/Facility Development"; Work Unit 35, "Extracting Architectural Design Objectives."

This research was performed by the Facilities Systems Division (FS), U.S. Army Construction Engineering Research Laboratory (USA-CERL). USA-CERL personnel directly involved in the study were Laura S. Bond, Kenneth Crawford, and Beth A. Symonds of the Design Systems Team. They wish to acknowledge the guidance of acting Team Leader L. Michael Golish. The technical editor was Jane Andrew, Information Management Office, USA-CERL.

The research analysis was done in cooperation with James R. Anderson, Professor of Architecture and Sue Weidemann, Professor of Landscape Architecture, both of whom are involved in the Housing Research and Development Program at the University of Illinois at Urbana-Champaign.

Dr. Michael J. O'Connor is Chief of the Facility Systems Division. COL Carl O. Magnell is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

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1 INTRODUCTION

Background

The ambiguous and intuitive nature of schematic and concept design makes it difficult to develop an adequate computer aided design system, since the computer is best at solving problems in a linear, general process. Despite the difficulties, such systems have been developed in the last twenty years, but without great success. Most of this development has concentrated on technical aspects of making a system work. The quality of the "fit" between the computer based design tool and the actual design process may be the determining factor of the tool's success. A design tool which requires the user to adopt new processes may adversely affect both the speed and the quality of a solution. Before computer-aided architectural design (CAAD) tools can truly enhance the quality and speed of design, more must be known about the architectural design process in general. To be successful, any such system must accommodate both the heuristic computer and the holistic designer.

No matter what accommodations are made, however, designers may resist the introduction of computers to the design process. Even so, the possible advantages of computer aided design systems are such that it is worthwhile to try to overcome this resistance. One major advantage is that a CAAD system could provide on-line analysis that would catch problems before they reach a stage where they are hard to change. Other useful features could include massing studies, cost analysis, and material take-off reports. With a developed CAAD system, it would also be possible to electronically transfer drawings from the designer to a technician to have the documentation finished. As the whole process of building design becomes automated, the designers would be able to more effectively detect system interference problems.

Objective

The objectives of this research were (1) to develop a prototype computer-aided concept design and (2) to perform a case study comparing the use of this system to traditional methods. The intent of these efforts was to gain insight into possible universal elements of the architectural design process and into how computers can accommodate them and assist in the process as a whole.

Approach

This research took place in two steps. First, USA-CERL researchers developed a prototype computer system, Charrette, that permits an architect to develop a preliminary concept design using one of several different methods, or a combination of methods. They investigated requirements that CAAD systems need to meet, then developed machine independent specifications for an extensive system. However, because of time and software constraints, only a portion of these specifications were implemented.

Second, a case study was performed using this system to compare the design process on a computer-aided system to traditional techniques and to generate user reactions to computer aided design. The design process was tracked, so that--if possible--common methodologies could be identified. The case study subjects consisted of several advanced design students from the University of Illinois at Urbana-Champaign who were trained in the use of Charrette. They did designs using both traditional methods and Charrette. Researchers observed and interviewed these users and obtained the users' self-reports of their experience. Because of the small sample, few observations could be made about the universals of architectural design, but valuable questions were raised for further research.

Mode of Technology Transfer

The data collected from this study is being used in developing the specifications for an automated architectural design system. The system is being developed at USA-CERL and tested in Corps District offices. After testing is complete, and enhancements added, the system will be distributed.

2 COMPUTER AIDED ARCHITECTURAL DESIGN SYSTEM REQUIREMENTS

When a designer, architectural or otherwise, sits down with a blank piece of paper to begin a design, there are a variety of possible solutions--and a variety of ways of arriving at them as well. "Many approaches to design are advocated and practiced by architects. While these approaches to designing may differ, there is one belief that the various architects and designers appear to share, namely, that their methods encapsulate the 'essence' of designing."[1] This ambiguous and intuitive nature of schematic and concept design makes it difficult to develop an adequate computer aided design system, since the computer is best at solving problems in a linear, general process.

Before developing a CAAD system, USA-CERL examined the requirements for such a system. These were taken as goals for the prototype system that evolved. Although many of these goals could not be implemented in the available time, it is worthwhile to discuss them.

Designers may resist the idea of using a computer during the design process. It will mean learning a new, "automatic" sketching technique, when pencil sketches done on the backs of envelopes seem more familiar. For designers to be comfortable with a computer, decades of tradition need to be changed. Thus, the CAAD system needs to have a proven track record. Seigel and Davis[2] have said that the presence of the computer based system should not intrude on the primary process that is occurring. They were referring to computer-based education, but the same is even more true of a complex, creative process such as design. Because concept and schematic design are the most changeable and intuitive phases of design, any CAAD system must be transparent to the user, that is, the user must be able to work as though the computer were not there.

A CAAD system must be extremely flexible, because there are as many "right" formulas for design as there are designers. There will be limitations because of the linear nature of computer processing, but if maximum flexibility is allowed in the computer system, the designer can follow his/her own "right" methodology. The areas where this flexibility is needed include: the required sequence of steps taken througn the program, the amount of design information needed at the outset, the ability to update and expand the information base, and the "hardness" (state of finality) in his/her design.

While each architect has his/her own design method, all architects know certain information prior to any designing. To perform as a decision support, graphic input, and space manipulation tool, a CAAD program must have a method for accepting this information, which comes from many sources. As an architect starts a design, he/she brings some knowledge with him/her, as an expert in the field. Some knowledge is presented to him/her through client requests, design guides, and building requirement programs. Often it is necessary to do additional research to complete the building program, covering, for example, additional areas needed, code criteria, material requirements, and building image.

While an architect has this information at the beginning of the design process, he/she may or may not use this knowledge as a starting point. Since it is distracting to

[1] Ramesh Krishnamurti, "The MOLE Picture Book: On a Logic for Design," *Design Computing*, Vol 1, No. 3, p171.

[2] M. Seigel and D. Davis, *Understanding Computer-Based Education* (Random House, New York, 1986).

the creativity of the architect to have to recall this information, the CAAD system should also be able to retrieve and present detailed information upon request, at the most appropriate time. Thus, the designer will be free to concentrate on the job at hand--creating the best design possible.

A CAAD system could go beyond information retrieval and become a true decision support tool if it "remembered" decisions made as the design progresses. The designer could recall these decisions to support later analysis and synthesis, and to trace the development of the design from the the original criteria. Many decisions made during design are applicable only to the current design, and can be used for analysis in later phases. But there are also decisions that are applicable not only to the specific design, but to that type of design. These can be codified into "rules of thumb" that can be used as analysis criteria for the current design, and to develop guidelines for future, similar projects. These "rules of thumb" can include rules for basic architectural features applicable to most buildings, as well as rules applicable to specific building types. For a CAAD system to be able to save this information it must maintain a knowledge data base common to all projects. Similar to a symbol library, this common knowledge base would use the computer as a warehouse of knowledge. A natural outgrowth of this knowledge pool could be the development of an expert system for checking criteria. With an expert system, or a library of past decisions, a CAAD system could use previous design decisions as criteria and guidelines of future design decisions.

Just as the design process varies, design decisions vary in levels of finality. The cumulative result of all the decisions is only seen in the final design, but during any step of the design process, some decisions will be hard and fast while others will be vague. With the interactive analysis and synthesis nature of design, each decision supports or overrules previous decisions. Thus, a CAAD system must allow the user's decisions to have degrees of vagueness. This means the system must allow the designer to make preliminary decisions with very little information. One way to do this would be to set up default values for widths, lengths, and square footages of areas, for example. These defaults could be available from external sources, particularly analysis criteria, as design automation progresses.

Any CAAD system must take advantage of the fact that the architect is an expert system in him/herself. The architect should be a decision maker, not just a data enterer. As Heckel points out, "A user expects to feel he is in control of both the computer and the task."[3] It is also important that a CAAD system speak the language of an architect, not only using architectural jargon, but using it the way traditional, professional architects understand it. By drawing on the existing knowledge of the users, a CAAD system can become a decision support tool.

In summary, a successful CAAD system would

- Include enough flexibility to accommodate personal variation in design methods
- Be transparent to the user
- Use profession-specific language
- Accept and retrieve preliminary building requirements and criteria

[3]Paul Heckel, *The Elements of Friendly Software Design* (Warner Books, Inc., 1984), p16.

- Accumulate decisions and help the designer use past experience to improve current and future designs
- Allow flexibility in these decisions
- Take advantage of the user's knowledge wherever possible.

3 COMPUTER SYSTEM ENVIRONMENT

Apollo Computer Inc.'s smallest engineering workstation, a Domain Dn 300, was the environment selected for the development of USA-CERL's prototype research program. The Dn 300 is a 32-bit workstation with virtual memory and a floating point processor, and multi-processing capabilities. It is possible to have up to 15 concurrent processes on each computer. In the Apollo DOMAIN system, each process that the user requests can run different functions simultaneously. For example, one process may be compiling a program, another editing a file, and another running a spreadsheet.

Apollo's operating system, AEGIS, is similar to UNIX. It includes additional capabilities which allow a ring of Apollo "nodes" (other Apollo computers) to take advantage of any unused processing power of the other nodes. The user interfaces with the operating system through both the keyboard and a 3-button mouse. The interface can be confusing to an inexperienced user. AEGIS has two kinds of commands. The shell commands include the most commonly used commands, such as copying and deleting files. The DOMAIN commands include commands such as logging in and out and changing some system configurations. To minimize confusion among the test subjects, USA-CERL researchers created some system files to do commonly needed tasks.

The operating system interface uses a graphically oriented desktop metaphor. Each process is visually represented as a separate window, creating a multiwindow environment. If the user is not entering data in the window, the process may be represented as an icon. The windows and icons may be selected and manipulated using a 3-button mouse.

The display is managed by a high resolution (1024 x 800) monochromatic, bit-mapped, graphic display. The monitor is a 17 in. raster screen available in either a landscape display (1024 x 800) or portrait display (800 x 1024) mode. Apollo supplies software to manipulate the windowing and graphic display.

The software used to develop this program included: a FORTRAN 77 compiler, Apollo's Graphics Metafile Resource (GMR) routines, Apollo's system commands to interact with the operating system, and Apollo's editor. The FORTRAN 77 compiler follows ANSI standards with a few additions to allow FORTRAN to "talk" better to Apollo's operating system.

The prototype research program uses the Apollo's Graphic Metafile Resource (GMR) routines. These are similar to the Graphic Kernel System (GKS) standard. These routines create graphic objects referred to as segments. A segment can include, for example, a geometrical shape, a text string, and an area fill. Once a segment is formed, it is possible to "instance" it onto another larger, primary segment. An instance is a copy of the graphical object which can be moved, rotated, and erased without affecting the original object. For this program's purposes, instances are created to represent architectural spaces and are manipulated by the user. The original object is never actually displayed, and the user is allowed to create only one copy at a time. By allowing the user to add, erase, move, and rotate these graphic objects, the program provides a highly interactive graphic interface.

To allow the user to manipulate text, the prototype program uses Apollo's editor. This editor is a visual editor that has some of the advantages of a word processor, and some of the disadvantages of a line editor. The user can enter text anywhere in a file by simply moving the cursor there and typing. However, the editor does not have an automatic word wrap option. For the user whose experience is mainly in using word processors, this can be confusing. Because of the idiosyncrasies of some of the system commands, it was necessary to tightly control how the users exit from the text mode. Although this detracted from the simplicity of the user interface, it was unavoidable.

The major disadvantage encountered by using the Apollo system was the nontransportability of the computer code. Apollo Computer, Inc. provided the developer with extensive proprietary software whose capabilities, unfortunately, are not duplicated on other systems. In addition, the initial higher cost of the Apollo hardware and software makes this system an unlikely entry level environment in average sized architectural and engineering firms and Corps offices.

4 PROTOTYPE SYSTEM: CHARRETTE*

"Charrette" is a computer program that has been developed for use in the initial stages of building design, i.e., for use in translating program requirements into the first graphic representations. At this stage of the design process the primary issues often include determining the appropriate amount of space for each activity, determining the appropriate proportions for each space, and determining the appropriate relationship of one space to another. These are the tasks that Charrette has been designed to address.

General Characteristics

Before computer code was developed for Charrette, project members developed a set of program specifications. These were a set of drawings reflecting most of the major options and the user interface ideas (Appendix A). These were developed on a personal computer graphics program and therefore were of a very visual nature. These specifications were developed with no regard to the machine they would be implemented on. The later translation to the Apollo system necessitated a different user interface for many of the options. Time restrictions also prevented full implementation of the specifications. This report discusses the elements that both the specifications and final product have in common.

Charrette is based on a hierarchy of spaces. It uses three types of spaces, ranging from zones to groups of rooms to individual rooms. This allows the architects to develop area layouts without being explicit about specific area types and square footage. As more design decisions are made and the level of spatial definition is developed, the designer can use smaller scale area types. With spatial types, the architects can solve architectural design problems at the appropriate scale. Each option functions on each type of space. The prototype system only manipulates one space type at a time.

Flexibility was a primary goal in the development of Charrette. By allowing the user to access any of the options at any time, Charrette makes the design process flexible. Although options use information from each other, it is not necessary to enter one before any other or to enter more than one option. By having a hierarchy of space, as discussed above, Charrette requires different levels of architectural definition throughout the concept design. This allows a level of vagueness corresponding to the level of decisions made. So that the architect is not forced to make area decisions prematurely, Charrette has default spatial parameters. These include the area's square footage, width, and length (100 sq ft, 10 ft, and 10 ft) and adjacency relationships (neutral). Even when the architect does not know the final values, the default values may, by comparison, allow the architect to arrive at approximate values.

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*The program's name has a bit of history behind it. In the 1800's the Ecole de Beaux d'Arts held a competition every semester for the best architectural design. The drawings were wheeled down the streets to the faculty jury on carts. Students would stand on the carts and put the finishing details on the drawings. Charrette is the French word for these carts. In today's architectural jargon, charrette stands for staying up all night to put one's last ounce of effort into completing a design.

Options

In the design process, different information becomes available at different times. To accommodate this, Charrette is divided into three parts: (1) Sketch Book, (2) Graphic Interpretation, and (3) Graphics. The designer may start a project in any of the options (see Figure 1). Each of the three gives the designer a different way to enter and manipulate information. The Sketch Book option is the principal way to access information gathered prior to the design project. It presents textual material to the designer regarding external program research, and allows him/her to make and note decisions. To take full advantage of the decision process, an ideal CAAD system would also allow the designer to designate information entered as "rules of thumb" that could be stored externally. This would make full use of the architect as expert, and save his/her time in the next design. The graphic interpretation option deals both with knowledge acquired prior to the design process and with that developed during the design process. This option allows the designer to use tables to directly translate program requirements into areas. While viewing the tables, the architects may make decisions and add new spaces to complete the design. When one enters the graphic options, Charrette will graphically represent any areas already defined in the options above. All areas defined and modified in any of the options are available in any other of the options.

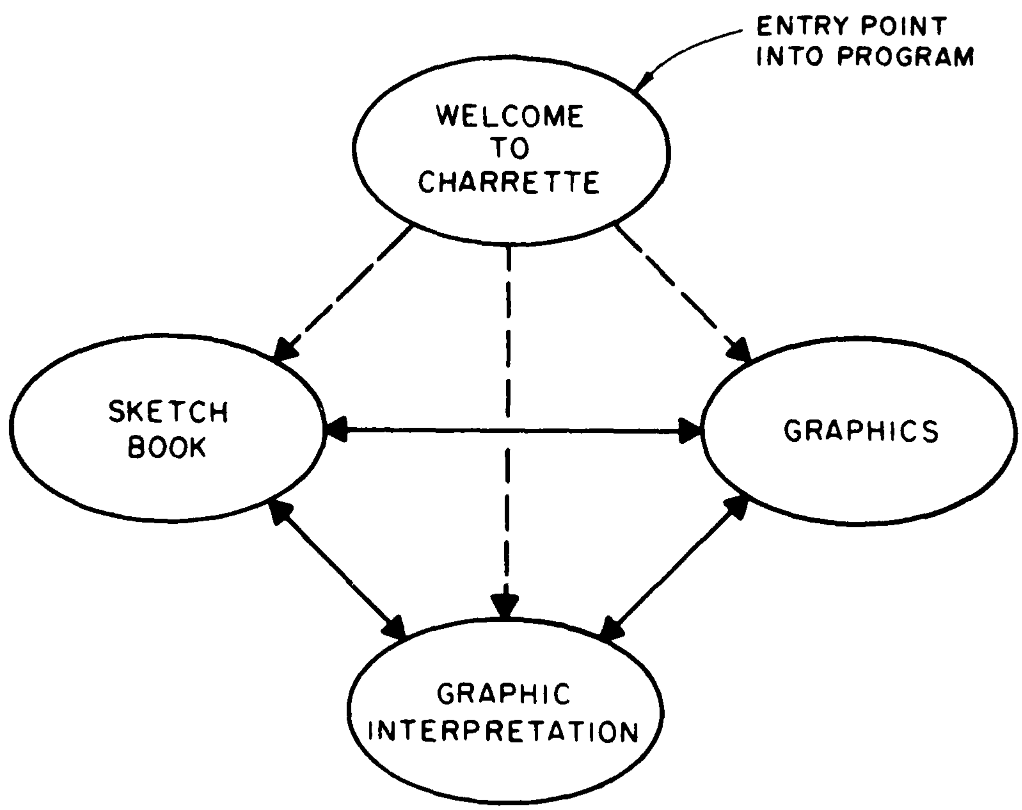

Figure 1. Flow diagram of Charrette's three major options.

Sketch Book

Similar to an actual notebook, the Sketch Book allows the designer to review program information and to write down his/her thoughts for future reference. The program information can be entered into external files that can then be accessed by the users. For the research analysis (see Chapter 5) the researchers created a set of external program files. Each subject was given copies of these files that they could modify through the Sketch Book option. In the Sketch Book option, the architect may define information that will later be useful, such as zone, group, and room names, and their relative adjacencies. These are the functions available in Sketch Book.

- Project Description
- Site Description
- Climate
- Code Requirements
- Building Requirements
- User Requirements
- Site Requirements
- Graphic Interpretation
- Graphics
- Stop.

Graphic Interpretation

Graphic interpretation allows the designer to store information about the building areas in tables. This information includes zone, group, and room names; adjacencies; and area sizes. This allows the user to quickly create and change areas and adjacencies. The functions are as follows.

- Assign Areas and Dimensions
- Define Adjacencies
- Spatial Organizations
- Sketch Book
- Graphics
- Stop.

Graphics

Graphics allows the architect to manipulate forms to create space layouts. The designer can create as many layouts as desired of the same set of spaces. There are three types of drawings presently included.

1. Adjacency Generated Bubble Diagrams. This drawing will display bubbles of the square footage previously entered, along with the adjacency relationships to other spaces.

2. Bubble Diagrams. This drawing will display bubbles of the square footage given by the designer here or previously and will allow the designer to manipulate them.

3. Block Layout. This drawing will display "blocks" of the width and length previously entered. The architect may manipulate the blocks and create new areas.

The graphics functions are as follows.

- Adjacency Generated Bubble Diagrams
- Bubble Diagrams
- Blocks Layout
- Sketch Book
- Graphic Interpretation
- Stop.

Implementation

The user selects Charrette options using menus and a mouse, along with keyboard entries. The user is prompted through every program selection: he/she is not expected to remember any explicit commands. For example, to make it easier to select current drawings when using the graphics options, the drawing titles are presented to the user in a menu from which the user selects one with the mouse. Where possible, any user input is a valid response. For example, in many of the graphic interpretation options one can select an option by hitting any mouse button or any keyboard key.

To make Charrette a true architect's tool, careful attention was paid to architectural terminology. The prompts use professional terms in a traditional manner. However, the English measuring system causes problems for architects who use computers. While a computer has no problems with decimal numbers, feet and inches have to be converted to an approximation for the computer. Because of the stage of development, this system has only decimal number entry. Any enhanced system would have to accept the architect's dimensions in the traditional form of feet and inches.

The number of options available in Charrette was limited to a core group necessary to do a preliminary test of concepts behind the program. Also, the development tools would not allow Charrette to control more than one process at a time. Therefore, some of the necessary support functions were not possible, including an internal calculator, and a good text editor. (The only way to provide these would have been to program them as part of the system, a time consuming task.)

Some special elements were added to this program to allow monitoring of the user. A record of the user's progress was sent to a record file. This file included a listing of which options were selected for which spatial type. The file recorded the major changes that were made and the time the user entered and left each particular suboption. The information was recorded sequentially, but every design change was not tracked. To get the users' immediate responses to each Charrette session, a response edit pad was brought up after each session. The users were prompted to write down any impressions and any additional options they would like.

5 CASE STUDY

This case study concerned the way architects proceed through the design process and how they interacted with the prototype computer-based design system, Charrette. The study was also concerned with exploring issues and procedures for possible future research. It also involved a user-based evaluation of Charrette. A user-based evaluation reveals how well the computer hardware/software system's capabilities match what the user does or expects to do. It recognizes that "user feedback is an integral part of any successful software system."[4]

As a case study, this investigation involved only a few subjects which raises several issues related to the use of small samples. In general, social scientists have examined populations by studying representative samples. They have then relied upon statistical inference to assess the generality of their findings. Larger samples increase the likelihood of findings being statistically significant. However, social scientists have also recognized the value of studies where the sample has been as small as one.

Dukes[5] pointed out that single subject (respondent) studies (N = 1) have contributed to the growth and understanding of many topics in psychology, and that they continue to occur as a legitimate research strategy. He suggests that N = 1 studies can be valuable in a number of ways, including studies of the uniqueness of the individual, studies when the between-individual variation is known to be minimal, studies refuting asserted or assumed "universal" relationships, and studies clarifying questions, defining variables, and indicating approaches. Runkel and McGrath note that the single case study may provide information that would help to improve that case (e.g., student, employee, city, etc.). They see a second legitimate role for single case studies: they are useful "when one is searching for *possibilities*."[6]

This study explored the intellectual process that accompanies architectural design and the fit between that intellectual process and the actual processes supported by the Charrette program. For these issues, there was little empirical literature to provide guidance in the development of either theory or research method. Thus, the very small sample used out of necessity was actually entirely appropriate. This strategy allowed the researchers to clarify questions, define variables, examine approaches, and discover possibilities.

Subjects

There were three sets of subjects for this study: (1) two researchers (Anderson and Weideman), (2) two research assistants, and (3) four advanced design students. Before the analysis could proceed the investigators needed to become familiar with the operation of Charrette. Thus, they were the first set of subjects to learn about and use the

[4] *Procomm Version 2, 3: Program Reference Manual* (PIL Software Systems, Columbia, Missouri, 1986).
[5] W. Dukes, "N = 1," in *Statistical Issues: A Reader for the Behavioral Sciences*, R. Kirk, ed. (Brooks/Cole Publishing Company, Monterey, CA, 1972).
[6] P. Runkel and J. McGrath, *Research on Human Behavior: A Systematic Guide to Method* (Holt, Rinehart and Winston, Inc., New York, 1972).

program. One of the researchers has used a PC based drafting program. The other researcher is familiar with a PC based drafting program through observation and through preparing course materials requirements.

Two research assistants were used in this study. Their tasks included procedural, developmental, and evaluative aspects. These assistants were selected by the investigators and were graduate students in the School of Architecture, University of Illinois at Urbana-Champaign. Each assistant was familiar with AutoCAD.*

The primary set of subjects for this evaluation consisted of four students from the School of Architecture and the Department of Landscape Architecture. They were solicited by advertisement in the above units during late July, 1986. Each was familiar with a PC based drafting program, e.g., AutoCAD. Also, the students were interviewed to determine whether they understood enough about design and the design process. Only students with experience of at least the equivalent of a first semester senior design studio were accepted. (It was also determined that all were familiar with the concept and use of bubble diagrams.)

Procedures

This study is concerned in part with the cognitive processes that take place during design; therefore, a procedure had to be found for recording those processes. It has been proposed[7] that effective data on cognitive processes can be generated by having the subjects explicitly verbalize their thoughts while solving a problem. Thus, students were asked to record whatever they were thinking to themselves as they worked on their designs. Two methods were considered for making this record: written notes or a tape recording of the student thinking aloud. First, the research assistants were asked to write down all their thoughts. However, since this interruption might be a source of reactivity, the students were asked to talk about what they were doing and thinking, while a small tape recorder captured their thoughts. These tapes were then transcribed. More details of the procedures followed by each set of subjects are given below.

Researchers

The researchers began learning to use Charrette on the Apollo workstation in the spring of 1986. An initial training session was conducted, and in subsequent sessions, the researchers learned the concepts and commands of Charrette, generally by working together. (At that time, there was no user's guide for the new user of Charrette on Apollo.) They then tried each of the elements of the Charrette program on various fictional problems. Many of the early sessions were essentially trial and error, and the researchers continued until they felt that they had a relatively good understanding of Charrette's elements and their interrelationships.

