

PATTERNMAKERS
AND
TOOLBUILDERS
THE DESIGN OF INFORMATION STRUCTURES
IN THE PROFESSIONAL PRACTICE
OF ARCHITECTURE

by

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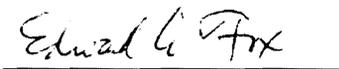
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Abstract

Patternmakers and Toolbuilders: The design of information structures in the professional practice of architecture

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This paper discusses the results of a study of architects at work, where the focus of attention was on the information used during the life of a design project. What became apparent during this study was that the business management of the project, and the artifacts associated with that phase of work, often overwhelmed the actual design effort in terms of time and attention.

A phenomenological approach to data collection was used; the author observed architects at work in two different offices over a period of several months, and assisted in the day to day work of each office. Sketches, photos, informal interviews and discussions, and extensive notes provided a rich set of data about work life in architectural practice. Structuralism was the primary analysis tool used to identify key elements of the data and their meaning in professional practice.

A model was developed of the kinds of information used to manage a design project. This model includes not only the data used in project management documents, but also categorizes each piece of information according to its current level of use. The document model identifies eight primary attributes for every document, and an object-oriented class hierarchy for documents provides for the inheritance of the base attributes as well as providing additional attributes in various sub-classes to facilitate modeling specific kinds of documents like letters, memos, notes, faxes, contracts, and construction drawings. Finally, a Design Project Manager with a complete set of document manipulation, storage, and retrieval tools was defined. These information tools have specific behaviors based on the patterns of document and information use observed in the subject offices.

The results suggest that the productivity of architects may be enhanced by a set of small, carefully designed information tools that help architects deal more easily with the complexity of managing design projects.

Preface

To seek knowledge for the sake of a thesis is to be a pimp. The only valid seeking is for one's own life project. Knowledge is not to be divorced from living. To learn, the pupil must change his life, accept the thought of his own death, control all his own thought and action within that perspective.

unknown

My interest in architecture and the work of architects began early. In seventh grade I began drawing and sketching, but for some reason I was unable to maintain the interest. I put away my charcoal, my pastels, and my sketchbook, and moved onto other things.

In time, I forgot about wanting to be an architect; I forgot about my interest in space, in the edges of things, in the structure of things, and I was attracted to the purity of computer logic. But in college, even as I forged a deep connection with the digital machines, something else was still going on. I found myself wandering over to Cowgill, time and again, drawn by some urge so deeply buried I could not explain it had someone asked. And I found myself deeply frustrated with computers, with their appalling inadequacy as workaday tools and the tremendous effort required to get them to perform the simplest of tasks. As I left school for the work world my unease continued, and I moved to human factors as a course of study, looking for answers. I found none, but was, fifteen years later, still wandering over to Cowgill without knowing why.

I finally remembered one day, nearly a year after I had entered the architecture program, that at the age of eleven I had wanted to be an architect.

I am still terribly frustrated with computers, although in the past five years the industry has made enormous strides in developing those workaday tools I had dreamed of so many years ago. For architects, though, these tools are, by and large, being designed by well-intentioned people who understand poorly what architects really do. I began to see that my work could serve as a bridge between two worlds that have traditionally had much difficulty communicating with one another.

There are two parts to my work here. The first part of the work concerns trying to describe what architects do, what information they use in the course of their work, what that information means to them, and the structure of that information.

The second part of this book talks about the kinds of tools that would be useful to architects, based on the insight gained from studying how they work. It seems patently clear to me that we can and should build better tools for architects. The difficulty has been in describing what architects do in a way that makes sense to the tool builders, who, in some strange turn of circumstances, do not recognize that they themselves are also designers, and could benefit as well from these ideas.

As I have struggled to complete this work I have come to realize that architecture is primarily about doing. I believe that there is some risk in pursuing architectural research because it is far easier to write about it than to create it, and the reward structure of academia encourages a certain detachment from the object of study that leads one to write more and act less. Nonetheless, this written work seeks to bridge two disciplines—information engineering and architecture. So the goal of this work has been to communicate well to the tool-builders. I am confident that if I have succeeded at this, the tools will follow.

John's Creek Mountain
March, 1993

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What we understand is based on what we already know, and what we already know comes from being able to understand—the hermeneutic circle.

Winograd and Flores
Understanding Computers and Cognition

Several people contributed substantially to this work; first and foremost, my wife Teresa gave me her unflagging support and encouragement through many long years as I labored to shape this work. Without her help I would not have finished.

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A Search for Structure

In short, no pattern is an isolated entity. Each pattern can exist in the world, only to the extent that is supported by other patterns: the larger patterns in which it is embedded, the patterns of the same size that surround it, and the smaller patterns which are embedded in it.

This is a fundamental view of the world. It says that when you build a thing you cannot merely build that thing in isolation, but must also repair the world around it, and within it, so that the larger world at that one place becomes more coherent, and more whole; and the thing which you make takes its place in the web of nature, as you make it.

Christopher Alexander
A Pattern Language

We use the things we work with because they mean something to us. Every item in our work environment is part of a network of associations that *enables* us to work. This network of associations composes a structure, an intellectual collection of information nodes and connections that represents our view of our work world.

For most, however, this is a largely unconscious framework. The connections have been made one at a time, over many years, as we adapt our environment to our needs and adapt ourselves to the limits of our environment. Martin Heidegger (1927) calls this unconscious connection between ourselves, our environment, and our work tools the ready-to-hand state, signifying that we are able to focus on solving a problem of interest because our tools are ready to hand. His classic example is that of a man using a hammer to drive a nail; the man does not think, "I am using this hammer to drive this nail." Rather, he is aware only of driving the nail, unless the hammer slips, and the man then becomes momentarily conscious of the tool itself. Heidegger calls this state of awareness breakdown.

The goal of this work is to describe the structure that reflects the information environment

of the working architect. In other words, to make momentarily conscious the intellectual network of the architect, with the hope that this will lead to the design of better tools. Design is by nature an intuitive process, and a dilemma in this research is that the end product, this notion of a structure, must try to reveal that which is usually hidden.

The point of understanding this structure is not to create a device that will replace us, not to design a machine that does the work for us, but rather to better *enable* us to do the work ourselves. As Dreyfus (1986) points out, there is a great difference between the appearance of intellect and the existence of intellect. Only the architect can design. The machine, as enabler, can give the designer access to more useful information, or transform it in ways that are difficult for humans, or manage and track more information, but the machine cannot design. As an intuitive process, design must be regarded partly as an act of faith. For all that has been written about design and its relationship with creativity and intuition, no consensus exists on how or why it works; at some point the discussion becomes a religious one.

One might reasonably ask why bother with this exercise if the problem is so difficult? The answer is simple: if those who have some experience with the process do not make the attempt, others will. This is already apparent in the often frustrating software packages with the misnomer of computer-aided design (CAD) or computer-aided architectural design (CAAD). At best, CAD is computer-aided drafting, a tool to be used after the design is essentially complete; CAD is useful for communicating that design to others, but current products have little to offer the designer during the early stages of the design process.

The debate over the value of automated tools for architects is not a new one. In the preface to his 1969 doctoral dissertation on the design of information systems for architects, Charles Burnette explains the impetus for his work:

"The liberal education, trained intuition, artistic talent and practical experience which they [architects] possess is being overwhelmed by the diversity of architectural problems, the variety of opportunities and constraints in society today and the complexity of the industrial system by which architecture is produced. It is clear that architectural problems have reached a complexity which defies the individual abilities and rudimentary means currently in use."

Burnette's notion that building systems have become too complex for architects to design by themselves is still under active debate, but architects, twenty-five years after Burnette wrote those words, are still successfully designing and constructing buildings with much more sophisticated materials and systems than those that existed in the sixties. Another interpretation of the 'crisis' in architecture is that architects have simply been slow to adopt tools to help them manage that complexity.

While most of the attention in design research has been directed toward the development of

computer aids for the development and management of construction drawings, and some work has been directed toward schematic design (the original basis of this dissertation), it became clear to me as I observed architects at work and talked to them about their work that there was another, largely neglected area of research and development.

The business of managing a professional practice has rarely been the focus of grant proposals, lacking the glamor, the glitzy new hardware, and the gushing promises of a better, more exciting way to design. In large firms, the business of design is managed by a professional staff that protects the architect from many of the more mundane accounting and clerical chores. Yet the majority of architects work in small firms with 10 or less employees (AIA, 1990), and firms of such small dimensions can rarely afford the kind of professional staff that are the mainstay of the large firms. In the small firm, the architect has to do it all: design, management, marketing, accounting, and all the other little chores that his small support staff (if any) cannot do.

In the two firms I studied, computers were used mainly to support clerical functions. The designers had little interest in the new 3-D, solid modeling, multi-media virtual reality design systems that are now commonly available. They viewed them as an impediment to accomplishing the basic work of the business: the high tech systems would only siphon off working capital, require expensive time and training just to learn basic skills, and then require inordinate amounts of time to master.

What they really wanted was simply more time to spend at the drawing table: relief from the tyranny of the telephone, relief from attending to a steady stream of requests for small bits of information, relief from the tedium of managing the accounting of multiple projects, each with its own set of paperwork, documentation, and information requirements.

Catalano (1990) of the Harvard School of Design makes the claim that managers of design firms must learn to act more like computer programmers to maximize use of new technology. At the same time he acknowledges that they must also perform as "true designers", with the designer's skill for creation and integration. This strikes me as a simultaneously impossible and horrifying concept. Impossible, because numerous studies (Burnette, 1979a) have shown that the best architects work at very high levels of intuitiveness, cognitive flexibility, and sensitivity to aesthetics; these are not qualities associated with the cool logic of computer code. Horrifying because it suggests that we cannot adapt the computer to the person, and that we should merely force the person to adapt to the machine.

How much better it would be to design a piece of software that allowed a visually-oriented and intuitive architect to work in those right brain modes while manipulating and using the computer to manage much of the business. Catalano's interests become more clear as he begins to use, later in his paper, the phrase 'informatizing designers', indicating that computerization is

something you do to architects, rather than information.

He continues on, criticizing firms that computerize yet continue to behave “as before”. Catalano wants to transform the office and the architect; I believe we should transform the information. Although he derides firms with a bottom-line mentality, throughout his paper he relentlessly makes the point that computers can make firms more profitable and more able to trounce the competition. While I agree in some respects with this, his motivation for computerization and mine are different: his message seems to be that with the latest high-powered computers, architects can maximize their potential to make money. I believe that with properly designed computer systems, architects can spend more time on the process of design and less time on the business of running a business. In both cases, an architect’s financial rewards may increase, but the reasons for the increase and the effect on the way that the architect prefers to work may be quite different.

Catalano (1990) talks about expert systems, decision support systems, networks, groupware, multimedia—all interesting ideas. But the architects I talked to simply wanted more time to design, more time working with paper and pencil, more time to think, more time to reflect on the human effects of their work, more time to do what they were trained to do. No one asked for four channel stereo sound input and output, 30 frames per second real-time video systems, or direct to tape 400 line videos of virtual reality simulations.

There are four chapters in this book that discuss data collection and analysis efforts. All of the work discussed in my original proposal is here, but I added some additional work, and changed the focus of some of my efforts, based on the early analysis of my data collection efforts. In summary:

Structural diagrams—presents the work I have done analyzing the structure of the thoughts of several architects and writers and the way that they view the work and meaning of architecture and built structure.

Student workspaces—a study of the information found in the workspaces of twenty-five architecture students at various academic levels in the undergraduate architecture program at Virginia Tech.

Professional workspaces—two studies of architects at work in two different offices over varying periods of time. The first study lasted two weeks, and the second study took place intermittently over several months.

Project information space—the analysis of design project information supplied by architects in the two offices where I observed them at work. This was not

part of the original proposal.

The outcome of this data collection and analysis is the design and presentation of a Design Project Manager intended to serve as an automated aid to the architect, not for the purpose of assisting in the design process, but to assist in the management of the kind of design projects observed in the studies. The structure of this Design Project Manager presents to the architect and user an interface that organizes the documents and information of design projects in a natural and familiar way while using technology to reduce the memory load on the user, provide convenient access to the information, and take over many of the routine clerical tasks associated with the work.

This was achieved by using an object-oriented approach to the design of the documents in the system. Each document, at the moment of its creation, is endowed with the information needed to exist in the electronic project workspace. The Design Project Manager provides, in addition to these 'smart' documents, a set of managers or *information tools* that offer the user access to the common actions he or she may normally apply to a certain kind of document.

Christopher Alexander (1964) speaks of architects as patternmakers; the sketches and drawings that constitute what most people recognize as "what architects do" represent only a small part of the patternmaking; the buildings themselves are patterns and create patterns of human habitation long after the architect and the drawings have disappeared. This book is a glimpse at some of the work of patternmakers, and about the tools that they use now and the tools that they could use. If the patterns in this book are good, then the toolbuilders can use them to create those tools.

It is also important to remember that although I have discussed this as an attempt to create a structure, it is really an attempt to create a description of structure. A structure already exists, and always has, for each and every designer. Each designer creates his or her own structure, a way of working, a way of using the tools of design. The work of this dissertation is merely an attempt to bring those structures into the light, to look for the common elements, to find relationships that exist for all (or only for some). It is an attempt to describe these elements and relationships to others, in a way that contributes to the development of beautiful things, in a way that attempts to put limits on the tyranny of productivity (Lyotard, 1984).

Literature review

The search for truth is in one way hard and in another way easy. For it is evident that no one can master it fully nor miss it wholly. But each adds a little to our knowledge of nature, and from all the facts assembled there arises a certain grandeur.

Aristotle

Design models and tools

Gero (1989) has theorized that designers begin exploring a problem by using prototypes, which may be chunks of knowledge at many different levels of abstraction. For example, if an architect is asked to build a house, Gero suggests that the initial prototype may contain information like style, location, cost, and knowledge of certain kinds of functional spaces. At a less abstract level, a kitchen prototype may exist, which contains additional information that provides more design details or requirements: a refrigerator is needed, plumbing is required for the sink, counter space is important, and so on. Prototypes are related to the AI concept of scripts, without the time element, and have three classes of information. These are information about:

- Functions that relate user goals with system behavior.
- Structures that define the relationships between elements of the system.

- Knowledge that relates structure to function, or function to structure (Gero, 1989).

Gero and his colleagues have taken an object-oriented approach to developing working models of prototypes, using classes and instantiation to test their ideas, which are still under development. However, not all architects agree with the notion of prototypes; while they may contribute to understanding a design problem, prototypes (and the information they contain) simultaneously place limits on what an architect might consider as the boundaries of the problem.

Oey (1986) has begun work on a similar design knowledge representation project called DARC (Design Assisting Representation Concept). This system is based on Minsky's concept of frames, which can be thought of as a network of nodes and relations (structure). Oey makes several important points in his discussion of design models.

- Much of what is called computer aided design is really computer aided drafting.
- Design activity is initiated by humans, not machines.
- Few computer-based tools exist for use during the early stages of design (Oey, 1986)

A prototype DARC system has been developed using Prolog; design information is characterized as 'objective' (rules, regulations, standards, etc.), or designer dependent (preference, standard approaches, standard solutions, etc.). Project requirements are also included in the database, and may be dependent upon the current project, dependent upon a particular type of project, or be project independent.

In 1978, Eastman described his work (Eastman, 1978) on an integrated design/database system. The GLIDE system was based on the conventional entity-attribute database model, but Eastman modified this to better accommodate the architectural designer. In particular, he found top-down, hierarchical decomposition of information restrictive in a design environment where the basic process model consists of analysis and synthesis; instead, a less-structured network was used to define the relationships among design entities.

These entities are called objects, and are members of abstract classes of objects from which functions and attributes (of the objects) are inherited. The ability for an object to multiply inherit attributes is considered a required feature; for example, a floor is an instance of both a surface and a boundary. The GLIDE design system provided methods for defining complex objects and the relations between them, and was able to create instances of these objects, display them, and let the designer manipulate them on-screen.

Eastman (1978) makes several general points about integrated design systems that still seem relevant:

- 1) Integrated design systems constrain the design process to the process models the system is able to accommodate.
- 2) Stand-alone CAD programs rely on a sequential ordering of tasks which may only be appropriate for high-volume, repetitive design work.
- 3) CAD systems with integrated databases that use sequential design models may be inflexible if a new building technology becomes available or other non-standard changes are desirable.
- 4) A good CAD system should accommodate as many design process models as possible, to give the designer the widest range of freedom.

The Architectural Design Information System (ADIS) described by Beheshti and Monroy (1987) has been focused on the needs of architect working alone or in a very small office. They note that the lone architect must manage the same amount of information (building codes, product specifications, site information, previous project data) as an architect working for a large firm, but without the support (clerical, drafting, filing) that a big organization can provide. They further note that no current system is able to accommodate the architect's needs during all phases of design. Five features are required for a comprehensive design support system.

- 1) An architectural database supporting product and other design information.
- 2) A design process database that accommodates multiple process models.
- 3) A design decision support system to aid the architect in manipulating information and analyzing the consequences of design choices.
- 4) A design expert system that can be modified by the user to provide fully automated analysis of design alternatives.
- 5) A communication system that allows the designer to communicate with others on a project, and to communicate with external sources of information like product manufacturer databases (Beheshti and Monroy, 1987).

The theoretical basis of the ADIS system is a structuralist one, using Piaget's definition of a system (transforming; self-regulating; objects and relationships among them). Beheshti and

Monroy argue that this approach can provide a complete chart of design activities, and from that a computer-based design aid can be developed.

The makers of the models and systems described above have attempted to develop a framework in which automated design tools can be described. However, several shortcomings are evident. First, virtually all of them focus on “structured” information; that is, information which can be described quantitatively and consequently can be analyzed and manipulated easily with computer-based tools. The physical characteristics of doors, windows, walls, roofs, and other structural elements appear frequently as examples. This type of information is important to the design task, but what remains unanswered is how to cope with intangible properties of physical objects (texture, color, aesthetic appeal, etc.) that often define the difference between good and great buildings.

None of the models discuss how to cope with visual information, in part, perhaps, because it is only very recently that the technology to store and manipulate visual images has become affordable. Two questions arise: is there a need for visual storage and manipulation tools, and if so, what are the characteristics of those tools?

Some of the models (DARC, Gero) focus mainly on a static model of the design process. Eastman and the ADIS system attempt to provide a framework in which multiple models can be accommodated, but provide scant information on how this might actually work. It would be useful to know what kinds of information is generally used in the varying design stages, and how the structure and organization of that information might change as the process changes.

Burnette has written extensively on the problems of information storage and retrieval for architects. In his dissertation (Burnette, 1969) he proposed a rather elaborate coding scheme for architectural information that relied heavily on additional effort by the architect to create a code for each document or bit of information that was to be stored in the system. The codes then made retrieval based on a set of search criteria relatively easy. His coding scheme was particularly ingenious because it was possible to encode and store not only the common business documents associated with a design project, but also could be used as a storage system for materials used in construction. In effect he had designed an indexing system that might store items later retrieved by a CAD program and used as part of a construction drawing.

Although cumbersome and unlikely to be practical in use because of the work required by the user to produce the codes, Burnette had already recognized the potential of an automated systems as an aid to architects.

Burnette later went on to write a series of reports for the AIA (American Institute of Architects) that attempted to take a more practical approach to the management of information in professional practice, and some of his observations bear repeating.

"Well balanced and informed professional judgement is ... increasingly dependent on direct access to information and to the appropriate techniques for applying it rather than on personal knowledge and experience."

"This legal responsibility under license rests on the individual professional and cannot be settled on any other legal entity such as a corporation. As a consequence the professional's need to know, his need for access to reliable information, is personal and acute."

"Access to reliable information is increasingly recognized as an important way to reduce exposure to liability claim....There is a fundamental paradox between the legal liability under which the architect labors and his professional responsibility to serve his clients and society in a creative way. In the first instance he is rewarded with lower insurance rates and greater economic return for not taking risks, for sticking with tried and true information, and in the second he must seek, assimilate, value, and apply more or less untested information in order to advance the state of the art, to gain the respect of his peers and to achieve a sense of personal fulfillment (Burnette, 1979a)."

In a second report Burnette notes that imposing search and file maintenance tasks related to an automated system on the architect (as the primary user) is probably doomed to failure, thus acknowledging at least indirectly that his earlier scheme would not work well in practice (Burnette, 1978b). In all his work, Burnette is emphatic about insisting that, for architects, the key to not only managing design projects but being able to compete successfully in the marketplace of design and construction services is convenient and easy access to information. He describes several requirements for an information system tailored for architects:

- 1) Publication of information must be continuous and up-to-date.
- 2) Information must be packaged and ready for use.
- 3) Information must appear consistently in the same format.
- 4) Information must be concisely presented in discrete chunks.
- 5) Information should be couched in operationally useful performance oriented descriptions.
- 6) Information must be accurate and complete, drawings precise, and to an easily used scale.
- 7) Evaluation and feedback must be built in.

At the time Burnette made his recommendations in the late sixties and seventies, the technology of information systems was still confined to large, very expensive systems that

required highly skilled personnel to assist in the operation and use of the equipment. These limitations put the kind of information system Burnette visualized out of the reach of most architects and firms. But the technology has changed, and desktop computers are now capable of managing the breadth and depth of information that Burnette specifies. In particular, direct manipulation interfaces built on top of an object model can potentially free the architect from knowing, understanding, or even caring about how the information is indexed and searched.

Cohill has proposed an architecture of information, stating that it is not enough to provide an interface, a set of data structures, and some algorithms that manipulate the information. He argues that only a design-based approach to information systems will alleviate the time and cost overruns, user dissatisfaction, and poor system performance experienced with many software development projects. He calls for design to take place in four areas: software engineering, ergonomics, environmental design, and organizational behavior. By having the design team focus on a holistic appraisal of user and system needs, he argues that both systems and users will perform better in the operating environment created by the introduction of advanced technology (Dayton, T., Barr, B., Burke, P.A., Cohill, A.M., et. al. 1993; Cohill, 1991a; Cohill 1991b; Cohill, 1989).

De Vries and Wagter have studied the use of information technology in the early stages of design, and note several problems with adapting computers to the tasks commonly found in the programming and schematic design phases of the work.

1) Architectural design is an ill-structured task; every design task can potentially be solved in a different way, using a different set of steps.

2) Architectural design is an open-ended task; that is, a design is never really 'complete' in the sense that the architect can never really say absolutely that there is no more room for improvement. Rather a design is 'finished' when the architect feels he or she has reached some balance in a complex set of conflicting requirements and constraints.

3) There is no fixed starting point in the process; assumptions about the problem form a starting place, but the design process includes an evaluation of the assumptions. "Solving" the problem may include changing the nature of the problem (de Vries and Wagter, 1990).

The two researchers go on to state that the typical Analysis-Synthesis-Evaluation model used to describe design activities does not adequately cover the early stages of design, because the model assumes well-defined objectives and criteria for the problem, which is not always the case for architectural design. As a replacement they propose a three cycle nested synthesis-evaluation process. They have created a prototype system using LISP that attempts to recognize and interpret some kinds of sketch information, but concede that their current system is crude

and needs much more development (de Vries and Wagter, 1990).

Cognitive maps

Geographers and those interested in environmental behavior have used the theory of cognitive distance to develop maps that describe a subject's perceptions of their environment, or spatial behavior. Lynch's work (1960) with urban spatial maps is one of the most well-known studies in this area. While the objects of study and the scale is different, I believe that some of the work in this area can be applied to the development of maps that describe a designer's use of design tools and information sources. One common way of estimating cognitive distance is to ask subjects to draw maps of their neighborhood or city, and compare these to objective maps which display distance and location using normal scales.

Briggs (1976) describes a variation on this method in which he studied the influence of subject knowledge of two endpoints on cognized distance. Subjects were given a list of twenty destinations in their city, and asked to describe them according to scales like "away/toward downtown" and "off/on a major north/south artery." Briggs found differences in cognitive distance based on factors like whether or not the roads connecting two points were straight or curved, and the proximity to the central downtown area.

In a study using a computer-based graphics display, Baird and Merrill (1978) examined the perceptions of Dartmouth students about their campus. The computer was used as an input device and data collection tool to ameliorate the variability of subjects to draw. Subjects were asked to place thirteen campus buildings on a grid (displayed on the video display terminal) using an x-y dial input device. Once subjects were satisfied with their arrangement, they were then asked to rank the buildings in order of importance. Results indicated that subjects were most accurate at estimating actual distances between two buildings ranked higher in importance than two buildings ranked low in importance.

Using the same set of subjects, they were then asked to arrange a pre-defined set of buildings/functions into a hypothetical town (Baird and Merrill, 1978). It was found that all subjects tended to group the same kinds of functions together (police/offices/hotel, school/apartments/recreation, etc.). This kind of mapping study might be applied to work environments as well, asking designers to draw and sketch associations between items in their workspace, and asking them to rank them in importance, or asking them to make sketches of the ideal workspace, and

comparing that to the actual environment.

Kaplan suggests that cognitive maps, in varying forms, provide the basis for many kinds of internal models of behavior, and notes that the concept has been applied in a wide range of research areas, including anthropology, education, planning, and psychology (Kaplan, 1976). He goes further to describe a set of requirements for an information processing approach to cognitive mapping.

First, object recognition is a fundamental requirement if an organism is to have the ability to have cognitive maps. That organism must also be able to anticipate future events; more generally, given an object, the subject must be able to predict a likely next object. The next need is the ability to abstract or generalize events, so that past experiences can be applied to future situations. Immediately following that is what Kaplan calls responsible innovation, or problem solving, which gives the organism the ability to use those abstractions constructively (Kaplan, 1976).

Kaplan takes a structuralist approach to cognitive mapping, noting that the maps form a network of objects with a set of links connecting them. The network is non-hierarchical, allowing the coding of overlapping and intersecting sequences that reduce the size of the structure. He warns that maps are only a discrete approximation to a continuous environment, so a "good" map must be connected and must be susceptible to an increase in completeness (Kaplan, 1976). The requirement of abstraction also suggests that these structures can be viewed as operating in layers, with each layer connected to other (sub) structures above and below, giving the organism the ability to deal with different levels of detail.

In a study of multi-function displays used on aircraft flight decks, introduced the term cognitive distance. The mental model used by pilots to organize and retrieve many different screens of information could be explained in part by considering that related information was separated by a shorter cognitive distance (Seidler and Wickens, 1992). They also believe that no single expert model exists for information organization.

In the organization of complex information displays, they suggest three variables: navigational distance (the number of required choice points between two chunks of information); cognitive distance, which corresponds to the user's mental model of information relatedness; and organizational distance, the imposed structure of the information system. Navigational distance was found to have important effects on performance. Cognitive distance can also affect performance when the user's mental model conflicts with the organizational model of the information.

Observation studies

Wang (1978) presented a descriptive study based on several weeks of observations of an architect preparing the preliminary sketches for a middle school in England. Wang's primary objective was to evaluate field study methods for design research. He used a variety of collection methods, including passive observation, interviews with the designer (recorded on audio tape), photographs of the work place, and notes and design documents supplied by the designer.

Wang made several observations about field studies of design activity:

- 1) He had started the study with a rigid schedule of daily interviews, but found that the pace and timing of design work made it difficult to keep the appointments. He found that one or two interviews a week was easier to arrange.
- 2) It was important to keep interference with regular studio activities to a minimum, to avoid changing the "normal" design atmosphere too much.
- 3) It took nearly a full week to become accepted as part of the organization. Once this happened, it was easier to talk to people and to collect information about their work.
- 4) Photographic records played an important part in the post-study data analysis, by providing visual clues about the chronology of the work and by giving him the opportunity to observe detail he missed while on site.
- 5) Involving the designer in data collection activities (note-taking, numbering and ordering of drawings) tended to create changes in the work atmosphere that slowed the normal pace of work.

Three kinds of data were described (Wang, 1978). Semantic information was derived from audio recordings, interviews, group meetings, letters, and other verbal sources. Behavioral information was collected from non-verbal sources: observable human actions, interactions, and expressions. Finally, graphic information was also important. Drawings and sketches from both the designers under study and those made by the observer were used as data sources.

Jones (1978) describes a set of behavioral studies that also offer insights into the practical aspects of behavioral observation. This paper details the work of several different groups observing children at play. In one instance, a simple spatial mapping notation was used to describe subject movement around the play area. This shorthand was easy to record and greatly simplified later data analysis.

Another group used a classification system that also provided a set of systematic data: each time period was categorized by behavior unit, type of individual under observation, and equipment and materials in use (codes were assigned to these objects). This data was converted into a behavioral map of the site, which made it possible to examine location and activity, program and activity, routine behaviors, environmental styles, and environmental issues like privacy and crowding. This group reported potential problems with on-site studies, including the difficulty of controlling site conditions, like number of participants under observation and accurately recording the type and activities of all participants. They also noted that when undertaking passive observation, the experimenter is at the mercy of unexpected events like fires, strikes, changes in policies, and other unpredictable occurrences that may disrupt data collection. However, they found that there were corresponding opportunities for serendipitous research results.

A third group described by Jones (1978) found that videotaping offered some opportunities over using live observers, including complete sequential records of behavior, the ability to review behavioral sequences in detail, and less variability in data because of observer bias. Attendant problems in the use of video cameras included equipment breakdowns, excessive amounts of data, and the fixed relationship between subjects and the observer (camera).

Pikaar (1989) used situation analysis techniques in a study of design draftspersons intended to improve current CAD systems. He found several difficulties in observing designers. As noted by Wang, it was important to be unobtrusive; very close observation (i.e., sitting directly with designers) disrupted normal activities sufficiently to make the validity of the data questionable. Like Wang, Pikaar settled for semi-structured interviews held once or twice a week and twice daily photographs of workspaces.

Because of the fluid nature of design activity, chronological data was difficult to collect and associate; that is, related events often happened apparently out of sequence, several days apart, or at greatly varying paces. He ended up focusing on activities and the relationships between those activities, rather than trying to preserve a sequential, time-ordered record of events. Verbal protocols were found to be unmanageable for many of the same reasons; design activity is an unstructured activity that may occur in an apparently random and/or overlapping sequence, and verbal protocols depend upon an ordered task composition (Pikaar, 1989). The results of the study showed that draftspersons preferred the early stages of design, as opposed to the production of detailed drawings and that they usually worked with two or more drawings at a time, transferring information rather frequently.

Controlled studies

Eckersley (1990) described a controlled study of design behavior that illustrates some of the problems of that kind of work. Eckersley's interest was in the application of heuristics by designers; the data collection technique used was protocol analysis; subjects were videotaped while trying to solve a design problem. Two groups of subjects were used; one group had training in the use of heuristic design rules, while the other (control) group did not. Analysis of the data showed that the heuristically trained subjects were able to solve the problem in less time and required fewer iterations through potential solutions.

The first problem with this work is the "design" task. It required subjects to allocate office space to a set of workers with specific preferences about the physical location of the office, rank in the organization, cost, personal preferences, and other factors. I would argue that this is not a true design problem at all, and that it could be solved using a series of linear equations. Controlled design studies tend to be difficult to administer because design problems that can be completed in a few hours (the limit of most subjects) are often trivial.

The subjects used in the studies were described as "undergraduate *pre-design* majors" [italics are mine]. This group hardly represents a random sample of professional designers. Dreyfus (1986) insists that the problem-solving behavior of novices and experts is very different, so Eckersley's attempt to extrapolate the result to the general design population are dangerous. This kind of problem is common to many controlled studies, because it is so difficult to find enough true experts who are willing to act as subjects.

Finally, while protocol analysis has been demonstrated to provide valuable data, it is still an intrusive collection technique. In this study, subjects that failed to maintain a continuous verbal monologue of their thoughts were interrupted every three to four seconds by the experimenter, reminding them to keep talking. In contrast, the phenomenological approach discourages this kind of invasive data collection in favor of passive observation and debriefings after the subject has completed a normal portion of work.

Protocol analysis was used as a data collection tool in a study by Chan (1990) in the Department of Architecture at Carnegie-Mellon. A single subject was used; in contrast to the previous work, this subject was a doctoral student in architecture with a total of eight years design experience, including two years with a professional firm. This subject thus might behave like "typical" professional designers. In addition, the work problem was realistic: to design a three bedroom house; certain practical limits were placed on the assignment— floor area was restricted to 2,200 square feet, and certain architectural features were asked to be included in the design. There

was no time limitation placed upon the subject, but a site plan, floor plan, and facade were requested as part of the solution. The subject spent about four hours working on the task.

Chan discussed design in the context of Herbert Simon's (1969) problem-solving model, which takes a mechanistic, rule-based approach to design behavior. The outcome of the data analysis was a set of rules by which the house had been designed. Chan argued that this work illustrates the kinds of cognitive search methods used in design, which may be true, but he went further to say that the extracted rules might be used to develop general design models. Dreyfus' remarks (1986) are again relevant; he feels that experts do not rely on rules at all, but instead use their knowledge of thousands of special cases (acquired through experience) to solve problems. The apparent derivation of rules from the data collected may be an artifact of protocol analysis, in which the subject, unable to articulate a gestalt-based, holistic approach to design, relies on uttering less important "rules" to satisfy the experimenter's needs.

Summary

In a study of professional practice, one must consider two questions: "What area or phase of design will be studied?" and "What is the correct protocol for the subject matter?" For those studying architects, the artifacts of the design process (construction drawings) have been the subject of intense scrutiny. I believe there are two reasons for this. First, these artifacts are accessible and comprehensible with only a shallow understanding of what processes and conscious and unconscious schemes and design knowledge were required to generate them. The drawings not only represent physical structures, they (the drawings) also are self-contained structures themselves, serving as both information storage and information display system. It is easy to work with them without the "soft" work of understanding the psyche of their creators.

Second, as the output of a well-understood phase of architecture (the generation of technical specifications of a building *after* the form has been determined), improvements to the process also have the potential of being lucrative. That is, CAAD research and development may not only be interesting but it may also be profitable. It would be interesting to compare the num-

ber of companies engaged in the sale of CAD/CAAD software and the number of companies selling software for the general management of an office engaged in professional practice. The quantity of the former will be much higher than the quantity of the latter.

As this book proceeds, I will make a case that office management, however mundane, has been a neglected area of study.

There are variety of protocols available to aid in the task of data collection. Controlled studies seem to have the least applicability. These are most useful when the question to be answered can be stated clearly and without any ambiguity. In the kind of exploratory study that I have undertaken, controlled studies seemed to be the least attractive alternative. The complexity of design tasks makes it difficult to decompose them into the neat questions required for controlled studies without simultaneously creating trivial questions (and trivial answers).

Cognitive maps are interesting because subjects have the opportunity to describe their experiences in a way that is meaningful to them and simultaneously create a structure for the information. But to use them effectively the researcher must be able to pose the question to be studied in a way that is comprehensible to the subjects. The subjects must then be able to communicate their maps to the researcher in a comprehensible way. The language of geography—places, routes, landmarks—is something we all have in common as part of our daily existence. The structure and scale is also readily apparent and comprehensible. The variety of often conflicting models of the architectural design process make it difficult to pose good questions and to receive good answers in kind unless one has already conducted research that helps frame the questions. Cognitive maps may be a useful tool for studies that try to build on the work presented here.

Observation studies seem to offer the most promise. They can be conducted unobtrusively in the workplace, which helps ensure that the fidelity of the data is high, unlike controlled studies which often place the subject in a highly constrained environment that may have little in common with the subject's normal work environment. Observing in the subject's workspace also presents the researcher with the opportunity to record and study items and processes of interest that may not have been articulated in the study proposal, leading to serendipitous results potentially as interesting as the original research questions.

Finally, with respect to the activities of professional practice and the complexity of the associated design tasks, observation studies may be the only way to understand and capture all the nuances of daily activities.

Research methods

We talk of the quality of life, but all our measures are quantitative. If we are to be concerned with the quality of work life for architects, and the effect upon that quality of life by (CAD) machines, then we must allow qualitative methods.

Charles C. Lozar

Structuralism

Piaget (1970) notes two key aspects of structuralism; first, there is an ideal of intrinsic intelligibility supported by the postulate that structures are self-sufficient and that, to grasp them, we do not have to make reference to extraneous elements. Second, we note that structures in general, despite their diversity, have certain common and perhaps necessary properties. He calls a structure a system of transformations, with the notions of wholeness, transformation, and self-regulation. Buckminster Fuller (1975) echoes this when he calls a structure a self-stabilizing pattern.

With physical structures a whole range of sensory elements define the building: size, shape, texture, light and darkness, sound, and smell. Not only that, the relationships among these elements (that form the structure) are firmly locked in the four-dimensional space-time matrix of the physical world: they can be experienced in much the same way by anyone.

To describe a cognitive structure we have only words and diagrams that attempt to communicate second-hand the elements of the structure and the relationships among those elements. It is important to remember that we cannot, as yet, experience someone else's cognitive structure directly, the way one experiences a building. This places inherent limitations on the usefulness of such descriptions, and their fidelity is difficult to measure.

Although these structures are personal and idiosyncratic, they all should have fundamental similarities. This work is to try to discern the form and shape of those common elements. By analogy, bricks are a common structural element of physical buildings, and the pattern in which they are laid creates a relationship among a set of bricks, but it would be pointless to try to list the myriad patterns that bricks and mortar can take, beyond a few descriptive examples.

There are those who take issue with structuralism, claiming that we are beyond that now, that we have entered a post-modern, post-structuralist era. Foucault (1970) argues that structuralism cannot transcend major historical periods or, perhaps, Kuhn's (1962) paradigm shifts. I believe that criticism to be true; it seems highly unlikely that there are more than a handful of structural absolutes. But Piaget (1970) himself argues that structuralism is a method more than a philosophy. As method, structuralism is a way of discovering, it is a search for some truth. It may very well be that this discovered "truth", in ten or one hundred years, may be unimportant. What matters is the value of the concept of truth while it exists as such.