In summary, the primary purpose for involving the researchers in the Charrette process was to introduce new users to the system, to allow them to learn it, and to evaluate their responses to it.

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*AutoCAD is published by Autodesk, Inc.

[7]K. A. Ericsson and H. Simon, *Protocol Analysis: Verbal Reports as Data* (MIT Press, Cambridge, Massachusetts, 1984); and R. Weisberg, *Creativity: Genius and Other Myths* (W. H. Freeman and Company, New York, 1986).

Research Assistants

The assistants were used as subjects in the development of procedures to study the design process. Initially, each was asked to develop a schematic design for two relatively short residential design problems. They were to use a traditional design approach, in that they were to produce a solution on tracing paper, using pen or pencil. To provide information about their process, they were asked to make written comments, as well as sketches on tracing paper, describing the issues they were thinking about as they went through the design process and arrived at a solution. This was based upon the "thinking out loud" strategy that Ericsson and Simon[8] have described as a viable approach for the study of problem solving by individuals. This procedure was intended to produce information about the design process, as well as to develop and test a procedure for recording information.

Students

The student subjects were asked to complete several different tasks. Table 1 summarizes the type of tasks and their respective purposes.

Table 1

Type and Purpose of Student Tasks

Type	Purpose
1. Paper and pencil (Problem 1)	Provide researchers with design process information Acquaint students with "think aloud" procedure
2. Charrette demonstration	Introduce students to Charrette, using USA-CERL draft user's manual (Appendix B)
3. Charrette practice (Student generated problems)	Allow students to learn concepts, elements manipulations of Charrette Provide researchers with information about design process
4. Charrette test (Problem 2)	Provide researchers with information about process solution quality

[8] K. A. Ericsson and H. Simon.

Paper and pencil task. Each subject was asked to prepare a schematic design for a bed and breakfast facility (Appendix C) using their own procedures and working out the solution on tracing paper. In order to obtain a record of the design process which each used, they were asked to record notes and sketches on the tracing paper. The subjects were provided with tracing paper, triangles, pencils, pens, and a large underlay grid (four squares per inch) to assist them in doing scaled sketches.

The subjects were also asked to "think out loud," thus making explicit the issues they were attending to as they proceeded through the process. Their verbal responses were recorded on a small, battery operated tape recorder, which they were responsible for operating. They were instructed to leave this recorder on during the whole time they worked. At this time, one subject dropped out of the study, reporting extreme difficulty in verbalizing his thoughts during the design process. One could hypothesize several explanations for his dropping out, e.g., a sense of vulnerability resulting from making decisions explicit, or a lack of skill in verbalizing design concepts. Further research would be needed to determine the degree to which this may be a common difficulty and the possible reasons for it.

Charrette demonstration. After completion of the paper/pencil design problem, the students were brought together for a demonstration and training session using the Charrette program and the Apollo computer.

The following day, the investigators met with the students to review questions that they had about the Charrette program and to provide procedures for naming files. Elements of the previous day's demonstration were repeated.

Charrette practice. Students then scheduled individual work sessions on the Apollo, in order to practice the use of the Charrette program. The students worked independently during this time, except for those times when the computer stopped functioning because of an inadvertent error by the operator. The students received help in solving these problems.

Students typically generated their own problems in order to learn and practice the program, much as the investigators had done as they learned it. The objectives were to become familiar with the elements of the Charrette program and the ways in which they could be used.

Charrette test. When students reached the point at which they felt they understood Charrette, the final design problem, a research library (Appendix D) was loaded into the machine. Once again, they were asked to think out loud, describing their thoughts and processes, while using Charrette to develop a desired floor plan. However, in this case, they were asked to turn the tape recorder off and on as needed. This was done to avoid long pauses which would inconvenience the transcriptionist. As a student worked on a design, the computer recorded his/her activities.

Available Data

Several types of data were generated by these various procedures. They are described below for each of the user groups.

Researchers

Written progress notes, made during the learning and practice phases of using Charrette, indicated difficulties and progress rates. In addition, notes were recorded in the "response" file at the conclusion of each Charrette session. Finally, experience recall was also useful for evaluation of the program.

Research Assistants

The research assistants helped in the development of the architectural programs for the student subjects, thus it was not appropriate for them to undertake the same design problems as the student subjects. Still, the assistants had two types of input: (1) the sketches, plans, and annotations they made while doing two paper and pencil tasks and (2) their opinions about Charrette, which were discussed after they were introduced to it.

Students

The students produced the greatest amount and variety of information about both the design process and Charrette. This consisted of: (1) tape recorded comments describing both process and program issues; (2) sketches, plans, and annotations from both the paper and pencil task and from the Charrette program; (3) the Charrette-generated files in which activities had been recorded; and (4) end interviews conducted by the investigators. The computer-generated records consisted of a "record" file which showed the sequence of actions taken while using the program, a "picture" file which showed the design as each of the graphic options was exited, and a "response" file in which comments could be made at the conclusion of each Charrette run.

6 FINDINGS AND OBSERVATIONS

Responses of Novice Users

In the first part of the study, the researchers became familiar with the operation of both the Apollo system and Charrette. In the process, program and system "bugs" were located. The researchers tried each element of the program and noted the results. Implicit rules about operating the system were made explicit, e.g., the need to be patient and avoid multiple mouse "clicks" and the need to input project titles only in upper case letters. Thus, the researchers learned the potentials of the system and identified problems in the user interface that could hinder novice users. The program was modified, where possible, to eliminate these interface problems.

After learning the concepts and commands of Charrette, the researchers used it to develop schematic plans for several imaginary design problems. Difficulty was encountered in using Sketch Book. Material was typed into Sketch Book as the basis for a building design. This part of the program has a highlighting feature that can be used to build up a list of spaces. Material for a building design was typed into Sketch Book in such a way that it could easily become a listing of building requirements. Such a list was made. However, the trouble arose later when the user wanted to describe adjacencies while in Sketch Book but had forgotten the exact names of spaces that had been highlighted. This occurred especially when abbreviations and shortened names were used.

The researchers had difficulty interacting with Charrette because of at least three factors. They often did things that an experienced user would not have done. During this process, interface problems were discovered that had to be corrected before the subjects used the system. Sometimes the novice users had received instructions about what to do but simply failed to recall portions of the instructions. Finally, there was no documentation in the form of a user's guide, at that time.

Paper and Pencil Task

The records from the paper and pencil design tasks included the drawing sheets and either written notes from the "thinking aloud" process or the transcript from the tape recorded "thinking aloud". These records were examined and a summary developed of the design sequence of each student. The research assistants were also students with design experience similar to the actual subjects. Therefore their responses to their two paper and pencil design tasks are included in this section. Figures 2 and 3 show the sequence of drawings for the two problems solved by research assistants; Figures 4 and 5 show the sequences for two student subjects.

In developing these summaries the drawings were of most use. The written notes and the recorded transcripts were less helpful, although both provided some degree of supplementary information regarding the plans. Of the two, the written notes were more complete and more closely tied to the drawings. The recorded transcripts had several problems. They were incomplete: some words did not get recorded and some statements were left incomplete. They had to be closely edited; the typists were sometimes unable to understand what was being said. Finally, the transcripts were difficult to relate back to the drawings. One transcript and the accompanying drawings are given in Appendices E and F, respectively.

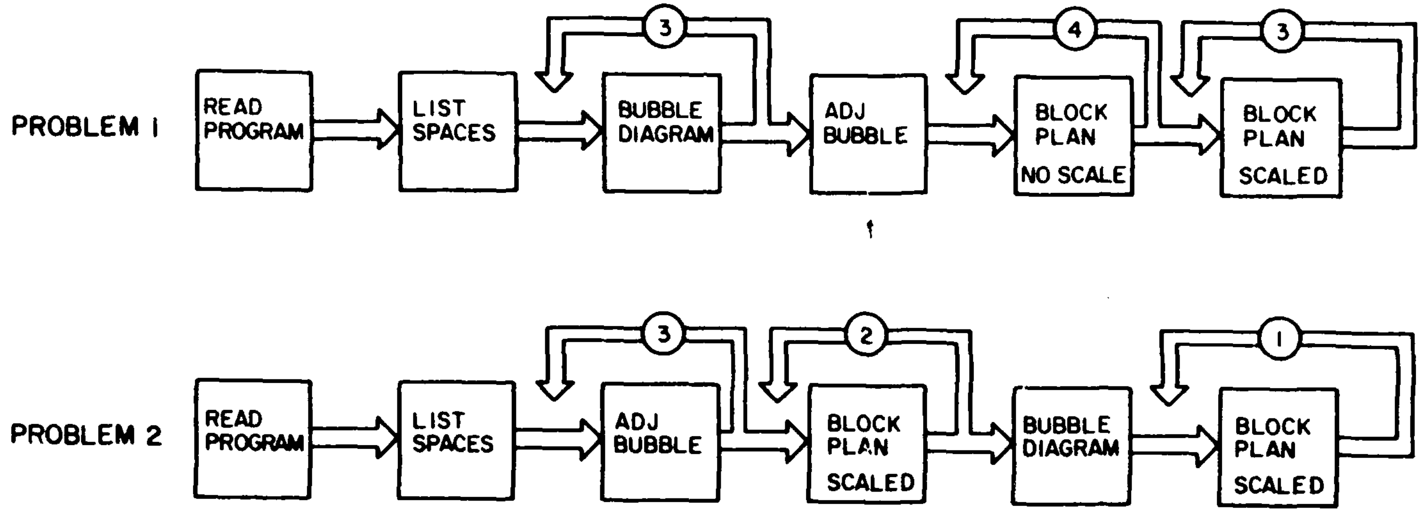

Figure 2. Sequence of drawings: research assistant, subject C.

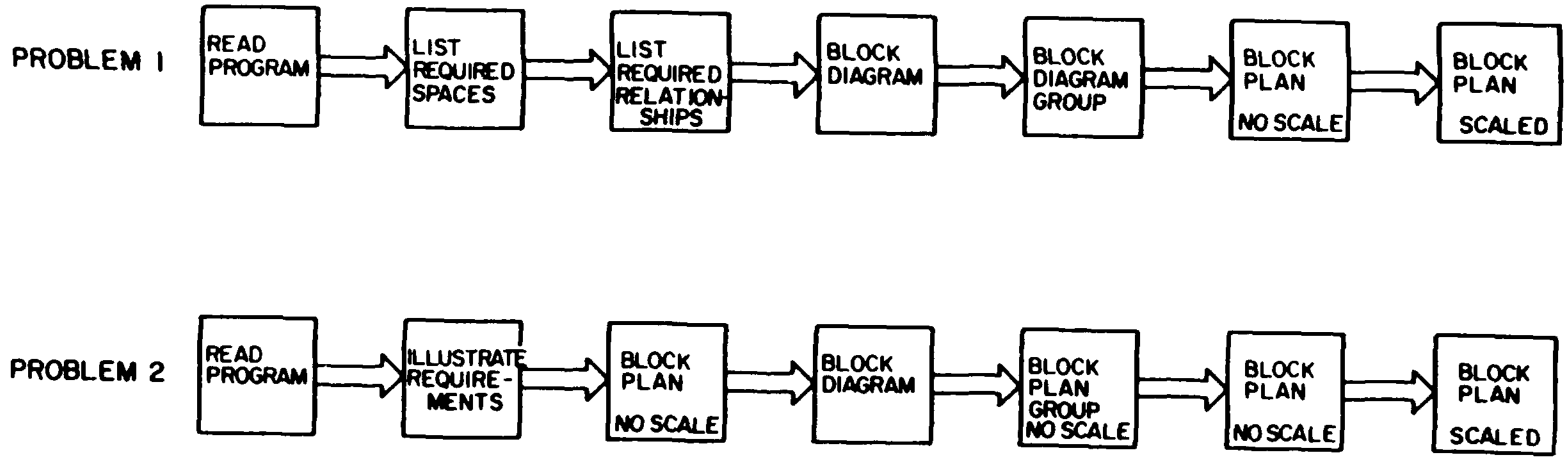

Figure 3. Sequence of drawings: research assistant, subject D.

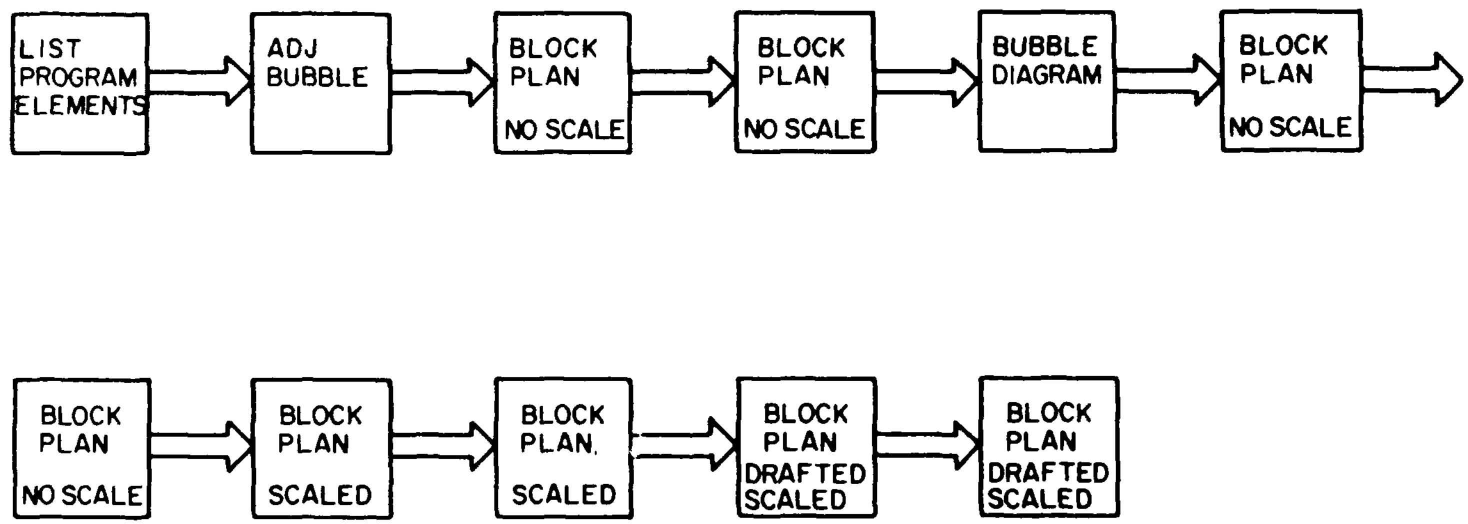

Figure 4. Sequence of drawings: student, subject A, paper and pencil task.

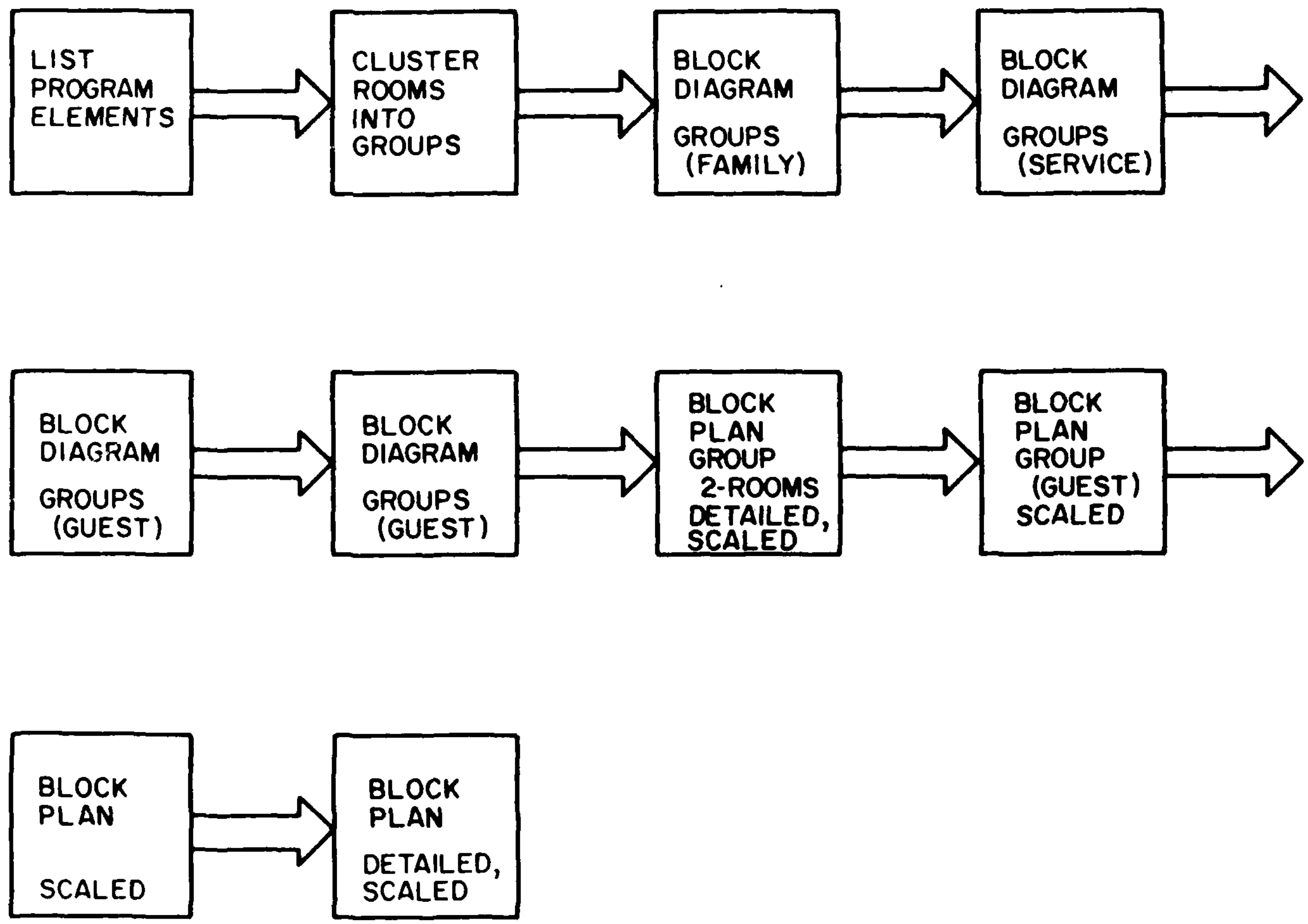

Figure 5. Sequence of drawings: student, subject B, paper and pencil task.

Sequence Description Rules

In developing these diagrammatic descriptions of the paper and pencil processes, labels approximating the equivalent Charrette element were used where appropriate. Thus, a Bubble Diagram is a drawing with labeled circles arranged on the paper. A Block Diagram is an arrangement of labeled blocks. An Adjacency Bubble Diagram provides additional information about the importance of relationships between spaces. In this study all instances showing the importance of adjacency relationships consisted of lines linking bubbles, with the importance of the link being shown by the width of the line. Block Plans were drawn both with and without reference to a scale. Some elements of the paper and pencil records had no direct Charrette analog, e.g., clustering rooms into groups; these instances are apparent in the diagrams. Finally, if a particular type of drawing, e.g., a bubble diagram, occurred more than once in sequence, this is shown by an arrow looping back and a number showing the total times this type of drawing occurred.

Paper and Pencil Observations

Not surprisingly, each of the student's process sequences begins with a reading of the program and then a listing of program requirements. And of course each sequence ends in a scaled block plan. What happens in between is similar, but hardly identical. For example, subject C, a research assistant (Figure 2), provided explicit consideration of the importance of relationships between spaces. This is especially true in problem 2 where three adjacency diagrams were drawn. After reading the program subject D, also a research assistant (Figure 3), began with some steps that did not fit with the Charrette analog. This included the drawing of small illustrations which served as caricatures of the verbal program requirements (Figure 6). In addition subject C began with a circular geometry in the initial diagrams, while subject D began with a rectilinear geometry. Subjects A and B were students that did both the paper and pencil task and the Charrette task. Figure 4 shows that subject A worked toward a solution, then, apparently dissatisfied with the direction, went back to a more general level. Subject A also began with an explicit representation of the importance of specific space relationships. Subject B made a specific effort to break down the overall problem by clustering spaces into groups and then developing block diagrams for those groups (Figure 5). No other subject was quite this explicit in proceeding hierarchically to a solution. On the other hand, subject B made no explicit statement of the importance of relating one space to another.

Students' Practice on Charrette

As previously mentioned, the researchers had trouble learning Charrette because there was no explicit documentation at that time. However, when the students learned Charrette, they had USA-CERL's thorough user's guide. The guide was apparently successful. The students encountered only a limited number of problems as they learned the system. One student described it as "Helpful . . . very well written."

Both the records of use and students' comments indicate that the students needed 10 to 12 hours to learn Charrette. During this time the students placed their own programs in Charrette, wrote in the Sketch Book, manipulated dimensional and adjacency information, and used the bubble and plan generating features.

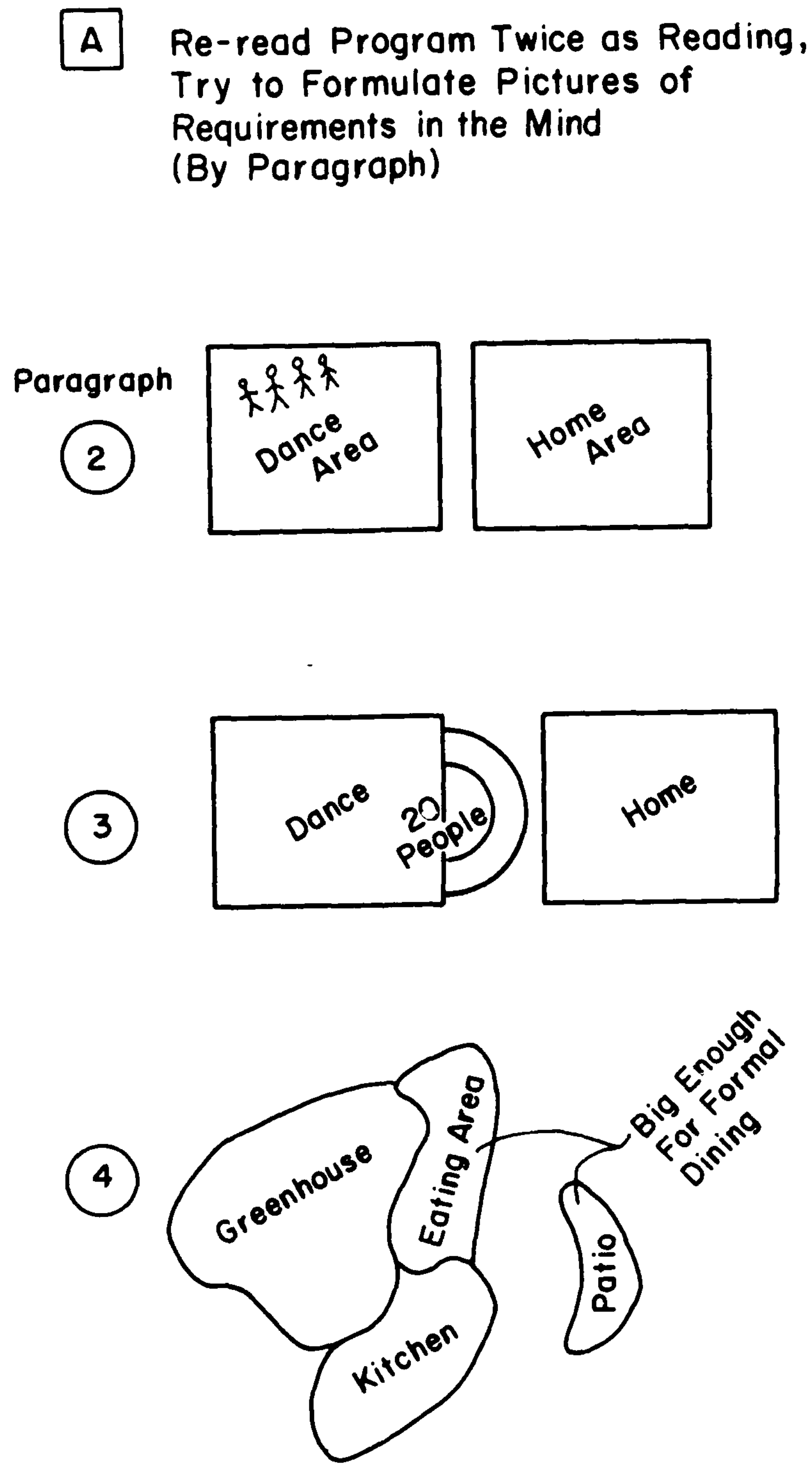

Figure 6. Caricatures of program requirements: student, subject D, paper and pencil task.

Exploratory Practice

While learning the Charrette program the students worked on problems of their own creation. These were small buildings and usually houses, although one student programmed a fast food restaurant. However, allowing the students to simply explore Charrette, a process of learning by discovery, did not insure that they learned the full potential of Charrette. There were three instances where the students failed to discover the significance of certain features. In one case, when a student reported that he was ready for the Charrette test, he was asked if he had used the highlighting feature within Sketch Book in order to fill the dimensional and adjacency tables. He had not, so he returned for more practice. Second, the students used the boxed arrows feature to examine the dimensional and adjacency tables. One student reported never creating an exploratory problem that had sufficient spaces to require these keys. Finally, the students appeared to be unfamiliar--or unimpressed--with the "zoom" feature.

In the transcript of one student's comments it is clear that the zoom feature was used during the bubble diagrams. However, its use did not generate much reaction from the students. There were no comments in the transcript about seeing things differently or better as a result of the zoom. Also, in the interviews conducted after the completion of Charrette there were no comments about the zoom. The researchers' own experience with zoom indicates that it may be valuable in cases where several relatively small spaces are placed close together. The lack of comments about specific graphic options may have been due to the subjects' previous experiences with computer aided drafting systems, which might have made them feel that an option such as zoom was nothing out of the ordinary.

One student attempted to explore the potential of Charrette in designing a three dimensional solution. Not satisfied with the implicit constraint that the schematic solutions be on one level, this student worked with two clusters of bubbles, representing a two level solution. These clusters were adjacent to one another in the format of a projected drawing (Figure 7).

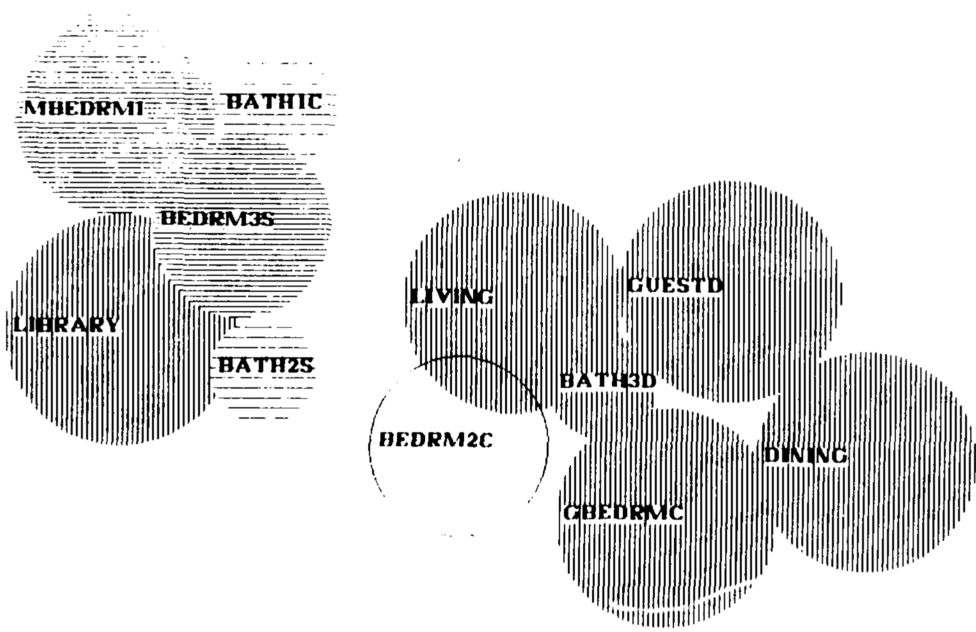

Figure 7. Student A: use of Charrette to develop a three dimensional solution.

Problems

One difficulty that some students had was accidentally "popping" to another window which was running below the program window. They would inadvertently place the cursor in the bottom command line, click the mouse and find that they had popped out of Charrette. This suggests that they had not read and fully understood the user manual. Instead they relied on the "sigp" command to "blast" out of an unwanted situation rather than "popping" back.

The subjects also had expectations that Charrette did not meet. Subjects stated that they expected that Charrette would generate an initial adjacency-based bubble diagram which could then be manipulated. They were surprised when this feature was not a part of the system. Students have also developed expectations from working with other systems. Thus, they saw it as an omission when a "pop up" calculator was not available to assist in the development of the areas and dimensions for rooms and when Sketch Book did not have functions similar to a word processor.

Charrette Design Task

Record of Charrette Use

Table 2 contains a description of the frequency with which the two student subjects used the major portions of Charrette. This information was obtained by examining the record file of each user. It shows that every major element was used by each subject, however some sub-elements were unused.

Table 2

Frequencies of Students' Charrette Activities During Charrette Task

	Subject A			Subject B		
	entered	reviewed	changed	entered	reviewed	changed
Sketch Book	18	-	-	20	-	-
Dimension Tables						
Zone	1	-	-	-	-	1
Group	3	1	-	-	-	-
Room	-	2	1	-	-	-
Adjacency Tab						
Zone	-	-	-	-	-	1
Group	-	-	-	-	1	-
Room	-	5	-	-	1	-
Spatial Organization	3	1	-	-	2	-
Adjacency						
Zone	1	-	-	1	-	1
Group	-	-	-	-	-	-
Room	1	-	1	1	-	2
Diagrams Bubble						
Zone	-	-	-	-	-	-
Group	-	-	-	-	-	-
Room	-	-	-	1	-	-
Plan						
Zone	-	-	-	-	-	-
Group	-	-	-	-	-	-
Room	1	-	5	1	-	1

Subject A made no use of the adjacency tables for zone or group, although time was spent on the dimension tables for these two levels of planning. Subject B, on the other hand, examined only the zone dimension table, while examining the adjacency tables at each level.

Neither subject created any diagrams at the group level. Because bubble diagrams can be converted into block plans and adjacency bubble diagrams can not, without going through the bubble diagram option, it was surprising that subject A made no use of the bubble diagram option.

Subject A made 44 distinct entries into the elements of Charrette before arriving at a solution. Subject B made only 34 entries (see Table 2). It can be hypothesized that this difference arose because subject A explored more alternatives; alternatively it can be hypothesized that subject B was more intent, and pursued a solution more efficiently. While the record files took samples of the subjects' work at certain intervals, it was not a continuous record, so that neither hypothesis can be accurately examined. Clearly, this is an area for considerable future research.

Description of Processes

Figures 8 and 9 show the sequence of Charrette activities for two student subjects as they developed their plan solutions for the research library program. The diagram shows when each major element was used, the level at which it was used (zone, group, and room) and what action was taken. As with the description of the paper and pencil processes, a Charrette element which is used more than one time sequentially is indicated by a return loop and a number indicating the total number of times the element was used at that point in the sequence.

Figures 8 and 9 show that both subjects began in the Sketch Book and completed an almost equal number of Sketch Book tasks (see Table 2). Essentially the records and transcripts reveal that they read through each element of the program. The subject had to start in Sketch Book to see the building program. An actual user wouldn't necessarily have to do this. Subject A used the Sketch Book to define the rooms and their sizes; subject B did the same and also defined some adjacencies. When the Sketch Book had been used to go through the program, subject A never returned to it, while subject B returned to it only once. This limited use was somewhat unexpected and undesirable, since the architectural program they entered in the Sketch Book contained some requirements that are not expressed in the dimension and adjacency tables, e.g., the user requirements (see the Program statements in Appendices C and D). Thus, it seems these requirements were not the focus of the design solution and may have been neglected.

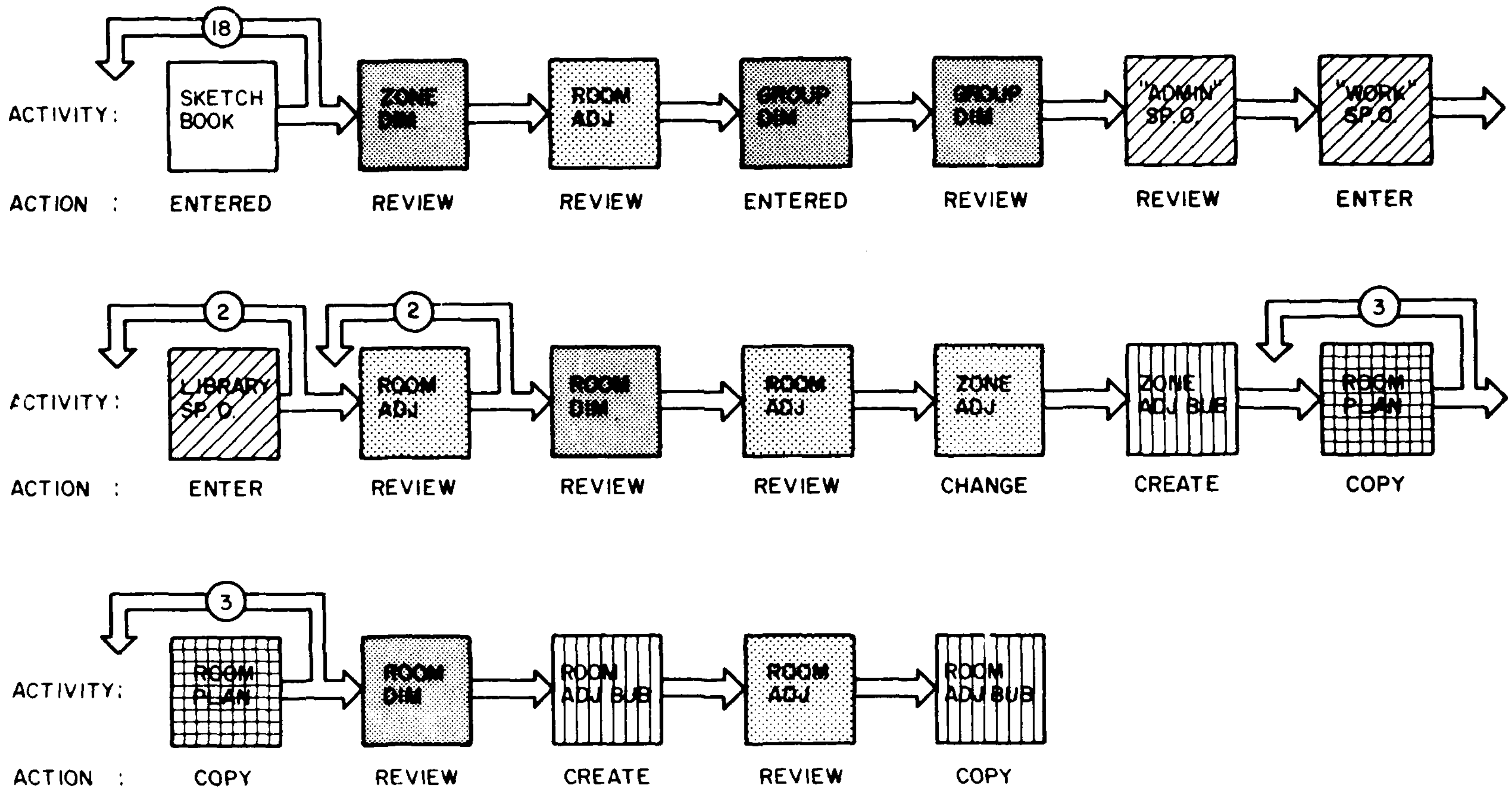

Figure 8. Sequence of Charrette activities: student, subject A, research library design.

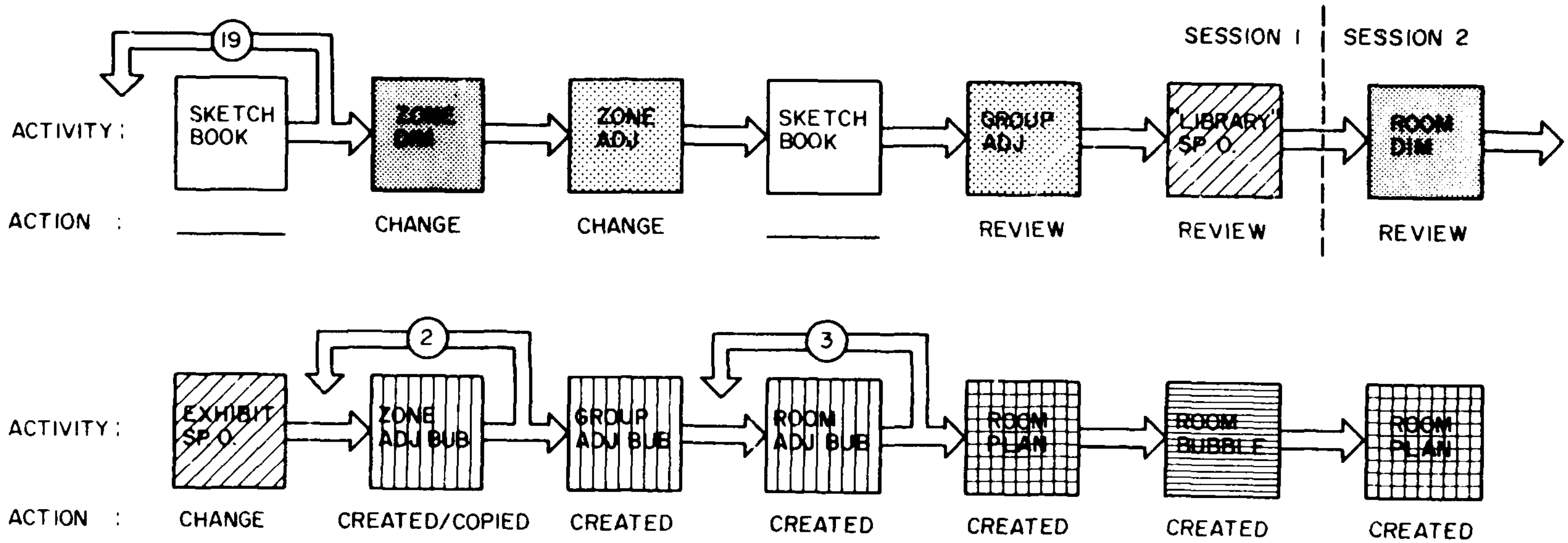

Figure 9. Student, subject B, research library design.

Observations on Charrrette Use

When given the task of developing a plan for a research library, students were able to create schematic designs with which they were satisfied. In particular, the Charrette program was used to develop designs for a moderately complex facility of up to twenty individual spaces. The intermediate drawings and the final solutions are shown in Appendix G. The Charrette system was not transparent (as easy to use as pencil and paper) to the subjects during the time they did the test design, but possibly it would have become less obtrusive with greater use and familiarity. How much practice is needed before transparency is achieved is a question for further research. Perhaps, for example, it would occur much more quickly for students who are introduced to the design process using the computer than it would for more experienced designers who have not previously used the computer.

Comparison of Paper and Pencil to Charrette

Continuity

When the students' paper and pencil drawings were compared to the "pictures" from Charrette, some differences became apparent. First, there were differences in the general nature of the two types of records. The paper and pencil drawings were continuous in nature, showing variations that had been tried and crossed out or abandoned. The Charrette drawings were "pictures" of how the solution looked only at the moment when the designer exited a portion of the Graphics option to go to another task. Thus the drawings for the Charrette session were sequential but not continuous.

Initial Shapes

There were also differences in the ways individuals began their solutions. Although the user can enter any of the Charrette graphics options in any order, the subjects followed an implied method of starting with bubbles and going to circles. However, of the six sets of paper and pencil drawings that were completed, three sets began immediately with rectilinear elements as spatial relationships were studied. The other three sets of paper and pencil drawings began immediately with circular representations.

Scale

The drawings that began with rectilinear elements raised the question of dimensionality because all those drawings were dimensionless. One individual went through several studies of relationships and only introduced an explicit dimensionality to the solution when a "final" solution was reached. However, the introduction of dimensionality indicated that the solution was not satisfactory. The spatial arrangement had to be solved again taking the dimensional nature of the spaces into account. Charrette is explicit about the dimensional nature of all spaces, avoiding such unpleasant surprises. The question of dimensions might be less of a problem for practicing, experienced designers. Such individuals might be able to introduce a sense of dimensionality by using elements with reasonably accurate proportions. Thus, their judgments of the relative size of each space might be reflected in their drawings, making their consideration of size and spatial relationship more like Charrette's.

Thinking Out Loud

The first paper and pencil solutions required the subjects to "think out loud" about their process, but to do that on paper. The remainder of the paper and pencil solutions required them to think out loud with a recorder continuously going. During the Charrette solutions they thought aloud while turning the recorder on and off. Examination of these records indicates the obtrusive nature of the Charrette system. For example, numerous comments were made regarding the specific operational aspects of the program (e.g., "once again I am going to zoom in, press the I button, and now I've zoomed in"). Thus, even though the students said they had learned the system, the records indicate that the system was very much on their minds. It is hard to determine if the subjects would have felt more at ease with Charrette if they had not been speaking for a tape recorder. Again, it would seem important to know, as for any computer based system, when it begins to become transparent.

Hierarchies

In using Charrette, students readily accepted the idea of conceptualizing their problems in a hierarchical manner. Zones, groups, and rooms were all identified. Subject B felt that Charrette was a great organizing tool. He felt he was not usually as explicit in setting up a hierarchy of space when using the traditional paper and pencil approach. However, examination of the process that he used in arriving at a solution to the paper and pencil task shows that he was already concerned with planning in a hierarchical manner.

Changes

Tables 3 and 4 examine the extent to which the subjects changed the area and proportions of the individual spaces in the two design modes. Comparison of these two gives an indication of the extent to which the flexibility of the Charrette system was used.

Table 3 was obtained by examining the drawings of the two subjects and visually evaluating the extent to which spaces were shown as square, as opposed to rectangular. The subjects behaved in two distinct ways. Subject A began with spaces of varying proportion and then made over half of them square later in the final solution. In fact, subject A was often inconsistent in the proportions for spaces until the final drawing. They varied from one drawing to the next. Subject B began by showing half of his spaces as squares. Then he changed many of them into other proportions in the final solution, so that few of the final spaces were square.

Table 4 contains the same type of information as Table 3 in its first two columns. However, rather than simply describing whether the final solution contained squares or not, it makes use of the precise dimensional data in the record files to illustrate the degree to which changes were made in the dimensions and proportions of spaces. In fact, the table shows neither subject changed the shape of any space from the beginning to the final solution. They were left as originally defined. This is a sharp contrast to the pencil and paper task in which both subjects made changes in the proportions of several spaces.

Table 4 also shows that over half of the time spaces were defined as square. This could have occurred because in Charrette it is most convenient to create a square. Subject A defined all the remaining spaces so that one dimension would be equal to at least one side of an already existing space. Subject B defined only about half of the non-square spaces in this way, while defining the rest some other way.

Table 3

Students' Changes in the Proportions of Spaces:
Paper and Pencil Task

Subject	Initial number of spaces	% Initially square	% Square at completion
A	18	33	56
B	20	50	15

Table 4

Students' Changes in the Proportions of Spaces:
Charrette Task

Subject	Initial number of spaces	% Initially square	% Initially fit to other space	% Changed proper.	% Changed dimens.
A	20	55	45	0	0
B	18	56	22	0	0

Effective Use of Charrette

Charrette allows the user to adjust the size and proportion of spaces quickly in the dimension tables. However, Table 4 shows that this was never done. In the paper and pencil processes, subjects made an initial judgment of the room geometry and size and later modified them; in Charrette, those judgments remained unaltered.

Charrette also allows the user to change the importance of relationships between rooms by modifying information in the adjacency table. The subjects did not take advantage of this. An examination of the record files shows that subject B initially established the adjacencies and did not change them. Subject A, on the other hand, did not initially establish adjacencies but waited until a later time (almost two thirds of the way through the solution process). Even then it appears that Subject A did not consider all adjacencies. Again, although Charrette provides flexibility for changing levels of adjacency, this was not used.

This apparent underuse of the flexibility of Charrette is an important issue. Perhaps it was a result of subjects still being somewhat unfamiliar with the use of all of Charrette's features. Perhaps it was a function of the individuals' design method. Only the responses of more subjects, over a wider range of problems and time of access, can begin to answer the questions raised by this study.

7 QUESTIONS FOR FUTURE RESEARCH AND DEVELOPMENT

As a result of the findings discussed above, several specific questions can be raised. These focus on the potential for further development of Charrette and on the need for further research in user response to computer-based design systems.

Charrette addresses an aspect of the design process not currently addressed by other known software: the examination of alternate spatial arrangement of activities and spaces. The enthusiastic response of one subject after completing the study, "Can I get a copy?" indicates that for at least some advanced design students Charrette serves a need. Its further development seems warranted, although whether it should be further developed on the Apollo should be examined closely, given trends in development of PC-based design and drafting systems.

If Charrette or other similar programs are to be further developed, the findings of this study indicate several issues that should be given consideration.

General Issues

Time

In this exploratory study it was not possible to examine all potentially relevant variables. One variable that deserves consideration is time. How much time is needed to learn the system, to reach a solution, to use various features, etc.? To examine this variable, some improvements would be needed in Charrette. For example, while times are included in the record files from Charrette, they only mark the times when the users exited Charrette elements. A minimum requirement would be to know when an element was entered, but it would also be important to have an indicator of the rate of the user's activity while in an element. But of course, a subject may be working on a problem mentally, even though no computer use is occurring.

In addition, the time needed to adequately learn to operate a computer-based system is different from the time it takes for the operation of that system to become transparent or unobtrusive (i.e., for the user to be able to concentrate on the design process, not on the process of operating the system). How long will it take a design professional to lose awareness of the system?

Finally, subjects in this study reported that Charrette reduced the amount of time necessary to solve the design problem. Can this design efficiency be demonstrated with a larger sample?

User's Level of Experience

The subjects in this study had varying degrees of experience with both traditional design and computer-based design. This raises the question, to what extent does greater experience with a traditional design approach inhibit or enhance the speed of learning a system and the speed and quality of solutions?

Charrette-Related Issues

Accessibility to Information

Computer based design information will be used most effectively if it is easy to access material in one part of a system while working in another part. In Charrette, it would be desirable to be able to view portions of the program statement without leaving the adjacency table, review the dimension table without having to leave the block diagrams, or to see a directory of room names created in Sketch Book, for example. Obviously, this suggests a programmable multi-processing environment.

Geometry and Area of Spaces

For the initial study of spatial relationships, circles are adequate. However, the completely rectilinear nature of the block diagrams should be reexamined. Users of Charrette felt it would be desirable to be able to chose other geometries (e.g., curved or triangular), to change the proportions of spaces while keeping the area constant, and to expand and contract the areas of individual spaces within certain limits. The computer game "Pinball Construction," published by Design Arts, is an example of a program that contains such features. Here, tools in the form of icons can be accessed that will push out the edge of a volume or cut off an unwanted piece. This type of interactive manipulation of the geometry and area of the spaces could be beneficial.

Bubble Options

The two separate bubble diagram options do not seem necessary. The ability to turn consideration of adjacencies "on" or "off", suggests that one bubble option might be sufficient. However, such an adjacencies "switch" might be as useful while working with block drawings as it is in the bubble diagram stage.

Adjacency Levels

Five levels of adjacency may be insufficient. A ratio scale could be used, as it is for real distance between spaces. While a ratio scale may not be necessary for describing adjacencies, many individuals will find the five point scale to be inadequate. Some will want to be able to discriminate more precisely, especially in situations with large numbers of spaces.

8 CONCLUSIONS

After developing a list of requirements for a successful CAAD system (given in Chapter 2), the researchers created a prototype system called Charrette. This system runs on Apollo Domain Dn 300 work stations. The interface is graphically oriented and is operated through a mouse and prompts. The software provides three general options: (1) Sketch Book lets the designer jot notes as he/she reviews the problem; (2) Graphic Interpretation stores verbal information about building areas; and (3) Graphics lets the designer create adjacency bubble diagrams, bubble diagrams, and block layouts.

Because of the small sample of subjects in the case study, no definitive statements can be made about the elements common to all design methods, but some generalizations can be proposed. By comparing the subjects' pencil and paper design process with their computer aided design process (Figures 2, 3, 4, 5, 8, and 9; Appendices F and G) some similarities can be noted. In both cases, the subjects went through a process of reading program requirements, evaluating them, then developing unscaled drawings, and finally developing scaled drawings. The subjects placed different emphasis on areas to evaluate while using both methods. The subjects' different evaluative techniques were accommodated by Charrette, demonstrating that the desired level of flexibility had been attained.

One difference in methods occurred when the subjects started adding scale to their designs. With the paper and pencil method, when the subjects started to add scale to their designs they found areas that did not fit in their original design schemes, and had to go back and change their designs (Figures 2 through 5). The computer aided design method had an implied scale even in bubble diagrams which decreased this process of redesign. However, while Charrette was designed to accommodate changing spatial areas, the subjects did not take much advantage of this. With a larger project, or if the subjects had been interested in developing design alternatives, this capability might have been used more.