Hermeneutic inquiry

Introduction

Hermeneutic phenomenology is an attempt to describe and study meaningful human phenomena in a careful and detailed manner as free as possible from prior theoretical assumptions, based instead on practical understanding (Packer, 1985). Although the techniques of phenomenological research are not well known, they are not new. Martin Heidegger, extending the work of Husserl, is considered the father of the discipline. Heidegger's philosophical work *Being and Time* (1927) is still considered a definitive work in the field.

In it, Heidegger proposes the notion of *ready-to-hand*, a mental state in which there is such a close fit between ourselves and the task we are performing that we are unaware that we are doing it. His classic example is that of using a hammer to drive a nail. As one strikes the nail repeatedly, one is not conscious of the hammer and the nail as such; rather one is thinking in more global terms of building a wall, or constructing a house.

It is only when an accident or a problem arises (e.g., the hammer slips and the nail is bent over) that we become aware of the hammer and the nail. Heidegger calls this transition breakdown, and one moves to a state called *unready-to-hand*. There is yet another state, called *present-at-hand*, in which we detach ourselves from the task entirely because we must find a way of dealing with the problem (how to remove the bent nail).

The primary implication of Heidegger's theory for cognitive research is *context*. That is, the best way to study human behavior is to examine it in the context of everyday life. This is in opposition to the rationalistic approach, in which new knowledge is developed through the process of hypothesis generation and testing, or the empirical approach, in which data collection forms the basis of new knowledge, prior to and independent of theory construction (Packer, 1985).

Although still not widely used, phenomenology has begun to attract more followers because of a perceived lack of results using other methods. Winograd and Flores (1986) have been two of the most prominent researchers to embrace it; they decry the heavy emphasis on the rationalistic paradigm and the "blindness" that it generates. Wixon, Holtzblatt, and Knox (1990), working in the area of human-computer interface development, claim much success with a hermeneutic-based process they call "contextual design."

There is little to gain in trying to demonstrate that one research strategy is better than another merely on ideological grounds. What is important is to choose a strategy that is appropriate for the environment of the subject and the information under study. The positivist tradition defines environment and behavior differently from phenomenological strategies, so it is simply not possible to 'prove' that one is better than the other (Franck, 1992).

Franck goes on to argue that design research has failed to take hold in the past 25 years because the researchers have expected the architects to become positivists. I would argue that to understand the work of the architect, the researcher must be prepared to dwell in the world of his subject, rather than trying to take the subject out of that world and placing him or her, as a subject, into the impersonal and controlled environment of the HCI lab, where it is impossible to recreate the richness and variety of activity that exists in professional practice.

Wertz describes a three stage approach to a phenomenological study (1984).

- Identification of the phenomenon; the starting point is a discrepancy between the phenomenon and what is already known about it.
- Manifestation of the phenomenon. This is done by choosing subjects who will expose the phenomenon and picking appropriate situations that manifest the structure. The data is verbal in nature, and reflects the lived experience of the subject, not the researcher's bias.
- Analysis of the phenomenon. This is a set of functions that involves reading, demarcating, eliminating, naming, placing, and ordering the data.

The researcher's attitude is critical to the success of the study. He must have an empathic attitude to the situation under study. He must slow down and listen carefully to what the subject says, without injecting his own bias into the interview (Wertz, 1984). He must, as much as possible, try to enter the world-view of the subject, and look for a sense of the whole in the discussion (Hycner, 1985).

Once the sessions with the subjects have been transcribed, and the researcher begins to study them, discarding irrelevant portions, eliminating redundancies, and clustering related units of data (Hycner, 1985). Finally, general themes are derived from the data, and a summary of the results are written.

The ecology of work

In a somewhat different tone, there has been increasing recognition of the "ecology of the workplace." Thomas and Kellog (1989) feel that the study of human-computer interaction can be more effective if researchers try to take into account the actual working environment of the end users, rather than relying solely on techniques like lab studies or simulation.

There is a growing use of the word ecology to describe the environment of the professional programmer (Rosson, et al., 1988; Shneiderman and Carroll, 1988). Ecology is the study of organisms and their interrelationships with their environment, which is another way of saying that one will study people in the *context* of their everyday life. Rasmussen (1992) emphasizes the importance of approaching computer systems design as multi-disciplinary endeavor. He wraps his arguments in a framework he calls the ecology of work, in which the several overlapping domains of what we call work must be considered concurrently. He mentions the purpose of the

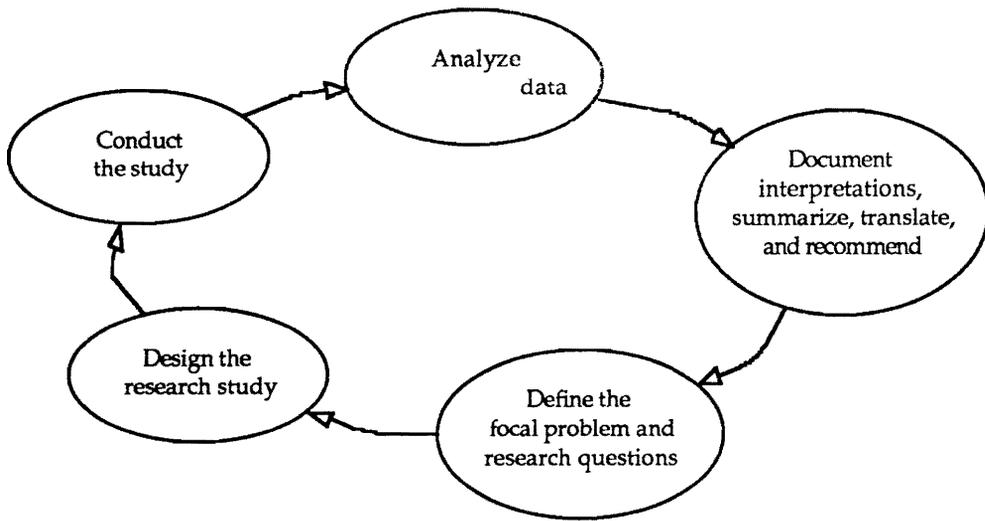


Figure 3-1: The cycle of phenomenological research

work; flows of money, information, people, energy, and mass; general work activities; specific work processes and physical equipment; and the appearance, location, and configuration of objects.

Context is an important issue when studying architects. The process of architectural design is personal and eclectic, and materials play an important part. It is not enough to just sit architects in front of a computer and ask them to design; to do that is to ignore the context, the environment that stimulates design. How the computer affects that environment is as important to some architects as what those architects actually do with the computer.

In this study, my interest was in the information that architects use during the course of a design project. I felt that it was critical to the success of the work to observe the manipulation of those information objects in the context of professional practice. The artifacts of design appear to be the clearest link with activity of design, but actually tell us very little about the process by which the design was created (Newton, 1989); to understand the artifacts one must understand the process.

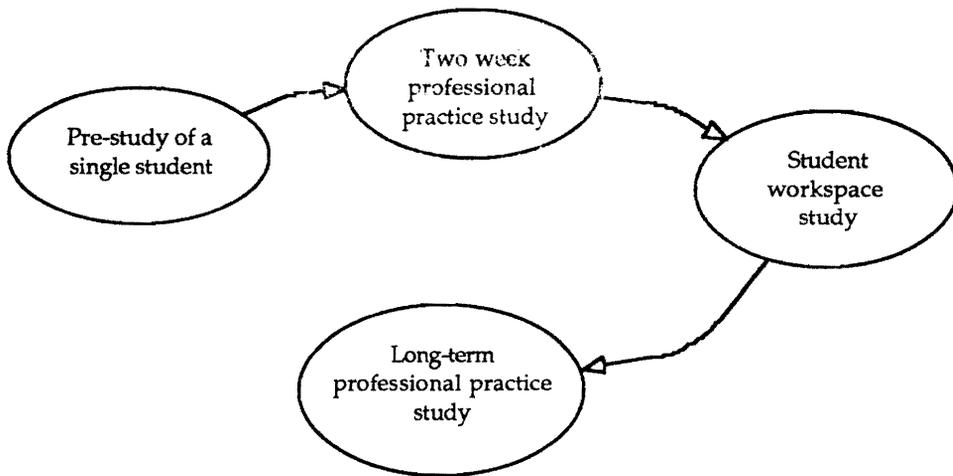


Figure 3-2: The four research studies

Method and approach

Observation studies

Moore, Tuttle, and Howe (1990) present a cyclical model for research shown in Figure 3-1 that illustrates the iterative, exploratory nature of phenomenological research. In this work I have iterated through this cycle four times: a pre-study, two studies of professional offices, and a study of student workspaces. Each study affected the focus and research questions pursued in the subsequent studies. As I collected data, conducted preliminary analyses, and assigned meaning to the data, the results became input to the next data collection effort. Each major cycle is represented by a primary data collection effort, as shown in Figure 3-2.

A pre-study was used to gain experience with the phenomenological approach to data collection, determine if the data collected seemed appropriate in both content and quantity, and to have an opportunity to adjust data collection methods before the start of the major studies, if necessary.

The first study of architects at work was a two week session at a small firm in the Washington, D. C. area. The firm, called New Design (all names have been changed to protect the privacy of the architects), was run by a successful, award-winning architect who worked with several architects and assistants. In this study, I was at the firm full-time from 8 until 5 Monday through Friday for each of the two weeks.

The next study documented 25 student workspaces in Cowgill Hall at VPI&SU. The student workspaces were chosen as a control group to help differentiate between information and documents related the design task and those documents coupled more closely with the business part of professional practice. The results of this work are presented in the chapter *The Student Workspace*.

The final study was with an architectural firm in the Blacksburg area (Design Futures) where three architects and some assistants shared office space and collaborated on some projects. This study took place over a long period of time: for four months I visited two to three days a week for three to four hours. For another four months, I visited less frequently, but usually stayed for about the same amount of time. This study had been originally planned as the same kind of two week stay as the study with New Design. While I collected a lot of data in that study, I felt that there were some limitations in the 'snapshot' approach to examining the work of a firm. Tracking the work of the firm over a longer period of time would give me a better opportunity to observe the full range of activities in a firm. The results of both studies with professional architects are presented in the chapter *The professional workspace*.

Analytic studies

In conjunction with the observation studies I began an analysis of the published work of several architects and writers. The goal of this work was to examine, dissect, and reconstruct the views of these authors on architecture and develop a set of diagrams that would reveal not only the underlying structure of each individual view but also to discover some common structural similarities.

The method used for each author was similar:

- Read each text critically, taking notes and assembling structural diagrams from the appropriate sections of each book.

- Draw and re-draw these diagrams until satisfying patterns emerged. To be satisfying these diagrams had to be both visually coherent and structurally sensible.

- ❑ Assemble the completed diagrams and compare them, looking for visual and structural similarities.
- ❑ Develop a final diagram, or pattern, that merges the common themes and attributes of the various diagrams and authors.

The results of this work is presented in the next chapter, *Structural Diagrams*.

Evaluation

Seamon (1987b) is emphatic in stating that the only workable phenomenological test of validity is corroboration, criticism, and clarification by phenomenologists and other interested parties; he calls this process intersubjective corroboration—that is, the verification of one person’s experiential accounts with others’. Rather than method, description is the basis of trustworthiness for any phenomenological study; Seamon cites Polkinghorne’s (1983; after Keen, 1975) four criteria to help readers judge the correctness of phenomenological accounts: vividness, accuracy, richness, and elegance.

- Vividness is a quality which draws readers in, creating a sense of reality and genuineness.
- Accuracy refers to believability, helping readers to see the phenomenon as a part of their own world of experience and meaning.
- Richness refers to the fullness and color of the description and relates to the aesthetic qualities of the phenomenon; a rich description helps the reader enter into the description emotionally as well as intellectually.
- Elegance relates to descriptive economy and a disclosure of the phenomenon in a graceful, even poignant way.

Franck has more to say about the outcomes of phenomenological research.

- You cannot specify the outcome in advance.
- Positivist research, with its hypotheses, analytic techniques, and statistically supported conclusions is both more accessible to critique and more remote experientially.
- Phenomenological research may reveal or clarify phenomena previously unnoticed or obscured.

- A phenomenological research strategy is not just a kind of free-wheeling, do-what-you-feel-like approach. It requires great discipline and careful thought on the part of the researcher precisely because the procedures are less formalized (Franck, 1992).

Pre-Study

A pre-study was used to test the phenomenological approach to data collection and to determine if enough data would be available to develop useful results. I observed a fifth year architecture student (Bruce) who was in the final stages of completing his thesis work. Over a three week period I visited his work area in his home and observed him at work for three sessions each week. Each session lasted between two and four hours, with the average about three hours.

I took handwritten notes, made sketches, took photographs of the workspaces, and conducted several interviews with the subject. I learned several things from this experience. Within the first week, it was obvious to me that this notion of dwelling in the life of the subject could provide a rich and bountiful source of data. The seed of the document model presented later in this book was germinated and developed here, and became a guiding temporary structure for thinking about the data that I would collect later in much larger quantities.

I had originally planned to visually document the workspaces with photographs. I used a Canon A-1 with a 35-105 mm zoom lens, attached flash, and tripod to take pictures of the workspace using a 400 ASA black and white film. The photographs were disappointing; even the widest angle shots were unable to capture in a single image the entire workspace used by Bruce. This seemed problematic in understanding and analyzing the overall layout of a user's workspace. The close-up photographs of individual work items and documents was even more disappointing; my inability to control the lighting properly without bringing in a lot of additional equipment resulted in low resolution photographs that would not reveal much detail without enlarging them greatly.

Bringing in additional lighting equipment I viewed as invasive and not in the spirit of the study. I noticed that Bruce was especially self-conscious when I brought out the camera and always insisted upon cleaning up his workspace, even when I assured him I did not care about general tidiness or untidiness. I began making hand-drawn sketches of his workspace, and

found that these solved several problems. In a small sketch, I was able to capture a full view of the entire work area that, for my purposes, contained the detail I needed for later reference. Making hand-drawn sketches was also completely non-invasive; I could do this while Bruce worked, unlike the inevitable interruption required by a camera.

Using sketches also allowed me to immediately annotate the drawing with more information about the items and documents in the workspace. With the photographs, there was a delay of several days between the time that the photograph was taken and the time that it was developed, and in that time the arrangement of the workspace often changed drastically, so I was unable to go back to the workspace and annotate the photograph properly if I needed more information.

The interviews I conducted with Bruce were a disappointment. I used a small hand-held tape recorder to make a record of the discussions. I observed two things: Bruce was not self-conscious about how he worked, and had very little insight into how he used information in his work. Questions about the importance of reference books, material that he used for casual browsing, and other items that I observed him using yielded very little information that was of use to me. Much of his work seemed to be on either an intuitive level that did not yield to introspective questions, or the result of ingrained work habits that he could not explain readily because they were so well-assimilated.

One other result I had not expected was the difficulty of remaining vigilant and alert over a period of hours. I had planned to make all the sessions four hours (Bruce had told me that he often worked for four or five hours at a stretch, so I was not imposing my needs on the subject), but this proved to be exhausting. After the first three sessions I began experimenting with two and three hour sessions, which seemed more reasonable time periods for me to work. I was concerned about my plans to conduct two week studies with professional architects where the work day was eight hours, but I assumed there would be more natural work breaks in a normal office environment. As it turned out, this was a problem but I solved it in a completely different way.

Study notes

(4/9) The radio is tuned to a public station. A long quiet classical piece is playing. The clack of the ruler on the vellum is the other dominant, regular sound in the room. Occasionally, Bruce stands up to measure a dimension on a drawing hung on the wall over the desk, and the legs of the chair scrape noisily on the linoleum floor. There are no visual distractions in the room; every object has to do with the work, with the possible exception of a single photograph that appears on a calendar on the wall.

(4/10) *He is working on a small section of the drawing tonight, and may be having some trouble; he has used his eraser frequently tonight. He referred to a book on Mario Botta repeatedly.*

The development of a completed drawing involves thousands of small actions, performed repetitively: measuring, picking up the pencil, placing the parallel bar, drawing a line, moving the bar away, putting the pencil down, examining the effect of the line, and doing it all again. A certain rhythm exists, a certain precision, even in erasures and mistakes.

(4/12) *Bruce has been looking at two different picture books tonight. He also has a couple of sheets of slides out on the desk. He has been referring to a set of blueprints of his parents' house because he has a good sense of the space there; he compares measurements from the blueprints to measurements on the drawing of his work in progress. Here, intimate knowledge of a space or spaces is playing an important role in the development of details in the current work.*

He uses Post-It notes to cover parts of the drawing, sketching on the note to try alternate solutions.

(4/15) *The drawings up on the wall are completely different tonight. Two days ago, the drawings were done in very light pencil, so that even from six to eight feet away where I am sitting, it was difficult to discern detail. Tonight, there are highly detailed site, plan, and section drawings hanging up, with the features clearly drawn in with a very dark pencil. The change is really extraordinary. I have felt as if I have been sitting in a fog for the last few days because it was so difficult to see the work. Now I can see the entire project easily.*

He has also hung the drawings differently. Formerly, he had three or four drawings hung up directly in front of him, and they overlapped each other. Now, each is hung separately, with three on the facing wall and two on the side wall.

He is working differently tonight; he seems to have passed or solved the problems he was struggling with in earlier evenings, and now he seems to work in a more directed manner. His mind seems made up about the details and is now simply filling in the picture, literally. He refers to the drawings on the wall frequently, often using a scale ruler to transfer a measurement for something already completed on the wall to the drawing on the table.

There are no books out tonight. One of the most frequent activities tonight is the constant re-sharpening of the drafting pencil. Although this activity is a necessity, it also seems to provide a momentary break to view the drawing as a whole, whereas while drawing his attention is focused on small portions of the whole image.

(4/24) *What seems most important to Bruce's work is access to his own drawings—the dozen or so*

views of the project that he has created. He has one on the table in front of him constantly, but he refers to the ones he has hanging on the wall frequently, and often gets up to look at the four or five in a stack on the adjacent table. In the course of two hours, as many as 3 or 4 of these drawings may change position as he works out a problem.

The next most important set of references are the drawings and pictures he has up on the wall that come from other sources—the set of blueprints from some other designer, and the magazine article on the house he admires. Finally, there are the books he has been using, but they certainly rank below these other materials in importance and frequency of use.

Structural diagrams

Patterns of culture do not operate in accordance with the laws of physics. How are you going to prove in terms of the laws of physics that a certain attitude exists within a culture? What is an attitude in terms of the laws of molecular attraction? What is a cultural value? How are you going to show scientifically that a certain culture has certain values?You can't.

Robert M. Pirsig
Lila

Vitruvius

One of the earliest writers to articulate a structure in which to think about architectural design was Vitruvius (50 B.C.), whose *Ten Books on Architecture* scholars believe dates from the time of Augustus Ceasar. As noted in the forward of the book, Vitruvius' skill as an architect and builder seems to far surpass his skill as a writer. The ten books referred to in the title correspond to chapters; what is not clear is exactly why Vitruvius chose to organize the book the way he did.

One possible explanation is that he attached some special importance to the number 10, and organized the book to fit. Avery (1977) describes the value ten as signifying unity, or possession of complete knowledge. Avery also notes that the ancient Greeks and Romans put great store in the significance of numbers. It may be that Vitruvius chose to categorize his knowledge in a way that resulted in ten parts or sections, thus representing a unified, or "complete" discussion of architecture.

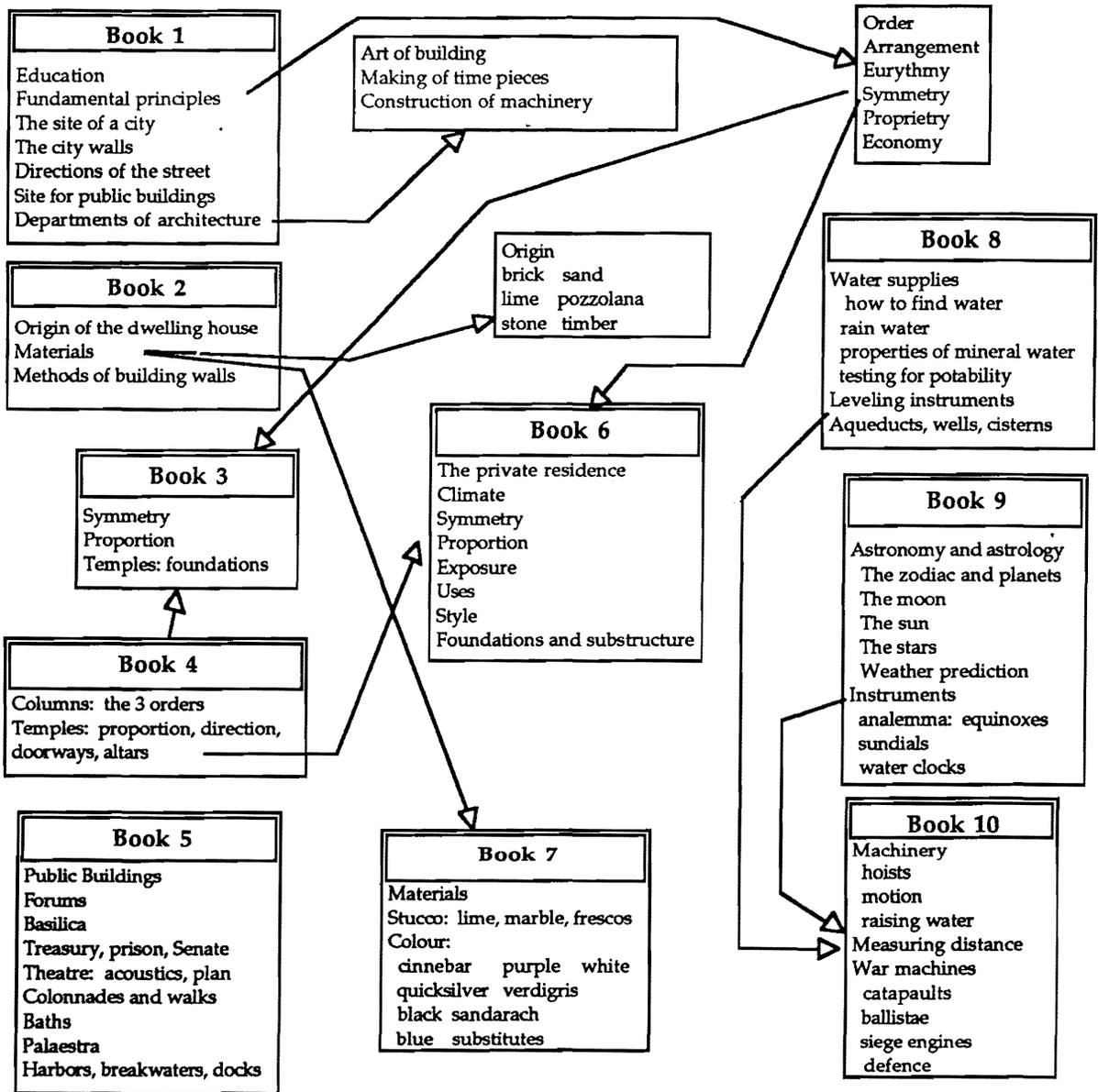


Figure 4-1: The original structure of Vitruvius

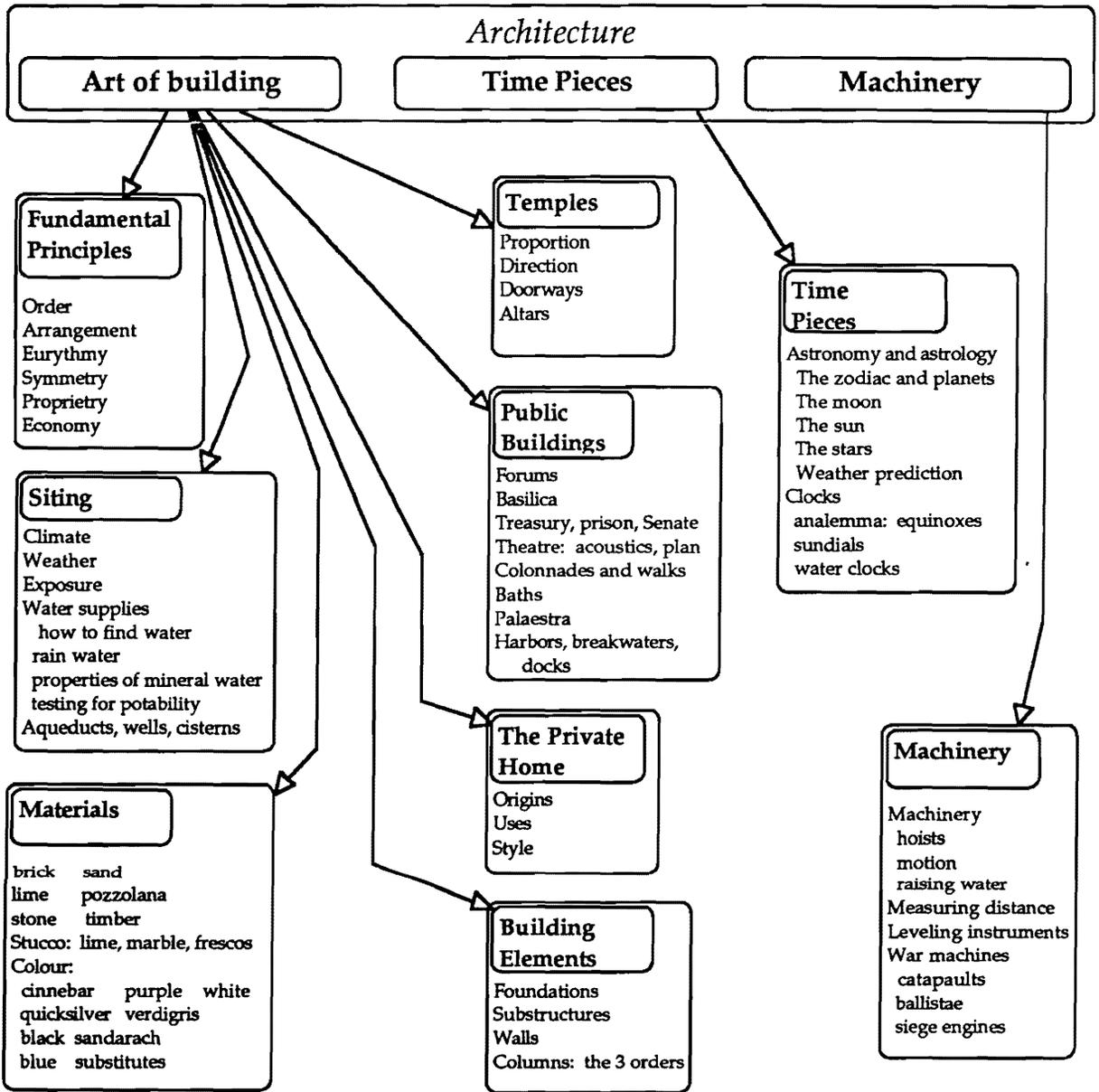


Figure 4-2: The structure of Vitruvius revisited

Figure 4–1 shows the structure of the book, as designed by Vitruvius. Figure 4–2 illustrates a structure that I re-designed in an attempt to connect related topics that may have appeared in different sections of the book, and to separate some topics that seem dissimilar but appear under the same heading. For example, the design and construction of temples is discussed in both Book 3 (Symmetry and Temples) and Book 4 (Columns and Temples). The titles have been added; Vitruvius did not use them.

One can argue that Vitruvius had a method: temples were (and still should be) designed with close attention to the layout and symmetry of the design. They were also frequently constructed with copious use of columns. As another example, Vitruvius discusses building materials in both Book 2 and Book 7. Most common building materials (brick, sand, stone, timber, etc.) appear in Book 2, but he waits until Book 7 to introduce the use of stucco, combining it with a discussion of color and pigments. He apparently felt that made sense because stucco was heavily used as a base for wall paintings.

The two diagrams illustrate two views, or structures, that provide a way of thinking about a designer's information needs. Although both are based upon the same information, one is a representation by a designer who actually lived when the information presumably represented the state of the art. The second diagram is a modern interpretation of that information. The point of this work is not to judge one "better" than the other, but rather to try to discern, by collecting and studying a variety of these structures, some common elements and relationships.

Norberg–Schulz

In his classic work *Intentions in Architecture* (1965), Christian Norberg–Schulz describes a theory of architecture using a structural approach to define and delineate the problem. He appropriately divides the scope into two parts: form is derived from a set of elements and the relations that act upon those elements. Figure 4–3 shows the elements of his model, and Figure 4–4 illustrates the relations he describes.

Three kinds of primary elements exist in built structure: mass, space, and surface. He further divides these categories into sub-categories; space is distinguished as closure or centralization. Surface can be represented by frame, hierarchy, or layers, or any combination. Mass, what we commonly encounter as the physicality of the building, is described with terms like

isolation, pregnant, corners, symmetry, and geometrization.

Eleven primary relations are identified.

Proximity	Succession	Similarity	Continuity
Fusion	Interpenetration	Addition	Ambiguity
Division	Closure	Geometricity	

Norberg-Schulz regards physical structures as a hierarchy of primary and secondary elements, in which the primary elements bind the building together (without them the building would lack compositional integrity), and secondary elements contribute to the wholeness of the design but participate by association with the primary elements. He goes further, though, to explain style in structural terms: a system of elements and relations which appear with varying degrees of probability (Norberg-Schulz, 1965).

By introducing the notion of probability, Norberg-Schulz has potentially reduced the analysis of architecture to a calculation: if a building has so many percent of cornices combined with a certain scheme of window and door placement, then it must be in the Period Twelve style, to fabricate an imaginary example. It would also be possible to take his models and construct a language that describes, in terms of probabilities, what is required to construct a building in a certain style. One might whimsically argue that one need look no further than any American sub-division to discover that this practice is already widespread, where a "Colonial-style" home is not, as one might expect, constructed with a floor plan that homes had in Colonial times, but with a certain percentage of stylistic appendages common to the Colonial period (Ritter, 1991).

Pursuit of this train of thought devolves quickly into quasi-religious arguments about the purpose of architects and architecture, and in particular, the role of machines in the design of built space. While it is certainly possible to construct an architectural machine (a computer program) bounded by a model like Norberg-Schulz's, that is capable of acting upon a set of rules that define common elements (windows, doors, stairways, and the like) that could then spit out a set of plans which a builder could use to construct, it would not be a very interesting use of such models.

While Norberg-Schulz acknowledges the effects of architecture (and the environment it creates) on its inhabitants in *Intentions in Architecture*, the book is largely based on an analytically approach to understanding what architecture is, without much space devoted to the needs of the humans who must dwell in that built space. In his later book *Genius Loci* (1980), he redeems himself by examining architecture again, but from an existential and phenomenological point of view. In this book he examines the human patterns that have converged to create built spaces. Figure 4-5 illustrates his notion of a structure of place, composed of:

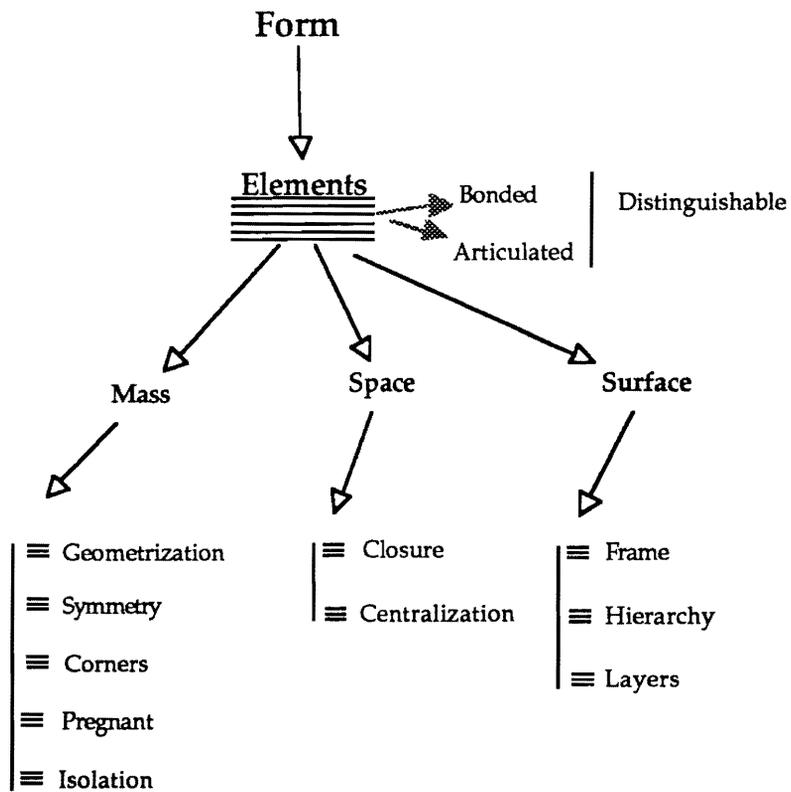


Figure 4-3: Norberg-Schulz's elements of form

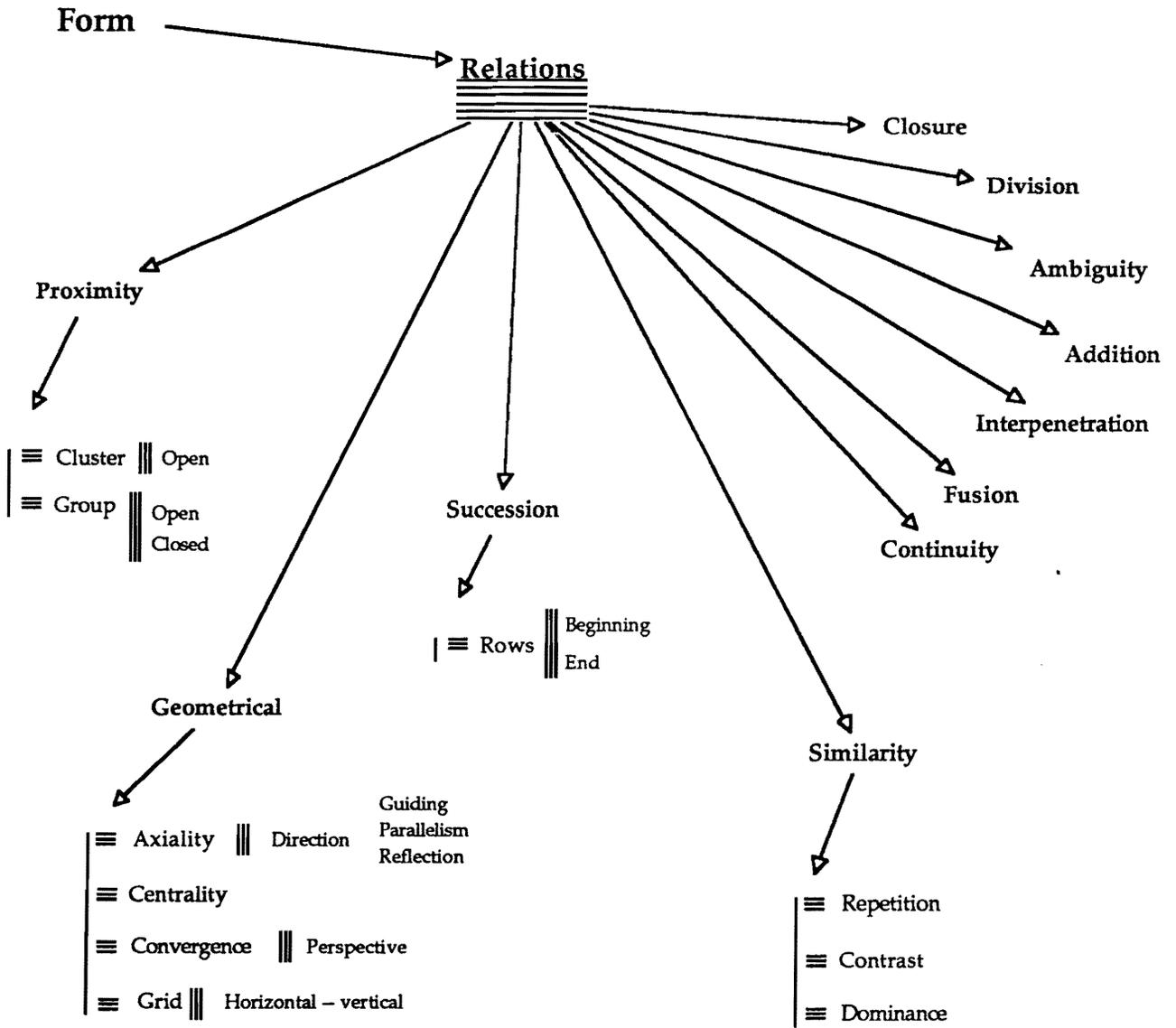


Figure 4-4: The relations that link the elements of form

Experience of space—what we feel and how we react as we inhabit built space

Space—the abstract elements and relationships that combine to form a space

Character—the qualities that combine to give a place feeling

Settlement—the physical elements that form a place

Landscape—the natural elements that interact with Settlement to form a place

In *Intentions in Architecture*, Norberg-Schulz has already completed, in great detail, an example of what I hoped to accomplish in this dissertation. He argues near the end of his book that a proper theory of architecture should be “empty” but coherent and capable of absorbing all architectural problems within its structure (Norberg-Schulz, 1965). Coupled with existential explication of place in *Genius Loci*, his ideas provide a useful starting place for an exploration into the design and development of automated design aids.

Bachelard

In *The Poetics of Space* (1964) Bachelard writes at length about the qualities that make a house a home. Bachelard, like Norberg-Schulz in the previous section, speaks from the phenomenological point of view. What does it mean when we say that we *dwell* in a house? How does a dwelling become a home?

Figure 4–6 illustrates graphically some of the qualities that he identifies as central to a building that exists for us a dwelling and their relationship to each other. Over and over in the book he returns to the twin notions of home and shelter and what these ideas, expressed in the physicality of the cellar, the rising up and verticality of the walls, and over all, a roof.

It is the walls that provide us with physical, mental, and spiritual limits; they protect and shelter us. He conjures the image of the storm that batters the walls of our home; inside, we

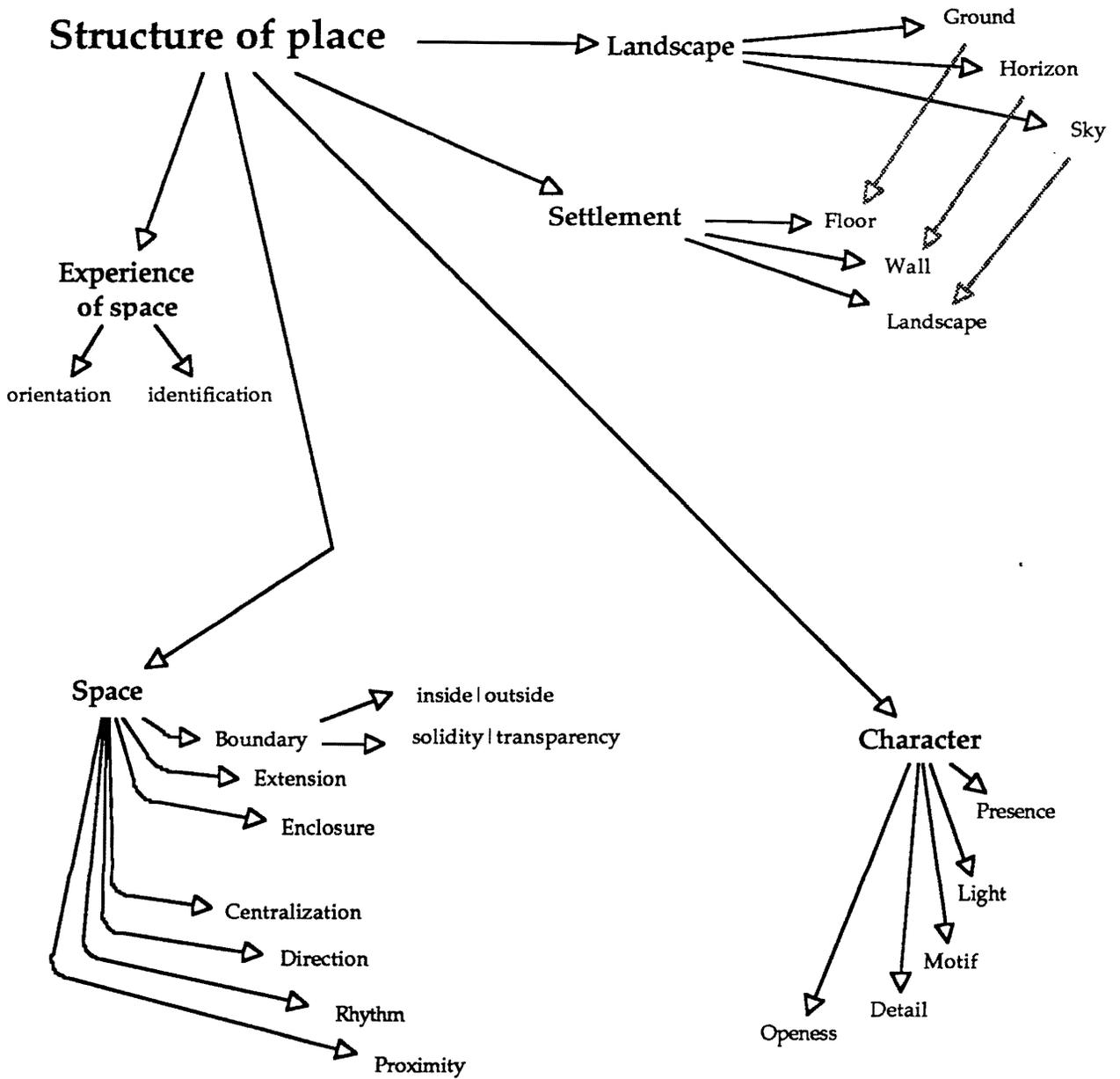


Figure 4-5: Norberg-Schulz's structure of place

listen to the shrieking of the storm as it tries to strip us of our protection; we also hear the groaning of the house itself as it strains against the force of the wind. But the noise is somehow reassuring; we are connected and protected by the house, and we experience the storm safely, secure in our refuge.

In Bachelard's ideal home there are three or four floors at most. The cellar extends down into the earth, rooting itself in the embrace of the soil, giving this abode a foundation, and we always walk *down* the steps to descend into the cellar. From the cellar we walk the steps up to the ground floor of the house, and perhaps up another set of steps to the bedroom. In these main floors, where we live most of the time, we travel both up and down the steps in familiar patterns. Finally, we go *up* a set of steps to the attic, where we seldom visit; the space is used as a repository and storehouse for our memories; the things of our past that we have not discarded because they still have some meaning for us.

The primary purpose of the home is to provide us with a place to dream in peace. In our home we are safe to wander mentally in the cellar and attic of our own minds, to explore our fears and daydreams in safety. The reality of the house provides us with a refuge; in the cellar we can explore our irrational connection with the earth, our rootedness. In the attic, sheltered by the rational design of the roof (to shed wind and water as efficiently as possible), we can pursue another kind of dreaming. In the attic the harmony and geometry of the supporting rafters of the roof tell us immediately of its strength. From the attic we have a clear view of the world, all the while sheltered and safe inside our home. As children we went to the attic when we were bored, and Bachelard wishes for that kind of mental attic as relief from the rationality and logic of the exterior world.

Bachelard's phenomenological home provides us with a structure on which to pin the physical components (walls, doors, roofs, windows, stairs, cellars) that comprise what we call shelter. In his view, the finest homes are not necessarily the grandest or the most expensive, but those that attend to and untruly our psychological needs as well as our physical needs. He writes lovingly of the hermit's hut, hunched low to the ground, sharply pitched and thatched roof reaching almost to the ground and extending straight up into the sky as a kind of archetype for shelter and home because the inherent simplicity of this structure makes us part of an intimate connection between the earth and the sky.

Bachelard, who wrote this work in the late fifties, has much in common with Norberg-Schulz and his explication of a phenomenology of place twenty years later. Both regard as central man's vertical connection with the universe, in which he rises up from the ground and pierces the sky. Both regard architecture as an expression of this experience of being. This is hardly a new idea; W. R. Lethaby, writing in 1892, points out that the archetype for all built space is the central column or pillar, rising up from the ground to support an enveloping roof. The first column,

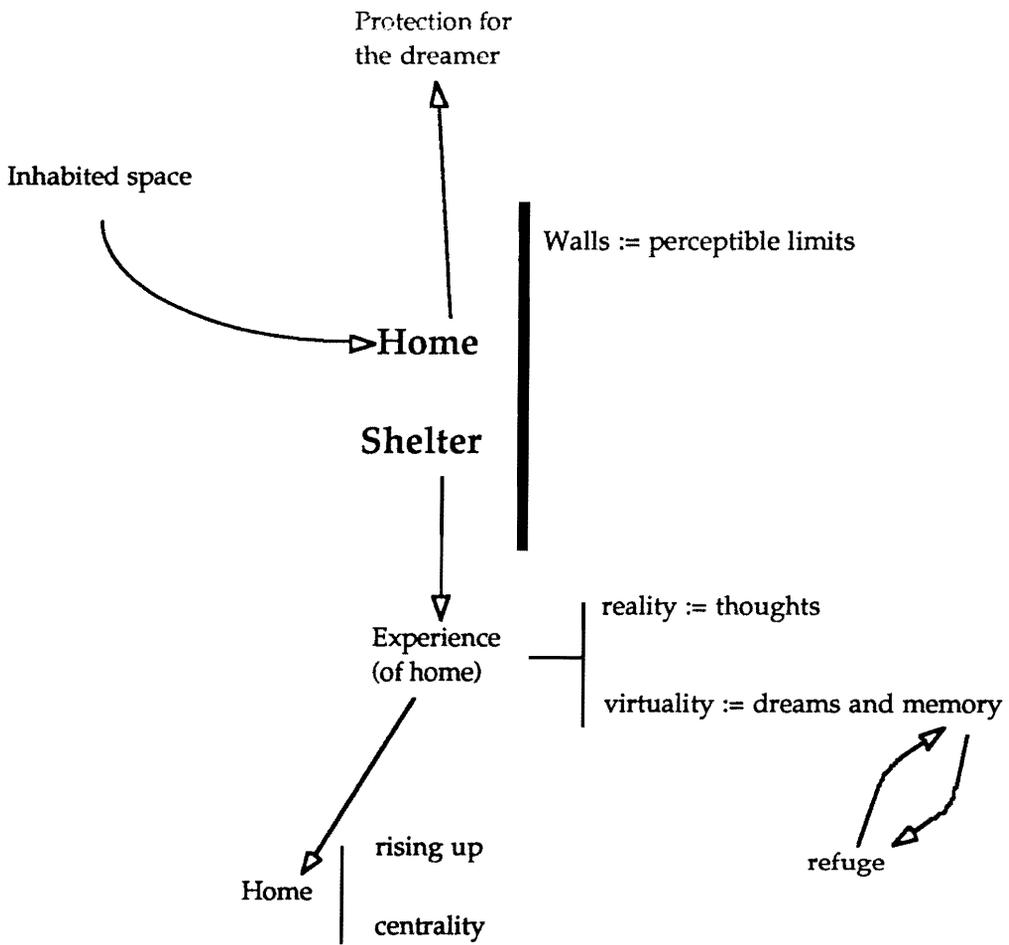


Figure 4-6: Bachelard's home and shelter

was, of course, a tree trunk, perhaps with some of the branches still intact to support whatever formed the fabric of the roof (Lethaby, 1892).

Ching

Francis D. K. Ching is an architect who has written several books that try to provide a visual introduction to the tools, work patterns, and knowledge needed to produce built space. In *Architecture: Form•Space & Order*, he provides visual references for what he feels are the essential elements and organizing principles of architecture. I chose this work because of its breadth and because he uses visual definitions (hand-drawn illustrations) to explicate his “theory” with small amounts of text to provide supplementary explanations. The other authors I have analyzed used written text with supplementary illustrations and photographs. Ching has focused on illustrating basic principles graphically with both simplified models of the ideas as well as sketches and drawings of well-known structures that demonstrate the application of these ideas. When performing an analysis like the one in this chapter, it is difficult to ignore Ching because he has published so widely, but his approach to explicating the experience and elements of architecture is not universally accepted.

Ching divided the work into seven sections:

Primary elements

Form

Form and space

Organizations

Circulation

Proportion and scale

Principles

Ching has used a linear organization to present the elements and qualities of these major areas, constrained, perhaps, by the limitations of the medium of printed books. On the next several pages I have created a set of hierarchical structures that illustrate the elements of Ching’s model and the connecting relationships between those elements. Ching did always state these relationships explicitly, so some of the connections represent extrapolations on my part in an

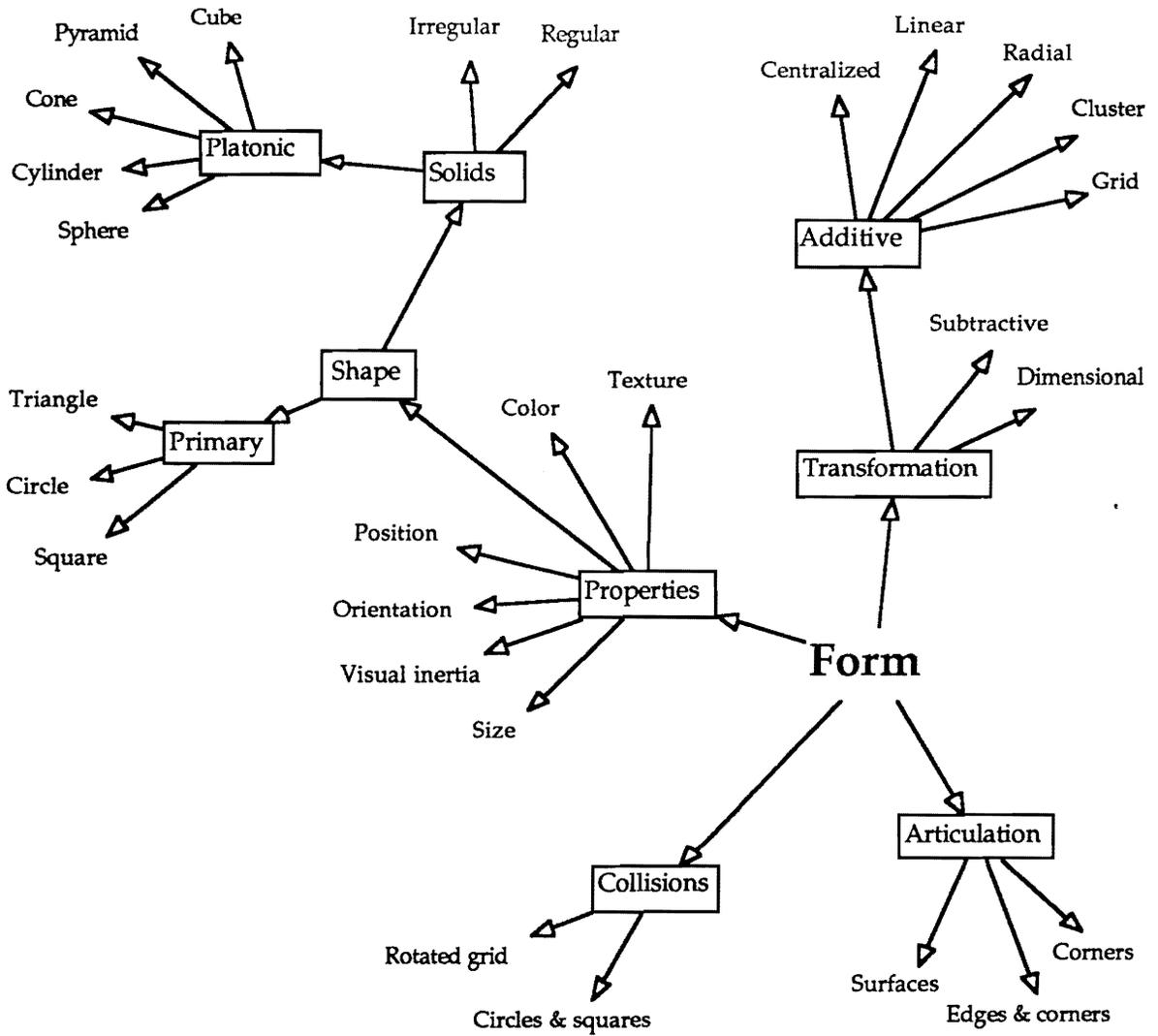


Figure 4-7: A radial model of Ching's Form

attempt to present a coherent visual model.

The first four illustrations (Figures 4-7, 4-8, 4-9, and 4-10) all represent the elements and features of basic form. Each figure, however, provides a different view of the same structure by using a different visual ordering principle. Figure 4-7 considers Form as a radial model. The representation seemed “noisy” and hard to interpret, so I then tried a linear design, as shown in Figure 4-8. This was more successful because the primary elements of the model (properties, collisions, articulation, and transformation) were more evident than in the radial model.

I was still concerned that it was difficult to associate different elements of the model with respect to the level of the hierarchy they formed. Shape, a node of the structure under Properties, can be decomposed into additional levels of nodes, yet it existed visually with other nodes of the structures that could not be further decomposed. In Figure 4-9, I moved some of the terminal nodes of the structure to the same level, but still did not have all the leaf or terminal nodes at the same level visually. Finally, in Figure 4-10, I have moved all terminal nodes in the structure to the same level.

In Figure 4-11, I used a tree-shaped diagram to represent Ching’s model of Proportion. In Figures 4-12 and 4-13 again tried different representations of the same model of Space and its elements. The former is a linear model that is similar to the representation I settled on for Form, and the latter is a return to a radial design. Finally, in Figure 4-14, I have presented a network design of the high level nodes of Ching’s complete model of Form and Space.

Although this seems like fairly simple exercise, I was searching for ways to represent what are principally abstract ideas (e.g., dimensional transformation) in an visually compelling model. I encountered several difficulties. A primary problem was the difficulty to developing readable diagrams that fit on a single page that also encompassed a coherent portion of the entire model. At a minimum, Figure 4-7 (radial Form), Figure 4-11 (Proportion), and Figure 4-13 (radial Space) should appear on a single piece of paper to properly show all the relationships among elements.

The size, depth, and breadth of this structure lends itself to a hypertext representation stored on a computer. A reader of this structure might begin with the illustration in Figure 4-14, which fits comfortably on a standard 13” computer video monitor. Clicking on any of the nodes would move the user to a new page showing additional structure. At any time, the user might pop up a box of explanatory text that would discuss a node and its relationship to other nodes in more detail. Additional hypertext connectors or buttons might also provide alternate means of moving around in the structure.

For example, in traversing the links Space→Circulation→Configuration, you arrive at a set of leaf nodes (Linear, Radial, Spiral, etc.) that are similar to the nodes found at the end of the set

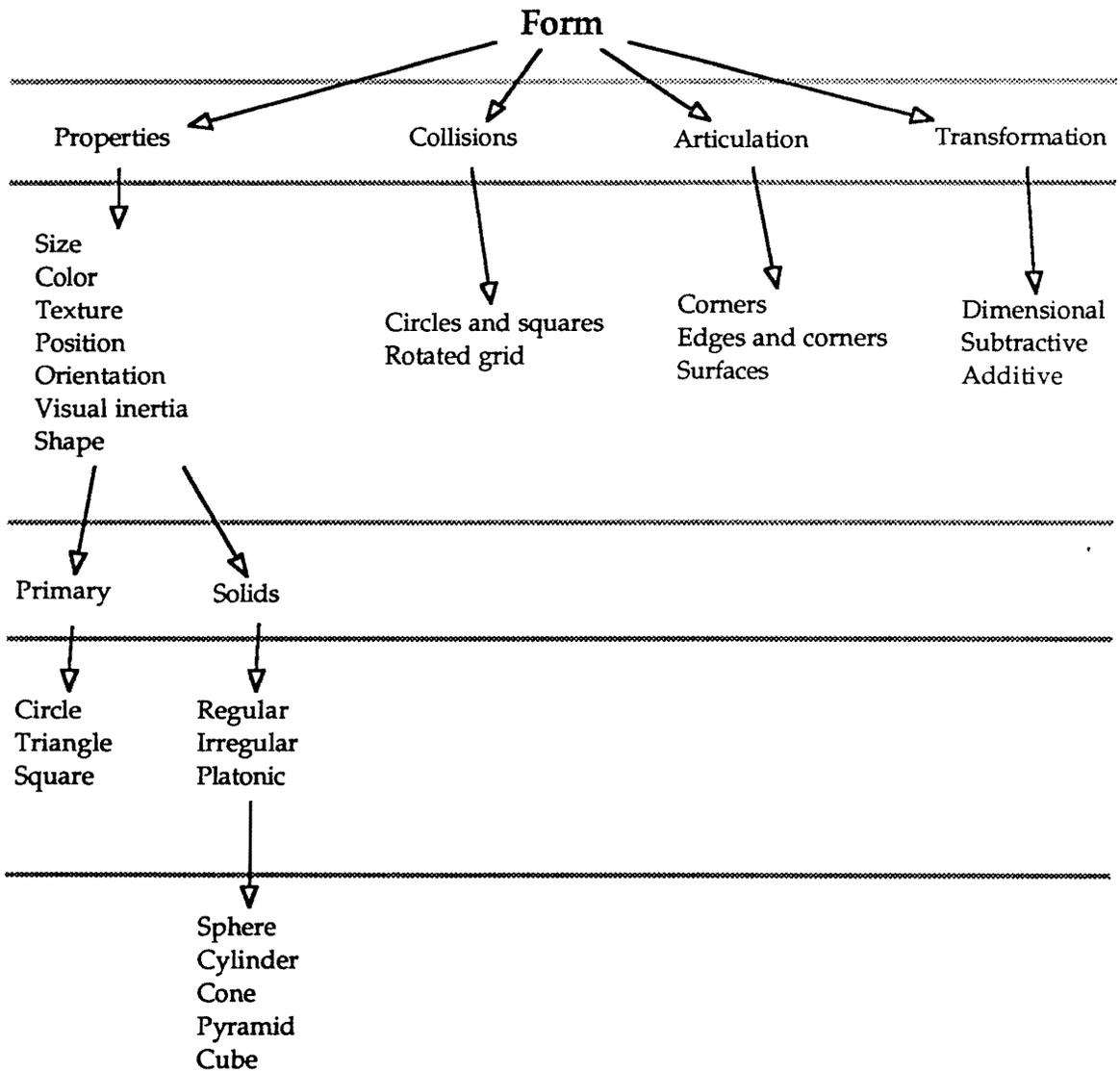


Figure 4-8: Version 1 of a hierarchical model of Ching's Form

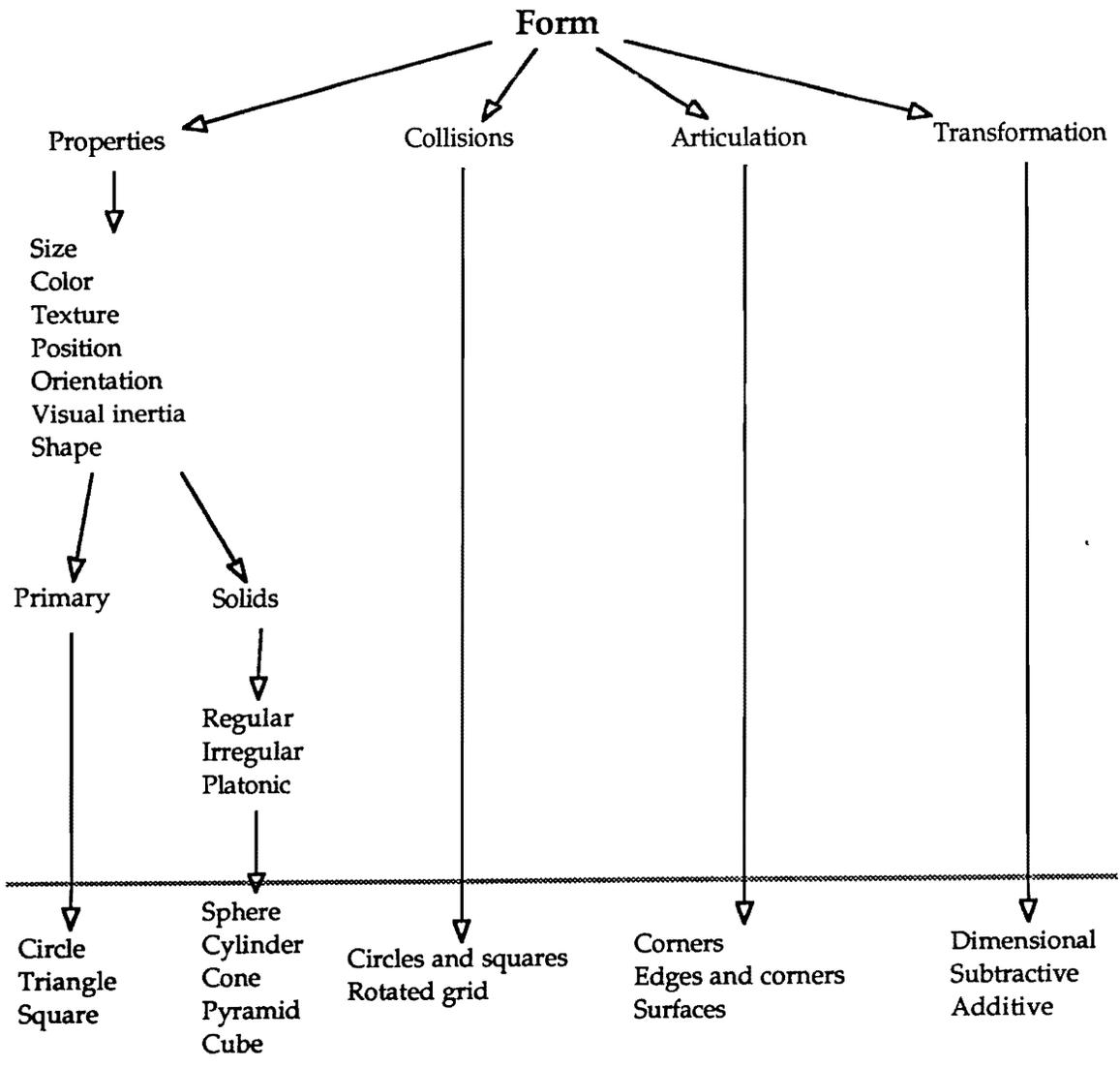


Figure 4-9: Version 2 of a hierarchical model of Ching's Form

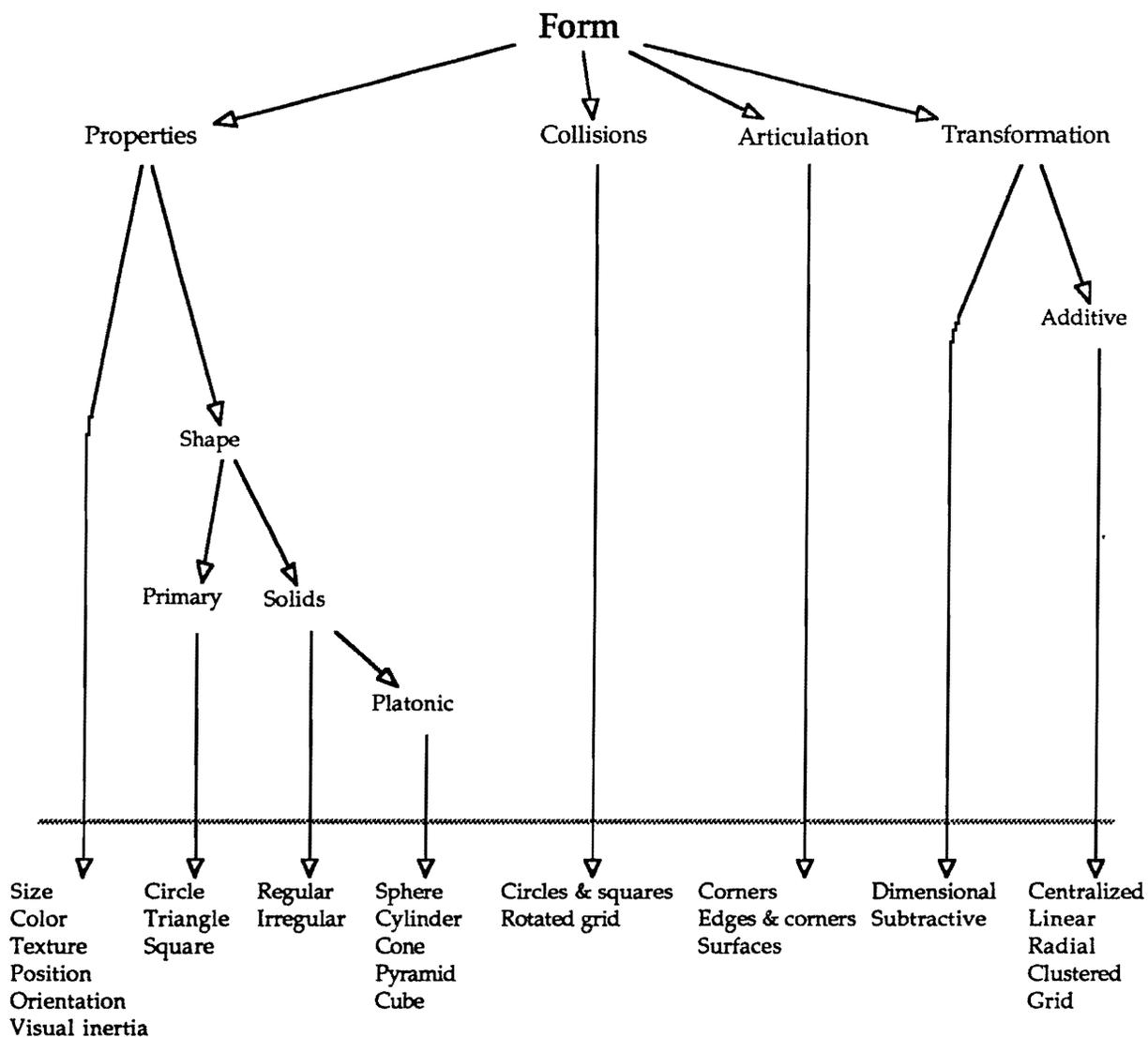


Figure 4-10: Version 3 of a hierarchical model of Ching's Form

of links described by Space→Organizations and Form→Transformation→Additive. It should be easy for the user to determine that there may be related topics and to move to them without a linear traversal up and down the entire structure.

Alexander

Christopher Alexander, in his book *A Pattern Language* (1977), has come closest to my own idea of the potential for a kind of structural archetype in design. In 1171 pages he presents what he calls a pattern language: a set of visual images and accompanying descriptions that he and his associates have identified as “timeless” elements of design.

The elements of this language are entities called patterns. Each pattern describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice.

There are 253 patterns described in the book, ranging in variety from macro design problems like Shopping Streets (pattern 32), interior housing considerations like Eating Atmosphere (pattern 182) and Open Shelves (pattern 200), to construction details like Wall Membrane (pattern 218). The format and layout of every pattern is similar to enhance the use of the book as a reference guide. The authors provide with every pattern:

a representative picture illustrating the idea,

an introductory paragraph to set the context for the pattern, including pointers to larger, encompassing patterns that may affect it,

a headline to present the essence of the problem in a sentence or two,

the body of text that describes the problem in detail, and

a final summary that connects the idea to other smaller, interrelated ideas in the text.

The two sets of pointers to other patterns that Alexander provides, the first set to tie it to

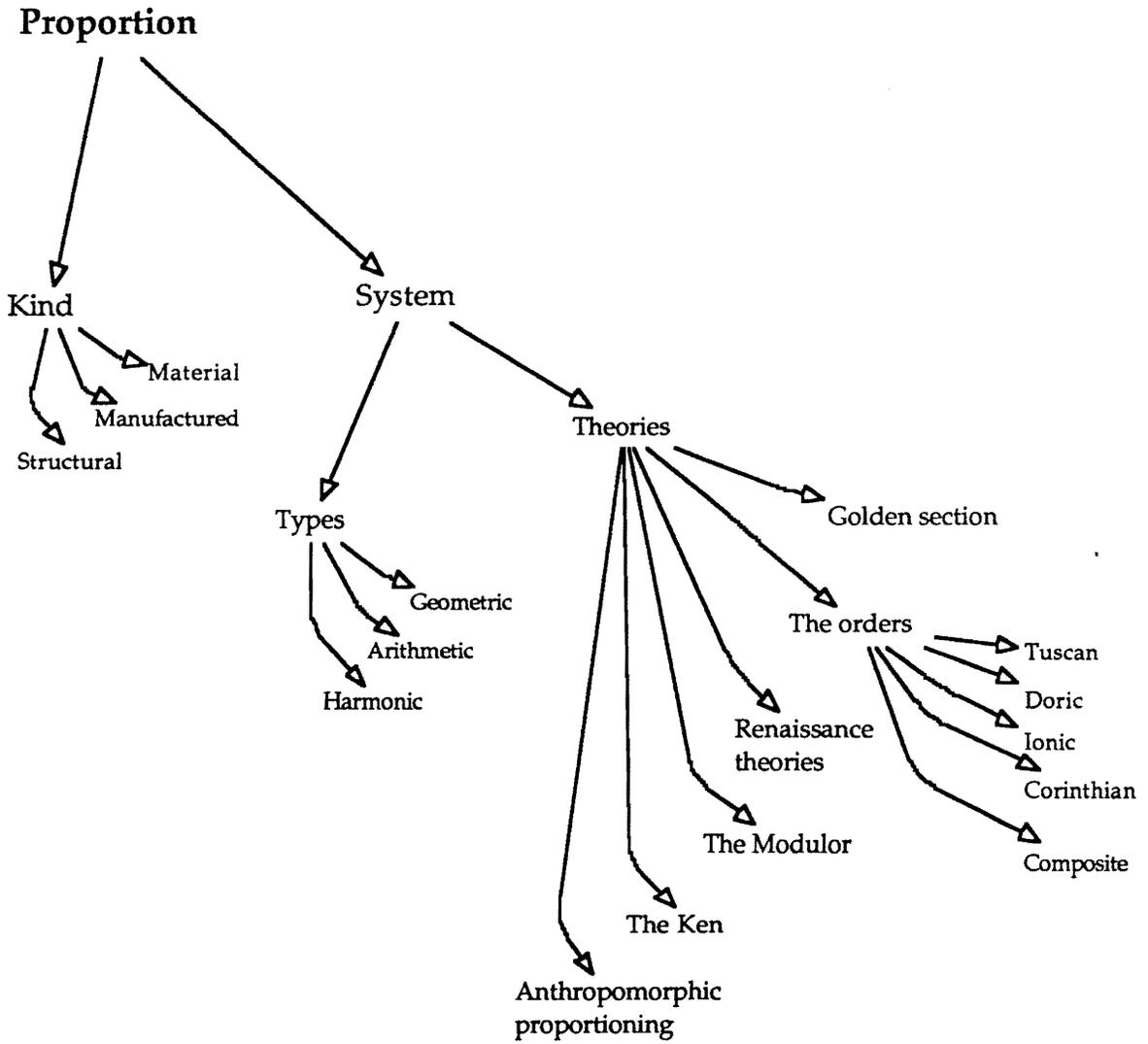


Figure 4-11: A tree-shaped model of Ching's Proportion

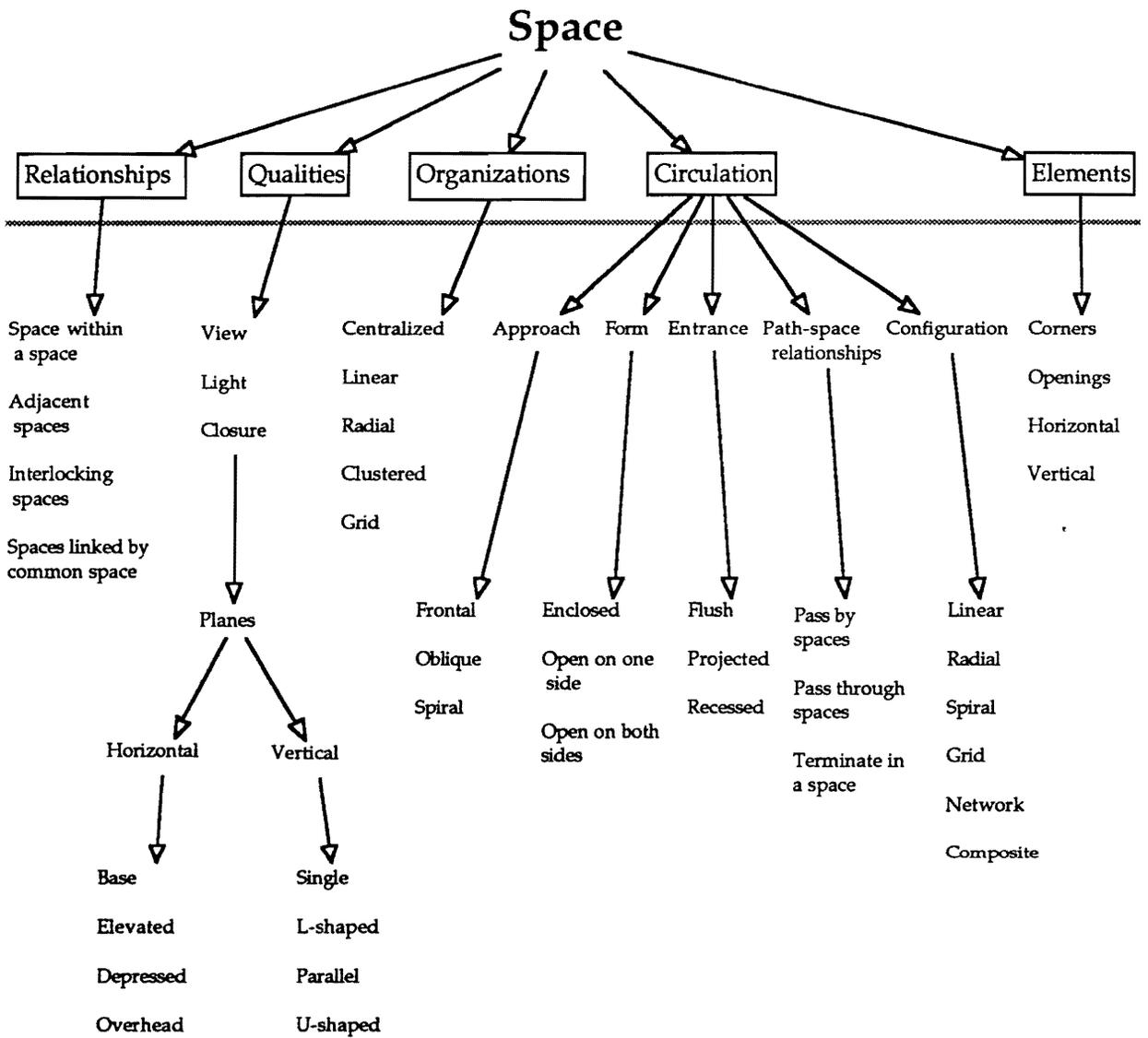


Figure 4-12: A hierarchical model of Ching's Space

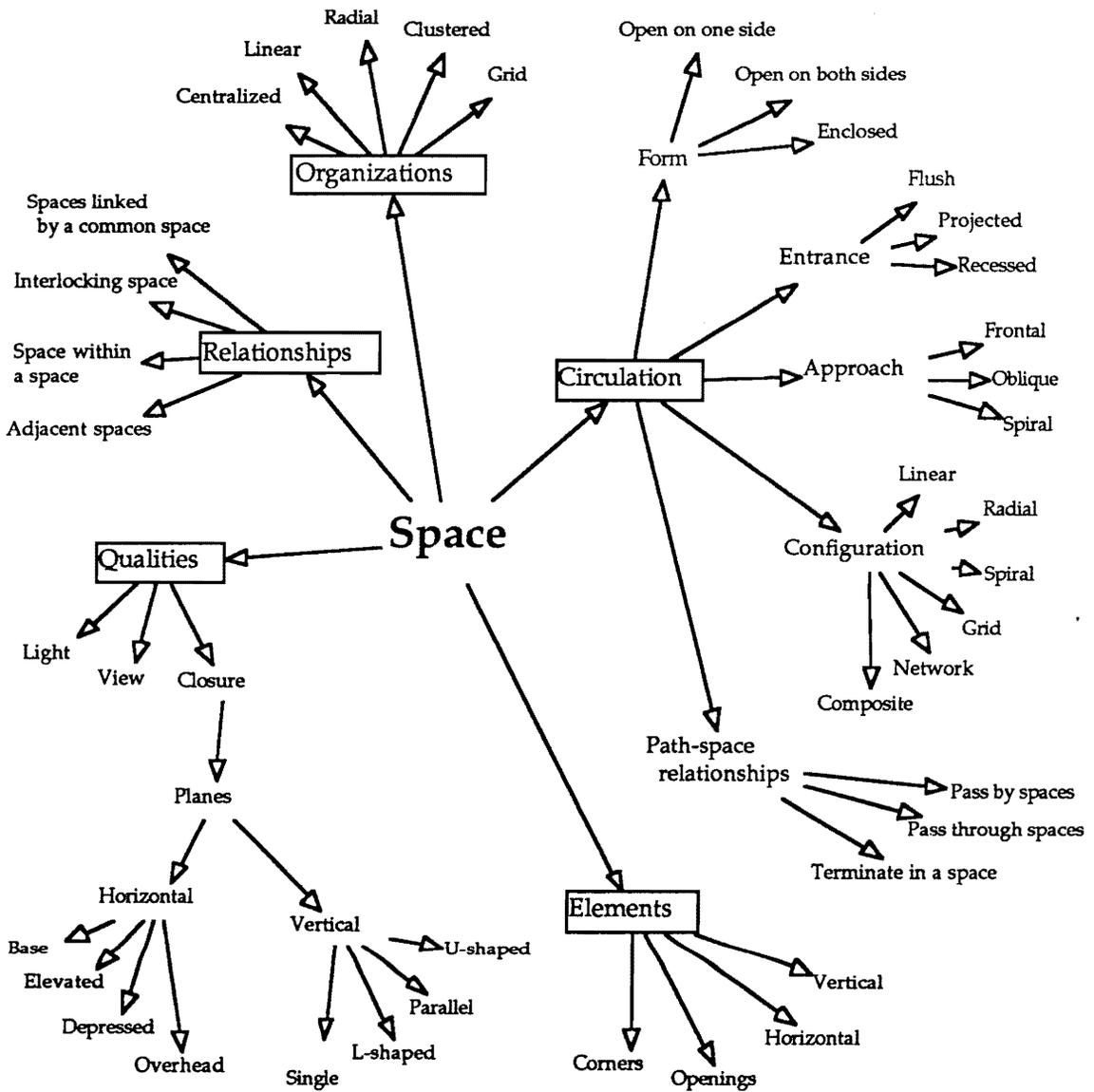


Figure 4-13: A radial model of Ching's Space

higher level patterns, the second set to link it to patterns that may in turn be affected by this pattern or be needed to complete it, are the most interesting part of the structure of the book. These links connect the 253 patterns in a dense, highly interdependent way that forms yet another structure independent of the physical structure imposed on the information by the selection of a book as the medium.