While most of Charrette's options were used by one or the other of the subjects, none of the subjects used every system option. While this may have been the result of unfamiliarity with the system, it may have also been the result of the individual user's design methods, or the nature of the project. The fact that the options were used by any of the subjects warrants their inclusion in Charrette. For a CAAD system to offer enough different options to allow designers to follow their individual methods, it is necessary to offer some things that will not be used by all.

The subjects' responses to Charrette show that the design process can benefit from a CAAD system. After the research project was done, the subjects asked for access to Charrette to develop other design projects. While this was not possible, due to equipment restraints, this indicates a desire for this kind of CAAD system. However, there is a scarcity of computer workstations of the Apollo scale in typical architecture and engineering firms, as well as academic institutions. Due to the greater prevalence and affordability of personal computers, any further CAAD system development should be in this environment.

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APPENDIX A:

PRELIMINARY RESEARCH SYSTEM SPECIFICATIONS

The preliminary specifications for Charrette took the form of screen designs. These designs were created using a PC graphics program. However, not all of these specifications could be included in the final program, as discussed in Chapter 4.

WELCOME TO CHARRETTE

PROJECT NAME? HOUSE

YOUR CHOICES ARE:

- #1 SKETCH BOOK
- #2 GRAPHIC_INTERPRETATION
- #3 GRAPHICS
- #4 STOP

TYPE CHOICE?

SKETCH BOOK

YOUR SKETCH BOOK HAS:

#1 PDB
#2 DD 1391
#3 DESIGN RECOMMENDATIONS
#4 RULES OF THUMB
#5 BUILDING
#6 SITE
#7 DOODLES
#8 YOUR OPTION
#9 GRAPHIC INTERPRETATION
#10 GRAPHICS
#11 STOP

TYPE CHOICE? 04

MIN. SQ. FT. REQUIRED	MAX. SQ. FT. REQUIRED	MIN. DIMENSION REQUIRED	MAX. DIMENSION REQUIRED	
Z - ZONE ZONE NAME	*G - GROUP* GROUP NAME	*A - AREA* AREA	SKETCH BOOK MENU	STOP
R-ROOM ROOM NAME	ADJACENCY *ROOM*ROOM* 1,2, OR 3* 1 = +, 2 = NEUTRAL, 3 = -	"ROOM" * NO * ROOM'S SQ. FT.	"ROOM" NO W X NO L ROOM'S DIMENSIONS	

SKETCH BOOK: PDB

FACILITY: COMPANY ADMINASTRATION/ SUPPLY BUILDING

TYPE OF SPACE	QTY. (SQ. FT.)	SIGNIFICANT REQUIREMENTS
CO OFFICE	106	
XO OFFICE	88	
CONFERENCE ROOM	144	
RE-ENLIST OFFICE	92	
TRAINING OFFICE	96	
ARM'S VAULT	524	PROVIDE ANCHOR RINGS ALONG EXT. WALLS
ORDERLY ROOM	458	PROVIDE COUNTER AND GATE BETWEEN ENTRY AND ANCHOR RING FOR SECURITY SAFE.
CBR AREA	160	
COMMO AREA	200	
EQUIP. MAINT AREA	1203	
STORAGE	1107	PROVIDE WIRE CAGE ALONG NON-EXTERIOR SIDES.
ISSUE	122	

THIS TABLE IS FOR INFORMATION ONLY. TO USE IT FOR THIS PROJECT, SELECT AN OPTION ABOVE (E.G. - ROOM) AND MARK THE DESIRED DATA.

MIN. SQ. FT. REQUIRED	MAX. SQ. FT. REQUIRED	MIN. DIMENSION REQUIRED	MAX. DIMENSION REQUIRED
Z - ZONE ZONE NAME	*G - GROUP* GROUP NAME	*A - AREA* AREA	STOP
*R-ROOM * ROOM NAME	ADJACENCY *ROOM *ROOM * 1,2, OR 3* 1 = +, 2 = NEUTRAL, 3 = -	"ROOM" * NO * ROOM'S SQ. FT.	"ROOM" NO W X NO L ROOM'S DIMENSIONS

SKETCH BOOK: BUILDING

IMAGE:

USER GROUPS:

CIRCULATION:

ENTRIES:

SITE RELATIONSHIP:

REQUIRED ROOMS/AREAS:

YOUR OPTION:

HEADING? PRIVACY

NOTES? SLEEPING ROOMS NEED
TO BE SEPARATE FROM
PUBLIC SPACES

MIN. SQ. FT. REQUIRED	MAX. SQ. FT. REQUIRED	MIN. DIMENSION REQUIRED	MAX. DIMENSION REQUIRED
Z - ZONE ZONE NAME	*G - GROUP* GROUP NAME	*A - AREA* AREA	STOP
R-ROOM ROOM NAME	ADJACENCY *ROOM*ROOM* 1,2, OR 3* 1 = +, 2 = NEUTRAL, 3 = -	"ROOM" * NO * ROOM'S SQ. FT.	"ROOM" NO W X NO L ROOM'S DIMENSIONS

SKETCH BOOK: YOUR OPTION

PAGE NAME? BUILDING DETAILS

YOUR OPTION:

HEADING? SITE MATERIALS

NOTES? PATIO SHOULD BRICK.
DECK SHOULD BE WOOD.

GRAPHICS INTERPRETATION

YOUR CHOICES ARE:

*1 ASSIGN SQUARE FOOTAGE

*2 ASSIGN DIMENSIONS (WIDTH AND LENGTH)

*3 DEFINE ADJACENCIES

*4 ASSIGN ROOMS TO GROUPS, GROUPS TO ZONES

*5 SKETCH BOOK

*6 GRAPHICS

*7 STOP

TYPE CHOICE? 02

NEW ZONES	LIST ZONES	NEW GROUPS	LIST GROUPS	NEW ROOM	LIST ROOMS	NEW AREA	LIST AREAS
SET DEFAULT	MAXIMUM SQ. FT.	MINIMUM SQ. FT.	GRAPHICS INTERPRETATION	STOP			

SQUARE FOOTAGE ASSIGNMENT

DEFAULT SQ. FT. = 100

LIST OF EXISTING ROOMS

1 LIVING ROOM
2 DINING ROOM
3 BED ROOM
4 KITCHEN
5 ENTRY
6 TOILET

ROOM? TOILET
SQ. FT.? 40

NEW ROOM
NAME? BED ROOM °2
SQ. FT.?
(DEFAULT) SQ. FT. = 100

SET DEFAULT (=100) ? YES
NEW SQ. FT. =? 150

ZONE AJACENCIES	GROUP AJACENCIES	ROOM AJACENCIES

LIST ZONE	LIST GROUP	LIST ROOMS	GRAPHICS INTERPRETATION	STOP

ADJACENCIES

EXISTING ZONES	EXISTING GROUPS	EXISTING ROOMS
1 HOUSE	1 LIVING	1 LIVING ROOM
	2 DINING	2 DINING ROOM
	3 SLEEPING	3 BED ROOM
	4 KITCHEN	4 KITCHEN
	5 ENTRY	5 ENTRY
	6 TOILETS	6 TOILET

GROUP ADJACENCIES

AJACENCY #1	AJACENCY #2	RELATIONSHIPS 1= + 2=NEUTRAL , 3= −
LIVING	DINING	0? 1
LIVING	SLEEPING	3
LIVING	KITCHEN	1
LIVING	ENTRY	1
LIVING	TOILETS	2
DINING	SLEEPING	3
DINING	KITCHEN	1
DINING	ENTRY	2
DINING	TOILETS	2

NEW ZONE	NEW GROUP	NEW ROOM	LIST ZONE	LIST GROUP	LIST ROOMS

GROUP TO ZONES	GROUPS TO ROOMS	NEW AREA	LIST AREAS	GRAPHICS INTERPRET'N	STOP

ROOMS ⟷ GROUPS ⟷ ZONES

EXISTING ZONES	EXISTING GROUPS	EXISTING ROOMS
1 HOUSE	1 LIVING	1 LIVING ROOM
	2 DINING	2 DINING ROOM
	3 SLEEPING	3 BED ROOM
	4 KITCHEN	4 KITCHEN
	5 ENTRY	5 ENTRY
	6 TOILETS	6 TOILET

ZONE - GROUP

ZONE? HOUSE
GROUP? SLEEPING
GROUP? « CR »
ZONE? « CR »

GROUP - ROOM

GROUP? SLEEPING
ROOM? BEDROOM
ROOM? BEDROOM ^2
ROOM? « CR »
GROUP? « CR »

NEW ROOM

NAME? BED ROOM ^3
DEFAULT SQ. FT. = 100 OK?
DEFAULT W X L = 10' X 10' OK? NO
NEW W X L? 9 X 10

GRAPHICS

YOUR CHOICES ARE:

*1 ADJACENCY GENERATED BUBBLE DIAGRAMS

*2 BUBBLE DIAGRAMS

*3 SITE/BUBBLE DIAGRAM

*4 GENERIC LAYOUT

*5 PLAN LAYOUT

*6 EQUIPMENT/FURNISHINGS

*7 SITE LAYOUT

*8 MODELLING

*9 CRITERIA CHECKING

*10 SKETCH BOOK

*11 GRAPHICS INTERPRETATION

*12 STOP

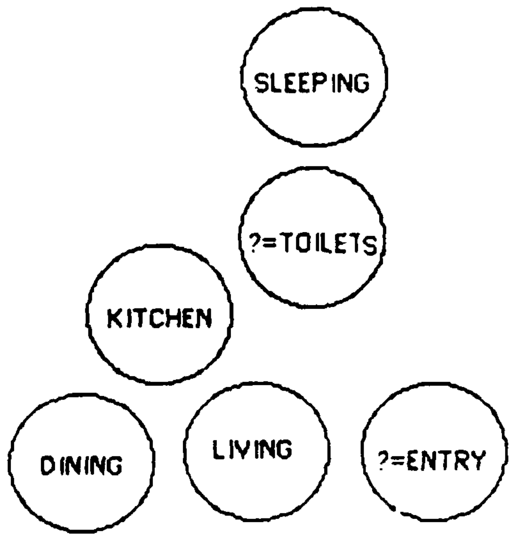
TYPE CHOICE? 0

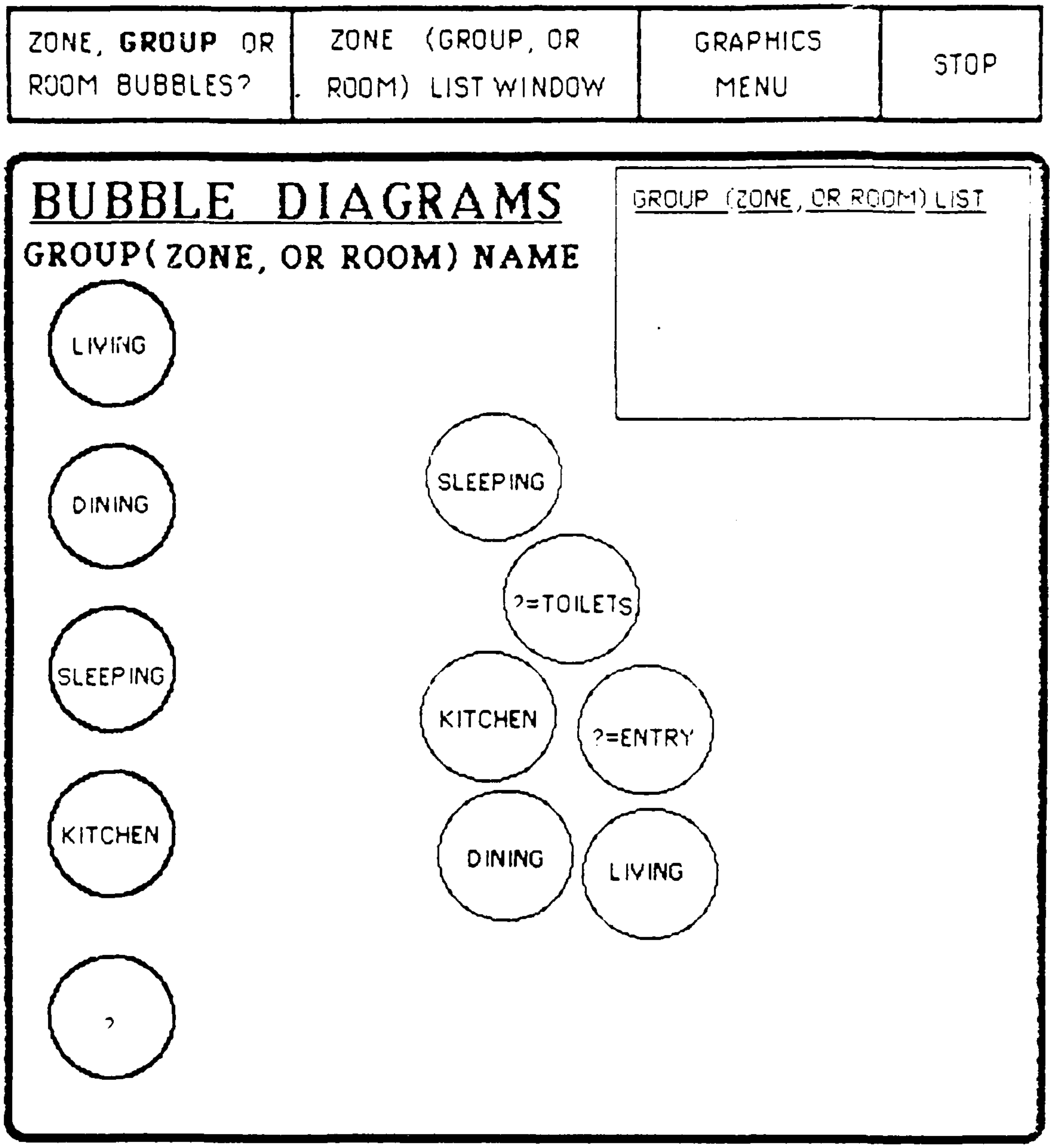
ZONE, **GROUP** OR ROOM BUBBLES?	ZONE (GROUP, OR ROOM) LIST WINDOW	GRAPHICS MENU	STOP