Figure 4–15 illustrates a small subset of the patterns presented in the book. I constructed this illustration by choosing Main Entrance (pattern 110) and following the links to what I regarded as some of the most important related patterns. Ten additional patterns (represented as shaded ovals) represent patterns that appear in the book immediately after Main Entrance; these are patterns 111 to 120. Patterns not delineated by shaded ovals are patterns that are related.

I did not include all the patterns referenced in the text of the 11 primary patterns I show because the diagram would be so densely populated that it would be difficult, if not impossible to read. There are 38 additional patterns that appear in the illustration. It was exceptionally difficult to massage the information in the illustration into its current form; I struggled for many hours to arrange the primary nodes of the structure into a form that minimized overlapping links.

The information, developed in the early '70s before the advent of hypermedia, nevertheless is ideally suited for that medium. Alexander's work, unlike all of the other authors in this study, has included a level of detail that relates the information more directly to the kinds of decisions required to execute and complete a design project.

Summary

The work of five authors has been presented in this chapter (Vitruvius, Norberg-Schulz, Bachelard, Ching, and Alexander); these models represent diverse views of the same subject matter. Only Alexander's work spans all four categories; this is not surprising because *A Pattern Language* is by far the largest and most comprehensive of the five authors presented in this chapter.

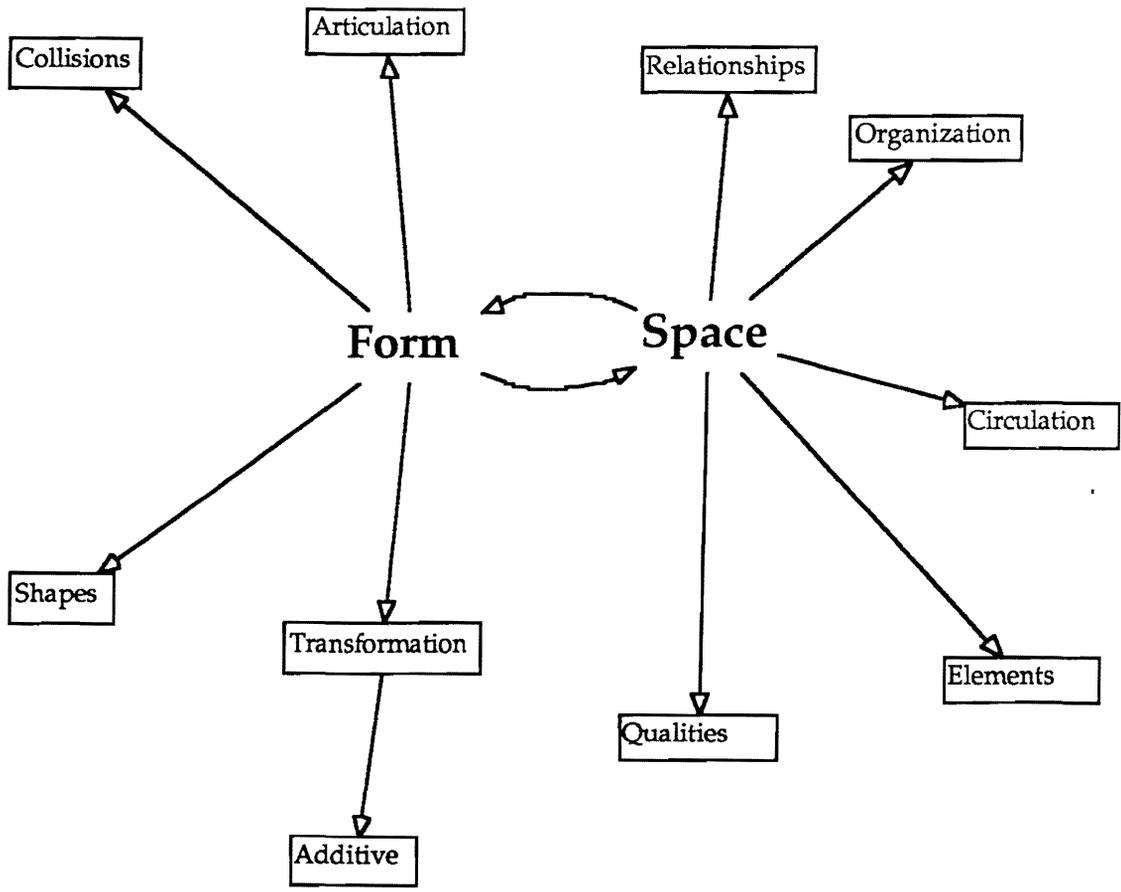


Figure 4-14: An overview of Ching's Form and Space

The work can be classified in four models or categories:

<i>Geometric</i>	Ching, Alexander
<i>Experiential</i>	Norberg-Schulz, Bachelard, Alexander
<i>Stylistic</i>	Ching, Vitruvius, Alexander, Norberg-Schulz
<i>Materialistic</i>	Vitruvius, Alexander

- ❑ **Geometric** – Differentiating design alternatives by shape, order, layout, and mathematical properties.
- ❑ **Experiential** – Using evoked feelings to classify and think about what it means to design dwellings.
- ❑ **Stylistic** – Using various architectural styles or visual appearance to differentiate and classify design information.
- ❑ **Materialistic** – A focus on the use of materials in design.

It seems clear to me now that the experiment of trying to explicate the structure of these architects and writers has been a failure. Three results stand out:

- ❑ The diagrams create a static structure. To look at the structure immediately creates a boundary around your understanding of the concepts that the author is trying to present.
- ❑ It is exceptionally difficult to represent any but the very simplest structures on paper. This alone seems an insurmountable problem to trying to grasp a gestalt-like view of all the nodes and edges at once.
- ❑ The diagram that represents my interpretation of Norberg-Schulz's ideas is meaningful *only to me* because it is based on the filter of my experience.

While I was initially surprised that none of these authors had included diagrams of their ideas in their own books, I came to understand the limits that these diagrams have as tools for understanding the concepts. The diagrams create a static set of rules for interpreting the concepts and their relationship to each other.

It is possible that hypermedia versions of these diagrams may have more potential. Converted to hypermedia, where the owner of the diagram is free to change and modify the links as needed would provide a dynamic interpretation. It would even be possible to have unused and

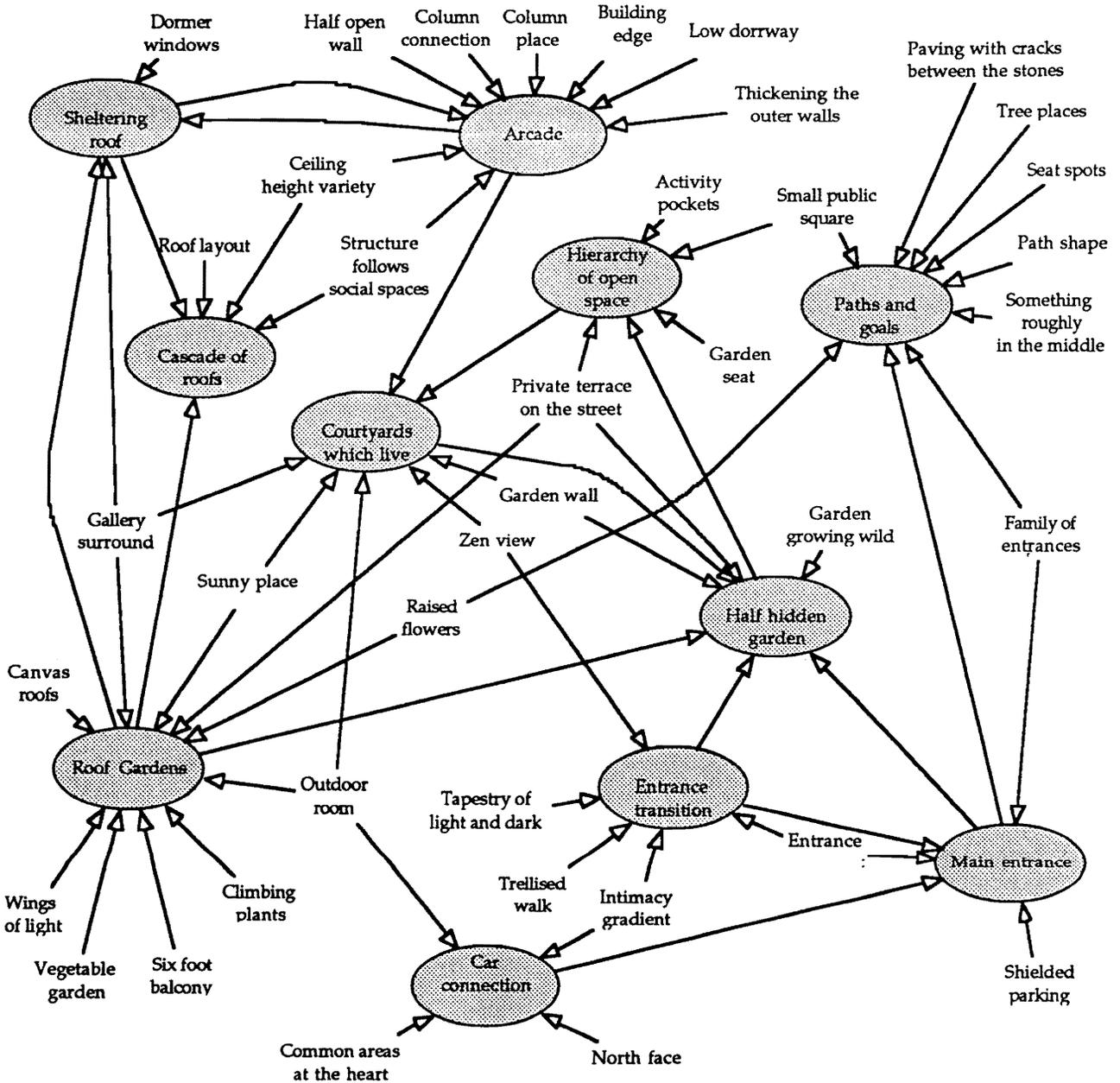


Figure 4-15: Alexander's network of associations

unexplored links removed automatically, so that the connections between frequently used areas are strengthened and the diagram adjusts itself to the way that the designer interacts with it. This, of course, is the great promise (largely unfulfilled) of hypermedia.

But to embrace digital technology as a medium in which to describe, explicate, and perhaps unify an area of study as broad, diverse, and controversial as a theory of architecture leads to another question:

What is the role of technology in a process that so drastically affects how we think and feel about ourselves and our environment?

When I began this work I was optimistic about my own abilities and the potential of digital technology to create a better medium for understanding and presenting a set of ideas related to schematic design. While I believe it is possible to develop automated tools to present the kind of theoretical information discussed by these authors, and perhaps even encourage and enable others to explore it and use it in a meaningful way, I believe that these tools will be useful only on a personal level. That is, the proper use of such tools will not be to produce designs, develop partial designs, or even measure the “correctness” of a design against some standard style guide of the kind mentioned by Norberg-Schulz. Rather, the only proper use of these tools would be to provide me, as an architect, another place to delve into the unconscious as I seek to the right form to wrap around the human need for shelter.

This view is a personal and philosophical one; I have no doubt that some of my colleagues in the software development world will exploit both an opportunity and a demand to produce software that purports to “design”. There are already low-end CAD packages on the market with names like *Expert Designer*; these packages, filled with a set of pre-defined elements, allow one to “design” a house in a sort of cookie-cutter fashion. Is that architecture? I don’t think that it is. In design, it is the sum of the architect’s vision and experience that can transform a natural space into a dwelling and a shelter for our dreams, not the digital patterns of pre-digested structures that have no connection to the *experience* of form and space.

The student workspace

What does make design a problem in real world cases is that we are trying to make a diagram for forces whose field we do not understand. Understanding the field of the context and inventing a form to fit it are really two aspects of the same process. It is because the context is obscure that we cannot give a direct, fully coherent criterion for the fit we are trying to achieve; and it is also its obscurity which makes the task of shaping a well-fitting form at all problematic.

Christopher Alexander

Notes on the Synthesis of Form

Overview

Student data was collected to provide a control group for the professional architects. By examining the workspace of students, it became possible to separate more clearly information and documents related to design and information and documents related to the requirements of managing a design business. Because students are engaged in design projects without the attendant work of running a business, it can be assumed that virtually all documents found in a student's workspace are related to the process of design.

The student data also provided insights into the organization of design documents. Students are able to use their entire workspace for design tasks, while the practicing architects that I observed had to share their workspace with business-related information.

Method

The student data was collected near the end of the fall semester, when students would be most likely to be deeply involved in completing design projects. This meant that there would not only be work in progress on their desks, but that it would be significant work and that it would also be visible (on the desktop).

I selected 25 desks from the Cowgill and Burruss studios, with the primary criteria that there had to be evidence of work in progress on the desk. Eight desks were selected from the third year student area, nine desks from the fourth year area, and eight desks from the fifth year area. I also tried to pick a variety of organizational schemes, which ranged from minimalist (very neat work areas with minimal items unrelated to work in progress) to extremely messy (poorly organized workspaces with many items not directly related to work in progress).

What was of interest to me was the kind of information (drawing, sketch, notes, etc.) and the mode of storage (rolled, stacked, in use, etc.) used during the design process.

I collected the data in three steps.

- A sketch was prepared of each workspace.
- Each item that was visible in the workspace was numbered on the sketch.
- A list describing each item was prepared.

Items stored inside closed containers were not counted, only the containers were counted. Footlockers are usually kept locked and usually contain high value items like power tools, expensive supplies, and personal items like portable stereos.

Stacks of papers were moved or sorted; when possible, I counted the number of papers or drawings in a stack, but many stacks were recorded as 'a stack'. It was usually evident what was in the stack even if I could not examine each item. All visually distinct items were counted. If several items were arranged as a group (a stack of papers, for example), the stack was counted, not the individual items in the stack. If items were arranged to partially overlap, or had some other structural organization (like a stack of papers, but with some obvious divider to separate chunks of items) then each chunk was counted.

Drawings, sketches, photos, models, and other visual and design-related information work were classified as "work in progress" or as "other work". There was no difficulty in discerning work in progress as it usually occupied a prominent position on the desk. Most often there was

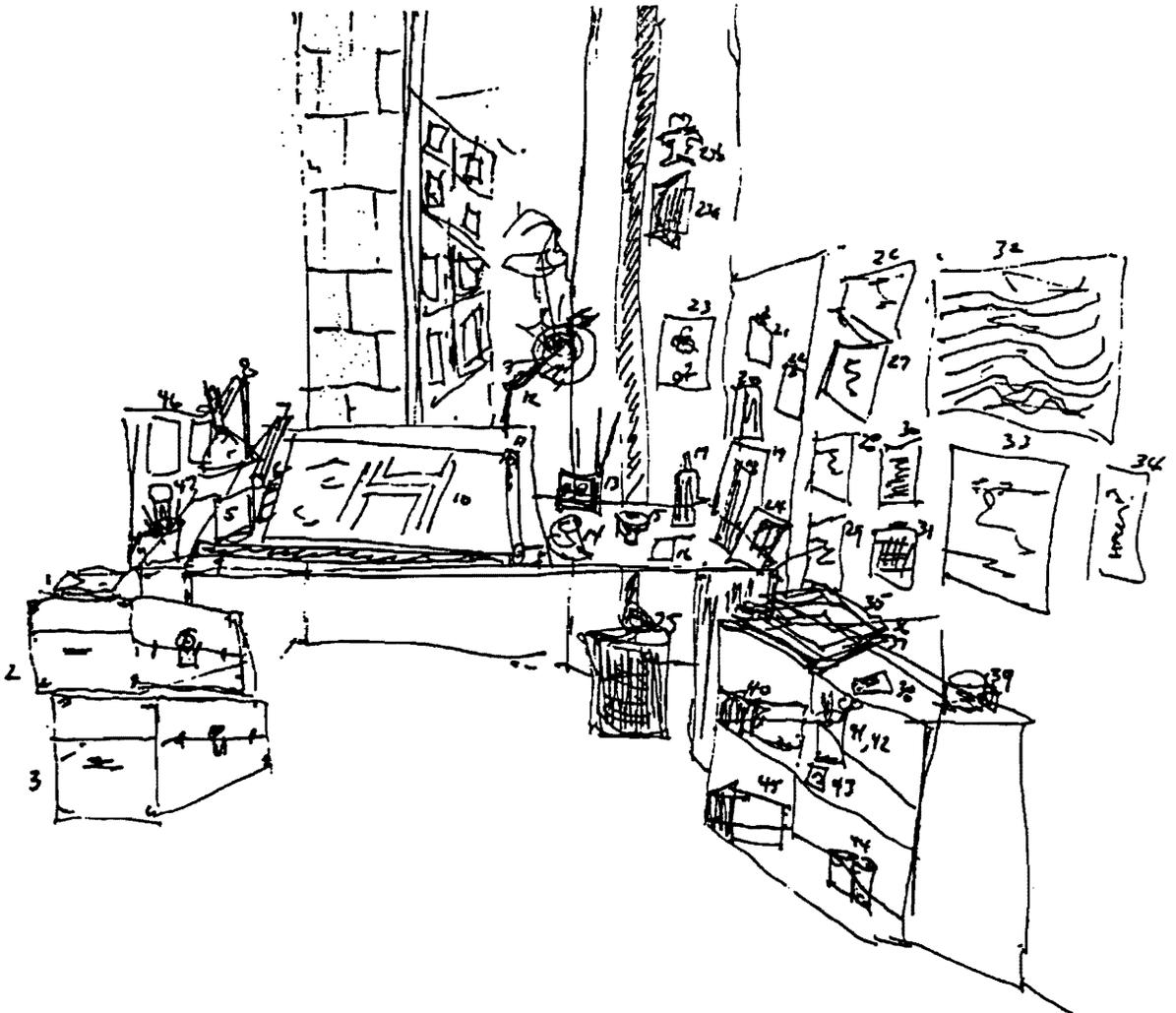


Figure 5-1: Student workspace #9

Table 5-1: Inventory of student workspace #18

Item	Description	Item	Description
1	gallon of developer (3)	29	pencil
2	footlocker	30	eraser
3	cardboard	31	pen
4	cardboard	32	brush
5	stack of sketches, wip, large, (11)	33	scale drawing, large, axon, wip
6	box of colored pencils	33a	scale drawing, plan, large, wip
7	box of colored pencils	33b	scale drawing, plan, large, wip
8	model	33c	scale drawing, plan, large, wip
9	model, wip	34	scale drawing, axon, large, wip
10	triangle	35	sketch, large, wip
11	triangle	36	photos (3)
12	template	37	text, notes
13	ruler	38	quotation
14	ruler	39	photo
15	drafting dots	40	cartoon
16	scale ruler	41	scale drawing, large, wip
17	scale ruler	42	bundle of drawings
18	pencil sharpener	43	bundle of sketches
19	mug of pencils (14)	44	roll of paper
20	drinking cup	45	roll of paper
21	block of wood	46	roll of paper
22	model	47	roll of paper
23	lamp	48	roll of drawings
24	parallel bar	49	3-ring binder, 1/2" of notes
25	model, wip	50	library book
26	scale ruler	51	spiral sketch pad
27	drafting tape	52	library book
28	triangle		

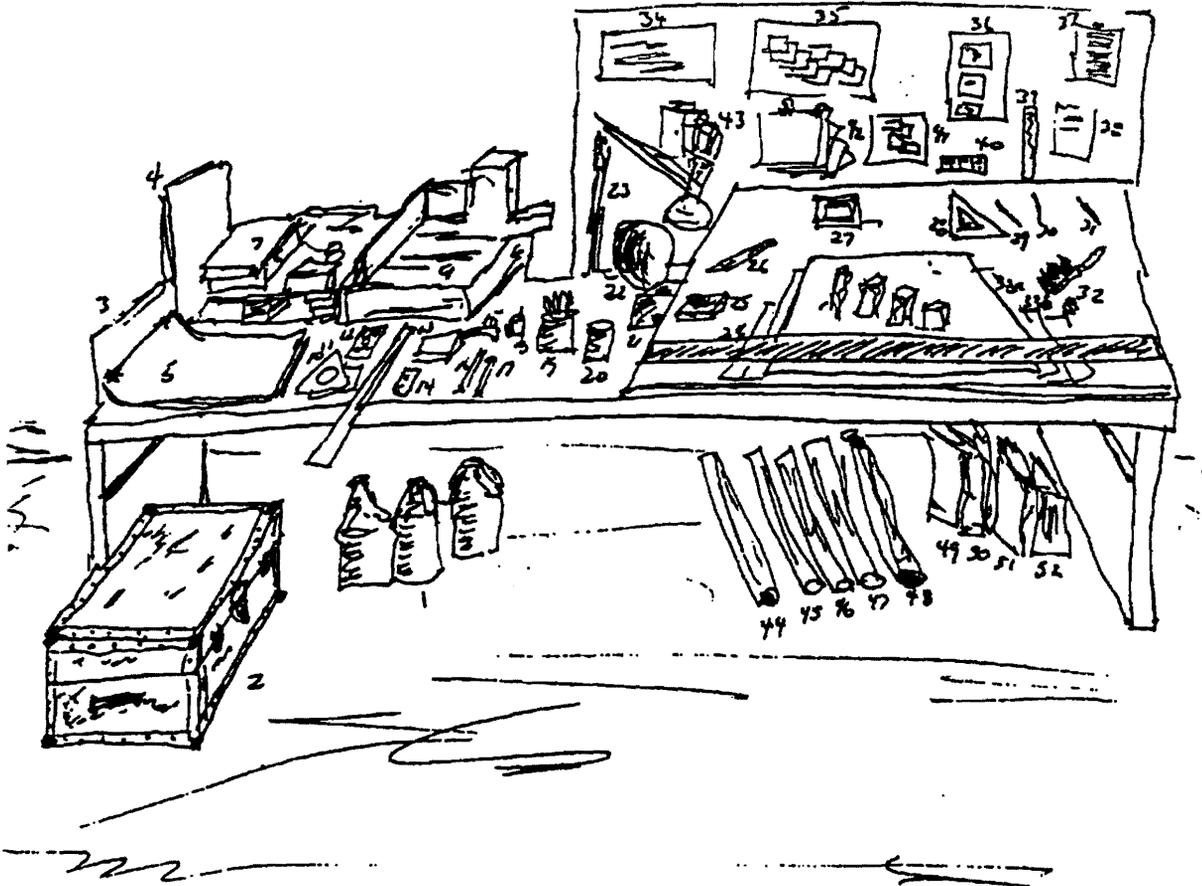


Figure 5-2: Student workspace #18

Table 5-2: Workspace inventory categories

Student workspace categories	Professional workspace categories
Work in progress	Work in progress
Other work and information	Other work and information
Drawing and design tools	Drawing and design tools
General tools and equipment	General tools and equipment
Drawing and design supplies	Drawing and design supplies

one or more drawings in progress on the table, and it was determined that other work and models in the workspace were related by visual inspection. A third category called "other information" was used to distinguish material that was not related to a particular design project. This included items like dictionaries, calendars, miscellaneous notes, class notes, and other mostly text-based information.

Inventory and analysis

The articles found in student workspaces were grouped into seven categories, based on their type and apparent purpose. Table 5-2 compares the categories used for students and the equivalent categories used for the items found in professional workspaces (discussed in detail in Chapter 6). A complete listing of the entire student data set is contained in Appendix A.

Work in progress consisted of drawings and sketches of various kinds, followed by models, parts of models, class notes related to the drawings, and photographs related to the drawings and sketches. Because it was the end of the semester, it was easy to discern work in progress; most desks had a drawing taped down, with several other drawings close by or pinned up vertically. Visual inspection was used to decide what documents were related to the central item or items.

Other work and information was a catch-all category for information items that were not related to the work in progress. Typically this included drawings and sketches not in use (stacked or rolled), notebooks, boxes of photographic slides, and miscellaneous notes and books.

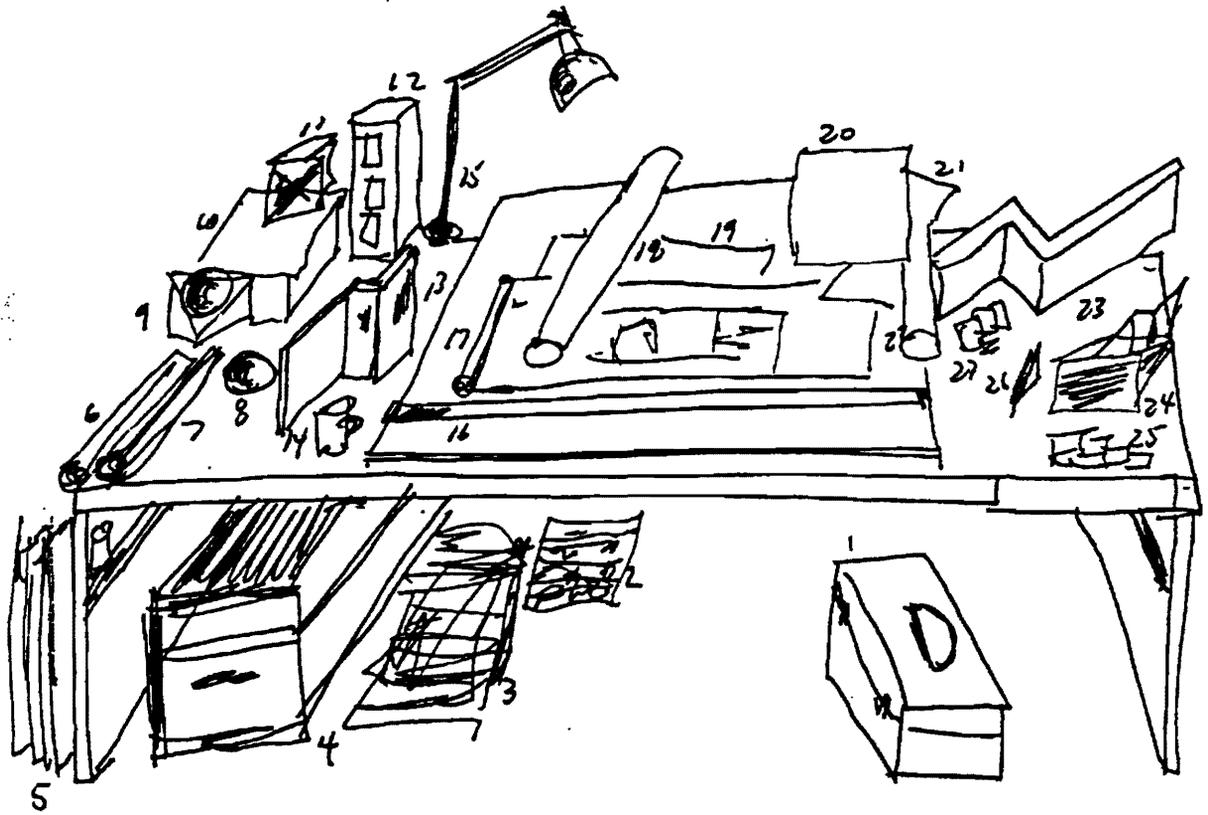


Figure 5-3: Student workspace #15



Figure 5-4: Student workspace #21

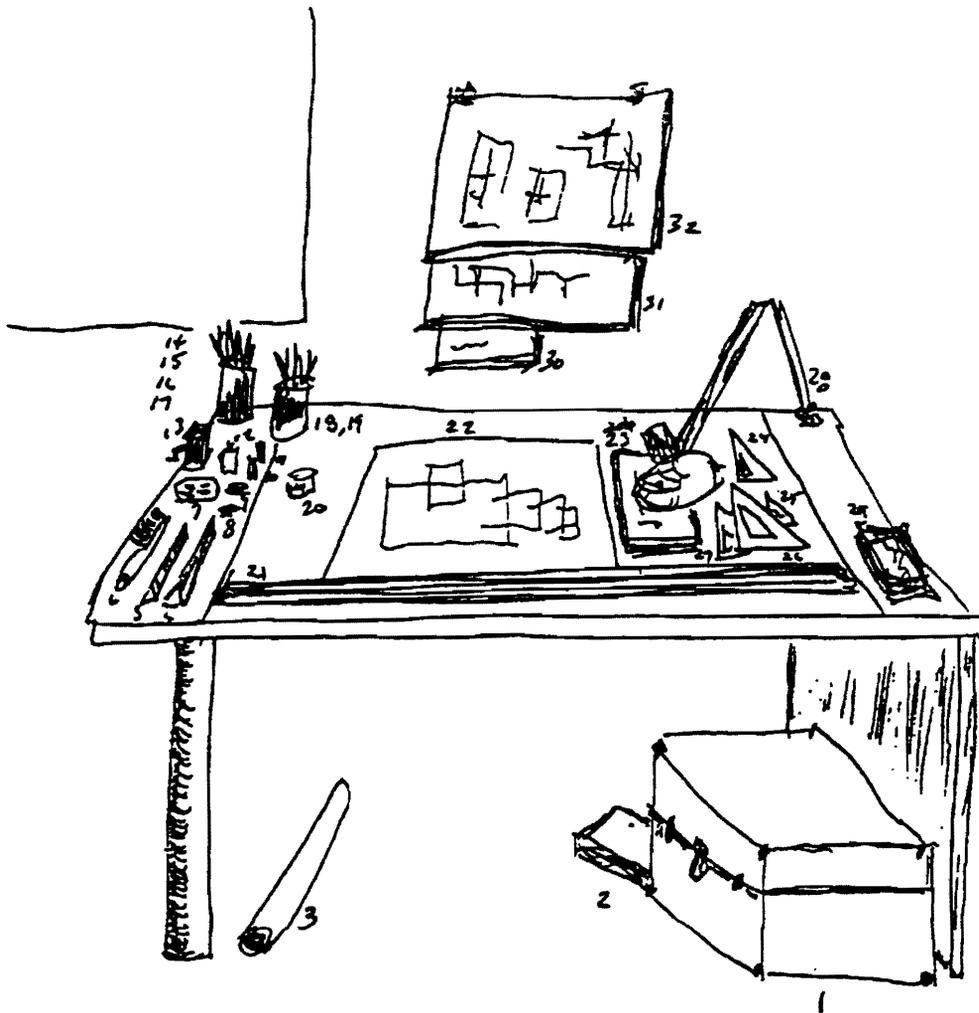


Figure 5-5: Student workspace #23

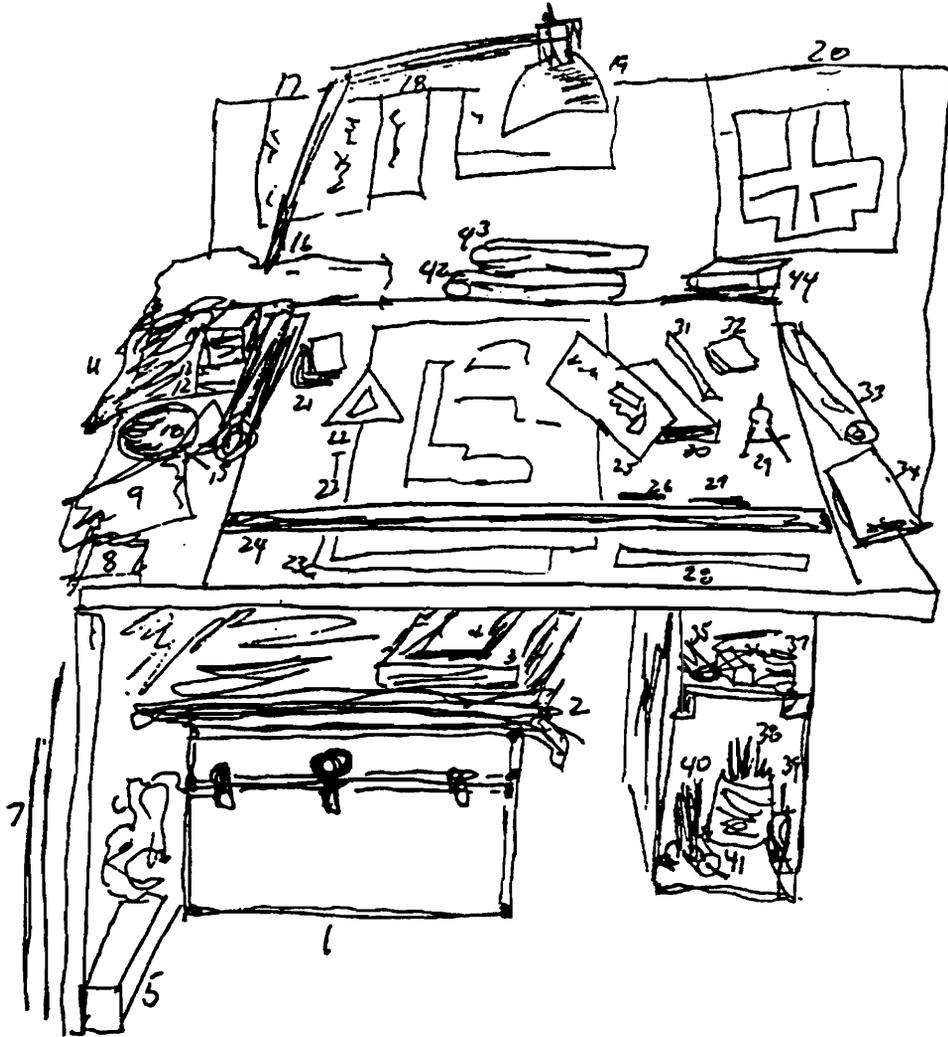


Figure 5-6: Student workspace #25

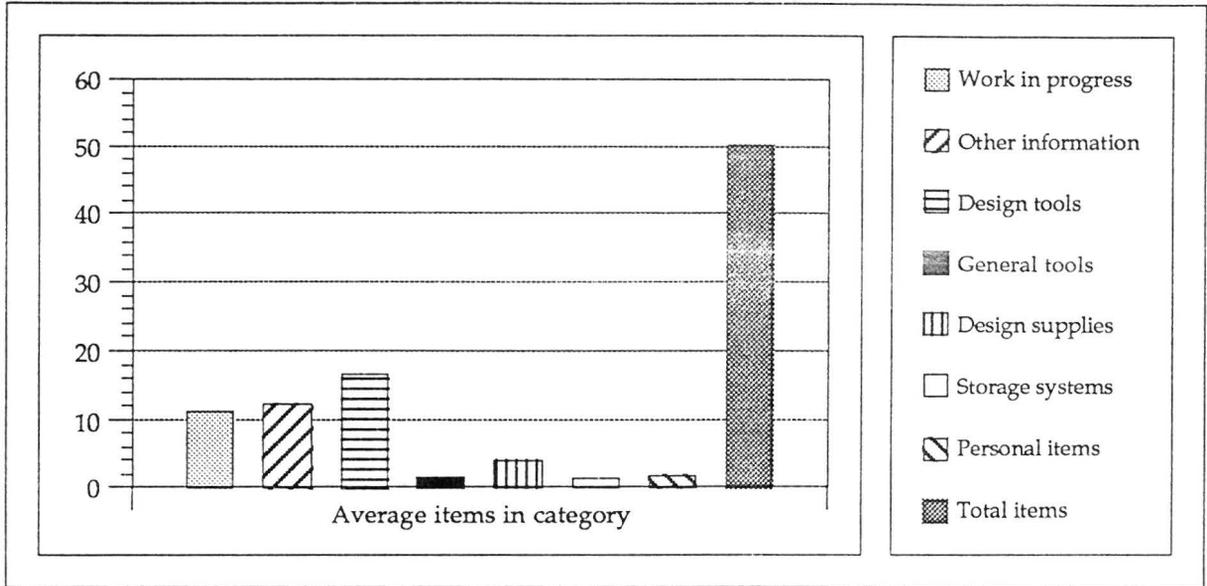


Figure 5-7: Average number of items in each category

Drawing and design tools included a full range of tools needed to develop visual information. The only item used by nearly every student (24 of 25) was parallel bar, reflecting the importance of this tool for routine drawing tasks. Pencils, pens, erasers, cutting tools, and pencil sharpeners are some of the other common items found. The frequency with which items in this category appear are not likely to be representative of their actual use because of the theft problem in Cowgill. Many students keep most tools and supplies locked in a storage chest or foot locker. With a sample of 25 students, the list of items does reflect the range of items commonly used.

General tools and equipment is a small category for items related to work but not associated with drawing and design tasks directly. Most students had a lamp, and some also had a wastebasket.

Drawing and design supplies are the raw materials of the design process; blank paper, vellum, poster paper for sketches, tracing or layout paper (also used for sketches), and cardboard and wood for models.

Storage systems ranged from foot lockers, which were owned by nearly every student (18

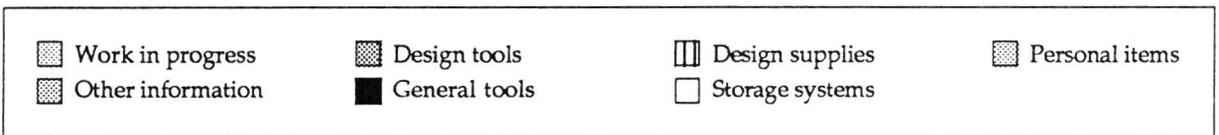
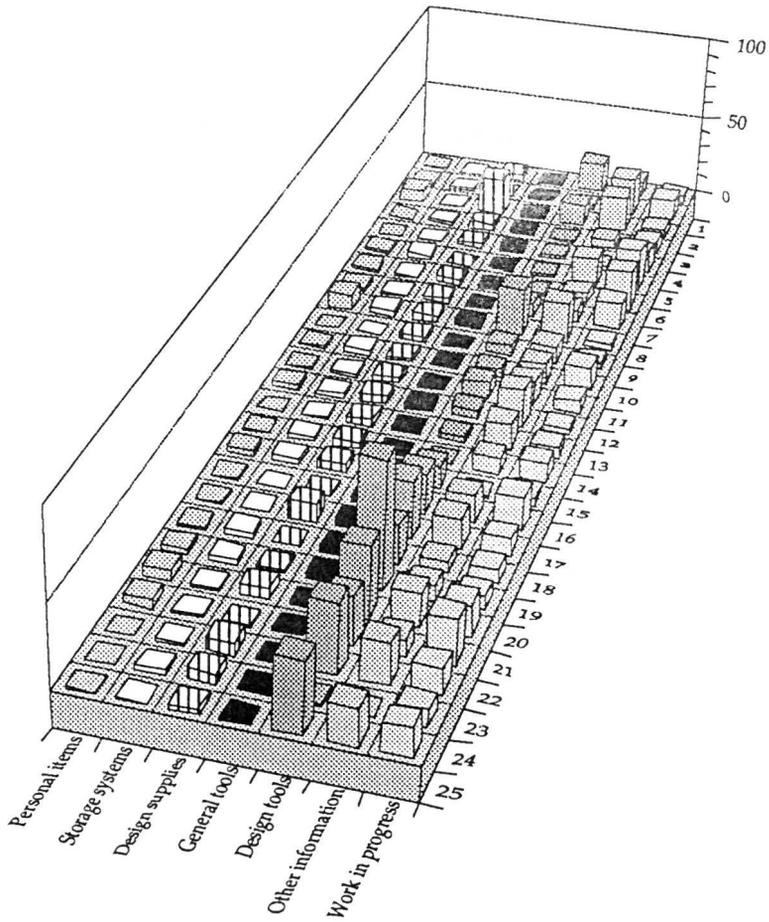


Figure 5-8: Distribution of items across all students

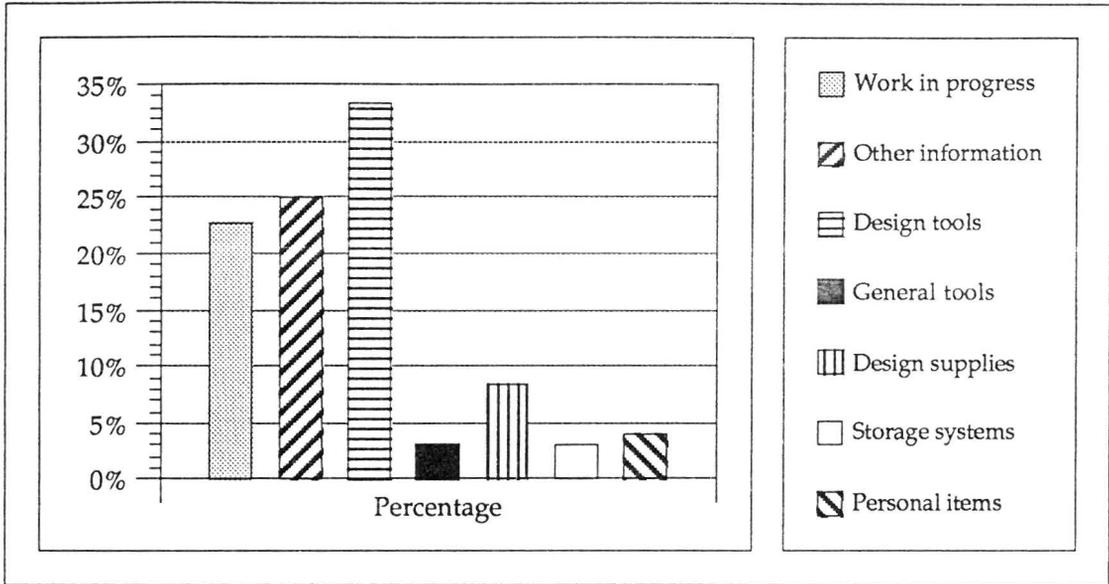


Figure 5-9: Percentage of items in each category

of 25) to toolboxes and coffee cups, which were used to hold pencils and pens.

Personal items were not widely evident, perhaps again in part due to the likelihood of theft in the building. Coffee mugs and drinking cups were found frequently.

Figure 5-7 shows the distribution of items across all students. The first three categories (work in progress, other work and information, design tools) account for most of the items found in student workspaces. The other four categories (general tools, drawing and design supplies, storage systems, personal items) account for only about 20% of all items. Figure 5-8 shows the average number of items found for students (about 50 items).

Figure 5-9 reflects the same distribution expressed as a percentage of the total items counted. Work in progress and other work are approximately equal. Student workspaces are used as a place of habitation that is often difficult for non-Cowgill inhabitants to understand; as such, these workspaces serve multiple functions, including providing archival space for finished work. Stacks of papers, rolls of drawings, finished models, and parts of models were found in every workspace.

Design tools accounted for the single largest category with 33% of the average items. Given the students intense focus on the production of sketches, drawings, and other visual information,

this hardly seems surprising. Had the contents of the foot lockers been accessible, this category would have increased drastically, since the lockers essentially represent a storage and supply room for students.

When compared to the distribution of items used by professional architects (discussed in more detail in the next chapter), there are several differences worth noting. The largest set of items used by students is design tools, while this category ranked third among professionals. This translates into students having about a third more design tools than professionals. Given that students that are able to focus almost entirely on design tasks, this does not seem unusual.

Surprisingly, the percentage of work in progress items across both groups is almost identical (about one-quarter of the items found on the desk). This changes if one looks more closely at the individual items in this category; among students, work in progress was almost entirely design drawings and sketches. Among professionals, nearly half of the work in progress items are business-related (contracts, faxes, letters, transmittals, etc.).

In three other categories (design supplies, storage systems, and personal items) distributions for students and professionals was similar. None of those categories accounted for more than ten percent of the total items stored on the desk in either group.

The professional workspace

I contend that the purpose of computers is human freedom.
And the better world we must have will be one in which
computers make life simpler, not harder, allow us to tie
together our work and have control of it, and bring us clarify-
ing overviews and understanding of everything we see and do.
Whereas right now, computers are still quite the opposite.

Ted Nelson

On the Xanadu Project

The study of professional workspaces was aimed at trying to discern the kind of information that affected the process of design in the early stages. As the work progressed, however, two things became clearer.

- ❑ In a professional office, the act of design is strongly interwoven in the fabric of the work required to run a business. Teasing useful information about design out of that tightly woven fabric was potentially a life's work.
- ❑ The longer I watched the architects in my study at work, the more it became apparent that there were more urgent problems in their professional practice than better and/or automated tools for the early stages of the design process.

The moment of revelation came near the end of the first week at New Design; I was finishing up an interview with Kevin, the owner of the firm. He had asked me to try to explain again what it was I had hoped to accomplish in my stay there, and I launched into my usual canned speech about my interest in the early stages of design and how I thought it might be possible to

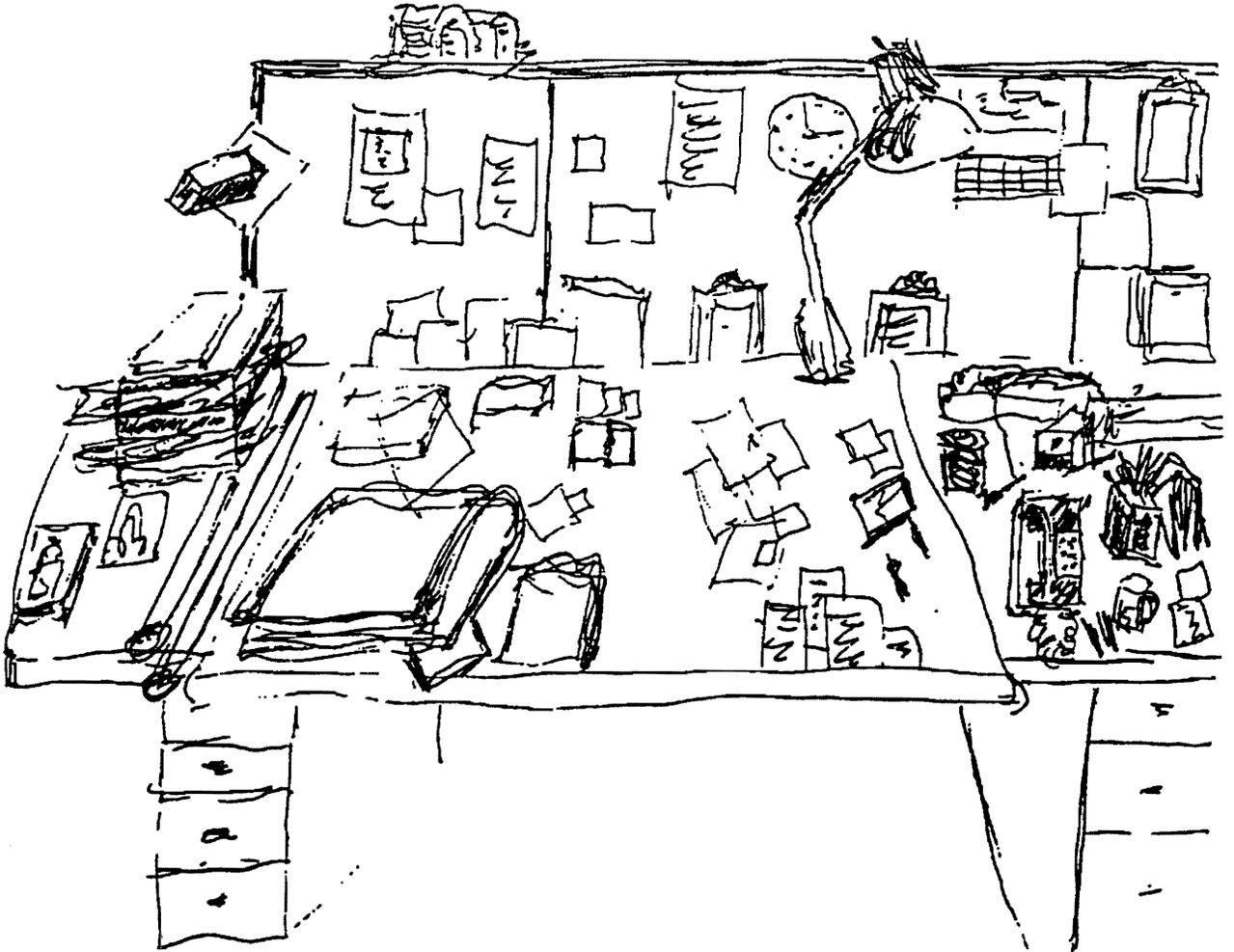


Figure 6-1: New Design—Kevin's workspace

design automated tools to aid in that process. I summed up my goals rather grandly with the statement, “Wouldn’t it be great if these new tools would let you spend half your day doing design work?”

At that, Kevin chuckled sardonically; “Andrew, you know, on a good day, if I’m really, fortunate, I might get to spend 30 minutes a day actually doing design work. The rest of the time is spent on things I don’t really want to do: answering the phone, making phone calls, talking to other people in the office, and worrying about what I have to do to keep the business of three or four projects moving.”

He paused briefly here, and smiled again. “If you could give me just 30 additional minutes a day to do design work, it would change my life”

With that, he excused himself and returned to work. I sat, thunderstruck by the remark. It was near five o’clock; I cleaned up my notes and books and left the office. I walked home, thinking about that remark, and spent several hours that evening walking around town, trying to sort out just what I needed to do to reconcile my original goals with what Kevin had pointed out. On one hand, the thirty extra minutes he had asked for seemed like a small thing, until I put it into perspective: delivering to Kevin those thirty minutes would *double* the time he spent on design, and I began to see how important thirty minutes could be to him.

With just two sentences he had humbled me completely. I came to see that my original goals, while lofty, had little to do with the reality of professional practice in a small office. What was needed were tools that aided architects in the management of their business; until this goal was met, it would not matter at all what kind of design tools I might deliver to Kevin—he would not have the time he needed to use them. And understanding this made all the difference; I returned to the office the next day with new energy and vigor, resolving to change focus and look at the management of design projects, with the hope of learning what kind of tools might be needed.

It was at this point that I added the additional data collection task of examining project files. In the New Design office, I asked to review their project files of completed work, and finally selected five projects of various sizes. For each project, I looked at the papers, notes, and drawings that had been archived in files folders. I tried to categorize this information by type and quantity. By the time I began my second study at Design Futures, I was even more convinced of the rightness of my new approach and scrutinized five more design projects in detail.

Method

The professional workspace data was collected during normal work hours at both New Design and Design Futures. I picked times when the architects were out of the office so that I would not disturb them, as it took about an hour to make the sketches and notes of the work area. I also picked a time when there was clearly some work in progress, rather than at time they might be in transition between projects or at some other time when the 'normal' clutter of work might not be evident (like a Monday morning or a Friday afternoon).

At New Design, I collected data on the areas listed below. The names of all the architects have been changed to protect their privacy.

- James—owner and principal, an architect with twenty-five years work experience.
- Louise—architect; ten years work experience
- Daniel—architect; ten years work experience
- Thomas—architect; eight years work experience

At Design Futures, I collected data on the following areas:

- Michael—principal and owner of his own firm; shared office space with Design Futures. Forty years experience.
- Larry—architectural student working as a draftsman and designer for Michael. Two years part-time experience.
- Philip—principal in the firm; twenty-five years experience.
- David—principal in the firm; twenty years experience.

What was of interest to me was the kind of information (drawing, sketch, notes, etc.) and the mode of storage (rolled, stacked, in use, etc.) used during the design process.

I collected the data in three steps.

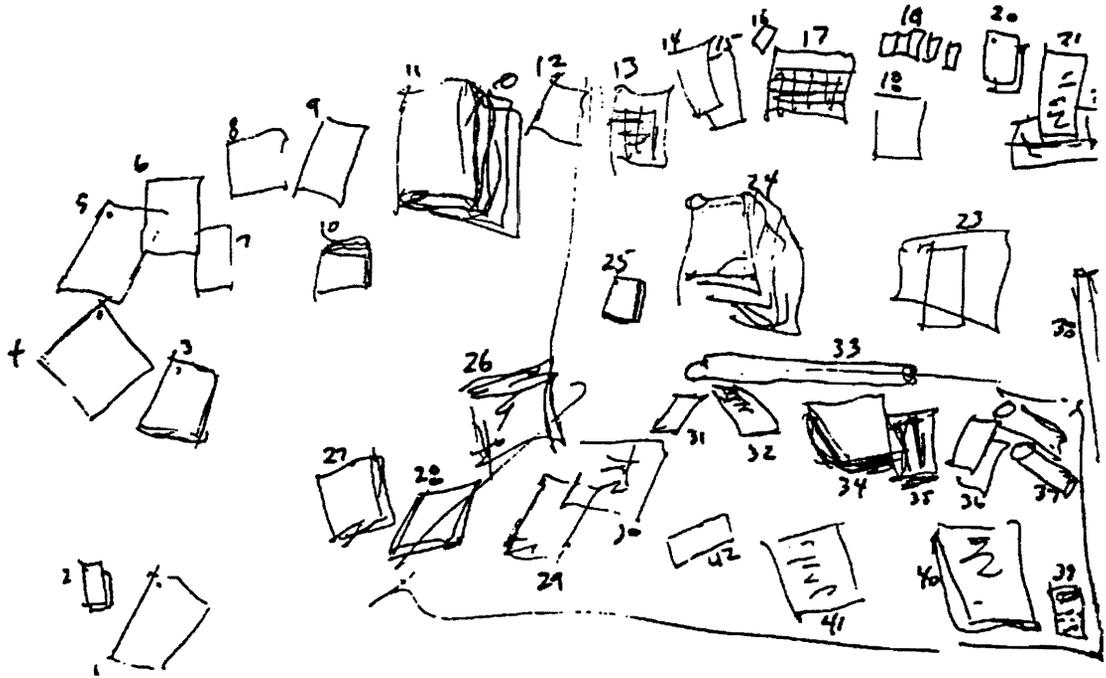


Figure 6-2: New Design-Daniel's workspace, abstracted to delineate documents

Table 6-1: New Design-Inventory of Daniel's workspace

Item	Description	Item	Description	Item	Description
1	time/job sheet	16	business card	31	box of slides
2	business card (2)	17	calendar	32	drawing supplies
3	computer cheat sheets	18	blank labels	33	roll of blueprints
4	blueprints	19	business cards (3)	34	notes on renovation job
5	spec sheets	20	film mailers	35	small notebook
6	note on job estimate	21	mylar name labels	36	photocopies of blueprint
7	letter	22	photograph	37	rolls of overlay paper (2)
8	job quote	23	sketches (2)	38	photocopies of beach house
9	contractor list	24	sketches on overlay (10)	39	calculator
10	photographs	25	phone call notes (10)	40	spec book for concrete
11	drawings on overlay paper	26	folders for renovation project	41	pad of transmittal forms
12	list of names/jobs	27	product catalogue	42	Post-it™ note pad
13	calendar	28	sketch book	43	two drawer filing cabinet
14	contractor list	29	project design specs from client	44	parallel bar
15	transmittal	30	floor plan sketch	45	paper holder

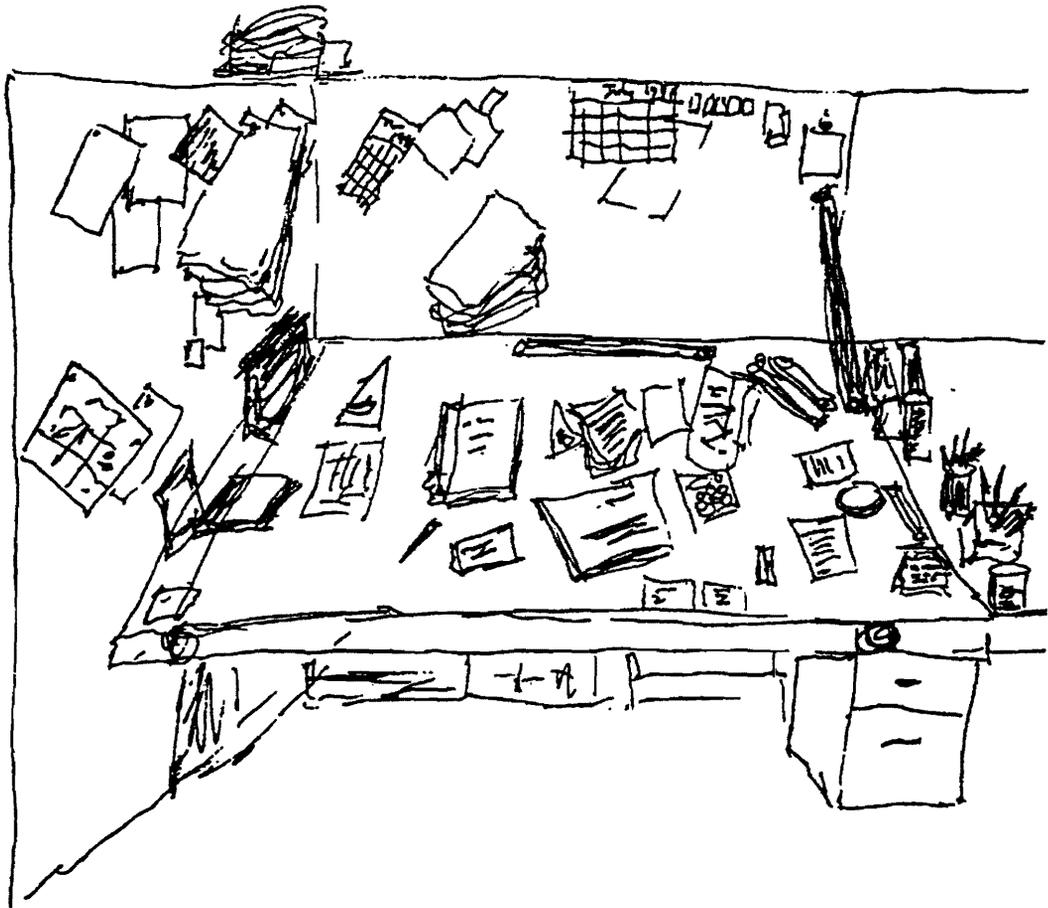


Figure 6-3 New Design-Daniel's workspace

- ❑ A sketch was prepared of each workspace.
- ❑ Each item that was visible in the workspace was numbered on the sketch.
- ❑ A list describing each item was prepared.

Items stored inside closed containers were not counted, only the containers were counted. If drawers or other under desk storage areas were open or otherwise accessible I would make note of the contents. I did not otherwise disturb closed drawers or other boxes and containers, as I viewed it as an invasion of the designer's privacy.

Stacks of papers were moved or sorted; when possible, I counted the number of papers or drawings in a stack, but many stacks were recorded as 'a stack'. It was usually evident what was in the stack even if I could not examine each item. All visually distinct items were counted. If several items were arranged as a group (a stack of papers, for example), the stack was counted, not the individual items in the stack. If items were arranged to partially overlap, or had some other structural organization (like a stack of papers, but with some obvious divider to separate chunks of items) then each chunk was counted.

Drawings, sketches, photos, models, and other visual and design-related information work were classified as "work in progress" or as "other work". There was no difficulty in discerning work in progress as it usually occupied a prominent position on the desk. Most often there was one or more drawings in progress on the table, and it was determined that other work and models in the workspace were related by visual inspection. A third category called "other information" was used to distinguish material that was not related to a particular design project. This included items like dictionaries, calendars, miscellaneous notes, class notes, and other mostly text-based information.

Workspace inventory

The items found in workspaces have been grouped into seven categories, based on the type of article and its intended purpose. The categories for both the student data and the professional data are similar, as noted in Table 5-1 in the previous chapter. A full listing of all items in the inventory of all subjects can be found in Appendix B.

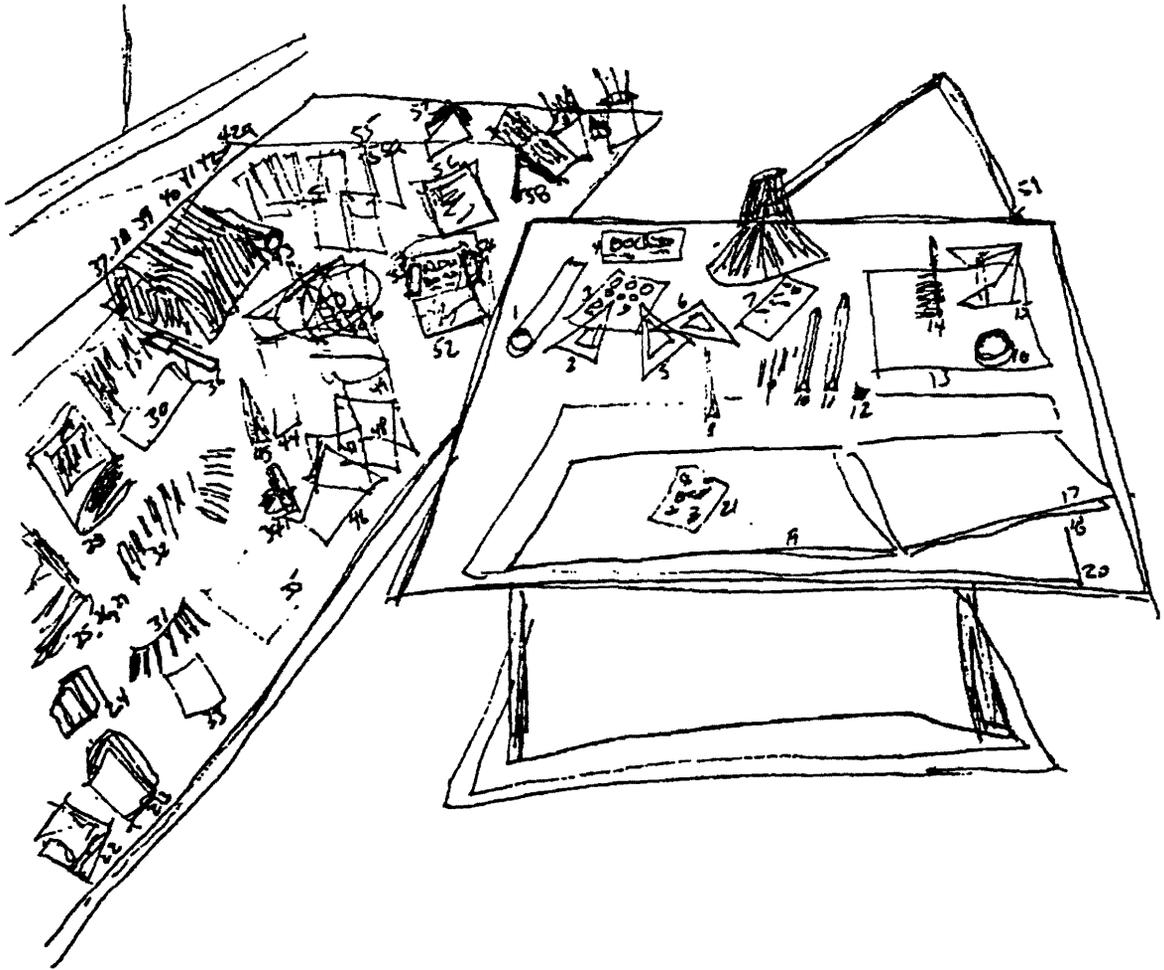


Figure 6-4: Design Futures—Michael's workspace

Work in progress items were drawings, sketches, and other visual information related to the current project. While I had to use visual inspection to determine which items should be classified as work in progress on student desks, for the professional architects I could simply ask if it was necessary. The professional workspaces, not surprisingly, were much more neatly arranged than most of the student workspaces. While they were often cluttered, the architects rarely had the random piles of unused items and drawings that were often in evidence on student desks.

Other work and information included all information items in the workspace that were not included in the previous category. This included contract paperwork, product catalogues and samples, price lists, magazines, books, transmittals, letters, and many kinds of less formal information, chiefly notes of various kinds (phone notes, Post-it notes, memos). Phone notes were the most common item on desks, appearing on 6 of 8 desks, and also showed up most frequently (43 times). When combined with the plain notes category, (22 notes on all 8 desks), it becomes clear that small bits of information play an important part in the daily routine.

Drawing and design tools showed much the same range of items that were found on student desks: pencils, pens, erasers, and cutting tools. Again, every single architect had a parallel bar on his or her drawing table. The student data showed more different kinds of items in higher frequencies, probably because students did not have to share their workspace with the business information found in the architect's workspaces, so students are able to keep more design related materials at hand. At Design Future, where they had more side tables at each workspace, many more items were visible, in contrast to Design Futures, where space was at a premium.

General tools and equipment included items like blank note and phone note pads, lamps, telephones, and other common items.

Drawing and design supplies was a very small category. Both firms had a well stocked supply room adjacent to the work area, so there was little need to keep items like vellum and blank paper at the desk. Another reason is that most of the time, the architects were not drawing but working on business-related information, unlike the students who could spend much more time drawing since they had no business-related information at all.

Storage systems were very similar to those used by the students, with the exception of the complete lack of footlockers, since the office space itself could be secured from public access, unlike Cowgill. Filing cabinets took the place of foot lockers, holding business information instead of tools and drawing supplies.

Personal items were less evident at the workspaces than at student desks. At New Design, there simply was no extra space for luxuries like personal items, but even at Design Futures,

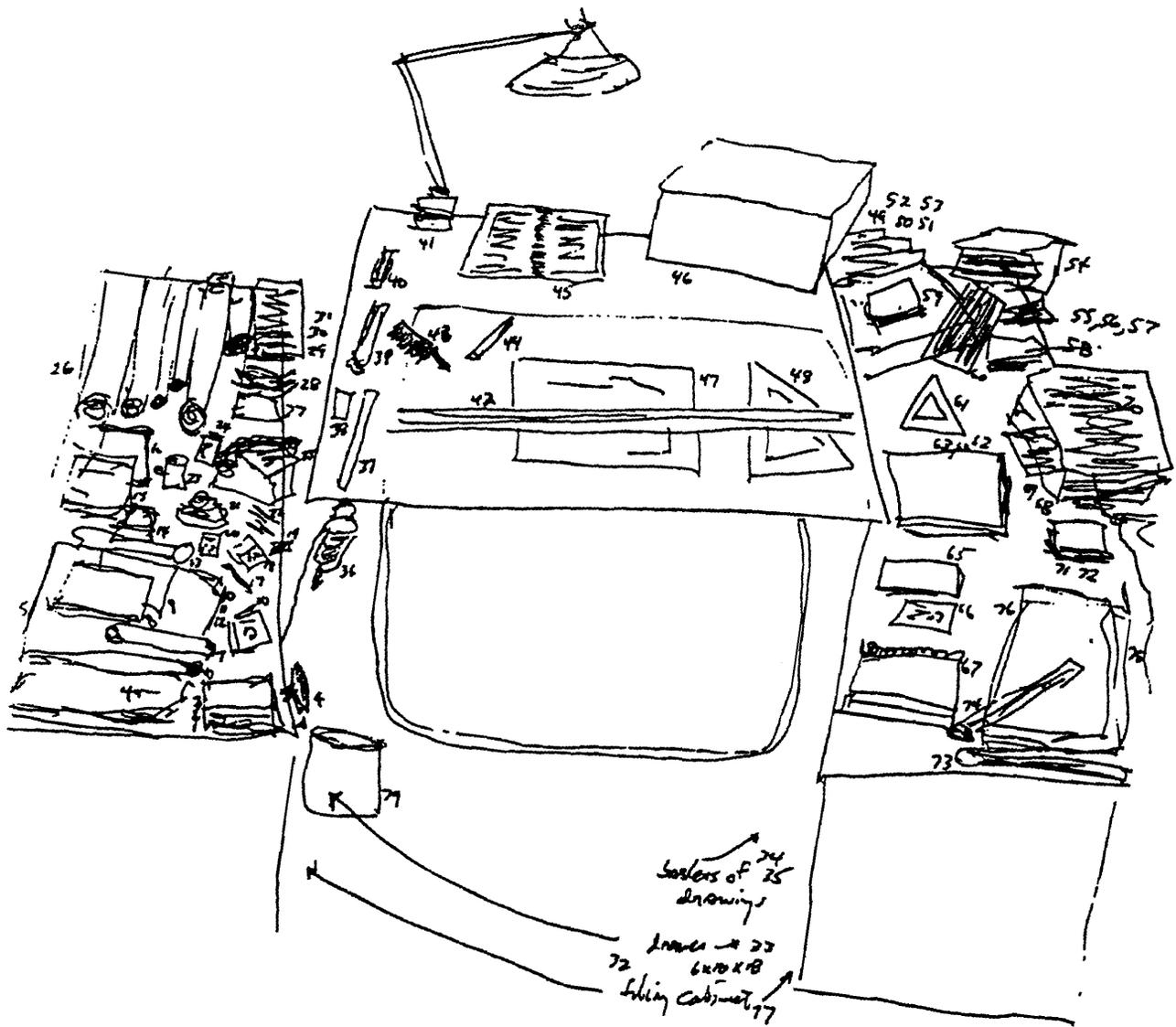


Figure 6-5: Design Futures—David's workspace

where space was not necessarily a limiting factor, few personal items were in view.

Table 6–2 shows the item count for each category, by architect. In Figure 6–6 below it, the item count total for each category is compared; business items, for all architects in the study, represent nearly 40% of the items found on desks. This is higher than any other category, and when combined with work in progress (drawings and sketches) paper documents represent about two-thirds of the total of all items. The other five categories (office supplies, drawing and design tools, drawing and design supplies, storage systems, personal items) appeared on desktops with much less frequency. Notes of all kinds accounted for about a third of all the items found on the desk. It is interesting that an unstructured, form-free information type plays such an important role in information storage and retrieval (for professional practice).

Figure 6–8 compares the count of work in progress items with business-related items. Five of the eight architects had more business items on their desk than drawings and sketches, and four of those five professionals would be considered the senior architects or principals in the firms.

Only drawing and design tools was above 10% of the items found, and this can be attributed mainly to the large variety of drawing tools (pens, pencils, color pencils and color markers) that most of the architects kept near their desk. Michael, who used color extensively in his drawings and sketches, had half the items in his workspace in the design tools category, and 75% of the 59 tools counted were pencils and colored markers.

When talking to the architects about their work, the telephone came up again and again as the tool that held their business together. Everyone in the New Design office had a handwritten list of telephone numbers on their desk, as well as Michael in Design Futures. Kevin also talked specifically about the fax machine on two different occasions as indispensable. He even used it on one occasion as a design tool, faxing designs back and forth between the office and a client office as a new building was discussed.

Figure 6–7 shows a bar chart illustrating the percentage of notes of all kinds as a percentage of all business information. The three kinds of notes (phone notes, and Post-It notes) were combined because different architects used different notes in the same way. In the New Design office, the standard pre-printed phone note pads (While You Were Out) were used for phone notes; in the Design Future office, Post-It notes were used for notes of all kinds, including phone notes. Not included in this count are the stacks of notes that some architects also had on their desks.