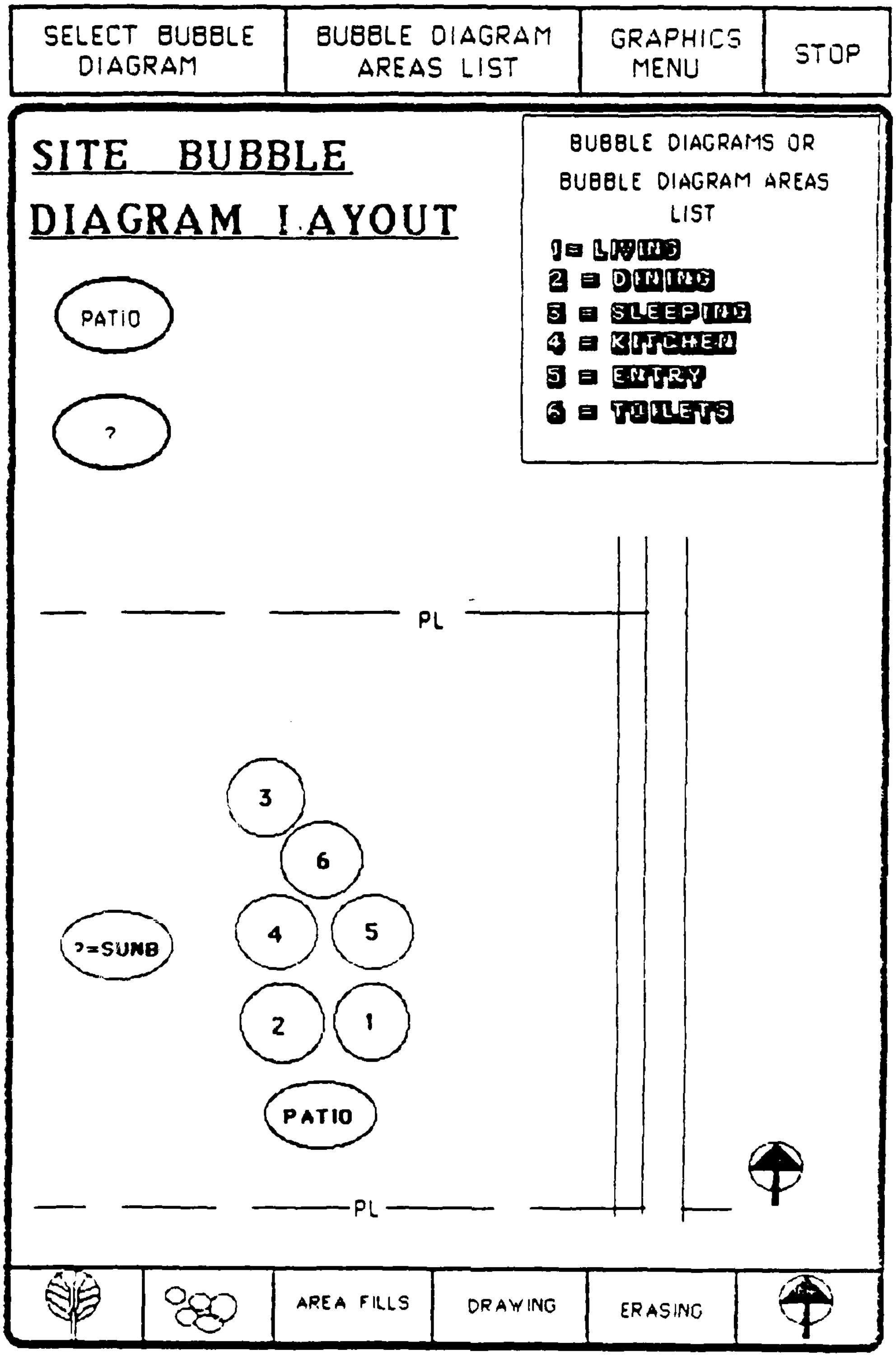
ADJACENCY GENERATED BUBBLE DIAGRAMS

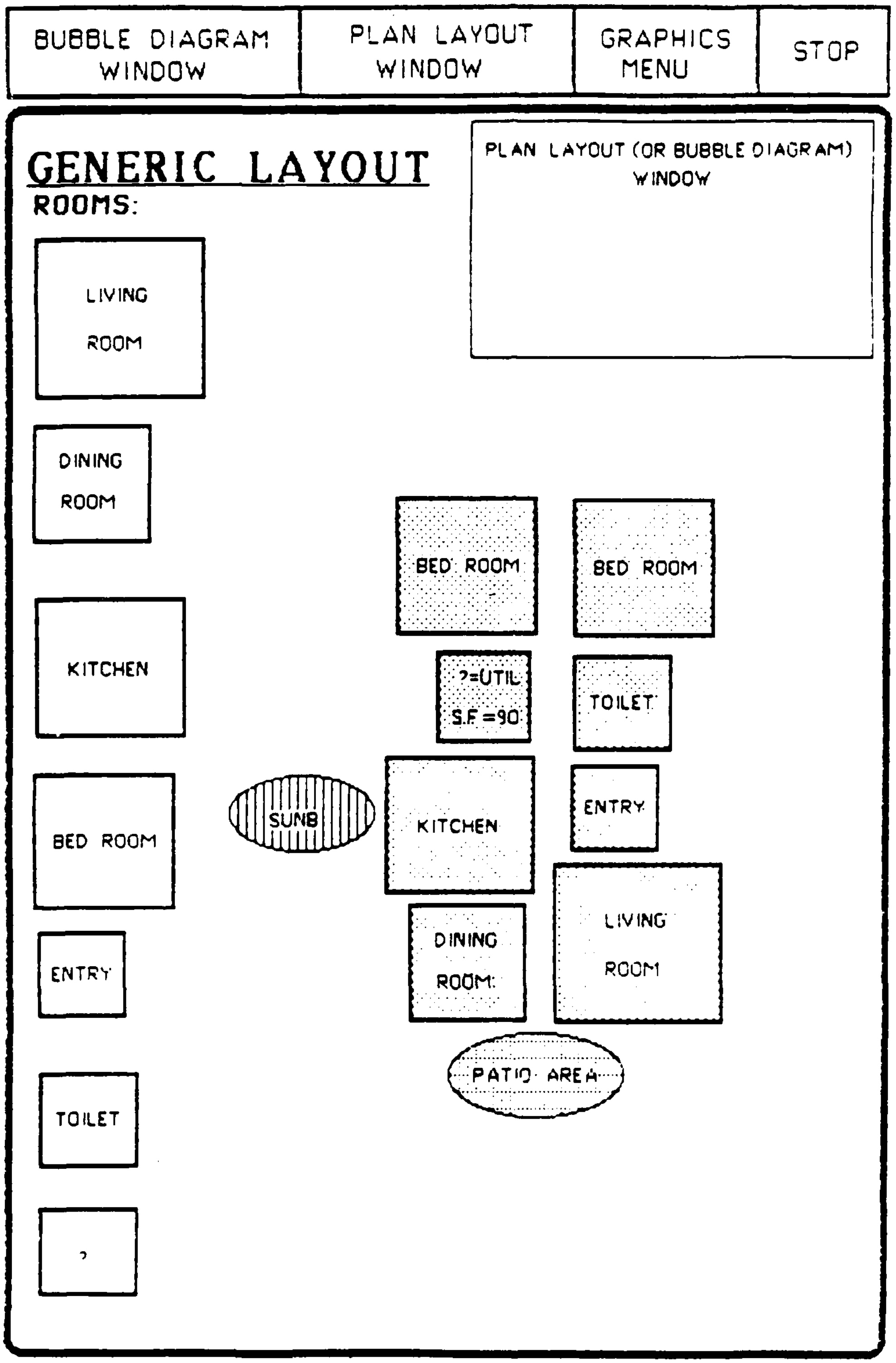
GROUP(ZONE, OR ROOM) NAME

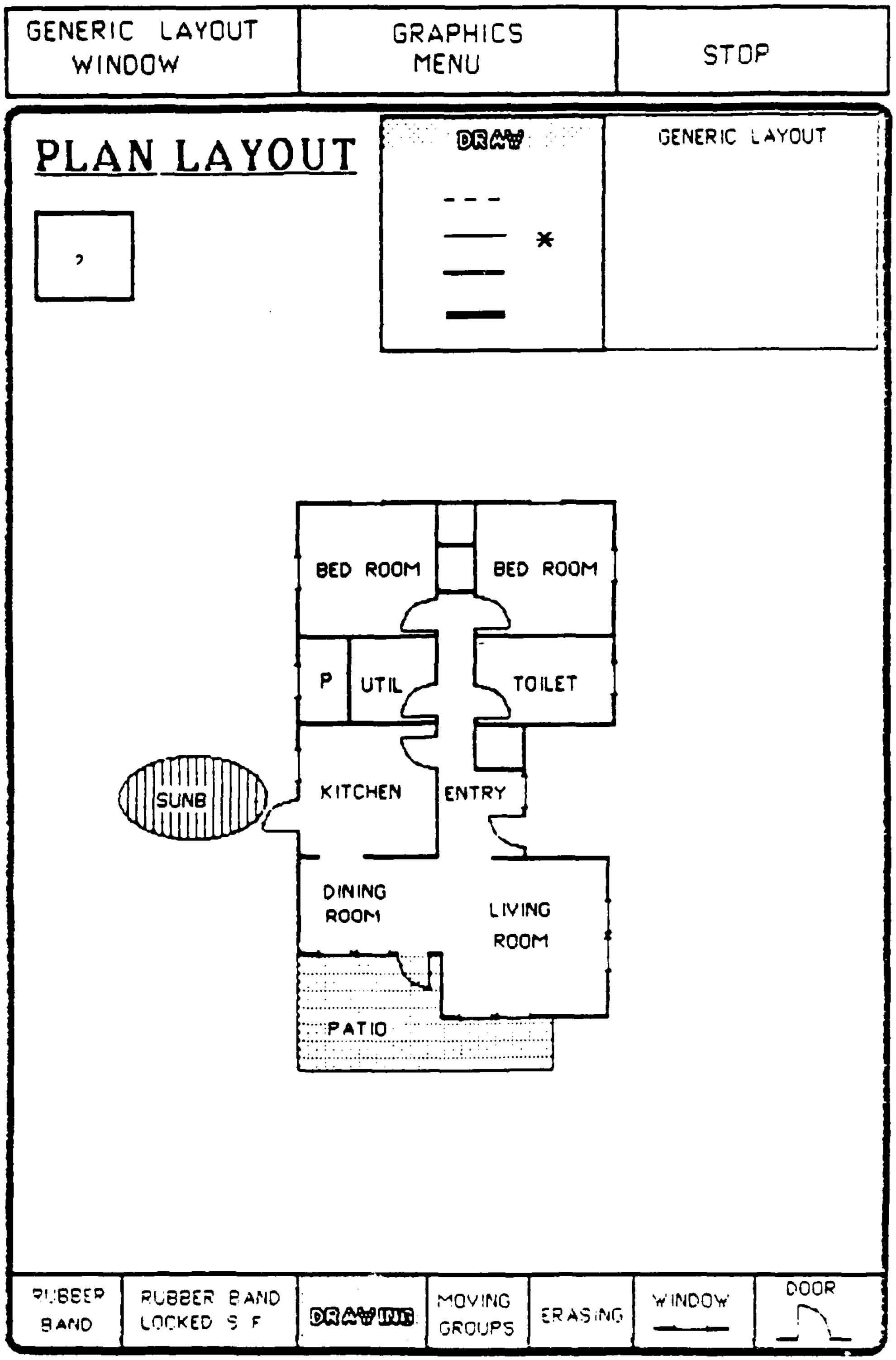
GROUP (ZONE, OR ROOM) LIST

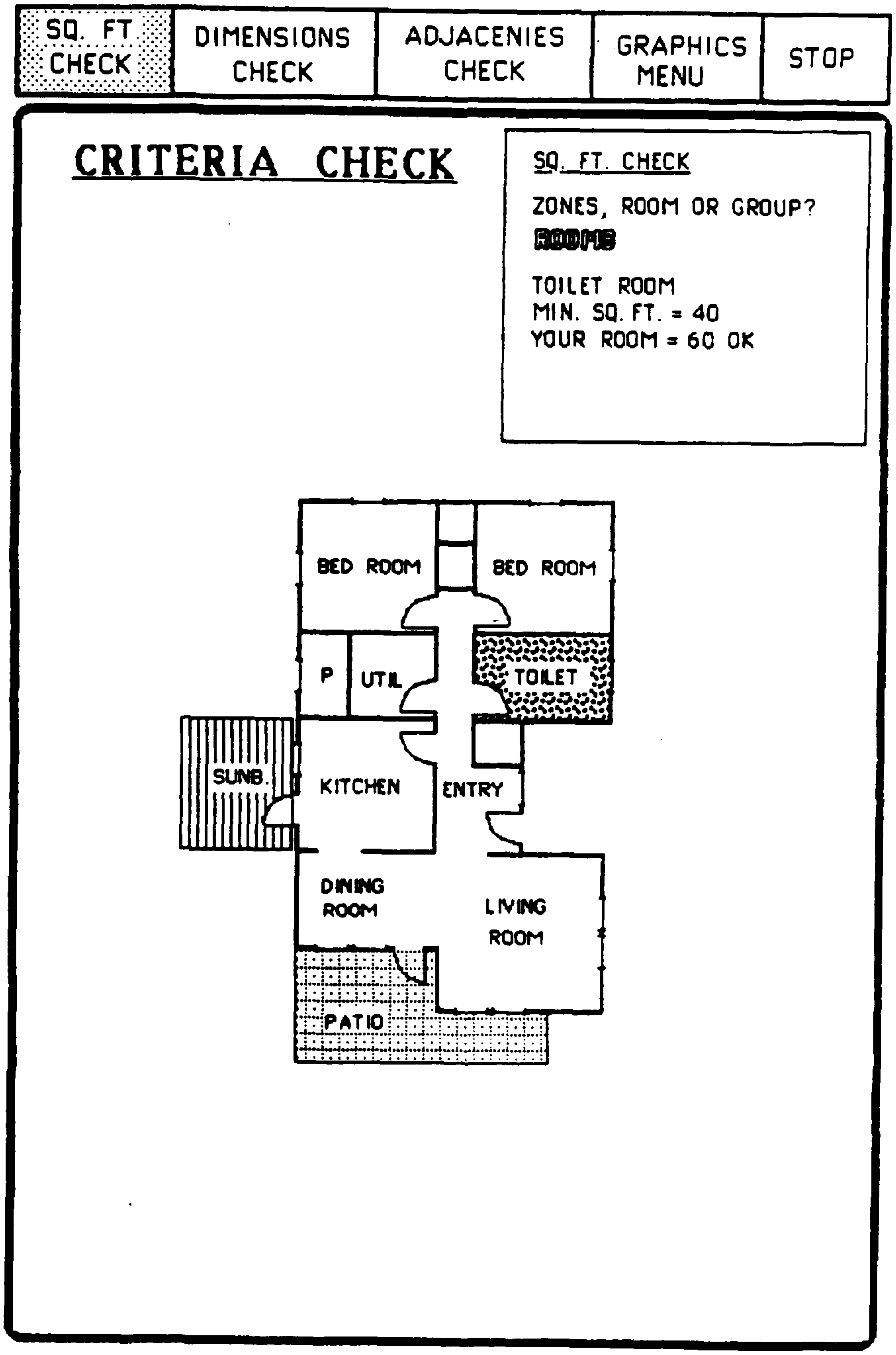



ZONE, GROUP OR ROOM BUBBLES?
ZONE (GROUP, OR ROOM) LIST WINDOW
GRAPHICS MENU
STOP
BUBBLE DIAGRAMS
GROUP(ZONE, OR ROOM) NAME
GROUP (ZONE, OR ROOM) LIST
LIVING
DINING
SLEEPING
KITCHEN
?
SLEEPING
?=TOILETS
KITCHEN
?=ENTRY
DINING
LIVING


SELECT BUBBLE DIAGRAM
BUBBLE DIAGRAM AREAS LIST
GRAPHICS MENU
STOP
SITE BUBBLE DIAGRAM LAYOUT
BUBBLE DIAGRAMS OR BUBBLE DIAGRAM AREAS LIST
1= LIVING
2 = DINING
3 = SLEEPING
4 = KITCHEN
5 = ENTRY
6 = TOILETS
PATIO
?
PL
3
6
?=SUNB
4
5
2
1
PATIO
PL
AREA FILLS
DRAWING
ERASING


BUBBLE DIAGRAM WINDOW
PLAN LAYOUT WINDOW
GRAPHICS MENU
STOP
GENERIC LAYOUT
ROOMS:
PLAN LAYOUT (OR BUBBLE DIAGRAM) WINDOW
LIVING ROOM
DINING ROOM
KITCHEN
BED ROOM
ENTRY
TOILET
?
BED ROOM
BED ROOM
?=UTIL S.F =90
TOILET
SUNB
KITCHEN
ENTRY
LIVING ROOM
DINING ROOM
PATIO AREA


GENERIC LAYOUT WINDOW
GRAPHICS MENU
STOP
PLAN LAYOUT
DRAW
GENERIC LAYOUT
BED ROOM
BED ROOM
P
UTIL
TOILET
SUNB
KITCHEN
ENTRY
DINING ROOM
LIVING ROOM
PATIO
RUBBER BAND
RUBBER BAND LOCKED
DRAWING
MOVING GROUPS
ERASING
WINDOW
DOOR


SQ. FT CHECK
DIMENSIONS CHECK
ADJACENIES CHECK
GRAPHICS MENU
STOP
CRITERIA CHECK
SQ. FT. CHECK
ZONES, ROOM OR GROUP?
ROOMS
TOILET ROOM
MIN. SQ. FT. = 40
YOUR ROOM = 60 OK
BED ROOM
BED ROOM
P
UTIL
TOILET
SUNB.
KITCHEN
ENTRY
DINING ROOM
LIVING ROOM
PATIO

APPENDIX B:

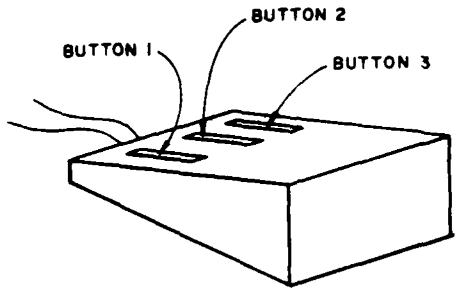
DRAFT USER'S MANUAL FOR CHARRETTE

Note: Except for minor format and phrase changes, this appendix is the same as the one given to the subjects. It tells how to use the mouse, enter/exit Apollo, enter/exit Charrette, and use Sketch Book, Graphic Interpretation, and Graphics options.

Overview of Apollo DOMAIN 300 Workstation

The Mouse (Charrette)

The mouse is the device that moves across the table top. It enables you to locate a certain point on the screen.



As you move the mouse across the table a crosshair (+) will move across the screen with it. Sometimes the crosshair may turn into a box.

When the program requires you to pick something, the user should move the cross-hairs or cursor box to position to pick and either:

1. Hit buttons 1, 2, or 3 on mouse.

2. Hit any keyboard button.

Sometimes the program will require certain buttons to be hit. The left button is button 1, the middle is 2, and the right is 3.

The (Apollo) Mouse

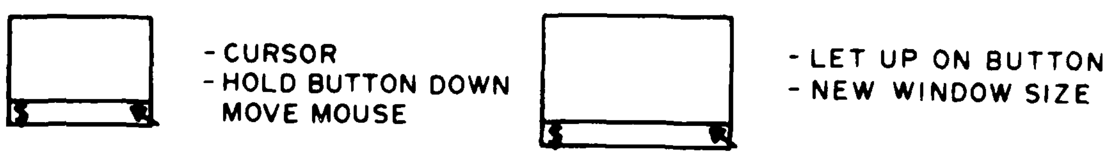
<u>Button 1</u> - Left Button:

1. Place cursor (arrow) on any corner of window.

2. Press down on button 1.

3. While holding button down, move mouse across table top. This will stretch the window.

4. When window reaches desired size, let up on button. This will stop the stretching.



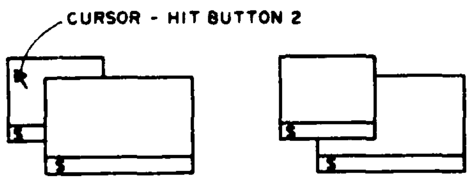
Button 2 - Middle Button

If window is hidden by another window

1. Place cursor (arrow) in window you would like to see.

2. Hit button 2.

3. This should pop the next window underneath to the top.

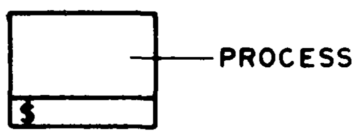


When Machine Stops Responding!

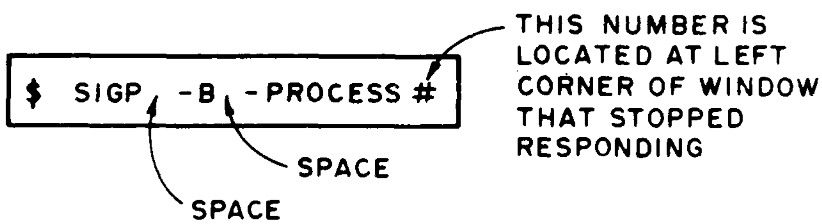
If the Apollo stops responding to any input, the program has run into a problem. Do this:

1. Hold <shift> key down.

2. Hit <shell> key.It is located in the keys on the left side of the keyboard, second column, third row. This will pop up a new process (window).



3. In process window type: "SIGP -B -PROCESS#".The # stands for the number located in the left upper corner of the window that stopped responding.



4. Place cursor in window that stopped responding.
   a. On keyboard press down, hold <ctrl> key (control key)
   b. Hit "N" key.

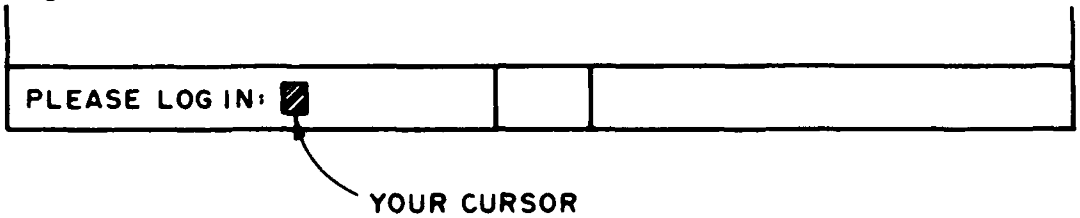
This should close down window. If this doesn't work do steps (a) and (b) again. If this doesn't work, start with step 3 and do again.

Entering and Exiting Apollo and Charrette

To Sign on to Apollo

1. Move your cursor (with the mouse) down to the lower lefthand corner where it says

"Please log in:".



2. Type "L CLASS".

3. Next the computer will prompt "Enter Password".

4. Type <CR>.

NOTE: Here and throughout <CR> means carriage return.

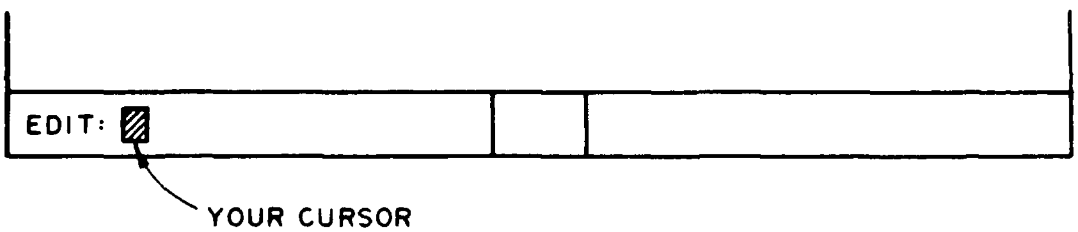
NOTE: When an instruction says to type something, the material to be typed is enclosed in quotation marks; DO NOT type the quotes.

You have now signed on to the Apollo.

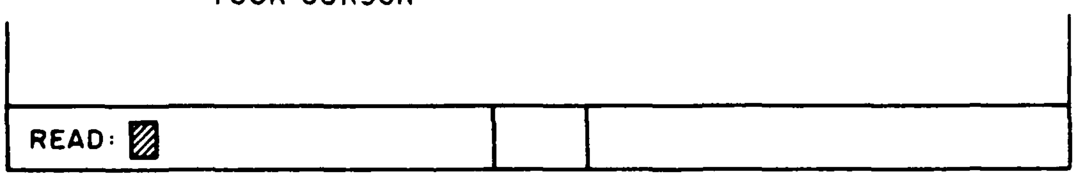
To Sign Off Apollo

1. Move your cursor (with the mouse) down to the lower lefthand corner where it will say:

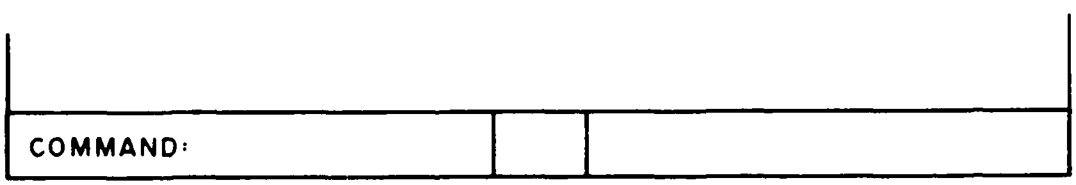
either



or



or

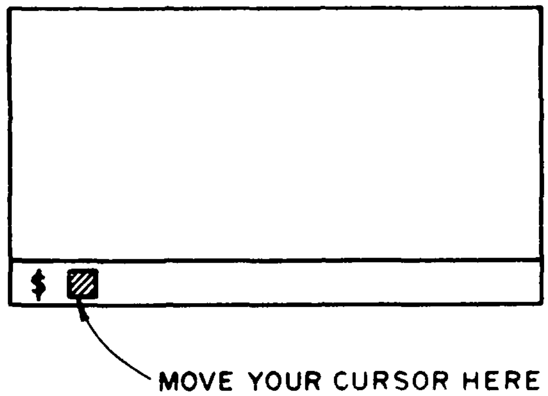


It is necessary to get the window into the Command mode. If it is not there already, put your cursor right after the colon and type <CR>.

When the "Command:" prompt is present, type "LO". You have logged off.

To Get Into Charrette

1. Move your cursor (using the mouse) to the bottom strip of the window on vour screen. (This is where the dollar sign is.)



2. Type "Charrette".

3. The program will start running. The first question Charrette prompts you with is "Please lock capitals on. Is caps lock key on? (Y)".

4. Your caps lock key (lower left corner of keyboard) must be locked on. Answer "Y" or "YES" to this prompt.

5. The next prompt is "Enter Project Name:". The cursor will position itself on the input line below the prompt.

6. Type your project name. A few words about project names...

   a. They can contain letters and numbers and underscores. DO NOT use other characters.
   b. They CAN NOT have any spaces in them.
   c. They must be typed in CAPITALS.

If you are trying to create a new project, you must use a project name that no one else has used. You can review names that have already been used before you get into Charrette by

1. Move cursor to input strip that has a "$" sign in it.

2. Type "LIST_PROJECTS".

To assure your project name is unique you may want to use your initials for the first three letters and then anything else, e.g., LSB_APT_BUILDING.

You are now in Charrette. See the following notes for further instructions.

Charrette Instructions

Charrette is divided into three parts: (a) Sketch Book, (b) Graphic Interpretation, and (c) Graphics. The user may start a project in ANY of the options. The user may also traverse from any section to any section. See the information on each section for more explicit instructions.

Charrette is a prototype research program that is trying to approach the needs of the designer. By its very nature, there are some problems in the system which can usually be circumvented by backing out of the option you're presently in, or out of Charrette, and trying again.

Description of Division Functions

Sketch Book

Similar to an actual notebook, the Sketch Book allows the user to review program information, and to write down their thoughts for future reference. The user may also start inputting information that will later be useful, such as zone, group, and room names, and adjacencies between these.

Graphic Interpretation

Graphic interpretation allows the user to store information about the building areas in a table format. This information includes: zone, group, and room names; adjacencies; and area sizes.

Graphics

Graphics allows the user to manipulate forms to create space layouts. There are three types of drawings you can make:

a. Adjacency Generated Bubble Diagrams. This drawing will display bubbles of the square footage entered previously, and the adjacency relationships to other spaces. (You CANNOT create new areas.)

b. Bubble Diagrams. This drawing will display bubbles of the square footage entered previously and allow the user to manipulate them. You can create new areas here.

c. Block Layout. This drawing will display "blocks" of the width and length previously entered. The user may manipulate the blocks and create new areas.

Selecting First Option

When you first enter Charrette the "Welcome to Charrette" menu will come up. You must select an option by moving the mouse over the option words. By clicking ANY mouse button (or any keyboard key), this option will be selected.

NOTE: Throughout Charrette, the user selects an option by moving the mouse into the correct area and either hitting a mouse button or keyboard key.

Next Options

Whichever option you selected will now be displayed. You must now select a suboption to continue. You may always go from one major option to the other two. If you select STOP at anytime during Charrette you will quit the whole program.

Sketch Book Options

- Project Description
- Site Description

- Climate
- Code Requirements
- Building Requirements
- User Requirements
- Site Requirements
- Graphic Interpretation
- Graphics
- Stop

Graphic Interpretations

- Assign Areas and Dimensions
- Define Adjacencies
- Spatial Organizations
- Sketch Book
- Graphics
- Stop

Graphics

- Adjacency Generated Bubble Diagrams
- Bubble Diagrams
- Blocks Layout
- Sketch Book
- Graphic Interpretation
- Stop

Things to Remember

1. Do not put blank space, or any character except letters, numbers, and underscores in a project name or drawing name.

2. Boxed Arrows (in lower lefthand corner of keyboard) will display other areas of "windows" - so that you can see text that has gone by.

   Note: Boxed arrows also pan in Graphics options.

3. Enter all dimensions as decimals of feet, e.g.,

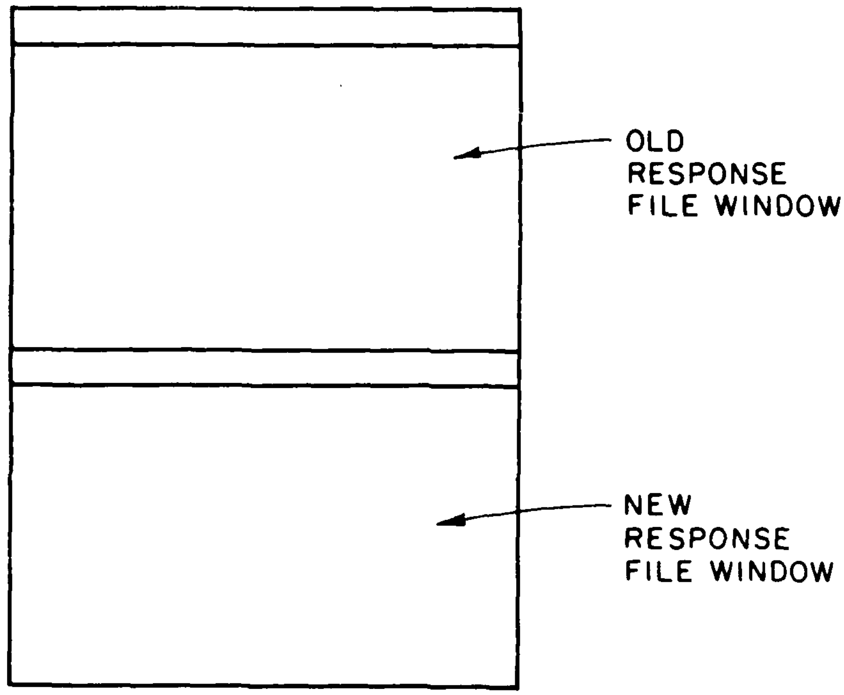
   1'-6" = 1.5
   2'0" = 2

4. All responses to Charrette questions must be followed by <CR> (= carriage return) to be accepted by the program.

Stopping Charrette

After you have stopped Charrette from any option, a response file will come up on the screen for you to enter your feelings about today's session. In the old response file window will be displayed your previous responses for you to review. To see older messages or newer messages that aren't displayed, position the cursor over the old response window and hit the boxed arrows: up to see earlier messages and down to see more recent messages.

The response file will appear like this:

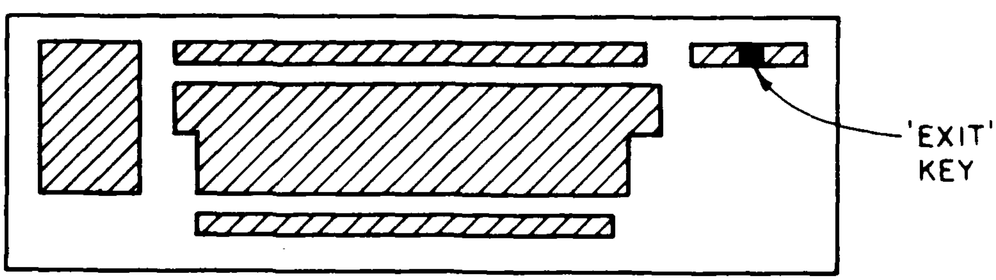


To Enter Your Response

Move the cursor to the new response file window. Type in whatever response you have. While you are editing, you can use the <Line Del>, <Char Del>, and <Backspace> keys to change your text. When you are finished, exit from response file.

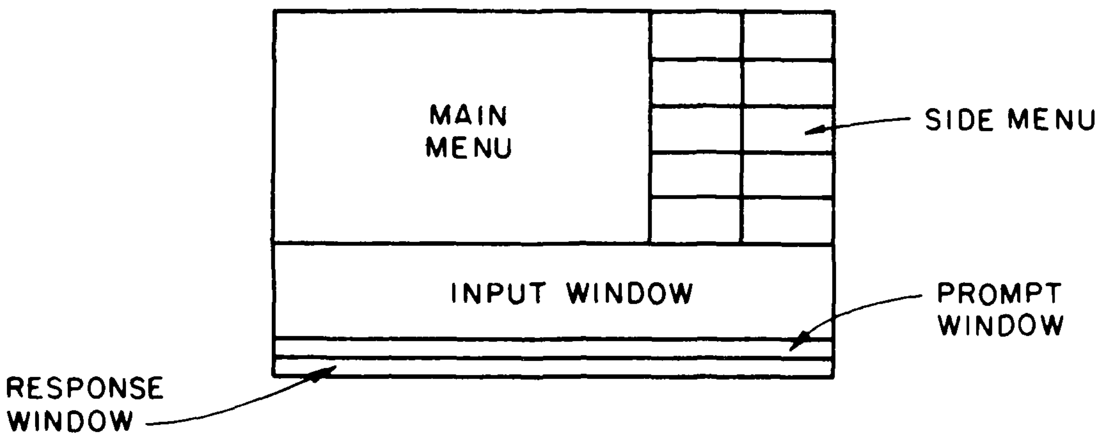
To Exit Response File

With the cursor over the new response file window, type the "exit" key. This key is located on the horizontal strip of keys on the upper righthand corner of the keyboard.



Sketch Book

1. Using Mouse: pick option from Sketch Book menu. The program will then pop up: a side menu, main menu, input window, prompt window, and response window.