Table 6-2: Summary workspace data

	Daniel	Louise	Kevin	Thomas	Michael	Larry	Phillip	Don	Totals
Work in progress	50	20	11	38	7	16	17	44	203
Other work and information	33	21	71	49	33	8	48	45	308
General tools and equipment	7	3	7	5	11	2	9	15	59
Drawing and design tools	12	4	9	7	59	33	12	36	172
Drawing and design supplies	2	1	0	0	1	8	4	0	16
Storage systems	2	3	3	3	0	0	6	10	27
Personal items	0	0	2	2	0	0	3	3	10
Total	106	52	103	104	111	67	99	153	795

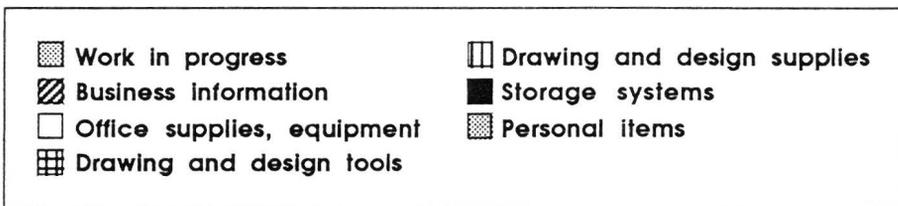
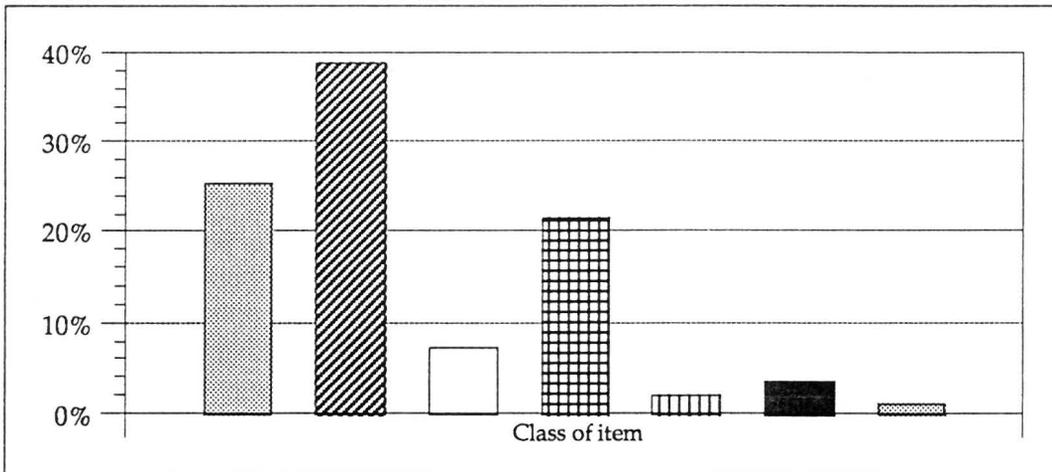


Figure 6-6: Distribution of items on the desktop by category

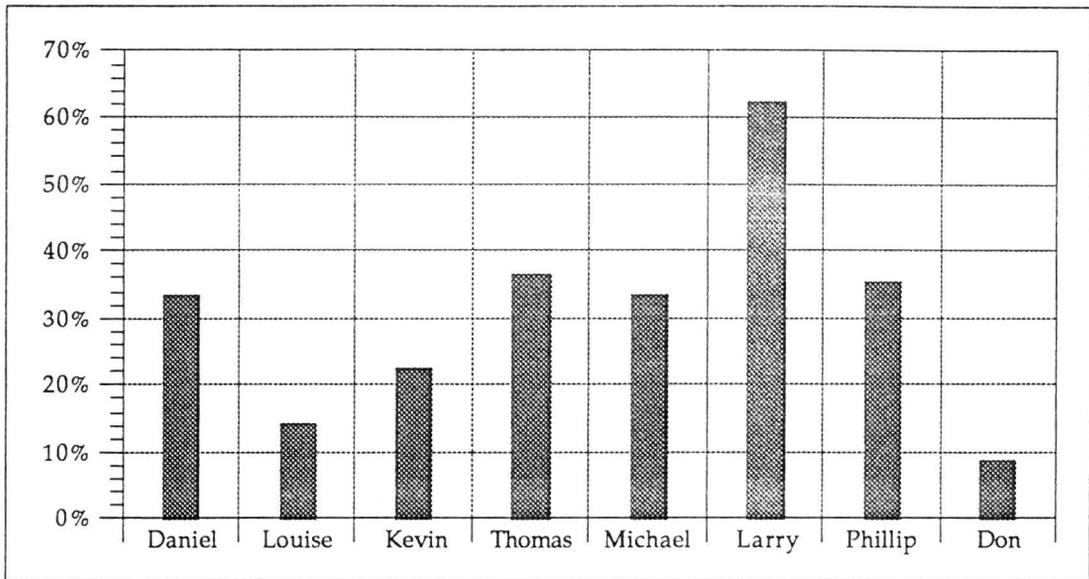


Figure 6-7: Notes of all kinds as a percentage of business items

Notes from the field

New Design

My visit to the New Design office took place during the summer of 1991. I spent two full weeks at the firm, which is located in the Washington, D. C. metro area. All the names of the subjects have been changed to protect their privacy. The name of the firm has also been changed.

When I began my work there, I had just completed my pre-study just a few months before and was still focused on the early stages of design. As I noted earlier in this chapter, it was during my stay at New Design that I realized that I needed to change the way I looked the office activities and what they meant.

(7/1) Space is at a premium here; the main office is about 20' x 30', with a small conference room, a *very small back room with space for two (very cramped)*, and a bathroom. Kevin works here with five other people, plus a secretary. This week two graduate students are here to help out on some beach

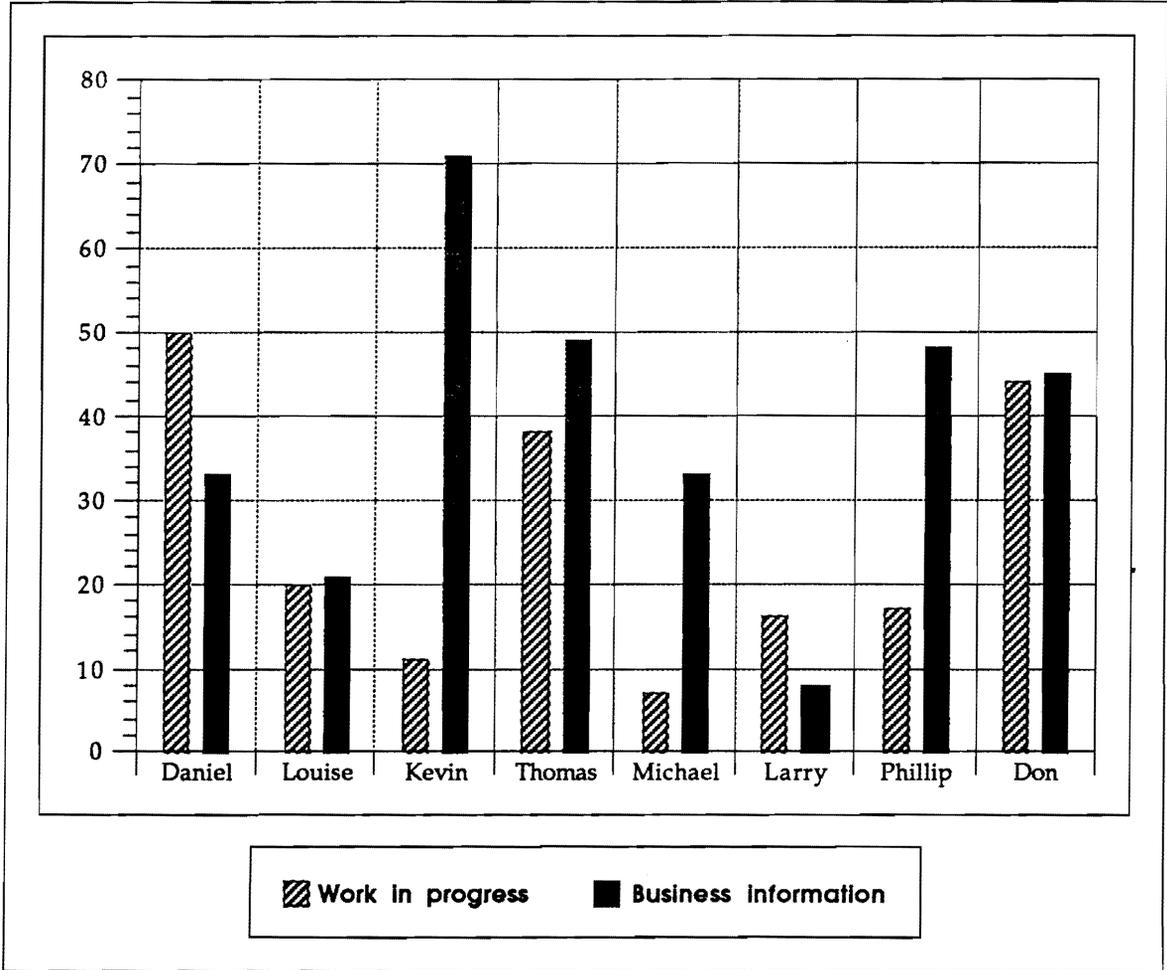


Figure 6-8: A comparison of work in progress (drawings, sketches) with business items

house designs.

There are four computers here, and this morning they figure prominently in the work. The Sun workstation crashed over the weekend, and they need the machine to complete some work. Thomas is on the phone trying to get instructions on how to reconfigure the Sun to work properly. There are two Macs, but the hard disks are completely full on both of them, so files have to be removed and/or archived to make room to store new work. Kevin has a very old IBM personal computer at his workspace which appears to be used just for correspondence.

I'm sitting behind and to the left of Kevin's workspace, and his area is covered with papers that seem to have more to do with running a business than design.

I had put off the visit to New Design for several months because Kevin kept telling me that they had no work and that there would be nothing to 'see'. After talking it over with my advisor, I decided not to put it off any longer and I told Kevin that I wanted to come up in early July. He agreed, and on the day I showed up everyone there was in fire-fighting mode. The office was crammed, with work laid on every horizontal surface available. With the two extra workers there was really no place for me to sit, so I perched on a folding chair in the corner. By 10 o'clock I was thinking it was going to be a long two weeks.

(7/1) Information is everywhere in this office; one whole wall is filled with reference books—mostly binders that contain detail on building components. All of the work surfaces are supported by bookcases that hold more books and binders. None of it is in use right now; Louise, Thomas, and Daniel are all completing final drawings for an office renovation.

I was exhausted by the end of the day. I was reminded of those scenes of the floor of the stock exchange, where everyone is milling around waving their arms and screaming at the top of their lungs. I had worried about making my subjects self-conscious with my presence, but the pace here was so terrifically busy that no one had paid the slightest attention to me. I wondered how I would ever get anyone to sit down for the formal interviews I had planned to do. I spent the evening mulling over what to do.

By the next morning, I had decided that if I was truly conducting a phenomenological study, then what I needed to do was to participate more actively in the life of the office. As soon as I arrived at the office I told Kevin that I wanted to help out, and asked what I could do. He was reluctant at first to take advantage of the free help, but I continued to press him to let me do some work, however menial, and he finally relented.

My first job was to help the secretary, Chris, sort out eighty-five sets of D size drawings and

specifications for an upcoming bid. Numbering the drawings was especially tedious because each set had to unrolled, numbered, and then rolled back up. One of the architects would have had to do the work if I had not volunteered to do it, and they seemed grateful for the help. A steady stream of builders and contractors flowed in and out of the office all day to pick up their copies of the documents. For the first couple of days the people in the office had been polite but distant to me, but after tackling this task I noticed that they immediately became much warmer towards me. Chatting with them became more casual and routine, and they began to ask me questions about my work.

I saw this change in attitude as a validation of the hermeneutic method; by making myself part of the office and doing some of the work that they had to do, I became more like them, rather than the Ph.D. student doing "research" as if they were some exotic species of laboratory rats.

(7/3) For the past two days I have kept myself busy with clerical tasks around the office. I re-arranged the supply closet, which took a good half day; it had not been cleaned up in some time, and I carefully cleaned every shelf, threw out obsolete forms and supplies, sorted materials by category, and managed to create a good bit of space in a formerly over-crowded closet.

I also sorted and straightened the supplier catalogues, which take up a set of shelves six feet high and fifteen feet long. They too have not been sorted in a long while, and Kevin indicated that much of the material was obsolete, but that he needed to determine which could be discarded himself, so I had to limit my activity to putting catalogues away and putting them in order. There were still catalogues on the floor when I was finished, but at least they took up less space and looked a bit neater.

New Design, like most architectural firms, subscribes to Sweet's, the industry standard catalogue of building components. The Sweet's catalogue comes in about sixteen volumes that occupies about three feet of shelf space, and is updated yearly. Both New Design and Design Futures, in addition to Sweet's, had hundreds of three ring binders from individual suppliers that contained even more detail than Sweet's. This information was used in the preparation of specifications for design projects, and much of the data was lifted out verbatim and inserted directly into the specification. In both offices, this information was copied or typed out by hand into the spec.

But in both offices I noticed that Sweet's included as part of the subscription a CD-ROM that contained much of the same information in the books, with the advantage that any boiler-plate text that someone wanted to insert into a spec could be cut and pasted directly, rather than transcribing it by hand. Yet, in both offices, the CD-ROM was regarded as a kind of exotic novelty item. When I questioned people at both offices about purchasing a CD-ROM reader, it was shrugged off as too expensive. The more I watched, though, I realized the real problem was far more complex.

An additional problem with the Sweet's CD-ROM was that it was available only in a DOS version. An architect using a Macintosh would not be able to use the CD-ROM at all. Over the course of the next year I checked with Sweet's several times, and they still had not committed to providing their catalogue in a Macintosh version.

The maintenance of the hundreds of supplier catalogues becomes an almost trivial task if the information is available on CD-ROM rather than on paper stored in 3-ring binders. Because there is a separate binder for each vendor, an enormous amount of shelf space has to be allocated for the catalogues not in use. Even if each vendor supplied their own catalogue on CD-ROM, the storage requirements would be about 1/100 of that needed for the 3-ring binders.

Updates to the binders often requires a tedious page-by-page search through a binder to replace old pages with old. There was a whole stack of updates waiting to be inserted in catalogues, and while cleaning up the shelves I was able to update some of the catalogues. The stack of updates was far enough behind that in at least one instance there were two successive updates to one vendor catalogue waiting to be changed. With an entire catalogue on CD-ROM, one merely tosses the old one in the recycling bin and replaces it with the new one; no muss, no fuss. And the designer always has the most current information available.

(7/8) David and Kevin are developing a color scheme for the renovation job. The color scheme has to encompass floor coverings, wall coverings, paint, window coverings, and acoustical ceiling tile.

Kevin proposes to use wall colors to differentiate the importance of spaces: private offices, meeting rooms, machine rooms, etc. Charles suggests using ceiling and floor coverings to differentiate spaces. After some discussion they decided not to specify exactly where the colors will be applied but to just prepare a set of color boards for the client and tell them to choose a color scheme.

<i>Information sources used:</i>	<i>detail drawings (D size)</i>
	<i>spec book</i>
	<i>overlay paper</i>
	<i>manufacturer's catalogues</i>
	<i>paint color chips</i>
	<i>vinyl wall covering chips</i>
	<i>ceramic tile samples</i>
	<i>carpet swatches</i>

They decided to start with a dark ceramic floor tile and molding, use a slightly lighter vinyl wainscoting, and an even lighter wall paint above the wainscoting. Kevin leaves to talk to another client.. David continues working with color samples. The carpet swatches for the floor seem to be the 'anchor' for the

color theme. He shuffles through a set of about forty vinyl wall covering samples, selecting three or four, then begins working with paint chips from a very large set of samples (500–600 samples). A single piece of black ceramic tile remains as another 'anchor'. He repeats this process several times, with different vinyl wall covering samples and paint chips.

Later in the day, he is still at work; Robert, who does a lot of the CAD work in the office, has been assembling a set of color boards for him that show several different color schemes. Kevin returns for a discussion at 5 o'clock, looking over the selections and making some suggestions about the colors chosen. Two more boards will be put together.

I watched a rather interesting use of technology today. Kevin went to Richmond to meet with a client. During the meeting, a proverbial cocktail napkin sketch of a potential building was developed, and Kevin faxed it back to the office. He then called up Sam and told to quickly produce a scale drawing from the sketch and fax it back to him. In about fifteen minutes, Kevin had a new drawing and went back to his meeting. A few minutes later, another fax arrived with more detail sketched in, and Sam took it and produced yet another quick scale drawing and faxed it back.

It came back one more time for a few more changes, and the elapsed time of the whole sequence was less than ninety minutes. Again I was struck by the apparent low-tech approach, but it was very effective. One could argue that if Kevin had a laptop computer he could have done the drawings himself or transmitted the sketches back via modem, but paper, pencil, and a fax machine gave Kevin a freedom of expression in the meeting that would be hard to duplicate if the clients all had to hunch over the screen of a laptop computer while Kevin scribbled away on it.

If Kevin was not making the best use of his computers, he was making very good use of some other technology. One obvious difference I saw was that the fax machine is dead simple: you stick in a piece of paper, key in a phone number, and hit a button. Away it goes. Compare that to the effort of learning a CAD drawing package or formatting tables in a word processing package. The fax will win on ease of use hands down. I did not begin to make the connection until later, but the fax is a simple, direct, easy to use tool, and Kevin was able to use it effectively. The computers he owned were not simple, not direct in their results, and not at all easy to use, and he was not able to use them effectively. This distinction is important because it would be easy to shrug off Kevin as a neo-Luddite who is simply unwilling to "get with the program". But when given good tools, he did not hesitate to put them to effective uses in his business.

(7/8) Kevin spends half an hour getting some help from an architecture student. He wanted to copy a perspective drawing from a drawing program on a Macintosh to a word processing package on the same machine. The main difficulty seemed to be in converting a 2-D representation to a 3-D one in the drawing

program. Kevin, who normally uses the old IBM pc at work, was unfamiliar with the routine cut-and-paste between programs that is available on the Macintosh.

The next problem involved printing; they were working on Kevin's Macintosh that he had brought in from home to help with the heavy workload, and it was not hooked up to the printer in the office. They decided to physically move the laser printer across the office to print the document (the printer cable was not long enough to reach). While trying to connect the cable to the computer they badly bent one of the tiny pins in the connector, and one of the student workers had to be sent out for a new cable. At this point, Kevin gave up, asked me to move the printer back to its original spot, and went back to his office.

He then spent nearly an hour calling several paint suppliers, trying to find a non-chalking paint to replace the deteriorating paint on a ten year old metal roof that belonged to a building he had designed. Several calls were made before settling on a paint manufacturer who had a local dealer. My impression was that the decision was based at least partly on the availability of information now, rather than trying to explore optimal solutions which required more effort and time to collect the needed data about the performance of the products.

When I began the work here I had hoped to be able to sit down for half an hour or so every other day for a semi-formal interview with Kevin, but that was clearly too much to ask, given the frenetic pace of work in the office. Late in the first week he finally found a few minutes to sit down with me near quitting time, and I turned on my tape recorder and began asking some questions.

It turned out to be a disappointing experience. It was clear that he did not really understand what it was that I was trying to accomplish, so he fell into the same kind of "salesman's pitch" that I had noticed with my pre-study subject. It had a real canned quality to, and he tended to talk about his personal design philosophy rather than really answer my questions.

I was in a dilemma; I did not wish to try to be explicit about what it was I was trying to do, because I did not want to influence how he worked. I detected a little impatience on his part because I seemed so vague about my goals, and more than once, as members of the office questioned me about what I was doing and I deliberately responded vaguely, I had the feeling that they were beginning to regard me as a sort of benign village idiot. On the one hand, I was getting a Ph.D., which seemed to impress them, but on the other hand, cleaning out closets apparently did not seem like the kind of behavior they expected from a doctoral student.

After reviewing my notes, I realized that the most useful bits of information that I seemed to be picking up were coming from casual conversations when there was a momentary lull in the workday. I had brought a big stack of research papers with me, and I went back to check Joe Wang's work; he had also spent time observing architects at work, and he had encountered the

same problem with scheduling. Everyone was so busy that I simply could not impose on them and expect to receive the time needed to do formal interviews; they had too many other things to attend to and I was, after all, their guest. I decided to give up the taped interviews completely and focus on helping out where I could.

(7/9) Kevin spends the entire morning sorting and following up on a stack of Post-It™ notes and phone notes that litter his desk.

The schematic design work here—the style of working—is with overlay paper. A roll of 12" paper is within reach of every workspace in the office, and detailed designs are derived from a series of sketches built up on layers of the overlay paper. For the beach house project last week, the elevation drawings were developed in precisely this way.

Workspace is at a premium here, so in contrast to the very orderly way that my pre-study student worked (hanging and distributing drawings near the drawing table), a single set of two waist high storage chests for flat drawings provide a flat surface for the temporary storage of work in progress. All drawings not in use are here in two disheveled stacks, and people are constantly shuffling through them to find a drawing they need.

By this time I am half way through the second week, and I have begun to realize that I need to change the focus of my study. It is clear to me that they have little need of tools to aid them in the early stages of design here. While it is true that they do not make especially good use of the computers for many of the tasks that they have to complete, Kevin has convinced me that CAD is not the area where he needs help.

The renovation project was done entirely on the Sun workstation, and that work is an excellent example of where CAD can excel. The job involves gutting and redesigning the floor plan for four floors of a much taller building, and many of the design elements are repeated on every floor. Kevin says that for a job like that he considers the CAD system indispensable, but insists that for smaller jobs like private residences and the home renovations and additions that provide much work for the firm, he sees little to gain from using the CAD system. I am not entirely convinced but understand his point that it is the management of the projects and the attendant paperwork that overwhelms him and steals his time, not drawing. He also has told me that he loves to draw, and hates the management work, and if he could choose which task he had automated tools for, it would be an easy decision: he wants tools to help him manage the business.

Later, after that conversation, I talked to him about taking a look at some of his archived projects, and he readily consented. For the next two days, I spent much of my time poring through file folders trying to identify the kinds of paper and information that comprise a design

project. One project, for a public library, has over a foot of paper associated with it. Almost none of it is related to the actual drawings and detailed design; most of it is correspondence and transmittals designed to document hundreds of very small changes to the original contract for the building. The extent of this paper trail and the effort that must have been expended to produce it is stupefying.

(7/10) Work today seems to have returned to a more normal pace. Kevin is at his desk, attending to his pile of memos and phone call slips. David is still working on some changes and paperwork for the renovation project. Louise is working on drawings for an addition to a private residence. Thomas is still working on the house design that has occupied him since I arrived here.

Late this afternoon Kevin mentions again the importance of the copier and the fax machine in his business. He has raised this point several times. Today he had to make some changes to a house addition for the building inspector, and combined part of a drawing with an illustration from some previous work that contained the needed information. He used the copier and a pair of scissors to combine the two, and then had only to sketch a few additional lines, instead of doing an otherwise fairly complicated drawing from scratch.

One could argue that if the office kept all their drawings on the computer, Kevin's little cut-and-paste exercise would have been totally unnecessary, but it is hard to argue with the low tech solution he used to solving a problem.

(7/11) Sam, one of the student employees, is working on a yacht club job this morning, and I watched him as he painstakingly drew a door schedule (a multi-column table) from scratch, copying the format from a previous table used in another job. I asked him why he did not do it on the computer, and he said he did not know how. While it is true that learning how would take more effort than that required to do complete this particular table by hand, I was still surprised that with several computers in the office this particular task, which is well-suited for a spreadsheet or word processor, would still be done manually.

The phone seems to be the driving force of the business; calls arrive regularly, but the incoming calls are short and most related to the delivery of papers and drawings. Outgoing calls are more project-directed. This morning Kevin and Louise each made 4 or 5 calls, trying to resolve a problem with the local city building inspector over a minor detail on a renovation project.

Kevin is on the phone constantly, in contrast to the architects and designers who work for him, and it is clear that there is a direct correlation between phone use and seniority in the firm. David, the second-in-command, is also on the phone with a higher frequency than Louise and Thomas, who are next in line in the hierarchy. At the bottom are the rest of group, who may work an entire day without receiving or making a single call.

Kevin has instructed Daniel to take all calls for the rest of the afternoon so that he can complete some drawings on a church that he must present to the church building committee this evening.

(7/12) The computers are relegated to a third or fourth class status; the two CAD machines are wedged on top of shelving along the front wall. There is barely space for the CPU box and the keyboard; the space on either side is cluttered with books and storage for the floppy disks. There is no space for drawings and notes, and there is barely space next to the keyboards for the mice. By making them difficult to use it reinforces a self-fulfilling prophecy that they are not especially useful.

Design Futures

I finished up at New Design in mid-July, and began visiting Design Futures in October of that year. I had more time to reflect on the data I had collected at the former, and continued to feel positive about my focus on the business aspects of running a practice. I also realized that it had the effect of narrowing the scope of my work, which I viewed as a good thing. Trying to say anything useful and/or interesting about the early stages of design was, I always knew, a calculated risk. In pursuing this interest in the practicum of running a business, I felt like I was on more solid ground. I could see that I could make a real contribution to professional practice if I was able to articulate to the toolbuilders and software developers what some of the needs of this professional community were. It also *felt* right, and I regarded this as an important sign.

I had learned several lessons from my work in July, so I arrived at Design Futures ready to pitch in and work on day one. As it turned out, they were re-arranging the entire office, and they welcomed an extra body for a few hours a week to help with some of the manual labor. My first job was virtually identical to the work I began with at New Design: moving vendor and product catalogues. In both offices, the problems were identical. The catalogues were not always updated regularly, they were not always shelved properly, they often ended up in random piles near workspaces instead of being re-shelved, and they took up a lot of floor and wall space. And Design Futures, like New Design, had a shiny new Sweet's CD-ROM perched on a shelf, unused and still in its shrink-wrap packaging.

I had also decided to change my approach to data collection. Rather than trying to take a two week snap-shot of the activity in the office, here I was going to visit a couple of days a week for a few hours in the morning. I hoped that the longer time frame would expose me to a larger

view of the regular activities in the office. As it turned out, I think that each way of working had something to offer.

(10/9) They are in the process of moving the office around to give some of the space back to the landlord for another tenant. Suzette is complaining about missing papers, which, as far as I can tell, have nothing to do with the move. Don comments that he finds it easier to locate documents stored on floppy disks than those stored on paper. He noted that the paper documents are often mis-filed, or are archived in the vault. The vault discourages one from going in, locating the proper box, wrestling it down from a stack of boxes so that it can be opened, and finally rummaging through a binder or folder for the document..

He shows me the way he organizes documents on floppy by project and type, rather than trying to cram as much as possible on a single diskette. So a project may have several floppies associated with it: one for correspondence, one for the project manual, one for contracts, and so on.

Design Futures has only one computer, a relatively modest IBM pc-compatible, but an improvement over the ancient pc in use at the New Design office. They use it for the same purposes as New Design; assembling boiler plate contracts using the AIA files that they purchase, and writing correspondence.

(10/15) Projects in the office are assigned project numbers, and each project has tasks associated with it. This coding system is used to track hours worked on time sheets. General overhead items also appear on time sheets, which includes 'General Office', 'Physical Plant', 'Bookkeeping', and 'Marketing'. Expense items for reimbursement are also tracked in a separate table on the time sheet, and each reimbursable item is assigned to a specific project for tracking purposes. But I noted that all this was done by hand, and I wondered if any of the data ever ended up on a management report that provided useful summary information about the actual cost of projects. I suspected that the time sheets went to the bookkeeper for billing, and ended up in a stack of papers somewhere. Information slowly turning back into useless data....

Ideally, all this time and expense tracking would be done with an automated tool and posted automatically to both accounts receivable and reporting/history files. Time could be tracked with a little tool that displays all active jobs; just clicking on a job would start a timer running. Clicking again on some other item would stop the clock, compute elapsed time, post it, and start the clock on the next job.

There are actually some off the shelf software packages like this available now, but they would not integrate the data into a complete 'project manager'. Nonetheless, it would be an improvement over the hand method, except that the pencil and paper technique can be used anywhere. This is the sort of application that would be perfect for one of the personal digital assistants that are being introduced: a small, well-designed tool that manages the time, note-taking, and information tracking required.

Everyone I have talked to here and at the other office seems self-conscious about the clutter, but perhaps that is the nature of this business: lots of paper, lots of details, lots of physical things, all being orchestrated by one or two people. It may also be that the practice of architecture attracts people who by nature are comfortable with a certain amount of disorder in their work environment. If that is so, the tools they use should be unobtrusive and un-demanding. What passes for organization in an architectural office may be regarded as bedlam in a more traditional business environment like a bank. At New Design, they filed old rolls of drawings in an enormous wicker basket in one corner of the office; this was, on first inspection, untidy and inefficient: How would you know what was in there? But after I thought about it for awhile, it was remarkably purposeful; all the drawings were tossed in the basket, so you knew you only had one place to look for a set of drawings. Furthermore, since the drawings were plainly visible, you could use size as a search criterion; that is, you know that the drawings for a residential addition are going to be a much smaller, thinner roll than the drawings for a three story office building.

Design Future keeps their drawings in large cardboard boxes in a vault in the building. I have been putting some of their finished work away, and have had an opportunity to think about this problem. Once the boxes are closed up, it is difficult to tell what is inside of them, short of labeling every single side of the box. Once stacked, they are heavy and hard to manage. The catch-all basket really began to have some appeal after an hour or so of rummaging through a poorly lit room fiddling with a lot of dusty boxes.

This example reveals an important dimension or characteristic of tools: they must accommodate the user, rather than forcing the user to accommodate. Too often computers impose a significant penalty on users by forcing them to do things in a certain way that may be at odds with established practice, and without any real justification. The price of organization (by computer) is simply too high; too often the structure imposed on users is arbitrary, and worse, it may also be tiresome. The tools have to be virtually invisible.

Heidegger's idea of breakdown began coming to mind again and again as I thought more and more about the behavior of tools. I began to sense that the behavior of the tools is as important as the function of the tools. In human factors research I believe there may be too much emphasis on task analysis (what people do and what tasks ought to be allocated to the computer) and too little emphasis on the behavior of the tools. Unfortunately, traditional task analysis focuses too much on individual sub-tasks at the expense of assembling the 'big picture' of the work. That is, while task analysis is very good at optimizing small units of work, it is not very good at providing a comprehensive view of the entire work environment that the user inhabits.

It is the computer that has created this dichotomy; our thousands of years of experience with physical tools, in which *what* the tool does is, in a sense, the behavior of the tool, is unlike computer-based tools where one can consider how the tools *behaves* quite apart from what it does.

(10/17) *The medium of paper here is so pervasive, so intimately linked with every phase of the work that it is hard to imagine moving just that part of the information to some other storage and display system. To be really successful one would have to take the entire process to that new medium.*

Paper is at once both storage system and display system, which accounts for much of its ease of use. In contrast, the computer stores the information in one format and displays it in another, and a series of actions is required by the user to move information from storage to display and back again.

(10/29) *In a conversation with Philip, I made a comment about how the computer as used in CAD seemed to create a hierarchy in the office, where some of the younger architects would become pigeon-holed as CAD operators. I said that it seemed to be a vicious circle, because as they spent more time doing CAD work, it became harder and harder to take them off the CAD work and put them into more conventional design work.*

Philip remarked that the phenomenon was not confined to CAD. He said that in a large office, the younger architects would become specialists in just one area like elevators (for high rise buildings), and that once identified in the firm as the 'elevator designer' it was very hard to break away from that label and gain the opportunity to do other work.

(11/5) *Design Futures has about the same amount of floor space as New Design, but they use the entire area as work space. In contrast, nearly half of the New Design office main work space was set aside for a reception area and a secretary's desk. The difference is dramatic; there are five drawing tables here, instead of the four at New Design, and at least triple the amount of horizontal adjunct work surfaces. Each drawing table here has at least one and sometimes two adjacent work tables (30" x 80").*

This extra space means that the drawing tables are usually clear and available for drawing, because all the supporting documents can be stored on the work tables. At New Design, for each work space, there was only a very small amount of work space adjacent to the drawing tables. This created a kind of tidal ebb and flow of information on the drawing table—the clutter of business documents would slowly fill the drawing table to overflowing. When drawing had to be done, the papers were sorted and filed, or more often, just piled off to one side, clearing the table for drawing. But once the urgency of the drawing job had passed, the clutter of documents would begin again.

(11/12) *Michael works heavily with overlay paper sketches, starting out with very loose, freehand drawings that are heavily annotated with comments to himself and/or to his assistants that collect site and building information for him. His assistants (usually advanced architecture students) also do most of the construction drawings.*

Once he has worked out the basic design issues on the overlay paper, he moves to more detailed floor plan sketches, but these are also drawn completely freehand; these begin to show the relative position of things (walls, doors, windows, appliances, etc.), but are also annotated with notes about circulation patterns, client interests and needs, heating and lighting information, and remarks about materials.

The next stage of drawing is still on overlay paper, but there are true scale drawings of floor plans, elevations, and sections. These contain much more detail, but are still drawn in a 'loose' style. Michael prefers a heavy ink line for the basic outlines of the drawing, and then uses colored markers (usually neutral or pastel colors) to accent architectural features.

These drawings Michael passes on to an assistant who completes a clean scale drawing, often on overlay paper. If the design is approved by the client, the assistant will begin to prepare D size construction drawings, supervised by Michael.

For client presentations, Michael also uses freehand perspective drawings on overlay paper, and records client comments and concerns directly on the drawings; in this way, the drawings begin to form a record of the client—architect collaboration. He also relies heavily on photographs of the site. Much of his work is renovation or additions to existing structures, and for a small residential addition he may have twelve to eighteen photos of the property, taken from various angles: backyard, sides, front, street, approaches to front door, etc. These photographs serve as the starting point for the perspective drawings that he makes.

He also constructs photo boards or story boards from the photographs, mounting from six to twelve photos on a foamcore board. A site board may show scenic views from the property, adjacent property views (neighbors), and close-ups of individual landscape features like large trees and rock outcroppings.

For a church addition project he constructed three photoboards which displayed a total of thirty photographs. One board had street views of the existing church, the second had closer exterior views and pictures of social gatherings (outside) at the church, and the third board consisted of a dozen photographs of the existing interior space: offices, nave, and common areas.

He also prepared seven large (18" x 24", 24" x 36") site plan and floor plan drawings. These were drawn to scale on vellum and mounted on foamcore. Most of the detail was focused on the addition; for example, only the outlines of the existing buildings were drawn in. Michael added some detail freehand; landscaping features, human figures, and automobiles were drawn in to help show the relative size of things in the pictures. Thumbnail elevations and small perspective view sketches were used as sidebars to provide more information. As usual, Michael had used colored markers to provide contrast and visual interest.

During all this time I had been visiting at least two mornings a week, and performing a

variety of work for the firm. During the two or three weeks that the office was being moved and renovated, in addition to re-arranging shelves and vendor catalogues I archived drawings and documents, performed minor housecleaning chores, and helped re-wire the phone system. Philip was exceptionally patient with my intrusions into the space and work of the firm. He went out of his way to find work for me to do, and for several weeks late in the fall I worked on some problems related to the church addition that he was working on.

One of the little tasks he assigned me was to fold a set of stairs into a very tightly-confined stairwell; it was the first time I had to put stairs into such a small space, and I struggled with for several days (part-time). When I finally had come up with a solution, he quietly showed me how he would have solved the problem, and it was clear to me that he had never really needed my help with it, but was content to let me learn what I could from the process.

(12/10) There are four people here today, a crowd by Design Futures standards, where there is often only one person in the office. Philip and Tillie are finishing the plans for the church (Tillie is a part-time assistant). Don is reviewing drawings for a renovation at a local college, and Larry, an assistant to Michael, is finishing the drawings for a private residence.

Tillie observed that Philip would not have all the work and desk space he usually has; he likes to use the extra tables to layout and separate different jobs that are in progress. It strikes me that this is a very efficient way to work if you have the space, since you do not have to take the time to clean up and put away work from one job before starting another job—you can just walk from table to table.

A system to support design work should have a way to open all the notes, documents, and drawings associated with a job as well as all the applications (word processor, drafting package, database, outliner, sketching tools, etc.) associated with the documents.

A few months after writing this I became aware of a little Macintosh application that I found on the net called Stapler. It works exactly as I described in the paragraph above; you 'staple' together a set of documents of any type and a new icon is created. When you double-click on that new icon, all the documents and applications 'stapled' together start up. The Xerox Parc 'rooms' interface and metaphor also expresses this idea of having virtual workspaces that enable us to organize our electronic documents the same way that we organize our physical documents.

(6/8) I have been out of the office for about four months (a new baby interferes somewhat with research activities), and there is much more activity here now than back in the winter. Michael is working on another church job, and Philip has five jobs in various stages of work, including the church that I had done some drawing on back in the fall. That job is finally in the final stages of construction.

Philip is now using three drafting tables to manage his work, as well as three of the side tables that sit adjacent to each of the drafting tables. Two of the drafting tables are used as storage space for active projects; the papers, drawings, and notes are arranged neatly in stacks. The third table is the 'work' table, which is kept clear to permit him to do drawing work or whatever other paperwork is required.

Much of the work here involves renovations and additions, which means that those jobs are accompanied by a sheaf of drawings from the previous architect. Those drawings are used heavily as a reference for the development of the new work. The big church job has roll of 25 D size drawings and the small addition to the other church has a very tattered set of 5 C size blueprints as well as a dozen photocopied blueprints (11" x 17").

It was during this time that I chose to record the workspaces of Don and Philip. I had wanted to wait until there were busy enough to provide a good representation of what the paperwork load was really like. During the previous fall, things had been slow enough in the office that their desks were usually very neat and orderly. I was looking, somewhat literally, for messy desks, for what they would reveal about the real problems of information management (and information overload) in the office.

(9/21) The activity here is still quite busy. Philip has several projects under way, and Don is working on a couple of jobs. Michael is in and out, but has some preliminary designs on his table.

Philip's workspace is densely packed with project information. His drawing table and adjacent tables are covered with correspondence, notes, and project documentation. He also has a second drafting table covered with stacks of archival information on projects. One other table is used to store rolls of blueprints associated with all the work. He has organized his work in four distinct areas:

- 1) Active work — his primary drawing table (things he is working on right now)*
- 2) Semi-active work — supporting documents and materials related to active projects*
- 3) Archival work — documents related to active projects but not in use or only rarely used*
- 4) Drawing area — flat areas for storage and use of large drawings related to active projects.*

Philip has been doing no drawing in the last five days; he has been writing and editing job specs on the computer, doing billing work, and other accounting jobs.

(9/23) Don has been completing work on a residential renovation, and has been drawing for the last week. His work area reflects that, with work-in-progress drawings on his table and on the tables to the

right and left.

During this time I spent most of my time reviewing some of the project files in the firm, cataloguing the kind and type of documents that were saved. I found some items that can only be described as scraps of paper in some of the projects. When I questioned Philip about why such apparently innocuous items had been saved, he told me that on the advice of his lawyer, he had been advised to save every scrap of paper related to the development of a project. The scrap of paper might record the notes of a phone conversation that might turn out to be crucial in deciding the outcome of a lawsuit against the architect.

This made sense, but I was bothered by the difficulty of ensuring that you have collected and retained all of the important, if not critical documents. If the small bits of paper like Post-It™ notes, phone notes, and memos must be preserved, how do you know if the one you really need is there, and that it did not fall off the desk, to be swept up by the cleaning service? Or perhaps the Post-It™ note made it into the project file, but ends up adhering to an inner page of a product catalogue, going unnoticed in a search of the file folder for certain documents. The advantages of a well-designed system that has inherent support for the orderly archival and later retrieval of documents seemed compelling.

(9/29) Philip said he would like to have a piece of software that was set up to help manage the routine paperwork of a project: memos, lists, notes, correspondence. I had not mentioned, at any time during my work there, any of my ideas along these lines of thought—only that I was looking at how information is used in the professional practice of architecture.

It seemed like a validation of my efforts, as my field work drew to a close, to hear that from one of my subjects.