2. Using Mouse: pick option from main menu. These items are specific areas of interest to your project that you want to make notes about.

NOTE: After picking option don't touch mouse until it positions itself in input window.

NOTE: First option picked will not work. So pick another option and then go back and pick first option.

3. After cursor positions itself in input window, you can edit existing material or add new material.

4. When finished with editing, pick either another option in main menu or pick an option in side menu.

   a. If you choose a main menu option, the prompt window will prompt "Did you edit or add text (Y/N)?". If you did, type "Y" or "Yes" in input window. If no type "N" or "No".

   b. If you picked side menu option "ZONE NAME", "GROUP NAME", or "ROOM NAME" it will say: "Mouse button 1 to mark start of entry 2. To mark end of entry then right menu to store". These will allow you to save zone, group and room names.

1. Take cursor to beginning of "name". Hit button 1.

2. Drag cursor to end of "name". Hit button 2.

3. Go hit side menu option again to store name. To repeat and define more names: use same procedure.

If you picked, "ADJACENT AREAS", "FAR AREAS", or "DIFFERENT AREAS" as your side menu option, you will repeat the same procedure as in group, zone, room name. These will allow you to give square footage for the areas. The prompt window will prompt you when to do it.

NOTE: Name or areas must have already been defined, either by Sketch Book or Graphic Interpretation's areas and dimensions options.

NOTE: In the Graphic Interpretation (Define Adjacencies) option, areas are or can be defined by how adjacent they are to one another. In Sketch Book these three options are defined by numbers between 1-5. These options are defined as:

Adjacent areas	=	1
Far areas	=	4
Different building areas	=	5

Sketch Book will assign these numbers to the areas you specify.

5. To get out of the Sketch Book option.

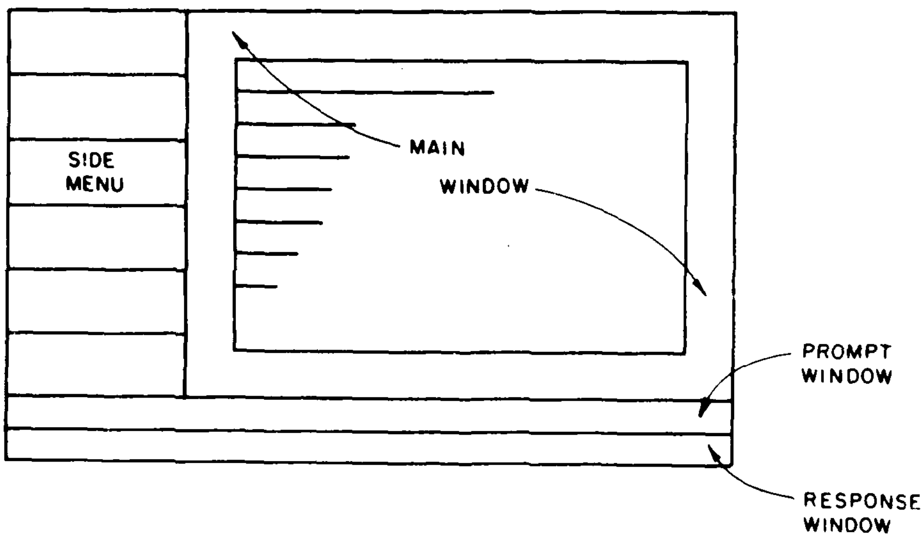
   a. Hit any of four bottom options on side menu.
   b. It will prompt you: "Did you edit or add text (Y/N)?"
   c. Answer "Y" or "N" to get out.

Graphic Interpretation Options

Assign Areas and Dimensions

To enter option: move cursor over "Assign areas and dimensions" with mouse and hit any mouse buttons.

After this option has been selected, menus will come up as shown:



It is first necessary to select a type of space you are putting information in for.

To Select Type of Dimensions Table Desired

Move the cursor to one of the top three boxes in the side menu, and select an area type. You may select "ZONE", "GROUPS (of rooms)", or "ROOMS". Remember, the drawings options in graphics will display one area type at a time. The option you have selected will light up and the table for that area type will be displayed.

Even if this is a new project, there will always be a new area type displayed with 100 square feet as a default area.

To Enter Information

Move cursor to box where you want to enter information. Push a mouse button and you will be queried in the prompt window. Type your answers in the response window. Details on entering each type of information follow.

Information You Can Enter:

Area No.	Area Name	Square Feet	Width (Ft)	Length (Ft)
1New Room	100.00	10.00	10.00	

Ways to Enter Information

Area Number

1. Area number will be assigned automatically with the creation of a new area. You can change the area number assigned by selecting this option.

2. Charrette will query in the prompt window "TYPE NEW NUMBER:"

3. Type in the new number desired. Hit <CR> to enter it into the system. Rules:

   a. Hitting just <CR> results in an unchanged area no.
   b. Area no. must be 8 letters and/or numbers or less.
   c. There can be spaces.
   d. There cannot be two areas (of the same type) with the same area no. If you mistakenly type in a duplicate area number, Charrette will ask you for another number.

Area Name

1. You may change an existing area name by selecting that name with the cursor. You may also create a new area by selecting "NEW ZONE", "NEW GROUPS OF ROOMS" or "NEW ROOM" with the cursor.

2. Charrette will ask:

   "Enter new area name:" or

   "Type new name for present area (CR to leave same):"

3. Type in desired new name and enter it into the system with <CR>.

   Rules of area names:

   a. Hitting just <CR> results in an unchanged area name.
   b. Area name must be no more than 32 letters and/or numbers long.
   c. There can be spaces.
   d. There can be as many areas as you want with the same name--but you will have to remember them.

Square Feet

1. To assign different square footages, move cursor to square footage to be changed and hit mouse button.

2. Charrette will ask: "Enter square footage:"

3. Type in desired square footage.

NOTE: Type feet in decimal format, i.e. 2'6" = 2.5.

4. Charrette queries: "Enter width (CR for equal width and length):".

5. Type width desired. If you want square area hit <CR>.

NOTE: Length will automatically be figured as square footage/width.

Width

1. To change width of a particular area, move cursor to width desired and hit mouse button.

2. Charrette will query: "Enter width:"

3. Type width desired.

NOTE: Type feet in decimal format.

4. Charrette will query: "Change sq footage (CR to remain same):"

5. If you want sq ft = new width x old length type "Y" or "Yes". If you want sq ft to remain the same and the length to change, type <CR> or "N". Charrette will display new values.

Length

Follow same procedure as width.

To Leave Dimensions Table

Move cursor to side menu over "GRAPH INT" (to return to graphic interpretations menu) or over "STOP" (to stop Charrette), and hit any mouse button.

NOTE: "Maximums", "minimums" and "PDB Reqts" have not been implemented. To select them will cause no action.

To See Lower Parts of Table

The dimensions table is 12 areas long. If you have more areas, they will not be displayed at first. To display them, move the cursor over the main menu and press the boxed down arrow key. To go up and see earlier areas, move the cursor over the main menu and press the boxed up arrow key.

Define Adjacencies

To enter option: move cursor over "Define Adjacencies" with mouse and hit any key or mouse button.

After this option has been selected, menus will come up as shown in Assign Areas this section, p. .

It is first necessary to select a type of space you are putting information in for.

To Select Type of Adjacencies Table

Move the cursor to one of the three top boxes in the side menu and select an area type. You should select an area type that you have already entered information for. You will not be allowed to create new areas in this option. After you have selected an area type Charrette will fill the adjacency table. The table will display the first seven areas in rows and four areas in columns. The adjacency relationship will default to a neutral setting of "3".

Adjacency Ranges

The adjacency relationships range from "1" to "5". "1" represents directly adjacent spaces, "2" represents slightly adjacent spaces, "3" represents a neutral relationship, "4" represents two spaces that should not be very close to each other, and "5" represents spaces that should be the farthest away, or in separate buildings.

To Enter Adjacencies

Method 1

1. Position cursor over box that represents the adjacency relationship and hit any mouse button.
2. Charrette will ask (in the prompt window): "Enter adjacency (1,2,3,4, or 5):"
3. Type in adjacency desired in response window. Enter this in the program by typing <CR>. The new number will be displayed in its box.

Method 2

1. Position cursor over box that represents the adjacency relationship you desire to change.

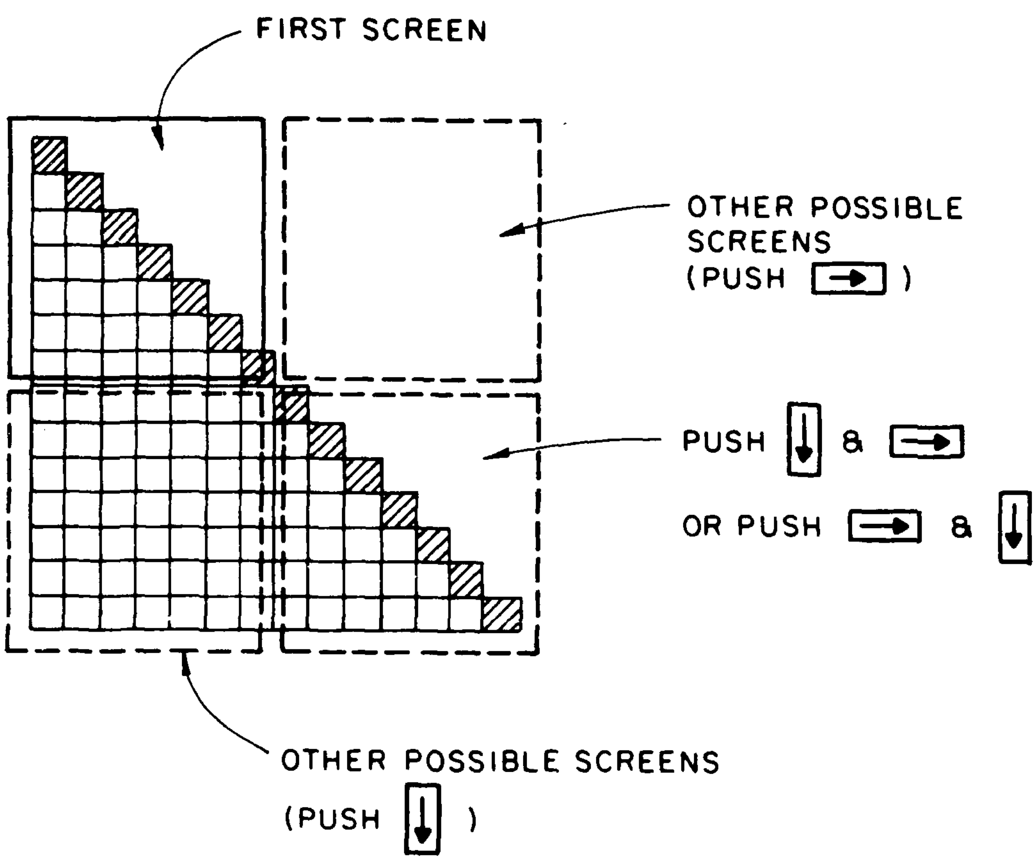
2. Type the adjacency desired (with the cursor still over the box). The number must range from 1-5. The number will be displayed in its box.

To Leave Adjacencies Table

Move cursor to side menu over either "Sketch Book", or "Graphic Inter", "Graphics", or "Stop". Push any mouse button to leave. The first three boxes will take you to one of the three options. "Stop" will take you out of the Charrette.

To See Other Parts of Adjacencies Table

Although Charrette will only show you seven rows by four columns of this table, it is best to imagine it as a larger table (see below).



To display other possible screens, position cursor over the main menu, and press any of the four boxed arrows keys. The screen will display the part of the table in the direction of the arrow.

Spatial Organizations Option

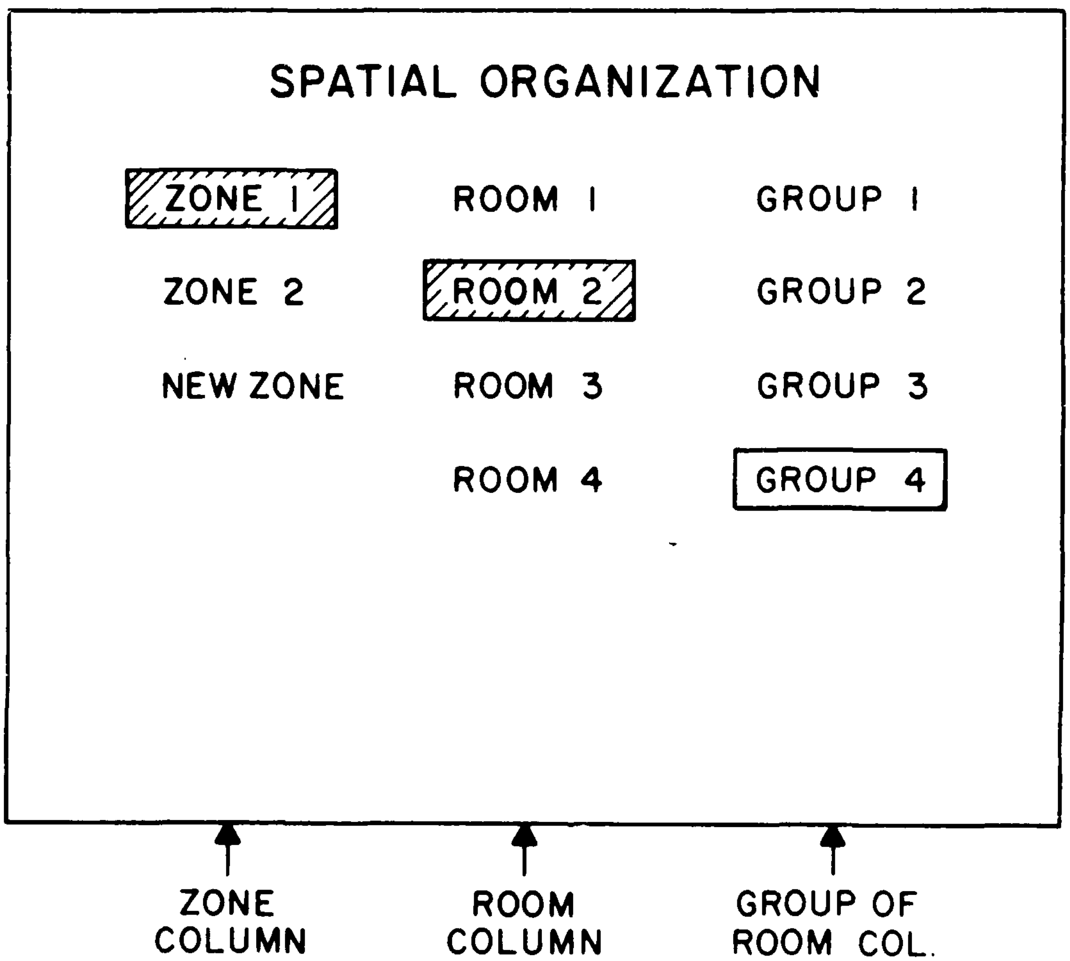
To enter option: Move cursor over "Spatial Organizations" with mouse and hit any key or mouse button.

After this option has been selected, menus will come up as in Assign Areas this section, p. .

This option allows you to assign rooms to zones. You can create new zones in this option. This information was originally intended to be reflected in drawings, but this was not developed. This option may help you organize zones.To use this option you must first "Select Zone to Assign Rooms and Groups to".

To Select Zone

Move cursor (with mouse) over zone desired and push any button. The selected zone will be highlighted as below. Any room and groups that belong to the zone will light up also.



NOTE: An empty box means that the room belongs to another zone than the one highlighted.

To Create New Zone

1. Move cursor over "New Zone" in main menu and hit mouse button 1 (left button).

2. Charrette will prompt: "Type new zone name:"

3. Enter zone name. Follow the same rules as listed under "Assign Areas and Dimensions - Area Names".

4. Charrette asks: "Zone square feet (type ! to quit, <CR> to skip)".

5. Type:

   a. Square feet desired in decimal format or
   b. "!" to stop the process of adding zone or
   c. <CR> to move on to entering width and length (and letting sq ft = width x length)

6. Charrette asks: "Width of zone? (Type ! to quit, <CR> for equal width and length)".

7. Type:

   a. Width desired in decimal format or
   b. "!" to stop process of adding zone or
   c. <CR> to create zone of equal length and width.

8. If you have skipped entering sq footage, you will now be queried for the desired length.

9. Now that you have selected a zone, Charrette will prompt:

   "Mouse Buttons 1 - Assign to current zone, 2 - Assign areas to general project, and 3 - Identify current zone"

You now must position the cursor over one of the rooms or groups to do one of these options.

NOTE: If you want to work with another zone, move the cursor over the other zone and hit mouse button 1 (left button).

To Assign to Current Zone

To assign a room or group of rooms to the current (highlighted zone), move the cursor over the area and click mouse button 1 (the left button). The area will automatically be assigned to the current zone.

NOTE: If the area belongs to another zone, it will be reassigned.

To Assign Areas to General Project

If you wish to assign an area to the general project (i.e., remove it from any zone), position the cursor over the area and push mouse button 2 (middle button). If the area belongs to the current zone, it will automatically be assigned to the general project. If the area belongs to another zone (indicated by an empty box around area name), Charrette will prompt "Room 1 is in Zone 1 zone. Do you want to change it? (CR to remain the same)?" If you wish to remove it from the zone listed type "Y" or "Yes". Otherwise, hit <CR> or "N".

To Identify Current Zone

To identify the current zone a room or groups of rooms is in, move cursor over area name and click mouse button 3 (right button). Charrette will respond: "Room 1 is in Zone_1 zone."

To see the mouse command list after this move the cursor over the main menu (but NOT over any words) and click any mouse button. The prompt line will appear in the prompt window.

To Leave Spatial Organization

Move the cursor to side menu over either "Sketch Book", "Graphic Interp", "Graphics", or "Stop". Click any mouse button, and you will be routed to either one of the three options or you will stop Charrette.

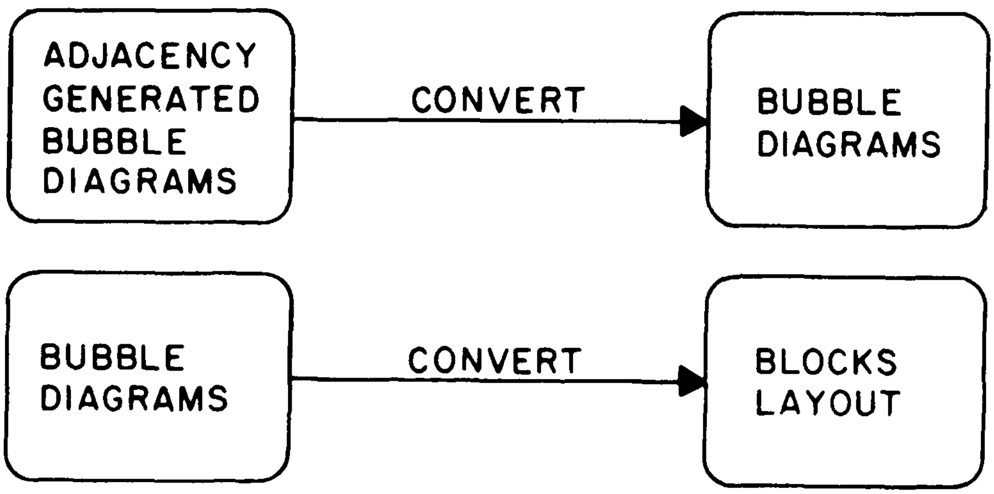
Graphics Option

You can create three kinds of space layouts in Graphics: Adjacency Generated Bubble Diagrams, Bubble Diagrams, and Blocks Layout. The process used for each is very similar, so these pages will first tell you the typical process and later point out the differences.

To Enter a Spatial Layout Mode

1. First, select the type of drawing you would like to work on by moving the cursor to the drawing type title and click any key.

2. If you have selected either Bubble Diagrams or Blocks Layout, you can convert a drawing from the previous mode to the current mode. See diagram below.



Charrette will query either:

"Wish to start from adjacency generated bubble diagrams?"

or

"Wish to start from bubble diagrams?"

If you answer "Y" or "Yes", the titles of any drawings in the previous mode will appear in the table of drawings to select from. These drawings will be converted to the current mode and given the same name as they had in the previous mode.

3. Once you have selected a drawing type, a table of all the drawings that are available to you will be displayed. Among the names of all the existing drawings there will be the names of "New Zone Layout", "New Groups Layout", and "New Room Layout". If you select these, you will be creating a new layout. If you select an existing drawing, you will work on a copy of the original. To select a drawing, move the cursor over the drawing title desired and click any button.

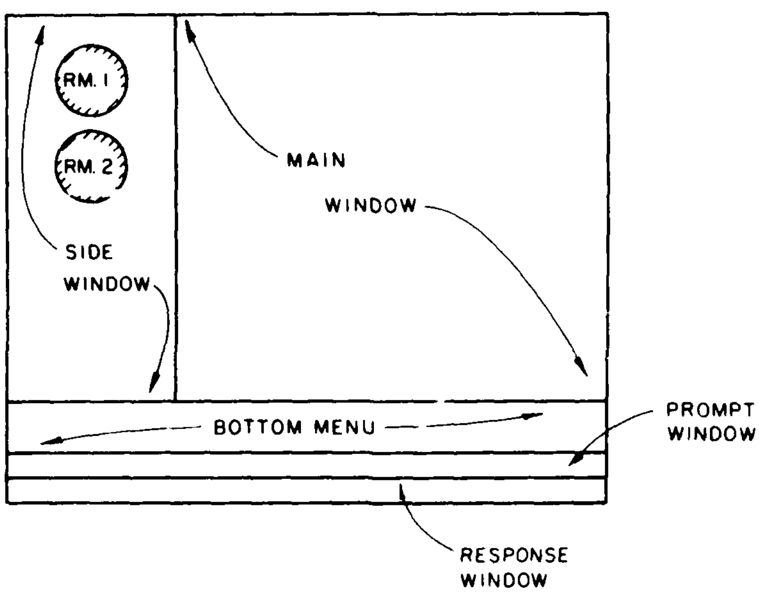
4. Charrette will not query for the title of the new drawing.

5. Type in the desired name of the drawing.
   Rules for drawing names:

   a. The name can contain letters and/or numbers and underscores. DO NOT use other characters.
   b. They CANNOT have any spaces in them.
   c. They MUST by typed in CAPITALS.

6. Charrette will then query: "Enter drawing field height:"7.Type the drawing field height desired. Although you will be able to increase the drawing height later, you will NOT be able to make the drawing smaller.

Each space layout mode is organized similarly. The menus will appear as shown:



In the side window, bubbles or blocks will appear. In bubble diagrams and blocks layout you may create new spaces as you wish. Each drawing type will allow you to create drawing of spaces that belong to one area type.

The bottom menu includes options you can select which will be discussed below.

The next section discusses the side menu options.

Mouse Commands and Keyboard Commands

In the prompt window, Charrette will give you a list of things you can do. It will say: "Mouse 1-Pick & Move 2-Rotate Right 3-Rotate Left E-Erase I-Zoom In 0-Zoom out Boxed Arrows to Pan".

1 - Pick and Move

Mouse button 1 (left mouse button) allows you to pick an area from the side menu and move in the main window.

To pick an area, move the cursor to the side menu over the desired area and click mouse button 1 (left mouse button). The area you selected will appear on the upper righthand corner of the main window.

NOTE: You cannot have an area displayed on the drawing twice. If you wish to have two identical areas, create a second area.

To move an area, position the cursor in the main window over the desired area, and click mouse button 1 (left button). Hold the button down as long as you wish to move the area. When you lift your finger off the button the area will stay where it is.

NOTE: You may have trouble moving an area if you have several of them stacked up. The only way to resolve this is to move them apart.

You may also have trouble if you name one area with a particularly long name. If the text hangs out past the area and over another area, you may have trouble moving the area under the tail of the name. For this reason, it is best to keep names short.

2 - Rotate Right

It is possible to rotate an area to the right by 15 degrees. Move the cursor over the desired area in the main window. Click mouse button 2 (the middle button) for as many times as desired. The area will rotate 15 degrees for each click.

3 - Rotate Left

It is possible to rotate an area to the left by 15 degrees. Move the cursor over the desired area in the main window. Click mouse button 3 (the right button) for as many times as desired. The area will rotate 15 degrees for each click.

E - Erase

To erase an area from the drawing, position the cursor over the desired area. Type the letter "E". The area will disappear. You can now "pick and move" the area again.

I - Zoom In

To zoom in, position the cursor over the main window at the point which you would like to be the new center of the drawing. Type "I". The picture will zoom in. You can zoom in as often as you like.

O - Zoom Out

To zoom out, position the cursor anywhere over the main window. Type "O" (the letter--not zero). The picture will zoom out to the original size.