The information space of design projects

Two aspects are common to all varieties of structuralism: first, an ideal of intrinsic intelligibility supported by the postulate that structures are self-sufficient and that, to grasp them, we do not have to make references to all sorts of extraneous elements; second, certain insights—to the extent that one has succeeded in actually making out certain structures, their theoretical employment has shown that structures in general have, despite their diversity, certain common and perhaps necessary properties.

Piaget

Structuralism

The decision to collect data on the information that represented a design project in an architect's office came after I had begun my field work. As I worked with and talked with my subjects, what I heard was a frustration with the effort of managing a business, which effectively kept them away from the activity which they really loved—the design of built space.

In the second week of my field work at New Design, I asked Kevin for permission to look through several boxes of archived project information. He readily agreed, and for much of the rest of that week, I opened folder after folder of information, looking for clues. At that time, I was not sure where this line of research was going to lead. Nonetheless, I kept looking and reading.

At each firm I asked to examine the information archived for completed projects. I chose completed work because this would ensure that I had a complete set of documents. At New Design I was given access to several cardboard boxes full of completed work (about 15 linear feet of file space), and I spent about two full days examining the contents of many of the folders. The documents retained for these projects were similar, so I settled on a detailed examination of five projects.

About two thirds of the folders represented work that was only partially completed, so I chose two projects that had been designed and built by the firm and three projects in which some design work had been completed but the building or house addition had not actually been built. I questioned Kevin about this and he said that this mix was typical; for one reason or another, many people started working with an architect on a building project (most often, private residential work) but never finished it.

At Design Futures, I also selected five projects. Four of the five projects here were fully completed. They did not have the same problem with canceled work. New Design is located in a large urban area with a fairly wealthy clientele for residential work and more access to a wide variety of commercial projects, large and small. Design Futures is located in a small town in a rural area with more middle class residential clients and mostly small to medium size commercial clients.

As an example, while I was at New Design they were completing the drawings for a four floor renovation of a much larger office building. This was a good sized job for them, but the floor space of the *renovation* work was larger than the largest new office buildings Design Futures had constructed recently, which in turn were two of the biggest office buildings in town.

At New Design, completed projects had, at a minimum, five manila folders associated with them, labeled as follows.

- Contracts
- Notes and memos
- Change orders
- Materials investigation
- Letters and transmittals

The two completed projects, however, had many other folders. One had a total of 19 folders of information that represented 18" of file space. The other project had 10 folders that were a total of 4" thick. The three remaining projects had only a single folder associated with them. For the larger projects, the documents were already pre-sorted by type which made counting and sorting the papers somewhat easier. For a folder marked "Letters/Transmittals" I merely had to count the number of sheets of paper in the folder.

At Design Futures, where finished projects were often smaller than those completed at New Design, just one or two folders labeled with the name of the client held the documents, so they were not sorted in any order. I had to go through all the folders sheet by sheet to sort and count the documents.

At both firms the notes and memos were among the most interesting documents, as the papers in this category had the most variety. Some examples of the range of information are listed below.

- ❑ 8 1/2" x 11" sheets of paper with neatly written information on them
- ❑ dozens or even hundreds of phone notes (the little pink pre-printed *While you were out* variety)
- ❑ lots of Post-It™ notes in various sizes, often stuck to some other piece of paper
- ❑ scraps of paper (literally scraps, torn from other sheets of paper)

The two kinds of notes that I found most interesting were the phone notes and the scraps of paper. When I questioned Philip at Design Futures about the scraps of paper in their files, he told me that on the advice of his lawyer, he kept every piece of paper that could be identified as related to a project, on the off chance that either a client might sue the architect for some problem, imagined or otherwise, or that the firm might have to sue a client to collect for work done but not paid for. In either case, Philip's lawyer felt that a complete record of all interactions with clients could be valuable.

Inventory

Thirty-seven different kinds of documents were counted and identified in the study. Table 7-1 shows summary data for the two firms, and Appendix C provides a complete list of all documents and their distribution across projects for both firms.

Business-related documents accounted for 64% of all documents associated with the ten projects analyzed; design documents (drawings, sketches, catalogues, photographs, etc.) accounted for 36% of the documents. There was a fair amount of variance in these figures when considered on a project-by-project basis, but even after Project A was removed (a public building which generated an enormous amount of paper relative to the other projects), the average still remained consistent. Figure 7-2 illustrates the distribution of business and documents by project.

Seven document types accounted for a very high percentage of all business documents. Of the 33 different types identified in the study (the 5 kinds of notes were counted together), the

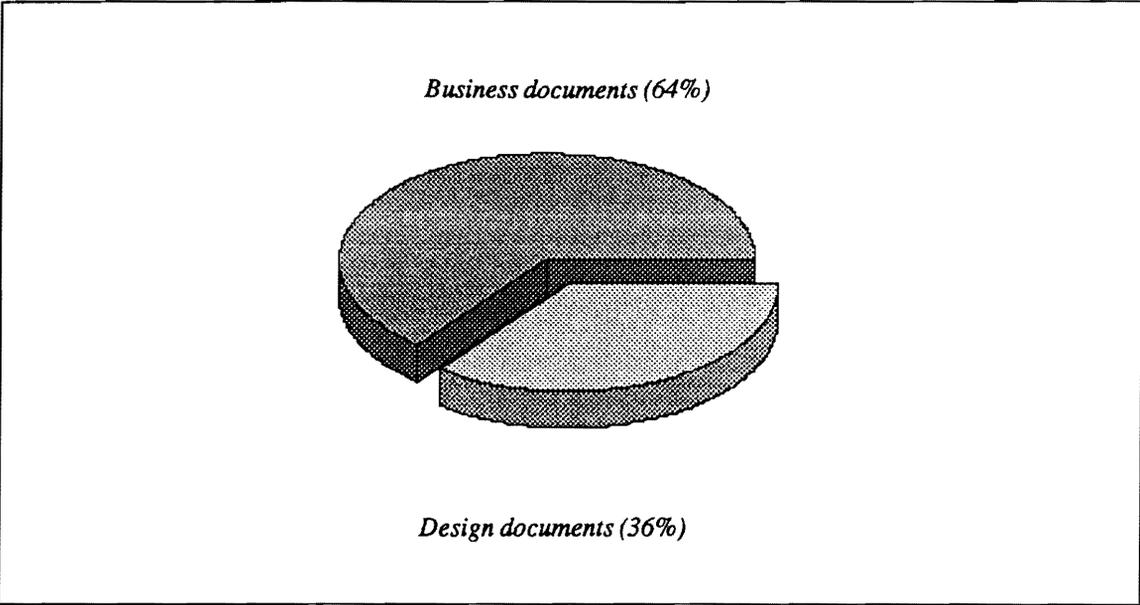


Figure 7-1: Average percentage of business documents and design documents

Table 7-1: Summary data by project and document type

	New Design					Design Future				
	A	B	C	D	E	F	G	H	I	J
Business documents	1577	26	8	20	298	650	25	62	212	138
Design documents	871	18	3	9	56	237	39	81	320	29
Totals	2448	44	11	29	354	887	64	143	532	167

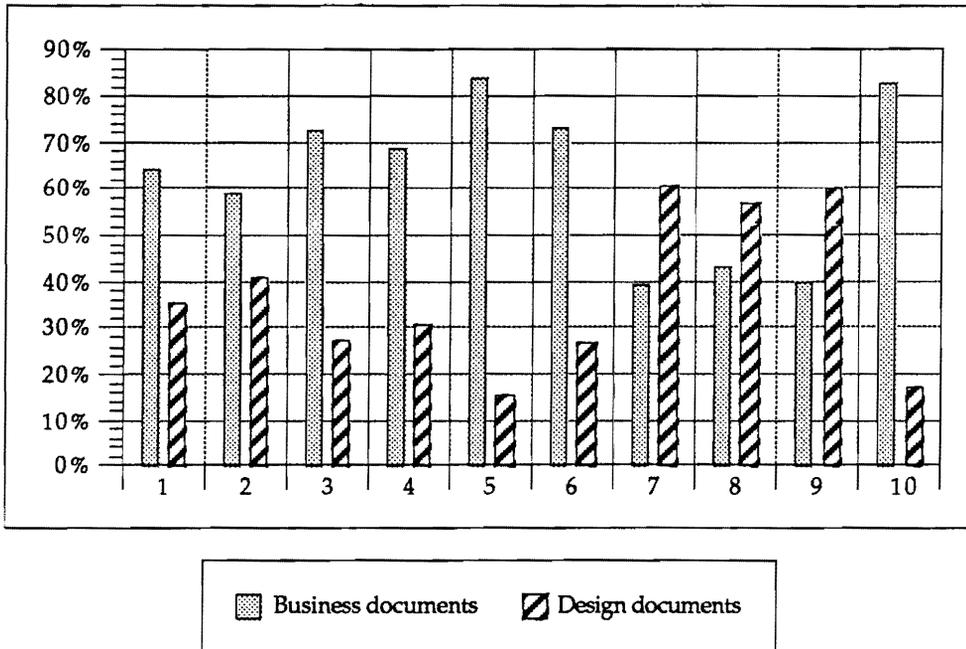


Figure 7-2: Distribution of documents by project

seven documents accounted, on the average, for 71% of the documents found. These document types are summarized below.

- ❑ **Transmittals**—these are used to provide a formal record of the transfer of documents or information from the architect to the client and/or builder. A transmittal accompanies the blueprints when they are delivered, or when a design change is made later in the construction phase and a new or changed drawing is required. It provides proof that the architect completed and delivered work as promised.
- ❑ **Letters and memos**—the usual correspondence between an architect and his or her client, builders and contractors, government agencies and representatives like building inspectors, and building supply vendors.
- ❑ **Faxes**—Formal or informal communications between the architect and any of the interested parties associated with a building project. Many faxes were

duplicates of transmittals and letters. Another common use of faxes (incoming) was to send the architect a portion of a vendor's product catalogue (specifications for a special window, as an example).

- ❑ Notes of all kinds—simple notes on all sizes of paper from small scraps up to normal letter size pages were the most common. Post-It notes, meeting notes, site visit notes, and phone notes were also very common. As previously mentioned, one office used pre-printed phone call pads and the other did not.
- ❑ Application for payment—Clients are often billed in installments, based on the phase of the project. Application for payment is a special purpose invoice that details work completed and the portion of the contract fees expected as payment.
- ❑ Invoices—both incoming and outgoing invoices were common. Incoming invoices requesting payment from the architect were often from engineering firms requested to provide consulting services on a project. Outgoing invoices were for a variety of services performed by the architect.
- ❑ Job specifications—these documents are the legal basis for all design work. Both firms used templates purchased from the AIA and supplied in common word processor formats. The specs detail the work to be done in a standard order using a standard language. For a small renovation or addition this document could be easily twenty or thirty pages long; for a large commercial job it might run to hundreds of pages. Much of the information is “boiler-plate” taken from the AIA templates or from files supplied by vendors, but it is left to the architect to determine the correct level of detail needed for a project.
- ❑ Time sheets—each firm used preprinted time sheets to track jobs, but the job was handled differently. New Design kept the time sheets in the folders with other project information, while Design Futures kept all time sheets in a three ring binder. Even though these items did not contribute much to the total document count, they are critical items as they are used to generate most of the billing information for the firm. Neither firm appeared able to capture much of the information on the sheets in a format that would have been useful in an automated system for generating information about profitable and unprofitable activities.

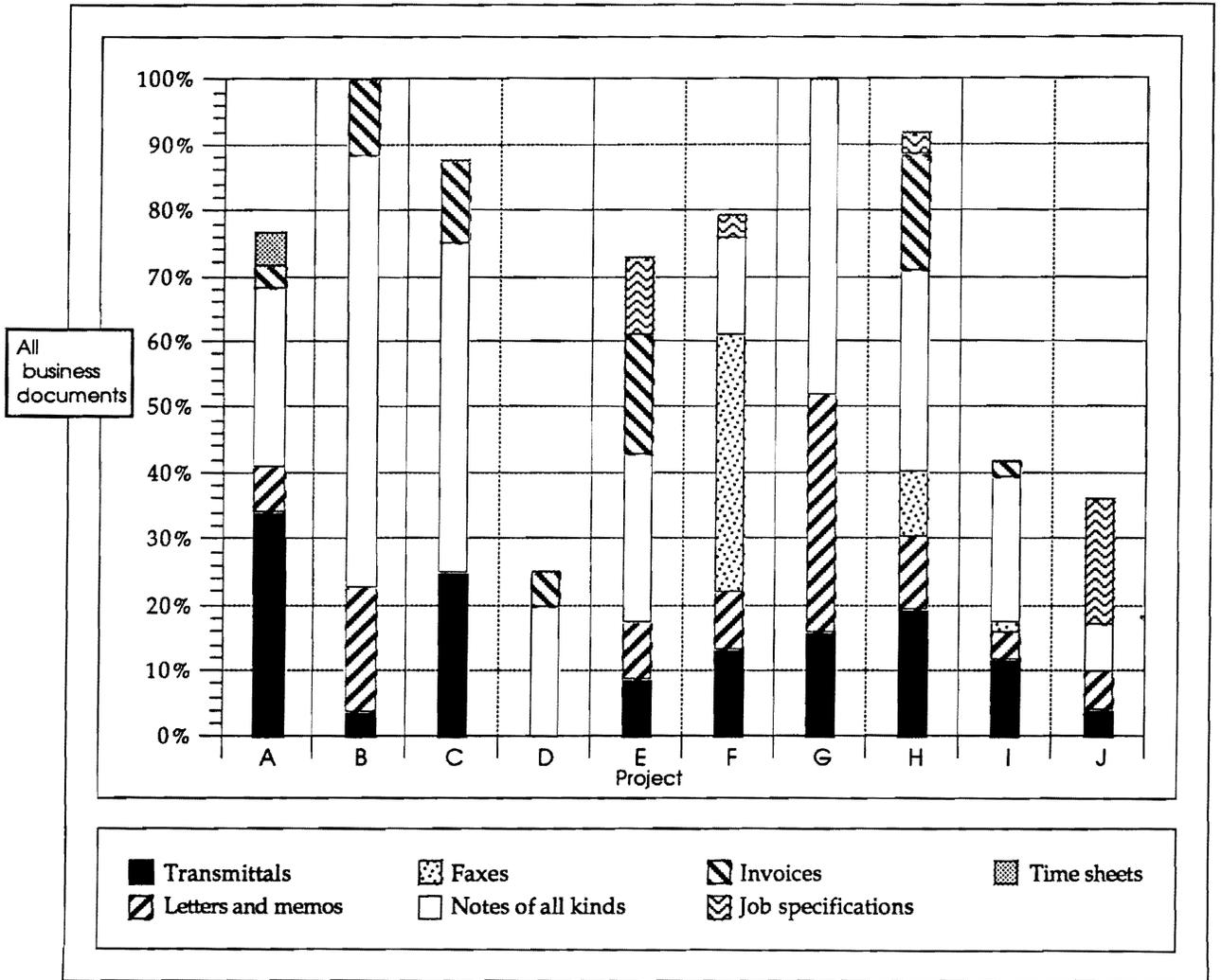


Figure 7-3: The most important business document types

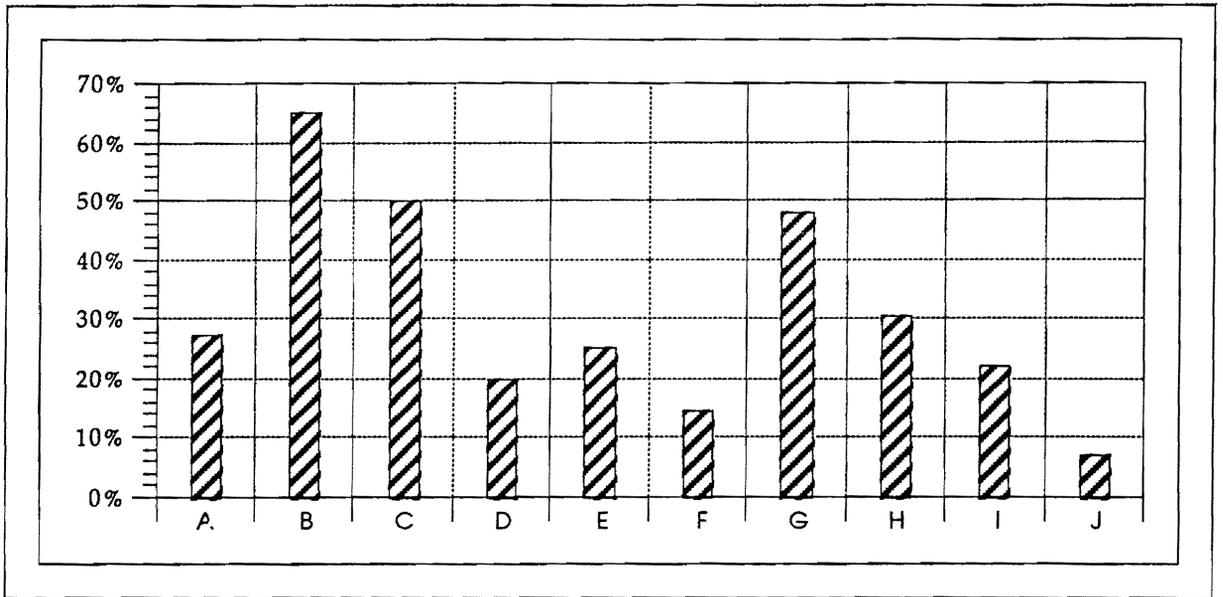


Figure 7-4: Notes as a percentage of business documents across projects

Figure 7-3 illustrates the distribution of these seven kinds of documents as a percentage of all business documents found in each project. In two projects (B and G) they comprised 100% of the documents used. In seven of the ten projects they accounted for over 70% of the documents.

Five kinds of notes were identified, and taken as a single kind of information, notes were the most frequent kind of information found in project files, accounting for 31% of the documents, on average, with one project where notes represented 65% of the documents. Figure 7-4 shows the distribution of notes across all projects. Despite the fact that this was for an unfinished project, where you might assume other kinds of documents were missing, this project (project B) actually had four of the seven document types, including invoices.

A structure for design projects

Inspiration is the moment of possibility when what to do meets
the means of doing it.

Louis Kahn
Credo

Several observations can be made from the data collected in the observation studies and the analysis of project paperwork. Every workspace I examined had a deliberate organization to it. Even at New Design, where they were extremely busy while I visited, creating the appearance of chaos to the un-initiated, every workspace has a certain organization. Some items had a fixed place on the desk or surrounding walls, lending permanence to the workspace. Even at a time when drawings, job specifications, transmittal forms, product samples, and other project-related items filled desks to overflowing, items like monthly calendars, lists of phone numbers, models of previous work, clocks, and telephones served as anchors, orienting the owners of the workspace and helping them find other items (I left it near the phone...).

The spatial orientation of work items played an important part in organizing the workspace. Every workspace occupied a three dimensional volume of space bounded by the floor, about eye level of user, the width of the desk, and the depth of the desk. In the workspace itself, items existed as work in progress or adjacent to current work, and everything else was approximately within arm's reach. In this space, objects also tended to oriented horizontally (flat) or vertically (hung up). Whether things were hung up or not depended on the availability of wall

space. In many of the student workspaces, the owners constructed their own walls and partitions, and if they had these enclosing walls they had invariably hung work upon them. At New Design the workspaces had been designed deliberately to provide vertical space at the rear of the desk. At Design Futures, an open, partition-less floor layout did not lend it self to hanging much on the walls. Mackinlay, Robertson, and Card (1991) have proposed something called a 'perspective wall', which enables users to 'hang up' documents on a wall in which the x dimension is represented by time and the y dimension can be represented by project. This idea gives users a virtual 3-dimensional space in which to view their work.

The stack or the pile also appeared frequently in every workspace I examined. Most stacks were stored flat on the desk or on adjacent shelves, but some "stacks" were also hung on the wall, where we might not think of them as a stack (stack in its usual sense connotes a horizontal orientation), but as an organizing method for these architects there was functionally no difference between a horizontal stack and a vertical stack. Stacks of paper are also common in the ordinary office; Apple Computer has found that users frequently organize their work in stacks, and plan to include support for 'stacks' of items at the system level of the Macintosh OS. Macintosh stacks will have built-in browsing and sorting tools for manipulating the contents of a stack (Harrington, 1993).

There were also stacks of stacks, and these too appeared both horizontally and vertically. One of the most organized collections of stacks belonged to Philip, who at one time took over a spare desk and completely filled it with stacks. He made a point of explaining his scheme to me; he had it partitioned off into three areas, one area for each of the three jobs currently in progress. Within each area he had two kinds of stacks: some stacks held archived material related to the project but did not expect to use; the other kind of stack held material upon which he was working actively. As he switched from job to job, he transferred items from the latter stack (active work) to his personal desk space while he worked, and then moved it back as he switched to one of the other design projects.

Philip had created three "virtual" workspaces; in each workspace only the documents related to a single project existed. In this way he managed some of the complexity of having to juggle the demands of working on several projects simultaneously and keeping all the paper straight. Had he even more desks and physical workspace available, I suspect he would have kept each project on a separate desk entirely, which would eliminate the need to shuttle information back and forth from the active desk space to the piles kept on the spare desk. The virtual workspace has been explored by researchers at Xerox in their 'rooms' metaphor, which allows users to separate work projects into virtual rooms (Card, Robertson, and Mackinlay; 1991).

Paper documents represented the bulk of the items on the architect's desks, and business documents, not design documents (drawings, sketches, etc.) were more prevalent. When one

considers the document count of the archived projects, where business documents represented two-thirds of the documents associated with a project, it is easy to begin to imagine automated tools to help with the management of all this information. While I never told my subjects specifically what it was I was studying, several spontaneous comments were directed toward me expressing a wish for aids to manage business information. No one ever asked for better drawing or drafting tools.

Burnette (1969) proposed a general indexing scheme that could be used to classify a similar range of documents. His scheme was both more general and more complex, and sought to aid retrieval of disparate kinds of design information by a series of codes that attempted to describe what a piece of information was about. His twenty-four year old scheme could be implemented easily on today's microcomputers, which did not exist at the time of his work. Whether it would prove useful except as an abstract model is another question. Much of the work of encoding would be placed directly on the user. My own opinion is that a simpler scheme should be employed, in which a document, at the time of its creation, knows immediately what it is and requires little or no additional input from the architect to classify it.

A tool to aid in the management of design projects should be organized around the standard phases of such jobs, and information should be accessible in a variety of ways, depending on need. In particular, the creation, sorting, and retrieval of documents in such a system should be natural and intuitive.

One possible framework for such a tool is the widely used Construction Specification Institute (AIA, 1981) organization of work, which consists of 16 categories of construction work and building components, as listed below.

- 1) General requirements
- 2) Tilework
- 3) Concrete
- 4) Masonry
- 5) Metals
- 6) Carpentry
- 7) Moisture protection
- 8) Doors, windows, and glass
- 9) Finishes

- 10) Specialties
- 11) Equipment
- 12) Furnishings
- 13) Special construction
- 14) Conveying systems
- 15) Mechanical
- 16) Electrical

In both offices, this system of codes was used to sort and organize product catalogues and other vendor information by labeling catalogues and binders with the number of the subject category and by storing them in sorted order. This scheme is also used by Sweet's (Burnette, 1979b), a set of product catalogues widely used in the industry as a supplement to product catalogues supplied directly by vendors.

Another organizational scheme in wide use is a classification system that sorts a project into a set of phases. The AIA (American Institute of Architects) publishes a wide variety of material that relates design and management work to this scheme, as described below (Haviland, 1981).

- 1) Predesign services
- 2) Site analysis services
- 3) Schematic design services
- 4) Design development services
- 5) Construction document services
- 6) Bidding or negotiation services
- 7) Construction contract administration services
- 8) Post-construction services
- 9) Supplemental services

This scheme is a useful one because every document generated by design project can be related to one of these nine categories. Perhaps more importantly, billing and fees for projects are tied closely to the delivery of work in these areas, so if documents are saved in part as evidence of

work performed, this scheme provides an excellent way of sorting documents.

A document model

A document model was developed that incorporates several kinds of information that would enable an automated system to identify, categorize, and store these documents in a way that mimics the way paper documents were used in the firms. This model is shown in Figure 7-1 and is adapted from previous models proposed by Cohill (1993c, 1992). Each document has eight primary attributes:

Type describes the function of the document. Although there are only 12 types listed in Figure 7-1 there are actually many more than that. The listed functions represent the information items that occurred most frequently in the workplace. As documents are created in the system, the user would assign a type from a menu, enter it manually, or have it assigned automatically (if the system is aware of the type at creation time).

Source provides a reference to the creator of the information. While several sample sources are supplied in the table above, there are actually no preset values here. The user would enter a source value from an address book, enter it manually, or have it created automatically (e.g., in the case where he or she is creating it).

Orientation has only two values, horizontal and vertical. Spatial cues contributed significantly to the arrangement and retrieval of items.

Distance also played an important part in the arrangement of information in the workplace, with six values ranging from active work (the center of the desktop) to items stored so far away that they were clearly not contributing to work in progress.

Visibility of documents also determined relative importance. Items that required

immediate attention were almost always completely visible (phone notes, letters requiring an immediate response), while many other items of less importance were partially or completely obscured, while nonetheless occupying space in the active work area.

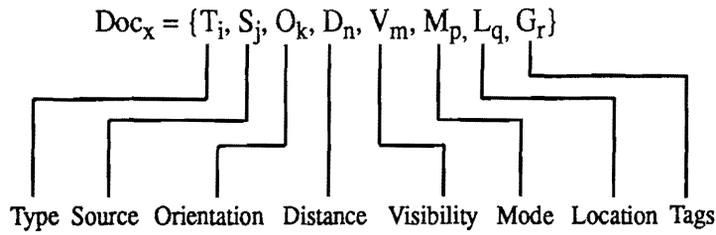
Mode is related to visibility because it describes information about physical relationship of information items to other objects in the workspace, but also signifies the relative importance of items. A document “in use” is likely to have more visibility than a document in the middle of a stack of paper or one that is rolled up.

Location as an attribute provides a place to store the absolute physical location of the document or information item, rather than a relative location like Visibility or Mode. The permanent value ‘home’ is provided for a convenient way to ‘put away’ documents quickly. When a document is first created, it can be assigned a default ‘home’ value or the user can be prompted to supply one.

Tags provide a place to assign user-defined categories and classifications to pieces of information. Two pre-defined tags are provided; the first allows the user to specify one of the 16 CSI categories to the document. A phone note from a plumbing contractor calling about a bid could be tagged with category 15 (Mechanical). The second tag is based on the AIA phases of design projects, allowing users to search and retrieve documents based on the stage of the work. Additional tags can be assigned by users as needed, using whatever keywords that are deemed useful. Once tagged, sets of documents can be retrieved based on the values of the tags. Tags serve as additional indices to the information items.

One may observe some overlap among some of the attributes of the model. Orientation could conceivably be extracted from the positional information stored in Location, but providing additional views of a document may contribute measurably to ease of use.

For example, by being able to specify orientation independently of location, a system could give the user the ability to specify that a document *always* be oriented vertically, thus making location dependent upon orientation. A feature like this may be quite useful when working with drawings; an interface might allow users to ‘hang up’ a drawing in a virtual work space, much as hanging up a real, physical drawing always creates a vertical orientation. Similarly, an interface that allowed users to create stacks of documents or drawings would also use orientation; anything placed in a stack would automatically receive an orientation value of ‘horizontal’.



<i>Type</i>	<i>Source</i>	<i>Orientation</i>	<i>Distance</i>	<i>Visibility</i>	<i>Mode</i>	<i>Location</i>	<i>Tags</i>
transmittals	self	horizontal	active work	completely visible	in use	home	CSI category
letters	client	vertical	adjacent to work	partially visible	stacked	current location	AIA phase
memos	supplier		within arm's reach	not visible	rolled		other tags
faxes	agency		within 1 or 2 steps		stored		
notes	contractor		within 3 to 5 steps		archived		
phone notes	other		not near workspace				
invoices							
job specs							
time sheets							
drawings							
sketches							
catalogues							

Figure 8-1: An abstract document model

This document model, presented as an ordered tuple, contains a basic set of attributes that every document would possess independent of any particular use (invoice, phone note, etc.) that would allow an automated design project manager manipulate these documents in ways that closely resemble the way that the architects who were the subjects of this study used similar documents.

A Design Project Manager

The architect's responsibility for the design of a building and the ensuing liability for problems that may ensue places an enormous burden on the architect to document completely all pertinent information that affects the design. This includes phone conversations, casual and formal client meetings, discussions with contractors, documentation of all changes to the plans, copies of product specifications, and many other information items.

A Design Project Manager (DPM) developed specifically to meet these needs would free the architect from some of the routine work of filing and sorting information and allow him or her to focus more on the design itself. The DPM would have sub-managers, or information tools, designed specifically to create, track, work with, and store specific kinds of information.

The concept of information tools is critical to ease of use; instead of a monolithic document management system which stores every possible document, and the subsequent problems of designing an interface that would permit convenient and easy creation, storage, and retrieval, these information tools would be designed for a single class of information. Because only a single kind of information needs to be 'understood' by the tool, the tools can be highly optimized for efficiency and ease of use. This notion of information tools is after Cohill (1993a, 1993b).

The Design Project Manager provides integrative abilities across individual information tools that permits project-wide management of information. This tool-based approach makes development of the DPM a less complex task since the tools are relatively small and can be completed more quickly. Moreover, not all the tools have to be complete to produce a useful

system. Finally, it is easy to replace current tools with better ones, or to add new tools with completely different functions than any of the existing tools. The overall goal is to produce small, elegant tools that are designed with a single purpose in mind and that enables effortless use.

The analysis of the spatial workspace data also provided results that were not anticipated. While the original study plan specifically avoided any direct work with CAD systems, it became clear that the workspace data offered important clues for the design of CAD systems, especially with respect to document management. While many CAD systems provide shortcut ways of accessing working drawings through the use of menus or icons, the subjects in the study all had different and idiosyncratic ways of organizing drawings for convenient access. None of the CAD systems with which the author is familiar provide the kind versatility in the access and display of drawings that would be required to accommodate the schemes observed in these offices.

In particular, many of the architects relied on particular spatial arrangements of documents as cues in locating a particular drawing (for even relatively small jobs, it is not unusual for an architect to work with fifteen or twenty drawings). While most CAD systems allow a designer to arrange windows in a particular order during a given work session, few will remember those window settings between sessions, and fewer still allow grouping those spatial arrangements of documents into work sets.

An object structure for documents

Using the data collected, an information structure was developed that describes design management activity as a collection of information objects. Each object consists of related pieces of information and data. Furthermore, each information object has associated with it a set of behaviors that relates it to other information objects and with the activities that take place in a professional office.

There are many high level objects that can be potentially manipulated by the system, and each high level object may be composed of several lower level information objects. As an example, something as simple as a message to return a phone call (a phone message object) contains a minimum of six additional information objects. These include the caller's name and phone number, any message from the caller, a time, a date, and a link to a specific project.

One of the most difficult tasks in the design of the DPM is determine what objects should be

linked and when. For example, it would be convenient, when recording a phone message, to have the system fill in some information like phone number once it knows the name of the caller. But what if the caller is not calling from his or her normal place of business? Or if the phone note is linked to a number in the Address Book, should the phone number on the phone note be changed if the number in the Address Book is changed? While these are simplistic examples, questions like these represent difficult design challenges. Users will want stability, and a system that makes far-reaching changes in ways that are difficult to understand is not likely to be used.

In an automated system, the project link could be generated automatically by having the system query a project file and name file simultaneously to make a connection between the two sources of information. Once the phone message is recorded in the system, it is linked not only to a sequential list of phone messages received (a list object), but is also linked to the correct project file. This provides the architect with two different views of the phone message.

The Document class and some sub-classes are shown in somewhat simplified form in Figure 8-2. The Document class contains or has access to sixteen attributes or instance variables that are assigned to every instance of class Document, and are also inherited by any Document sub-classes. The Text subclass adds one additional attribute called Message, which contains the text of the document. The subclass Memo/Note adds a subject field, and finally, the subclass Phone Note adds four more attributes specific to phone messages.

Because an instance of class Phone Note inherits all the attributes of the classes above it in the inheritance chain, a phone note actually contains fifteen information items. The class Phone Mgr has several attributes that help manage phone notes, including a list of all phone notes and a list of phone notes that require follow-up.

The message can be examined as part of sequential list (What phone messages did I receive today?) but also as part of a specific design project (What phone messages have I received related to project X?) This automatic linking and relationship-creating activity frees the architect from much of the tedious work of sorting such information manually, giving him or her more time to pursue other tasks. It is precisely this automation of detail that Burnette (1979b) feels would benefit practicing architects the most..

The document classes may be real containers for documents, or they could be set up to point to documents that exist outside the DPM itself. As an example, it would not be necessary to have a CAD-like drawing tool exist in the workspace of the DPM. When a user created a new drawing, the DPM could send the name of the new drawing to the CAD application and request it to create a new drawing with that name. The user would use the CAD tool to develop the drawing, but the Drawing Manager in the Design Project Manager would track the location of the document for the user. This is easily done on a computer with a modern operating system like

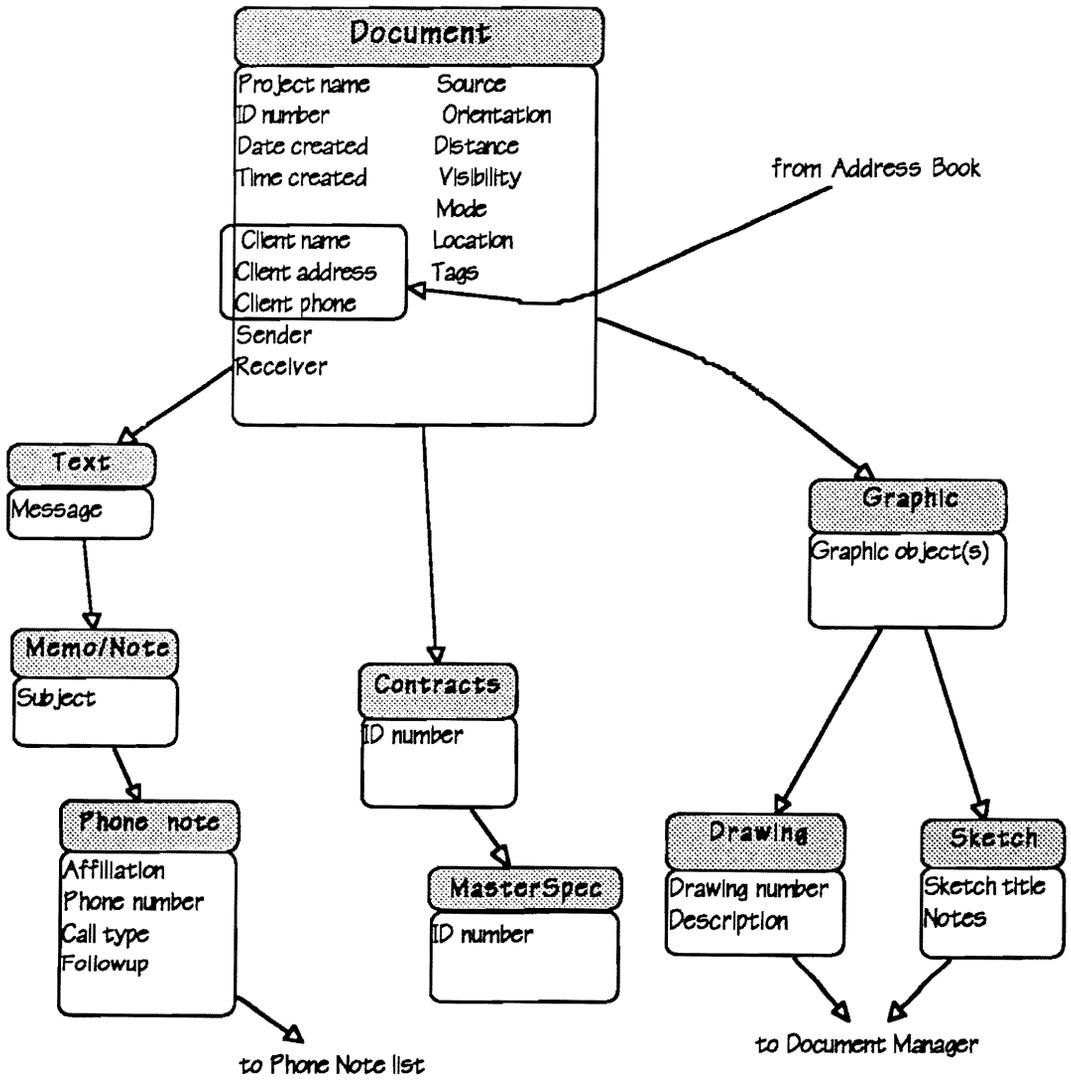


Figure 8-2: Partial document object hierarchy

the Macintosh OS.

Manager class—this class is the parent class for all document managers in the system. It contains methods for basic operations like creating new documents, archiving documents, inspecting public attributes of documents, deleting documents, printing, duplicating, and setting tags. Many of these methods would be overridden by methods in the children classes. A simplified view of the Manager class appears in Figure 8-2.

Document class—this class is the parent class for all documents in the system. It contains the primary attributes used by individual document managers and by the system to manage and control the place and appearance of documents.

Text class—The Text class is a container for documents holding primarily text. It is an abstract class and not intended to be used to create actual document objects.

Memo class—Inherited from the Text class, and the simplest form of document; it has a subject attribute and a body text attribute.

Phone note class—used as a container for the common “While you were out” style of phone messages. Attributes include items like subject, message, who called, status, and phone number.

Person class—A container for the kind of information found in address books, including name, address, phone number, email address, fax number, and notes (free form text) that can be stored with the basic information.

Letter class—A class used to hold formal correspondence. This class would probably provide a pointer to documents stored outside the DPM (created with an off-the-shelf word processor). It would be used to track who the letter was written to, the date, and other information that one must normally open the file to determine in a normal system.