Boxed Arrows to Pan

After you have zoomed-in on the drawing, you may find it necessary to pan over to another part of the drawing. To pan, position the cursor over the main window and type one of the boxed arrows, located at the bottom left corner of the keyboard. These arrows pan in the directions shown below.

[↑]	PANS UP
[↓]	PANS DOWN
[→]	PANS RIGHT
[←]	PANS LEFT

Bottom Menu Options

The diagrams below show the possible bottom menu selections. Some of these are present in all drawings modes, some are not.

Adjacency Generated Bubble Diagrams Menu

CLICK	LARGER DRAWING	REVIEW ADJACENCIES	SKETCH BOOK	GRAPHIC INTERP	GRAPHICS	STOP

Bubble Diagrams or Blocks Layout Menu

CLICK	LARGER DRAWING	MENUS	SKETCH BOOK	GRAPHIC INTERP	GRAPHICS	STOP

Click

"Click" refers to a different method of moving. Charrette allows you to drag each area by default. If you activate the click option, the area is moved by pressing the mouse without dragging the area.

To turn on/off the click option:

1. Move the cursor over the box in the bottom menu labeled "Click".

2. Press any mouse button. The box will highlight to indicate the option is turned on. 3. To turn off "click" option, repeat this process, and the box will return to normal to indicate that the option is turned off.

To move an area with click on:

1. Position the cursor over the desired area (in the main window), and click mouse button 1 (left button). The area will disappear from the drawing.

2. To "move" the area, position the cursor over the new desired location for the area and click mouse button 1. The area will appear centered around the cursor position.

Larger Drawing

If you wish to increase the size of your drawing, position the cursor over the box labeled "Larger Drawing" and push any mouse key.

1. Charrette will query: "Enter New Drawing Height:".

2. Type in the desired new drawing height in decimal format (i.e., 2'6" = 2.5).

The drawing height must be larger than the current height of the drawing. The drawing will redraw with the new height.

Menus

This option does NOT work.

Review Adjacencies

It is possible to review adjacencies to the current space without picking and moving an area. This option is only possible in Adjacency Generated Bubble Diagrams.

To Select Review Adjacencies Option

Move cursor over box labeled "Review Adjacencies" in the bottom menu and click any mouse button. The box will light up to remind you the "Review Adjacencies" mode is in.

To Review Adjacencies

Move cursor to area in main window that you would like to review the adjacency relationships of, and click any mouse button. The area you have selected will become the current area and all the other areas will display an area fill displaying their relationship to the current area (see Adjacency Table).

To Turn Off the Review Adjacency Mode

Move cursor over box labeled "Review Adjacencies" in the bottom menu and click any mouse button. The box will return to normal and you can now perform the regular options with the mouse.

Sketch Book, Graphic Interp, or Graphics

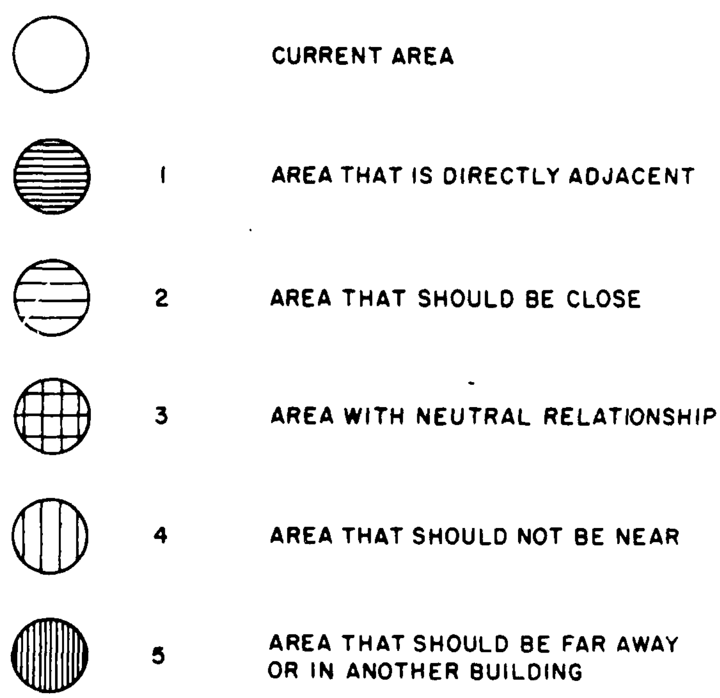
To go to any of these options, position the cursor over the appropriately labeled box in the bottom menu. Click any mouse button and you will go to the selected option. The drawing you have been working on will be saved.

Stop

To leave Charrette, position the cursor over the box in the button menu labeled "stop". Click any mouse button and Charrette will be shut down. The drawing you have been working on will be saved.

Adjacency Generated Bubble Diagrams

This option will allow you to manipulate areas while they are displaying their adjacency relationships to the current area. To review adjacency ranges, see "Define Adjacencies" option in Graphic Interpretation. The current area is the area last picked and/or moved. It will be represented as a clear bubble. All the other areas in the main window will display one of the area *fills* given below that shows their adjacency relationship to this space. To review the adjacencies of bubbles that are not current, use the Review Adjacencies option discussed in Bottom Menu Options above.



Bubble Diagrams and Blocks Layout

In Bubble Diagrams and Blocks Layout you can create new areas. To create new areas:

Position the cursor over the "New Room", "New Group", or "New Zone" bubble or block and hit mouse button 1 (left button).

1. Charrette will ask for the area name.

2. Type in the desired area name. Follow the rules in "Assign Areas and Dimensions - Area Names" in the Graphic Interpretation section.

3. Charrette will then ask for square footage, width and/or length. For help with these questions, see "Spatial Organizations" to create a new zone in graphic interpretation.

APPENDIX C:

PROGRAM MATERIAL USED IN THE PAPER/PENCIL TASK: BED AND BREAKFAST FACILITY

Design Problem Solving Study

Develop a two-dimensional solution to the following design problem. As you proceed, deliberately think aloud all of your thoughts about the problem and the solution you are developing. These comments will be recorded on a small dictaphone and later transcribed. Speak aloud all of your thoughts, questions, ideas from the moment you begin reading the program. It is important that we be able to keep all drawings and "thinking aloud" comments as a sequential set. Thus, number your drawings and use those numbers in your thinking aloud. The final solution should consist of a scale drawing of what you consider to be the optimum spatial arrangement.

Project Statement

A couple from Tuscon, Arizona, has asked you to design a bed and breakfast home for them. Owning and running a bed and breakfast business has been a dream of theirs for years, and now they finally have enough financial backing to make their dream come true. They see great potential in the idea of a personalized, family-run bed and breakfast located outside a large city of mostly commercial strips. They plan to cater to families and couples looking for a peaceful retreat with personalized service. The couple has two children, a girl, age 8, and a boy, age 6. It is important that the children have a hand in the family business without being deprived of a sense of personal space and a strong family unit. The family's privacy should not be disrupted by the intrusion of guests into their living areas. A vernacular, one-level adobe structure is appropriate, they feel, for this type of building. They would also like to include in the bed and breakfast experience the local use of interior courtyards and a strong relationship with the outdoors.

Site Description

The site is located in a small town just south of Tucson. The lot is basically flat but has spectacular views of the mountains to the north and east. The access road approaches the site from the south.

Soil: The soil, consisting mostly of clay, is basically sound for a one-level structure.

Utilities: Underground gas, power, water, sanitary sewer, storm sewer, and telephone services are readily available.

Code Requirements

The requirements for protecting life, health, and safety, as well as for minimizing property damage, must be incorporated into your solution. A fire resistive construction is required.

Climate:

Summer:	Days - hot, dry, windy, temps. - 95-100 °F Nights - cool, dry, temps. - 60-75 °F
Winter:	Days - mild, temps. - 50-75 °F Nights - cool, 35-50 °F
Precipitation:	Summer - occasional heavy rain Winter - periods of constant heavy rainfall
Sun Angles:	June 22, 82 degrees at noon December 22, 53 degrees at noon

Energy Use and Conservation

The owners desire that the building be as energy efficient as possible in all seasons. Building orientation and form, shading, use of natural lighting, and energy efficiency must be considered and incorporated into the design.

Site Requirements

Parking: Off-street parking for four guest cars is to be in the front. The family carport for two vehicles will be accessed separately.

Activity: Outdoor courtyard space for use by guests. Also, visually private outdoor spaces for clients, adjacent to living room. View of mountains is important.

Building Requirements

Guest Area:

a. Lobby/reception

b. Common living space, 200 SF, for guests--this space could double as the dining area where breakfast would be served. It should have access to the interior courtyard.

c. Interior courtyard--a place, 400 SF, for guests to sit and relax or eat outside if they wish. It must have shaded sitting areas and nice landscaping, possibly a small pool with a fountain.

d. Four guest rooms- each room, 150 SF, should have a view of the mountains, and possibly access to the courtyard. A sink will be located in each room.

e. Two common bathrooms--in each bathroom: a sink, toilet, and bathtub/ shower. They would prefer to give the bathing area, 30 SF, and toilet, 25 SF, separate entries so they must be used simultaneously.

f. Laundry--an area, 50 SF, for washing linens, etc., from the guest rooms, as well as the family laundry. It is expected that the children will help with this.

g. Storage--adequate storage, 15 SF, for clean linens, towels, etc.

Private Family Area:

a. Kitchen--to be used for guest and private family cooking, so it must have access to both the guest space and the family's private eating area, 150 SF.

b. Dining--off the kitchen. A place to dine as a family or with personal friends, 150 SF.

c. Living space--an informal room, 200 SF, for family and friends.

d. Master bedroom--a place, 300 SF, with a view of the mountains and a private bath, 50 SF.

e. Two children's rooms, 120 SF.

f. One children's bathroom, 40 SF.

g. Children's play area adjacent to private outdoor area, 120 SF.

h. Separate carport, 400 SF.

i. Office space--for bookkeeping, etc. This space, 120 SF, should allow a family member to observe and monitor guest entrance but, at the same time, allow participation in household activities, e.g., food preparation.

User Requirements

The clients are sensitive to the increased desire of disabled persons to travel and want to keep this bed and breakfast accessible to persons in wheelchairs.

Some guests will be going out for evening activities, therefore, it is important that their comings and goings do not annoy the clients and their children.

Avoid rooms where the width is less than two-thirds the length.

Research has shown that it is important for residential satisfaction for children and adults to have control of clearly distinguishable territories.

APPENDIX D:

PAPER AND PENCIL DESIGN PROCESS: ONE SUBJECT'S SELF-REPORT

(See Appendix E for drawings corresponding to this transcript.)

We're doing the first problem without the Charrette program so I guess I am going talk you people through what I'm doing here.

First thing I will be doing is reading the program and as I am going through the program I am going to write down certain important points as I usually do and make an outline of special points to hit.

Okay, we have a family here, so it mentions that the family's privacy cannot be affected by the intrusion of guests, bed and breakfast business has to be separate from the family's residence, and these are the major points that are mentioned.

As far as special style, special considerations, aesthetics, we want a vernacular structure, adobe, one level. We also want a strong relationship to outdoors in the courtyard. I hope this is picking up. I should probably be talking louder. Under site, flat, a good view of the mountains in the north, and the road approaches from the south. Style is okay, ... Facilities are okay. As far as code requirements go, there should be no major problems with the adobe .... Climate is pretty temperate. .... probably orient the windows to the north probably with temperate climate, we have for all practical purposes a desert, so we want the daylight and the sun .... different shading. Window openings to the north .... to provide shading for the south openings. Going back to the site, we have the parking for customers and two family cars, and those should be separate. Guest cars .... the front. Hmmm. As far as business spaces go, ... two parking spaces for the residence, but the guests we want to have outdoor courtyard space and also .... spaces adjacent to the living room, a good view of mountains, and maybe we'll have some kind of sliding glass door .... patio looking outdoors to the courtyard, perhaps looking out to the mountains. .... lobby or reception area. What I am doing here is I am going to make ...... diagrams ...... are not .... sized .... checking .... flow charts ...... lobby or reception area and I'll put a box of random size and go to next space which is a kind of living space, and then show how to relate some of them. ..... living space, interior courtyard, I am putting boxes at random, so we can get a flow chart going. Okay, we have four guest rooms, and I'll number them 1, 2, 3, and 4, each should have a view of the mountains. .... living space .... private. Two common bathrooms, they should have bathing area and toilet, separate entries for each, so perhaps they should have .... Laundry .... guest rooms, one laundry for both houses is what I am assuming here .... side .... flow chart .... the residence portion of the complex ...... storage for the linens, and I think the linen storage should be right next to .... I think will make sense. Now we'll go over to the private family area. Back to the family area. Now that has to have a kitchen for guests and private family cooking so ...... access to guest space and private family eating area so let me put this in the middle of the house ...... once again I am using a random size box ...... really .... flow. The dining area, should be .... kitchen . ..... to keep it private for just family, ... keep family area to one side. And off of that should be the living space, and that should be away from the business .... bedroom, two childrens rooms, ... other complex, then childrens' bathrooms, lucky kids with their own bathrooms. Kids' play area ..... carport, ... We have an office space which should be for bookkeeping and should allow family members ...... business entrance .... Now we are going to play connect the dots. I really .... find, ...

somehow to put these together .... configuration and then keeping in mind we want a view of the mountains, privacy needs, the use of courtyards, codes, handicap facilities. okay .... these requirements .... less than two thirds the length, research has shown that it is important for residential satisfaction for children and adults to have control of clearly distinguishable territories. I think the important thing .... connecting boxes .... I was going to connect these boxes, but I think .... I think it's important to have the lobby in the center ...... at one point we'll start with that .... the drive comes up .... access road approaches from the south, I think the lobby or reception areas should be one of the first things you come to so I will try to gear the entrance to what .... from the south. I think that's pretty important. ...... take care of that .... Lobby has the .... from that lobby .... that .... mainly because I think that lobby is used for similar functions as far as meeting people under somewhat social places in the same way as the living room .... I think should be somewhat social area and this could be next to each other, perhaps .... together .... has to be .... lobby .... right there now .... the house in a minute. .... find a place for .... dining area in there too so I think the kitchen is going to have to be right off of that. Let's put the kitchen off of that then ..... kitchen off the living space .... lobby and I think off of those two by the kitchen we should have the laundry because if you use common plumbing ..... people are washing .... can go and do laundry ...... so we'll put that off there too .... And, of course, linen storage should be right by the laundry area, well we'll come back to that in a second. Once again, the office area should be kind of in common with both the business and the residence so .... what I think we'll do is take that .... living area .... lobby .... kitchen and the office, we have the kitchen, we have the .... office .... we have that off to there .... reception and lobby .... sixteen .... living area .... biggest part. Kitchen ...... ten by fifteen. I'm just going to make the reception area, I think will be .... eight by eight, ... I think the office should be right off of that and the office will be twelve by ten. In the center here .... I don't know if that's good or bad ...... kitchen around this way .... rearranging some of the rooms, I'm just trying to put the kitchen and the office and the laundry room all in to one area, with the exception of the office I don't think a view is very important, somewhat nice to have a view but I think they are less important than .... bedrooms or living room. Getting back to the business part, I think there are four guest rooms .... courtyard, I think what has happened is that the living space .... courtyard in one area and .... three .... here. .... courtyard, twenty by twenty courtyard. Living space .... same .... courtyard .... four guest rooms .... sort of like an atrium or something .... we have .... courtyard ...... ten by fifteen .... we have a living room .... inside .... two bathrooms .... in here? .... sheet two we are going to .... view now too .... courtyard here and then I'm stuck .... twenty .... rooms six feet .... ten feet there, I'm using .... box .... four feet, there you go. .... better if I slip forward just a little bit there, I think that's better .... through here. Kitchen, laundry, office, here we go. 9:25, let's get back to doing this. I am trying to work out our orientation and spatial relationship, first taking into account the .... of the design. What I am doing here is still trying to orient the rooms around the courtyard here .... kind of a loop. I guess I should .... in a loop around the courtyard. .... bathrooms .... I think we have .... business portion ...... of the complex, I am going to switch, concentrating more on the family area .... For that we need a separate entrance area. .... I'm going to .... out some of these spaces .... I guess what I should here do .... I should .... put it here .... two foot wide .... handicaps .... walls .... that is five feet.

END OF TAPE - SIDE THREE

Still working on the toilets in the bathroom, a shower .... here and I'd like to get a toilet set up here, across from the sink .... I could use that .... so I think ideally a handicap toilet should be five by five .... four by five .... five by five. .... five foot by five foot .... Okay, so the toilet goes there, ... five foot .... that should leave it handicapped accessible. That will give me four feet wide there so I think that it will be a little awkward .... five, four, two, hmmm. Okay, let's come back to that. Eight feet across here .... here would be seven feet wide .... thirteen .... Another sheet .... Twenty by twenty courtyard. I'm still working on the bathrooms and just drawing them .... for handicapped .... extra large .... separate the toilet from the tub. .... floor with the room arranged to the outside .... I have those put together. .... living space which would be in through here .... away from the side where the residence .... close to the living room, ... kitchen. Entry right here .... office right off of there, the office will be twelve by eight .... the kitchen will be right off the office .... central with a view out ..... courtyard, so you can see out to the courtyard .... seems to work out that way. We're still mapping out the floorplan for the business portion of the plan. Dining area, kitchen here. Hmmm. ..... central courtyard with everything around it .... Well, I hope it works. 10:30. The problem seems here to be trying to get everything to fit around the courtyard. I don't know if that's a good idea. I thought it was a good idea .... spaces between .... I think I'll leave some of the wall here ...... courtyard facing the wall up there ...... privacy .... over a little bit. .... Still on sheet three .... do here .... fifteen by fifteen. ...... fourteen by fourteen .... reception area right here .... ten feet here of the kitchen area .... right along side there. For the rest of it, the three bedrooms, up to the laundry area, space for the laundry .... won't work because .... 11:00. I see that this is a bit too complex. I think I should simplify things a bit ...... all these spaces around, protruding out and it looks like a big octopus, that's a bit much. That's probably why I had to take the break. Too much, but I think that what I need do is simplify things. What we're doing here. I think what we are going to do, instead of having this all pan out from around the central area .... boxed in ..... getting a bit out of hand here. All the rooms .... ten by fifteen, approximately the same .... being used. .... I think that makes a lot more sense. .... and then, ... we have the courtyard here, ... wall on two sides, ... maybe I could possibly put spaces around the courtyard .... blank walls. Then we have the central living space .... office. It's really amazing how much you can accomplish by not looking at this for a time and then coming back and looking at it again .... fresh look .... entrance here in the center. I am going back to our private area, toward the residence ..... dining area off the kitchen, should be 150 square feet .... fifteen. And then the dining .... that doesn't really have to have a special orientation, ... face toward the south would be kind of not too. .... I think we'll leave it like that. Perhaps .... except when they are eating ..... generally ..... sit around the table and talk all the time. I think we'll leave that for now. ...... living room. .... I've got the dining room .... living room's up in front here .... common kitchen, I'll head the bedrooms off to the side away from the business portion of it so that they would be less disturbed at night from both occupants--the people who are living there or the people who are staying there. I think I have a pretty rough draft of what we are going to have here for this thing .... living room, separate entrance there. ..... I think pretty much I have addressed every issue here except possibly a play area for the kids, and .... I think that now I am at the point where I mainly everything seems to work except for. .... What I am going to do is draw this on a larger scale .... to make sure I've addressed all the important issues, looked through my notes here to see if I have addressed that. I haven't addressed the issue of parking .... spaces .... the entrance .... (2 hours so far) I am going to sit here and get the plans kind of finalized .... to scale and get a final print on that. Right now I pretty much have all the rooms and have decided where they are going to go and right now I'm going to finalize and make sure that's where they are going to go so they can fit together. .... sixteenths, I hate to use it, but .... right now .... I'm still drawing this thing. I'm pretty much copying what I have here and make sure everything fits. So far, pretty much everything does fit. I'm still drawing things in. So far I've decided that it can pretty much can stay the same, I'm coming down to the final part of the residence portion of the complex and I think that perhaps I should bring the living room .... and get more light into it and bring the dining room portion up. I think what would be better, I realize that I hadn't put any windows in the dining room .... division between the living room and the dining room since they are so small, I'll make this a living and dining area combined .... off the kitchen and then that should open up things more and give more light - get light into the dining room and alleviate the window problem. The living room is sixteen by twelve. The two spaces between the living room and dining room, even though it's one long space actually has a division .... entry coming through .... really divides into two .... to the right, so there's the living room and to the left is the dining room. .... Ten feet. I have to get a little bit wider around it here, maybe twelve feet, two feet .... on the side. .... This seems all pretty much to work. .... Parking .... interior courtyard. We put the carport back .... I think we'll put the carport along side of the living room there, then they can just walk up to the doorway .... living room and dining room. .... childrens' play area. Perhaps I can give, I think by giving the front wall, ... a little wall here it could divide it up into a separate territory, ... sort of front yard to the residence and that will provide the childrens' play area .... and the carport could come up that way right here .... twenty by twenty. .... Two and a half hours. I think probably only, the main thing I wish about this is that perhaps the plan was a little simpler, like I have a bathroom jutting out which I'm not too happy with. Perhaps the private parking could be somewhat a little more out of the way so it wouldn't be so readily visible and possibly available to those visitors who might be .... parking. It could be accomplished with signage but I think it would probably be better if you just didn't see it and that would save a lot of problems. I'm kind of unhappy about that. I'm kind of unhappy that I don't have more light into the dining room, it's kind of buried in there. It's a little bit .... considering but it is opening up to the living room and that has a western exposure. I am happy that I've been able to minimize the number of windows facing the south, or possibilities for windows. I'm not putting windows in the laundry, office I am but .... living room I could or could not, childrens' rooms to the east, so I'm pretty happy about that and I feel that I've gotten everybody a view of the mountains for those who need a view of the mountains, I don't know about the kids, they don't have them but .... I think .... pretty well handicapped. I'm finished now and it's three minutes to 12. Four hours with breaks. Two hours and forty minutes.

APPENDIX E:

PENCIL AND PAPER DRAWINGS: BED AND BREAKFAST TASK

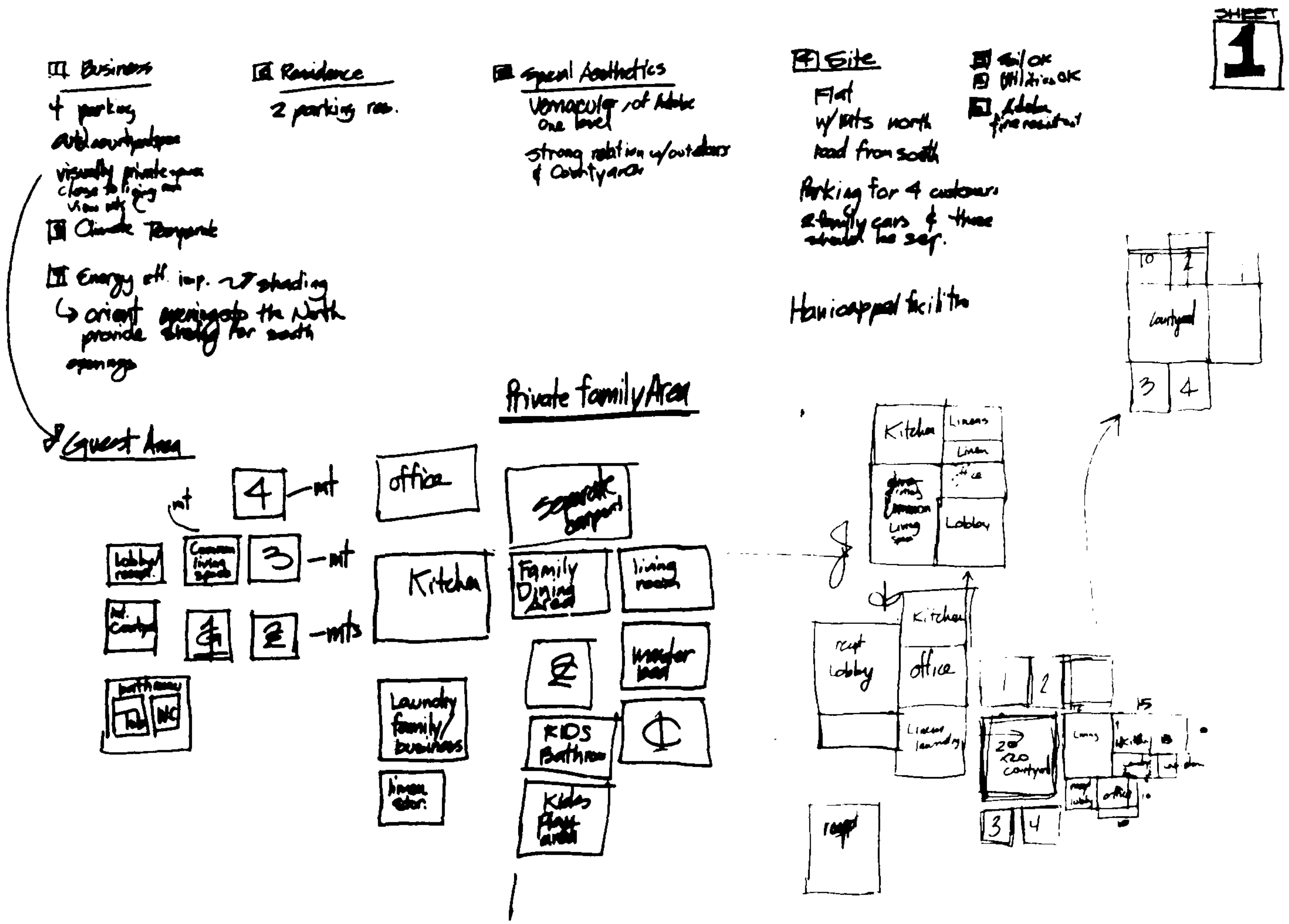


Figure E1. Bed and breakfast problem: notes, flowchart with random sized boxes, preliminary spatial relationships.

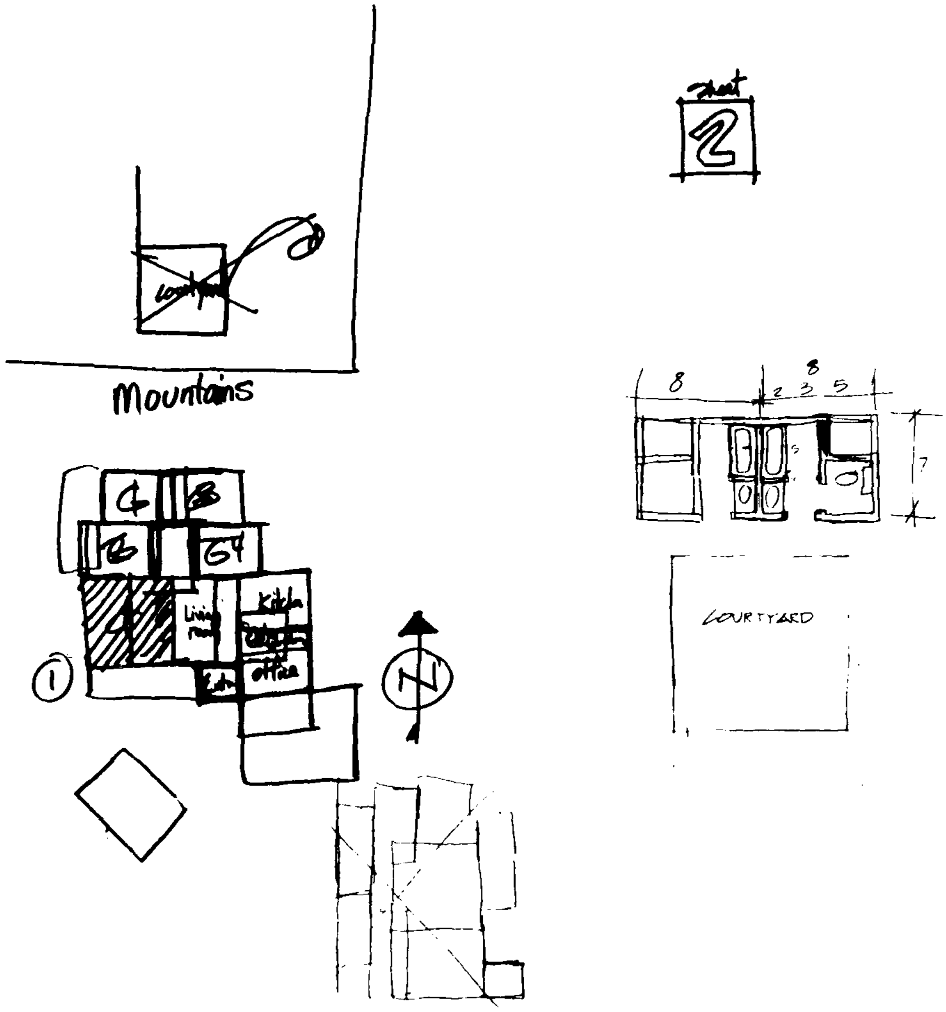


Figure E2. A false start; relation of rooms to courtyard; dimensions of bathroom.

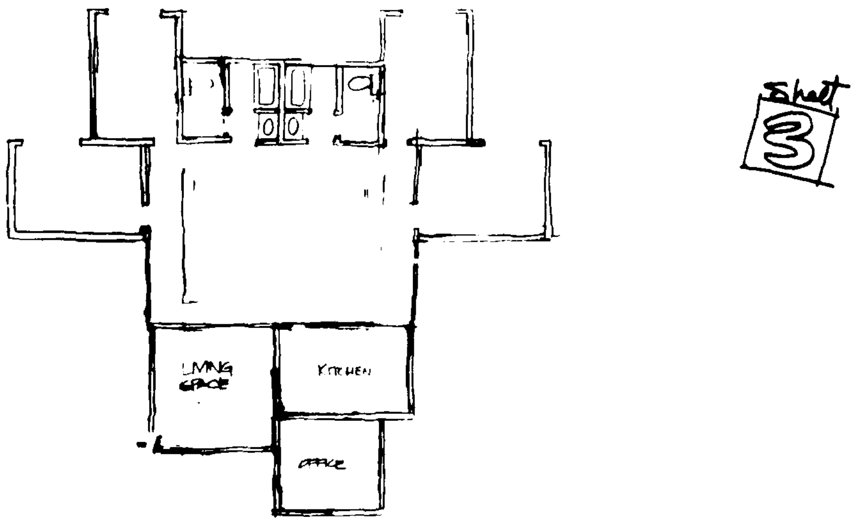


Figure E3. Bathrooms; rooms around courtyard (student unhappy with courtyard).

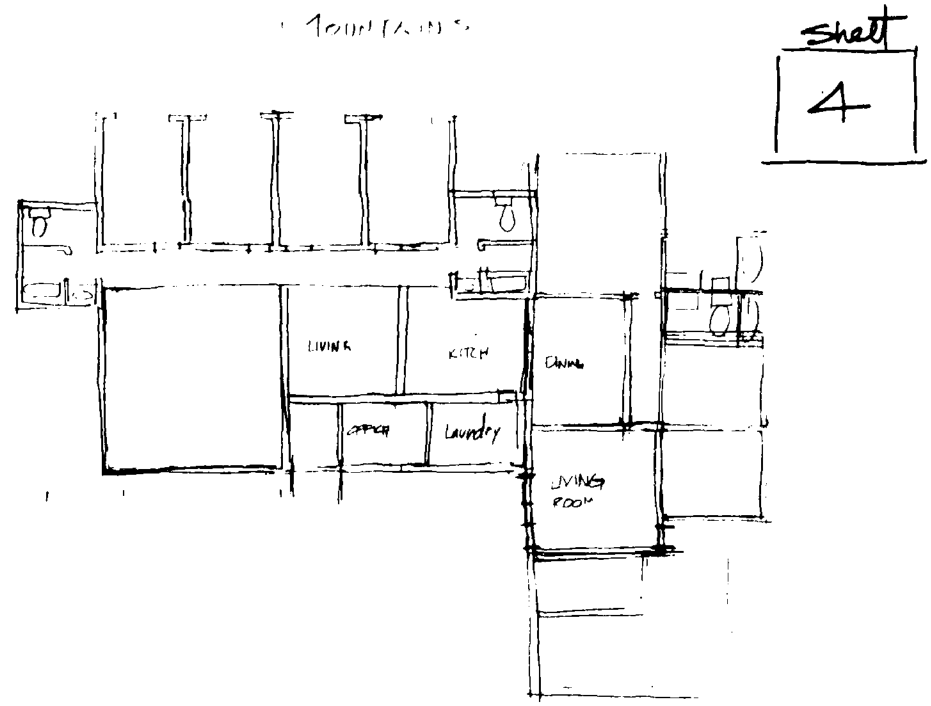


Figure E4. New conception of courtyard and resulting rearrangement.

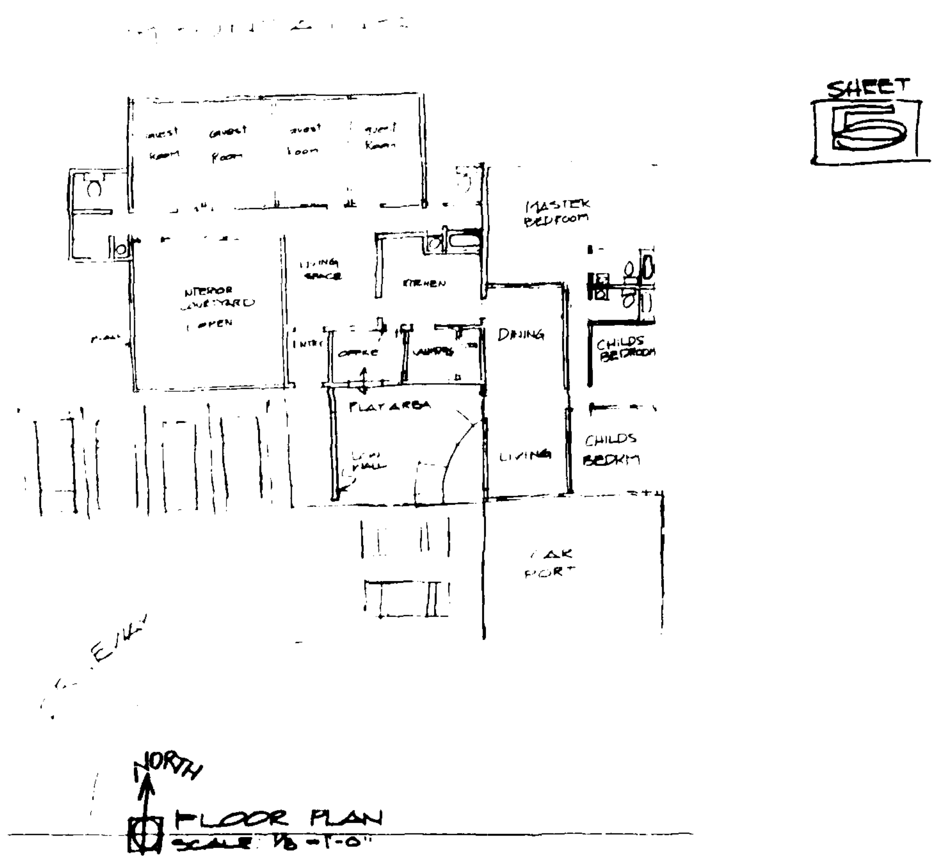


Figure E5. Final solution with additional play and parking areas.

APPENDIX F:

PROCRAM MATERIAL USED IN THE CHARRETTE TASK: A RESEARCH LIBRARY

General

The building space requirements are indicated in net square feet. Gross building square footage shall not exceed the net square footage by more than 25 percent.

Entry

An entry lobby will be required, 1,000 SF, containing an information desk. The staff at the information desk will have visual control of the building entry, as well as entry to the exhibit hall and physical research area. Access to the library will be from this space, but the library will maintain control of its own space. The space is used for waiting, circulating, and the use of public telephones.

Exhibit Hall

Space used for the exhibition, 4,000 SF, will be directly accessible from the public entry lobby. Provide service access for receiving large exhibits. Natural lighting should be considered.

Administration

Accessible from the entry lobby, this space, 500 SF, will contain the administrator's office, the administrative aide, and a conference room.

Physical Research Area

This will contain an archival/collection room, 1,500 SF, for the storage of samples of historic building materials and artifacts. An adjacent studio/laboratory, 1,500 SF, will provide a place for the study and analysis of historic building samples and artifacts, as well as the office and security control for this area.

General Work Space

A general workspace, 2,000 SF, shall be provided with areas for shipping/receiving, refuse, 300 SF, sorting and cataloging, 700 SF, and work space, 1,000 SF. This is not a public space.

Research Library

A non-circulating library (no material leaves the premises) of 7,500 SF that is composed of six functional areas:

1. Control, 50 SF, containing a check desk for security control of the research library.
2. Administration, 450 SF, including the librarian's office, the assistant librarian's office, and the library work space.
3. Patron reading, 2,100 SF.
4. Document storage, 3,500 SF, open stacks for the storage of books, periodicals, prints, and plans.
5. Archival research, 1,000 SF, of rare manuscripts, prints and plans. This must be in a secure space with limited access controlled by staff. It should be adjacent to library administration for access and control.
6. Microfilm review and document copying, 400 SF. This should be located within controlled area.

Service Areas

Public toilets and janitorial space will be required in the controlled areas of the library, as well as in the more public areas. Include two spaces, 450 SF, to contain these service elements.

Summary

The building contains two major zones. These focus on the library and the exhibit spaces. The library contains a hierarchy of security within it. In the exhibit zone there are spaces that are clearly public and non-public.

APPENDIX G:

CHARRETTE DRAWINGS: SUBJECTS A AND B, RESEARCH LIBRARY

The graphics shown in Figures G1 through G4 were made by subject A, a student, in arriving at a design for the research library program given in Appendix F. Figures G5 and G6 are graphics created by subject B (also a student) in response to the same material.

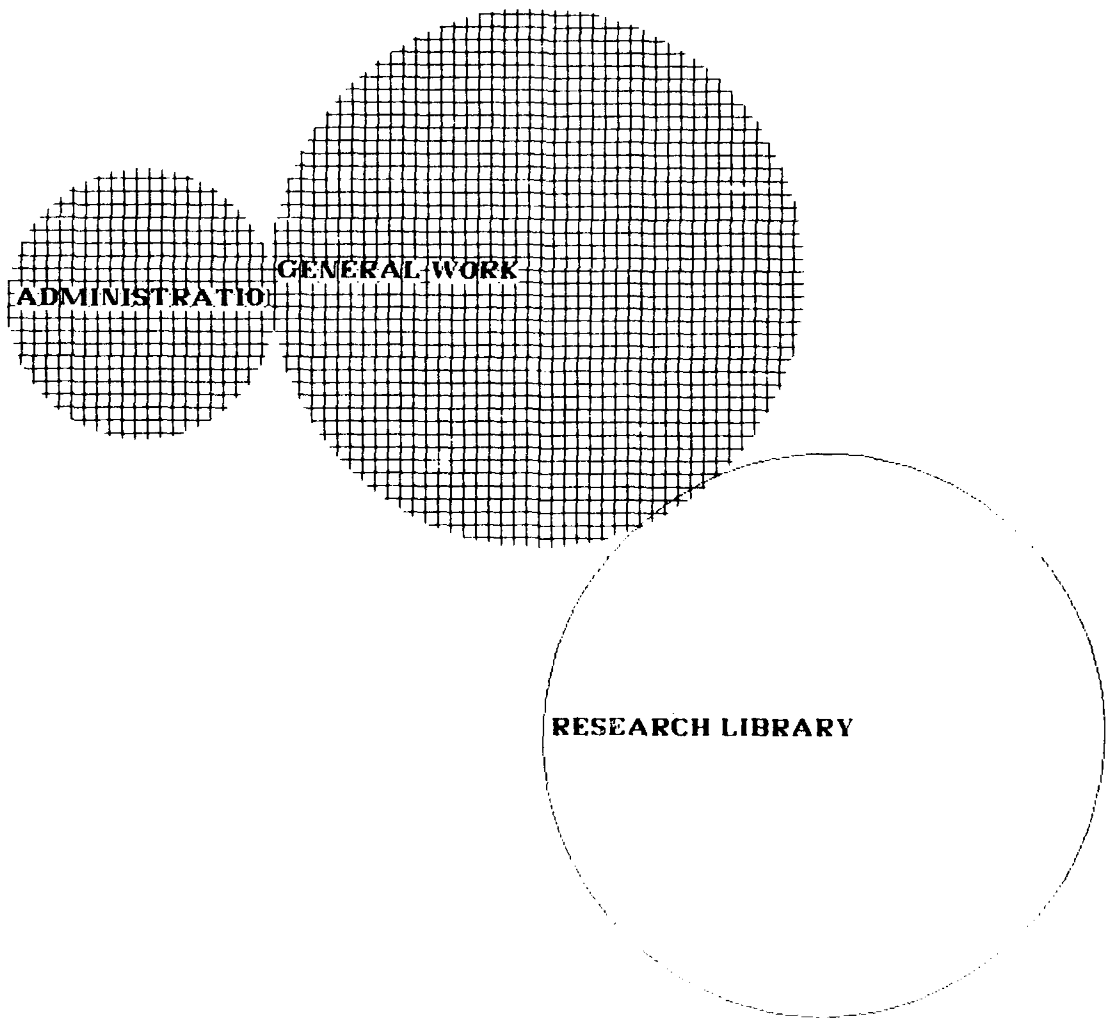


Figure G1. Subject A: Use of zone bubbles as the first design graphic.

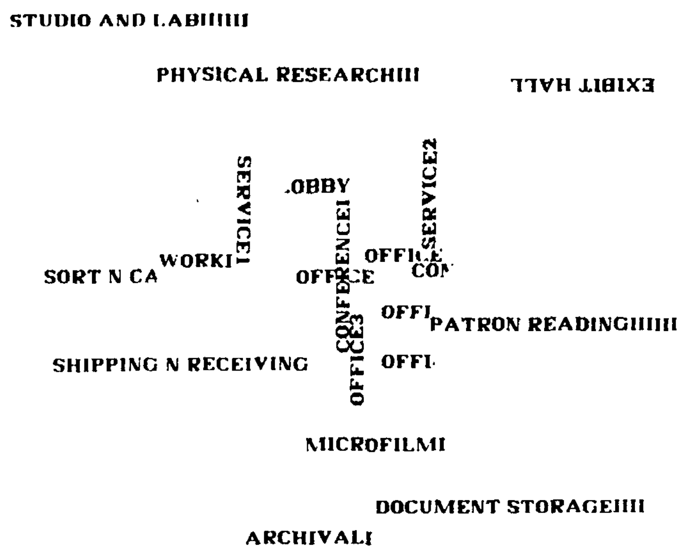


Figure G2. Subject A: Final bubble diagram for research library.

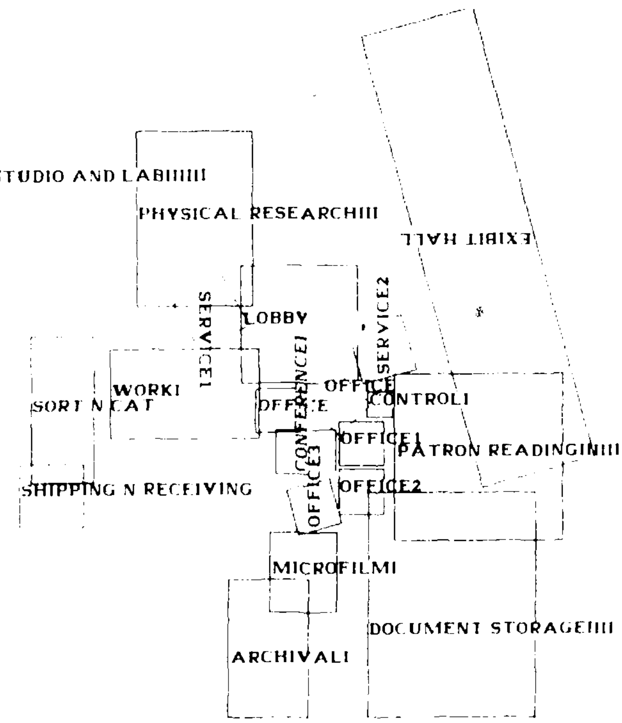


Figure G3. Subject A: Surprised to find partially rotated blocks when coming into blocks from bubbles.

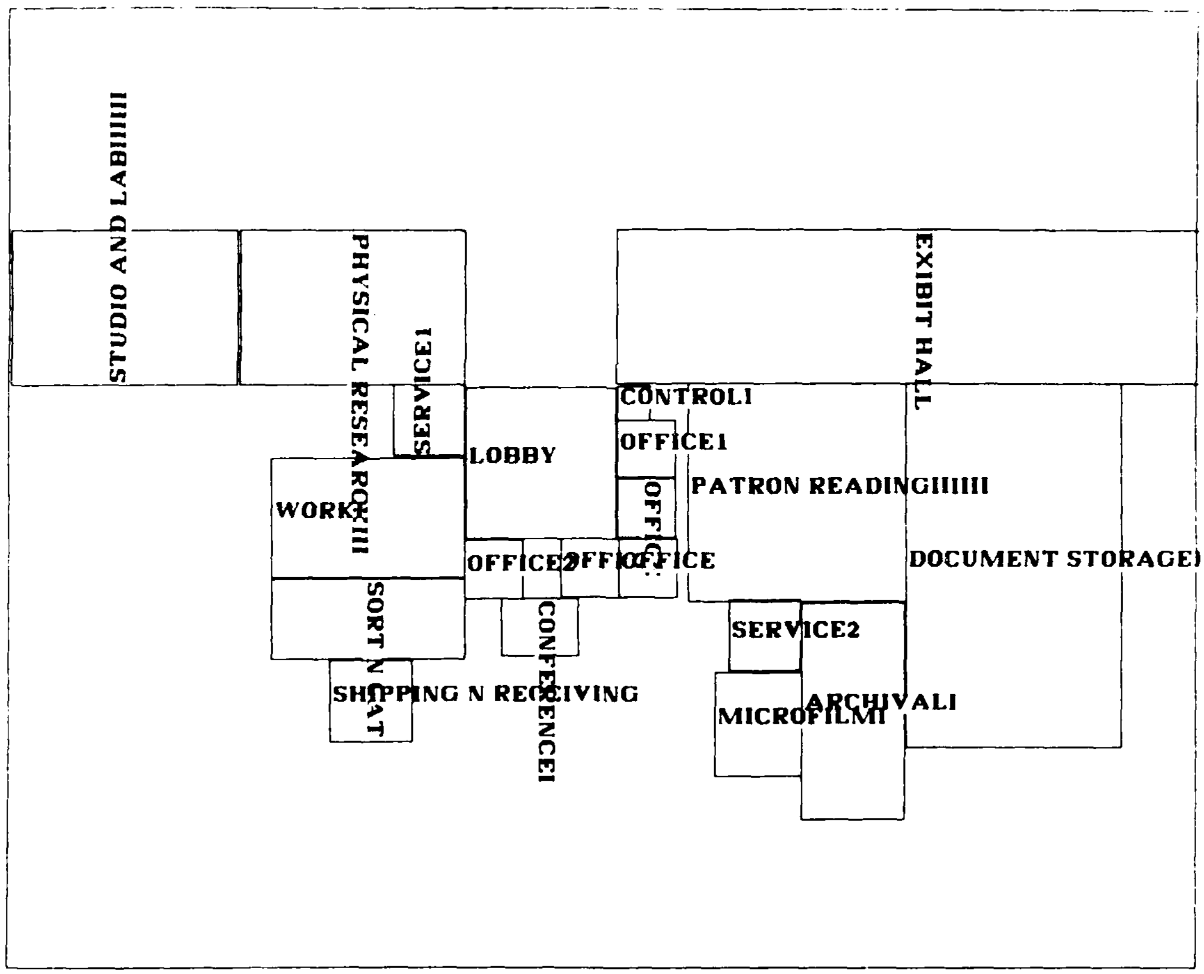


Figure G4. Subject A: Final block diagram for research library.

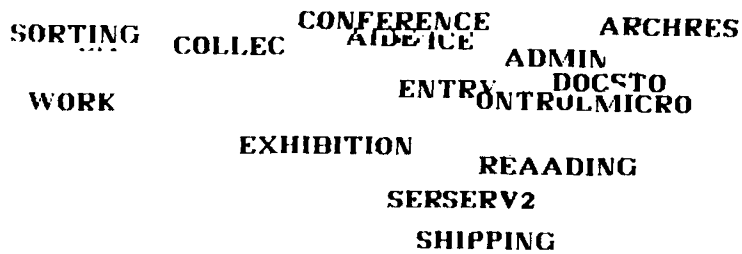


Figure G5. Subject B: Final bubble diagram, research library. (Note: Spatial arrangement occured when student went to blocks.)

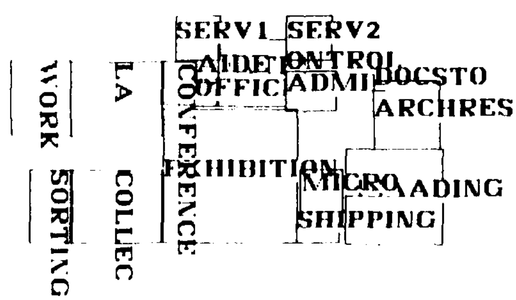


Figure G6. Subject B: Final solution, research library.

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