Fax class—The Fax class holds the bit-map images of faxes, and can be used to hold both incoming and outgoing faxes. The computer being used would have to have a fax/modem attached to take advantage of this.

Contract class—Like correspondence, contract editing might actually be performed with a word processor. This class would be used to provide pointers to

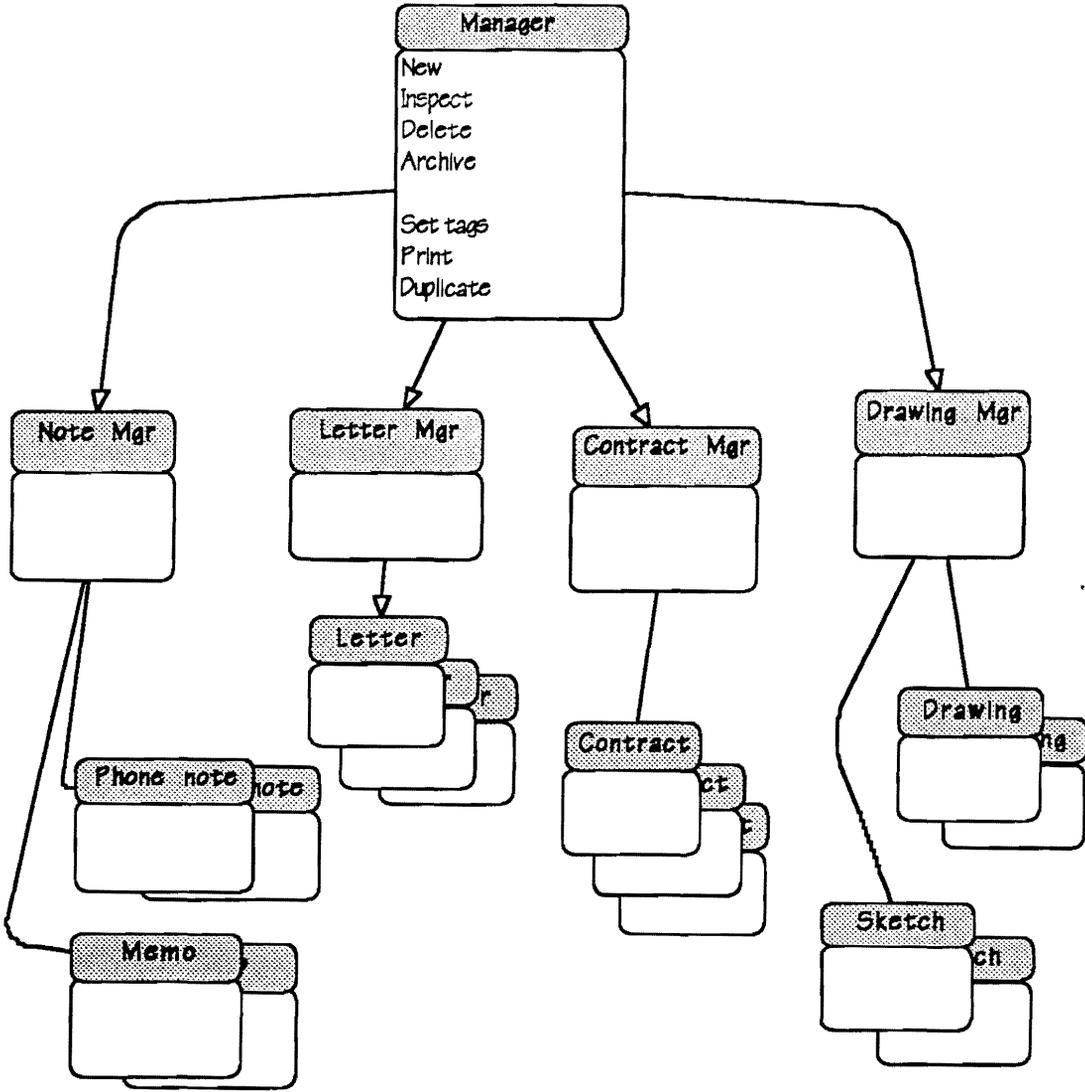


Figure 8-3: Manager objects and some documents

documents outside the DPM.

Photo class—photo objects would be stored in this class. Users would scan photographs and this class would be used as a container to track photographs and slides related to project work.

Notebook class—a place to keep free form notes.

Transmittal class—a document or form stored directly in the DPM.

Timesheet class—a complex object to help track the time spent on various billable activities related to project work.

Drawing class—as previously noted, this object would hold drawing titles and other project information, but the drawings themselves would exist as files outside the DPM.

Sketch class—similar to the Drawing class. Used to help manage the sketches and visual notes associated with a project.

The virtual workspace

The virtual workspace provides the organizing paradigm for the Design Project Manager. Every project would have its own workspace in which all documents associated with that project exist. Switching from workspace to workspace would be as simple as the click of mouse button. Figure 8-4 illustrates what the workspace for a single project would look like. Users might have several of these windows set up, with each one representing all the documents and activity associated with a single building project.

Users would be relieved of the manual sorting and filing of paper. At the time of creation, a document would “know” its type and both it and the Design Project Manager would always know what it is and where it belonged. As described in the previous section, every document in

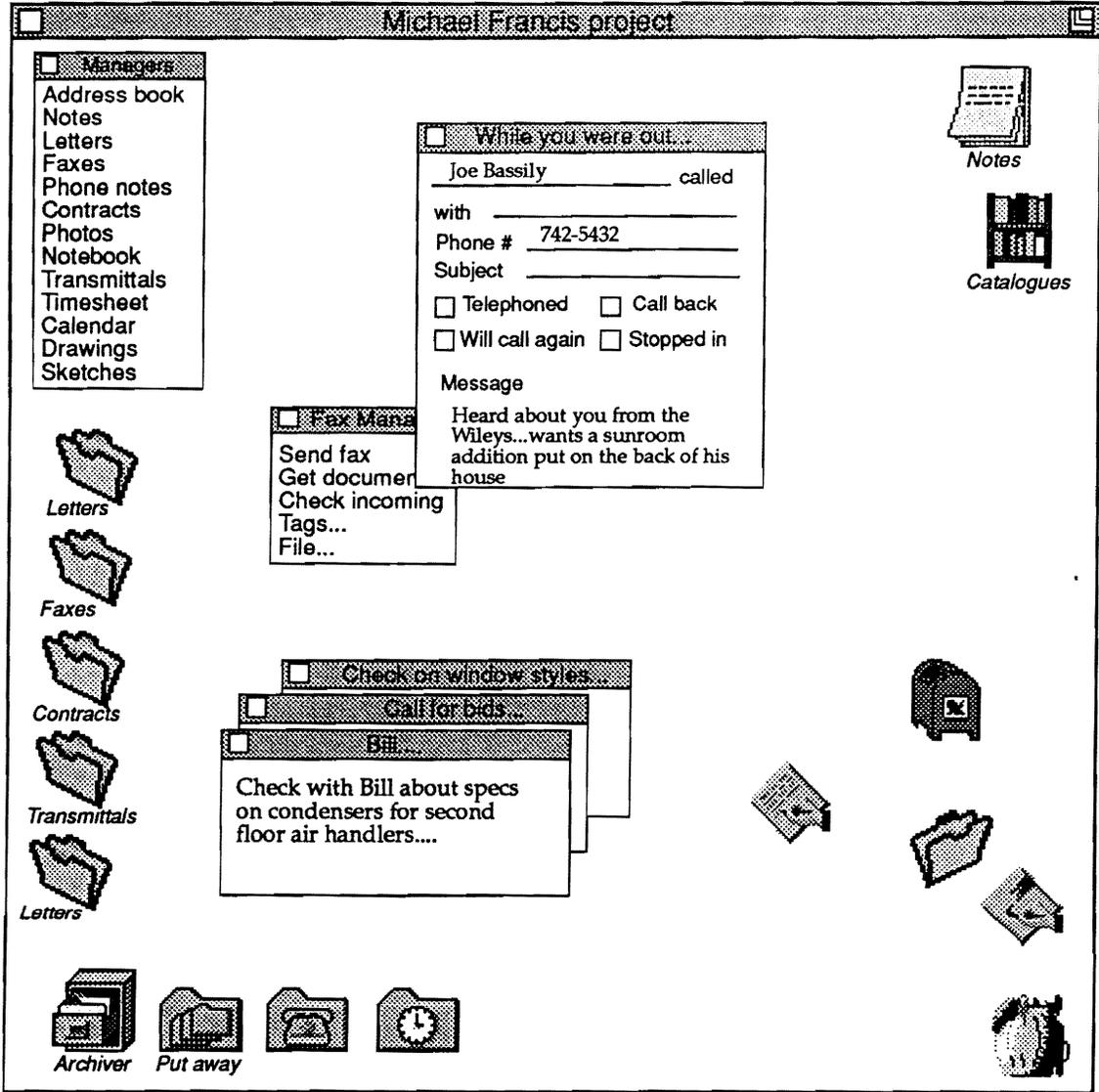


Figure 8-4: The virtual workspace of a project

this workspace would know what project it is part of, when it was created, who created it, and how it is normally stored visually (stacked, rolled, etc.). Tags are provided to let the architect sort and retrieve documents by keywords and other subject descriptors. Every document has two default tags set up for the CSI categories and the AIA project phases.

A set of thirteen document or information managers are provided for the architect. Each manager is designed to sort, organize, display, print, and archive a single kind of document used in a design project. Creating a document with a document manager automatically adds it to the list of active documents stored for the project; the act of creating the document with the manager initializes all the attributes associated with a document. The user does not have to be concerned with file management details like where the document is stored or trying to create file names that describe what the document is.

All folders that appear in the virtual workspace are active folders; that is, they know what kind of documents belong in them and what attributes the documents possess. If a user creates a letter on the desktop and drops in the wrong folder (say Faxes) it pops back out again, and the Fax folder will post an alert message asking if the user would like the document placed in the Letters folder. Once in the correct folder, all tags and attributes are examined and all lists and document indices are updated automatically. The folders act as an extension of the managers to which they are related, providing an alternate way for users to interact with documents, instead of using the manager menus.

The *Archiver* object accepts a document of any type; it examines the document to determine its attributes and adds it to a second set of document sets organized exactly like the document sets and lists accessed by the managers. However, documents stored by the *Archiver* are only accessible through the *Archiver* itself. The size of the active lists can be reduced by moving the documents to the *Archiver*, so the architect is not forced to sort and search through long lists of documents when only a small fraction of them are related to the current activities or phases of work. Documents can also be moved back out of *Archiver* and back into the active lists.

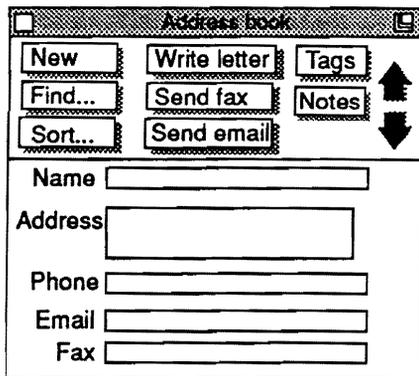


Figure 8-5: The Address Book

The *Put away* object allows users to select a group of documents of any type, drag them on top of the *Put away* folder, and have them all filed correctly without the normal alert dialogues.

Document managers

For common types of documents, a document manager is provided to give users convenient access to common operations on those documents. These functions and uses of these managers is described in more detail below.

Address Book—this manager is the only tool that manages a single set of information across all projects. The Address Book provides the equivalent of an electronic Rolodex and more. Buttons for common functions like writing letters, sending faxes, and sending email to associates in the office or around the world let users select the person with whom they wish to share information and generate a document with the correct information inserted (name, address, etc.) without any additional effort—not even the now common cut-and-paste operations. Tags can be associated with each person in the Address Book, so setting the CSI tag to Mechanical would let a user quickly access only those entries in the book associated with that type of work.

Note Manager—this tool provides users with an electronic scratch pad for jotting notes. Each note can be assigned a subject and tags, so notes can be sorted and reviewed based on a variety of project-

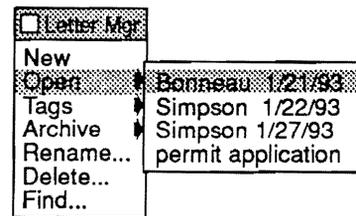


Figure 8-6: The Letter Manager

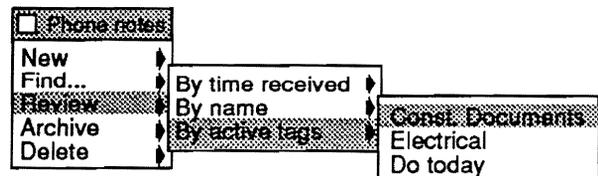


Figure 8-7: The Phone Note Manager

related criteria.

Letter Manager—this manager keeps a list of all formal correspondence generated during the course of a project. Letters can be retrieved by title or by the tags set for the documents. An important feature of all the managers is the archive function, which allows the architect to move correspondence off the active list. On a large project that may span months and years archiving letters allows the architect to reduce the amount of electronic ‘paper’ that must be considered without giving up the ability to retrieve documents quickly by going to the Archive list to search for an item.

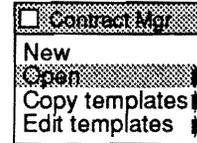


Figure 8-8: The Contract Manager

Phone Note Manager—this tool puts a structure around the most ubiquitous piece of paper found on architects’ desks during the study. An electronic analogue of the common “While you were out” message pad is provided to record messages. Notes can be reviewed and sorted by time and date, by name, and by tag. Combined with the Address Book, these two information tools help the architect reduce the chores associated with responding to and tracking phone calls.

Fax Manager—this tool lets users send and receive faxes without the problems that paper introduces. Incoming and outgoing faxes can be tagged for easy sorting and retrieval, and notes and sketches transmitted by fax can be easily cut and pasted into other documents without re-copying them by hand.

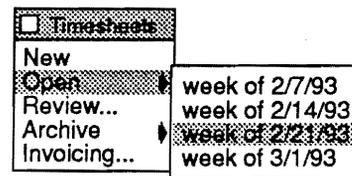


Figure 8-9: The Timesheet Manager

Contract Manager—a critical component of every project is the formal contract that specifies the work to be done. All the architects in the study used the AIA templates arranged around the CSI categories. The Contract Manager allows the architect to retrieve and edit contracts by CSI category. Templates, or “boiler-plate” text can also be opened and edited or duplicated as a new contract is developed.

Photo Manager—this tool allows the architect to manage photos and slides scanned as grey-scale or color images.

Timesheet Manager—the timesheet manager provides the architect with a tool to track the billable activities associated with a project. Organized on a weekly basis, this tool provides a spreadsheet-style matrix of activities that can be associated with the AIA phases. A timer provided in the Project Status window can be toggled on and off, with the elapsed times posted automatically to the categories or phase tags that the architect has set up as ‘billable’. The integration of a timer with the billable categories maintained by the Timesheet Manager reduces time tracking and invoice generation to a few mouse clicks. Invoices can be created automatically once time has been tallied for a week.

Drawing Manager—the development of construction drawings is an important source of revenue for architectural firms, and this tool aids in the tracking and management of drawings. Four preset tags are provided (architectural, structural, mechanical, electrical); these tags are commonly used to classify drawings. Titles can be assigned to each drawing, and as previously noted, the manager is able to work with a CAD package external to the Design Project Manager, making it easy to access drawings without sacrificing the power of a feature-rich drawing tool.

Transmittal Manager—transmittals can number in the hundreds or thousands since they provide a formal way of documenting the flow of documents among architect, contractors, clients, and other parties involved in the effort of constructing a building. This manager provides the usual tools to sort,

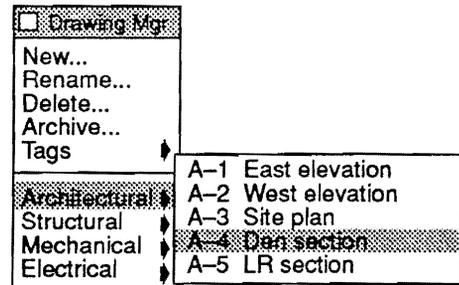


Figure 8-10: The Drawing Manager

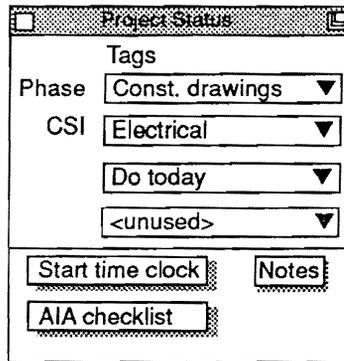


Figure 8-11: The Project Status window

organize, and retrieve documents. The archive feature will be particularly important here because of the volume of documents.

Notebook—every project has a notebook associated with it that provides a page-style document (larger than notes) that allows the architect to store text and sketches that may not need the structure imposed by some of the other managers.

Sketch Manager—the Sketch Manager provides a list of sketches associated with a project. Using a specified drawing or sketching tool, users can open sketch documents directly from the list. Documents can be added, deleted, or retitled. Default tags for CSI categories or AIA project phases can be applied from pop-up menus, allowing sorting and retrieval by work type or project phase.

Project Status window—this window lets the architect set a group of tags that are referenced by all the managers and documents that use tags. If the architect is currently in the construction drawing phase of work and is generating the drawings related to electrical work for the building, he or she could set the tags in the Project Status window, and whenever another manager is activated Status window tags are automatically set. As an example, if the Notes Manager is activated, any notes presented are already sorted and presented based on the tags in the Status window.

The goal is always to reduce the amount of work required by the architect to process the

paperwork associated with a project. Each manager is designed to know about, manipulate, and organize a single kind of information well. Coupled with documents that carry a rich set of attributes and information with them, the complexity of managing multiple projects is greatly reduced.

A key feature of the Design Project Manager is providing a workspace for every project, with the same set of managers active in every workspace, but presenting only those documents related to the active workspace. Just as the architects in the study tried to use spatial cues to help sort and organize paper documents, each project has a workspace in which documents can be arranged and managed without interference from other, unrelated work.

If an architect sets a project aside for a week or a month, the next time he or she opens that workspace window, it will appear exactly as it was left the last time the architect worked there. The architect is never required to spend time arranging, sorting, and storing files at the logical directory level of the computer, as most systems now require the architect to do.

Patternmakers and toolbuilders

Thought....is the faculty that doubts and inquires, that recognizes time and space and the material limitations, that slowly systemizes, that works by small increments and cumulation, that formulates, that concentrates, works, reworks and reviews, that goes slowly, deliberately, that makes very firm and sure, and that eventually arrives at a science of logical statement that shall shape and define the scheme and structure that is to underlie, penetrate and support the form of an art work. It is the hard, the bony structure, it is the tough, tendinous fibre; it may be at times perhaps as limber as the lips that move, yet it is never the need of smiling—never the smile.

Louis Sullivan

Kindergarten Chats and Other Writings

When I started this research, I had hoped to contribute to the understanding of the early stages of the design process, the schematic design. This was, perhaps, both naive and presumptuous. But the thought of appearing either naive or presumptuous (or both) has not stopped many others from trying to make a contribution in this area, and it did not stop me.

At the start of my work the area that I thought held the most promise was the study of the writings of other architects about the various phases of design, and what they saw as the critical components and activities of schematic design. From analyzing each author's viewpoint critically and carefully, I had expected that I would be able to synthesize some new and possibly important viewpoint that would contribute to understanding the requirements for new design tools.

That did not happen. I was initially excited about the work; what I found was that none of the authors that I studied had created diagrams or patterns of their own thoughts, and I saw an opportunity to do that, and believed that these patterns, brought to the light, would yield some useful information. So I drew and re-drew the patterns, moving ideas and the connections

between about the page until I exhausted all the reasonable possibilities. Finally, all I could say was that I had made the patterns, but what they meant with respect to the design of better design tools had eluded me.

I had also been stymied in another area of my research. I had thought that the time I would spend with architects, observing them work and talking to them about their work, would also reveal to me important ideas about the design of design tools. My interest, of course, has been in automated design tools. But as I watched these architects work and listened to them describe what was important to them about their work and how they approached it, what they told me, over and over again, was that they had little interest in computers. They were a nuisance.

And they went much further. They were not only a nuisance, but the machines were costly. It was difficult to know what software to buy and to use. The software that they did buy often turned out to be useless, either because, functionally, it was designed poorly for the tasks it was supposed to do, or because it was difficult to learn and to use.

Except for a very circumscribed set of design tasks, they wanted nothing to do with them. And it was worse than that. My conversations with Robert, the CAD 'operator' at New Design, were even more revealing. As the 'designated' CAD person in the firm, he felt that he was working as little more than a technician, merely cleaning up the work of others, making only the most repetitive kinds of changes, and was expected to perform many routine clerical tasks associated with the computer that had nothing to do with design at all (backups, disk maintenance, software installations and upgrades, etc.).

At the time I talked to him he was extremely dissatisfied with his work and was actively looking for another job. Several months later, he left the firm. The conversation with Robert was another data point that made me change the focus of my study of architects at work. Kevin, the owner of New Design, remarked more than once that the business of running a design firm was frustrating and necessary. During the day, he had to attend to the business aspects of the practice first, just to stay in business. He did most of his design work by staying late at the office or by working at home.

So I began examining the information that comprised the management aspects of running a professional practice. I began to see that while a general structure for schematic design had eluded me, there were common elements among the projects that I looked at. I began the work of defining those elements and the relationships that existed among them, and out of that was born the Design Project Manager. But I still failed to make a connection between it and the kinds of tools that I had originally hoped to find for schematic design.

What I knew so far was this:

- The architects I had spoken with enjoyed drawing, and were frustrated with the relative clumsiness of the current generation of CAD tools.
- I had been unable to find a common set of ideas and relationships among the work of architects who had written about schematic design. Each one had developed a unique perspective and explanation of what he saw and what it meant to him.
- The architects I had spoken with were interested in tools that would enable them to manage their business better, which in turn would leave them more time for design activities.

One evening I picked up Christopher Alexander's 1964 seminal work, *Notes on the Synthesis of Form*, and re-read the Preface. In it he states that the important thing is to make patterns (or diagrams), and to use those diagrams to create designs that are whole. He went on to state that it is not important how the designs were created, just that they were.

I immediately saw three things:

- The diagrams that I had created from the analysis of writers like Bachelard, Ching, and Norberg-Schulz were important only to me. I had created them out of my interpretation of their experience. It would be difficult, if not impossible, to develop a general schema. Each person interested in the work of these authors had to read them for him or herself, and develop their own diagrams and patterns, in light of their own experience.
- The making of patterns is critical to design, and it was not a mistake to pursue the analytical work of developing diagrams in this book; rather it was merely my expectations of the results of making them that were wrong.
- While my expectations were wrong, my motives were right: to make patterns, the patternmakers need tools, and my desire to develop new and better tools is correct.

What resulted from this research is the design of a tool, though not for use in schematic design. I followed the trail of my data and found a need for better tools in another part of professional practice, and used that data to design the tool.

But what of schematic design? It seems clear to me that the current CAD tools have failed the Heideggerian test: it is not possible to use them unconsciously, as it is possible for architects to work with pencil, paper, and parallel bar. On the face of it, it is almost absurd to compare

them:

Take a paper size of 34" x 22" and consider the number of possible points on it using a 0.2 millimeter pencil. Now consider the virtually infinite flexibility of the pencil with respect to line shape, thickness, and darkness. Understand now that a complete design for a building can be executed on this one piece of paper with this one pencil, a parallel bar, and a triangle without ever selecting a tool "mode", without zooming in or out, without "saving" your drawing, and without choosing a different tool to draw, say, curved lines.

Now take a typical CAD setup, using a large screen monitor (19") and a mouse. The effective window on a 34" x 22" document is only 12" square, so you can never see the entire work at once unless you reduce the scale (a conscious decision). Instead of drawing with an extremely lightweight and instantaneous direct feedback device like a pencil, one must now draw with a large and bulky mouse on a 9" square mouse pad. What is more, you cannot look directly at the mouse as you move it, but must watch the screen, and this indirect feedback provides no information about the "feel" of the mouse and the kind of line that you are trying to draw. Each time a line is drawn, a conscious decision must be made about what mode the drawing tool must be in, and none of these decisions are related to the task at hand: the design of physical space.

My hypothesis for this research was that there is a need for new and better design tools. I can say now that this is true. The software engineers and ergonomics engineers have largely failed to create the kinds of tools that architects want to use in professional practice.

- In schematic design, almost no suitable tools exist.
- In detailed design, some tools exist but are viewed as difficult to use and of little value to smaller firms.
- In the management of professional practice, some tools exist but are not adapted for the task of managing the full range of information that must be tracked during a design project.

Part of the problem for the toolbuilders has been the difficulty of understanding the needs of architects, and this is due partly because the toolbuilders have failed to recognize that they themselves are designers; if they knew this, really understood this, I do not believe that they would be satisfied with the tools that they are now creating and selling (without much success).

But not every toolbuilder can be expected to understand the full depth and breadth of the tasks for which he designs. This problem can be alleviated by design research like the kind undertaken in this book, which can serve as a bridge between the patternmakers and their needs

and the toolmakers and their skills. This book describes the design of a tool to aid architects in professional practice, based on hard data gathered over the course of eighteen months of observation of and discussion with the patternmakers.

The patternmakers need the toolbuilders. And the toolbuilders should aspire to create tools of exceptional craftsmanship, not only because the designers expect it but because the design of tools can be an end in itself.

The analysis of books on and about architecture, while it did not contribute significantly to the design of the Design Project Manager, was a necessary step in the process for me. The work of trying to make sense of those writers and the effort of creating those diagrams forced me to evaluate my original motives for this work. While certainly noble, they were not, in retrospect, very practical. I was humbled by the effort, and the result was that I paid closer attention to other phases of my work. The diagrams, whenever I struggled with them, continually put my work in perspective.

The student workspace data provided a useful glimpse at what design workspaces might be like if the architects were unencumbered by the detail of managing a business. Some of the organizing schemes and structures used by both professional architects were identical. Both relied heavily on stacks of things, on vertical display spaces, and on spatial cues to sort, organize and locate information.

The professional workspace data was a critical part of the work. The snapshots of their workspaces provided a wealth of information about how they worked with the documents of design projects. Conversations with them proved even more valuable, and affirmed the choice of hermeneutic observation; only because I was willing to dwell patiently in their world were the architects willing to share their work and their idea with me.

The analysis of the completed design projects was also important to this work. In the manila folders used to archive those projects both the organization that the architects had imposed on the design information and sometimes the lack of it indicated much about what shape the information tools ought to take to manipulate the information found in design projects.

Let this work be the starting point for a new set of tools, based on careful study of the tool users, designed with exceptional attention to detail, and crafted to exacting standards. In use, it should be easy to develop basic skills and easy to exercise its capabilities. In time, its use should become unconscious, so that the user is unaware of the tool, and can focus his or her full attention on the real task: the design of spaces that are whole.

Notes on method

In both firms, if I had tried to determine the architects' attitudes toward CAD by formal surveys or interviews, I would have 'found' what many others believe to be true; that is, all architects should be using CAD. The architects I talked to were uneasy with the technology, even the experienced CAD operator, who could use the CAD system well, but was not proficient in handling the maintenance required by the underlying computer system.

But while they *thought* they needed to be more involved with CAD, it was a defensive belief. To not say that would be to admit that they were not on the cutting edge of architectural design, to admit to some intellectual failure. What was even more interesting was the reaction of my colleagues in the human-computer interface design community with whom I discussed my work. The typical reaction, when told that many architects were not using CAD, was simply disbelief.

First, they could not believe that all architects were not already using CAD for every design project; one person firmly believed that all design projects, no matter what the scale, would involve complete 3-D visualization and animated walkthroughs. Second, their reaction, when told that some architects *did not want to use* the technology, was even stronger. They simply did not believe me. While there is nothing scientific about these anecdotes, I believe they reveal why there continues to be such a serious mis-match between software and the needs of users. If the toolbuilders choose to continue a love affair with technology at the expense of users, users will avoid the toolbuilders and their tools.

This book is not about a debate between the pros and cons of CAD and drawing by hand, but there were three clear reasons for the benign neglect of the new technology by the subjects I studied.

- ❑ In the crush of work required to keep a small professional practice viable (attention to current clients, solicitation of new clients, routine demands of running a business) it is difficult to make the time available to become really proficient with a new and complex system like CAD.
- ❑ The architects enjoyed drawing by hand. There is a directness, physicality, and sensuality connected with pencil and paper techniques that does not exist with current CAD systems.
- ❑ For many jobs with few repetitive design elements and where the work is unlikely to be

re-used on another project (virtually all residential design, much small commercial work), the initial creation of the detailed design and subsequent maintenance of the drawings could be done more quickly and simply by hand.

CAD has a place in every architectural firm, large and small, and this book is not intended to be an argument against CAD but rather a demonstration that there are other areas of fruitful and interesting research in professional practice. The professional practice of architecture is different in both qualitative and quantitative ways from other businesses. Few other businessmen are required to simultaneously exercise such high levels of intuitiveness, creativity and aesthetic sensitivity while juggling the rigorous demands of building safe, carefully designed structures that meet all the legal requirements of the often several governments involved in overseeing and inspecting the process.

In the near future, as a new generation of architects who have grown up in a culture that takes computers and information technology for granted begin to open their own offices, it may be that CAD will be the preferred way of producing construction drawings. But my results will be no less valid. The tools to manage the business still need to be well-integrated with whatever tools the architect chooses to use.

..

Directions for the future

Because I studied architects who learned their craft long before computers were common on the desktop, one might argue that the new generation of architects now in training will be better equipped to harness the power of the computer to manage their work. I am not convinced that this may be so; the design of information systems equipped to handle data of the complexity required by architects in professional practice may continue to require the assistance of *information* architects, who have the skills to build structures in cyberspace. Burnette doubts that architects, by training or by temperament, have the ability to design the kind of information tools that they need without enlisting the help of allies (Burnette, 1979a). One age-related difference that may be valid is that younger architects may be more willing to embrace automated tools than architects who have developed a set of methods for managing their work over a period of years in professional practice.

But I doubt even that. The architects I talked to and worked with were already using information technology whenever and wherever it proved comprehensible and cost-effective.

Based on my conversations with them and observations of them, I have no reason to believe that they will not embrace and use good tools when they become available.

It would be interesting, as a follow-on study, to perform the same kind of observation studies in a two larger firms. It would be useful to determine if the information needs and organization schemes are similar in small and large firms, or if there is some significant difference in the way information is used and managed.

Postscript

Dennis unlocked the outer door to his office and walked in. He flipped on the lights as he passed the wall switch and dropped his briefcase on his chair in front of his drawing table. After putting his coat away and turning on the lights in the back room, he came back out and sat down at his workspace.

He touched the mouse on his desk and the three 19" monitors sprang to life. Two of them were arrayed on a wide table to his right where there was space in front of them for D size drawings, and the other one was suspended from a swing-arm attached to the back of his drawing table. This let him move to a comfortable position anywhere on the desk without actually using any physical space directly on the desk.

A flashing icon in the upper left corner of the screen alerted him that faxes had arrived overnight. He started a pot of coffee, emptied the wastebaskets while waiting for it to brew, and finally sat down with a cup of coffee and began to browse the new faxes. He clicked on *Check incoming* on the *Fax Manager* menu, and it showed a list of four faxes. He clicked quickly through them, filing them as he went. The fax reader window allowed him to assign each fax to the appropriate project; from a pop-up menu he selected the project name, and from his *Address Book* pop-up menu he selected a name to associate with the fax (who it was from). None of them required any immediate reply, so once they were filed he turned to other work.

He usually started off the day by reviewing his phone notes and to-do notes. He first selected the complete list of all phone notes from the three active projects and looked those over, just to get a sense of what needed to be done. He did the same for his to-do notes. Having looked them over, he decided that there was nothing new on the hospital project today and

that he could spend his time on the Michaels addition and the convenience store facelift.

With a single mouse click he set the current project in the DPM to the Michaels addition, and the project workspace window appeared as he had left it last. There was a problem with the hot tub installation, and he had to go out to the site to figure out what to do. He set a couple of the project tags to *Mechanical* and *Construction Documents*; about half of the documents in the project window disappeared and a few new ones popped up. According to the plumber, the manufacturer of the hot tub had either shipped the wrong item or had changed the specs on it. The tub was two inches larger than the space he had designed for it, and it was possible that an interior wall and the hot and cold water supply pipes would have to be moved. He used the Drawing Manager to open the relevant drawing, which appeared on one of the two monitors to his right.

Because he had already set the tags, when he used the *Contract Manager* to look at the specs for the tub, it showed him only the sections he had previously tagged as *Mechanical*, and he found what he was looking for quickly. He compared his part number for the tub to the manufacturer's spec and they matched. He then checked the manufacturer's dimensions against his drawing, and they also matched, so he had determined that it was definitely the manufacturer who was at fault, not him. However, that did not solve the problem. He popped up his *Address Book*; again, because the *Mechanical* tag was set, he had to pick from just a short list of names that matched that tag, and quickly found the phone number of the hot tub maker. After a short conversation, Dennis determined that the company had substituted a different tub but had labeled and billed it under the part number he had originally ordered. They suggested cutting off a short flange in the back of the tub that accounted for most of the difference in the size, and Dennis agreed to do that if they agreed to reduce the price and maintain the original warranty. After he hung up, he quickly typed up a note detailing the conversation; once he was done, he collapsed the note into an icon and dragged it over to the DPM *Put Away* icon and dropped it. The note was time-stamped, tagged, and filed as part of the Michaels project.

He still had to go out to the site and check the tub, but he decided to do that just before lunch. He checked the notes on the project again and decided to take care of the window change requested by the owner. They had read an article in a magazine about low-E windows and had decided to spend the extra money to upgrade the six windows that were going to be installed in the new room. He reset his tags to *Doors, windows, glass* and *Bidding*, popped up the Fax Manager again and quickly created a fax for the window manufacturer, requesting a substitute for the order he had already placed with them. The Fax Manager noticed the project context and the tags he had set and automatically filed a copy of the fax in the Michaels project files as the fax was sent out.

He then typed a transmittal for the builder notifying them of the change and the difference

in cost, and created a copy for Jim Michaels, the client. He collapsed the transmittal to an icon, dragged it onto the printer icon, and dropped it. In a few seconds the laser printer whirred and spit out a completed transmittal. The document reappeared on the project desktop and he dragged it over to the Put Away icon. It disappeared from the desktop permanently, but it was now stored and tagged with the contractor's name, the client's name, *Bidding*, and *Windows, doors, glass*. If he needed it again later he could find it easily.

The phone rang as he picked the transmittal up from the printer; he sat down at his desk, used the Phone note Manager to pop up a new phone note, and had it open before he picked up the phone. Someone was calling for an appointment to talk to him about having a house built for them; he made a few notes as he listened, popped up his Calendar to set an hour aside two days from now, and bid the prospect good-bye. He set a reminder bell to go off thirty minutes before the appointment so that he could make sure the small meeting room in the back of the office was clean, and turned back to his work.

He set the current project to the convenience store, reset the tags to Schematic design and General requirements, and studied the project desktop for a few moments. It contained just one document, a page of notes he had taken at the initial client meeting. The owner wanted a complete face lift on an aging convenience store, and had asked Dennis to prepare some sketches for possible changes. He was behind in getting back to the client, so he decided to take the hour or so remaining before going out to the Michaels site to work on some sketches. He set the project timer on; this would log elapsed time directly into the *DPM Timesheet Manager*, sparing him the effort of keying his time in manually. He often forgot to use this feature of the DPM, and on Friday afternoon usually had to take a half hour to review his work for the week and bring the timesheets for each project up to date.

He worked steadily; about 11:30 he clicked on the timer to turn it off and stepped away from the desk to look at the sketches he had put together. He was running late, but he quickly opened up the Sketch Manager, turned the scanner on, and scanned four of the most complete ideas. He quickly labeled each one, and the Sketch Manager filed them away for him. He would not have to worry about losing them, and would have a permanent record of all the ideas he had put together if he needed to refer to them later.

He was late now, and threw his jacket on and headed out the door. As he turned the key in the lock, he heard computer beeping at him—another fax was coming in. He would have to check it after lunch.

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Appendix A

Student raw data

Work in progress

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
drawing, axon, large	3									2								2			6				
drawing, site plan	1						1																	1	
drawing, small							1								2										
drawing, medium							1	3																	
drawing, large		4	4	1			6				8			5				1	5			3	1		
drawing, plan					1	1									1			2							1
drawing, plan, very large																		1							3
drawing, elevation					2	1																1			1
drawing, elevation, very large																1					4				
rendered drawing											1														
rendered drawing, plan						1																			
rendered drawing, elevation						1																			1
drawing, CAD						1							3												
drawing, section, very large																					4				
sketch, small																		1							
sketch, medium							10	6	1		1						10			6	6	6			
sketch, large				1	1				1							2	1	1							
sketch, very large																						1			
sketch, plan		1																							
sketch, site plan					1	9																		1	
sketch, site map																									
colored sketch						4																			
sketch on tracing paper								1			4														3
stack of drawings, sketches		1					1	1			1						1	1	2	2	3	1	4	2	
roll of drawings, sketches						1	1				1				1							5	1		
sketch pad				1														1							
xerox of site plan		1																							
xerox of drawing		2								2															
xerox, mixed text and graphics				4			1																		
xerox, map						1																			
xerox, topographical map								1																	1
xerox, enlargement, topo map								3																	
xerox, blueprint										2															
model		2		1	1	2	1				2			1	6	1	5	2			1	2	4	4	1
partial model		1			2																				
model parts					3	1																			
cardboard template					1																				
class notes							1	1	1		1		1			1									
photograph						1																7			4
stack of photos																									1

Other work and information

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
sketchbook	1								1	2	1	2	1				3	1	1		4				1	
drawing	1		8											4												
sketch, small									1																2	
sketch, medium										1																
sketch, large									1																	
CAD drawing													1													
stack of papers	1								2	1	2					2		1	2						1	
stack of drawings		2																								1
roll of drawings			5												1	2	2				1					5
roll of sketches, tracing paper										1	4			2			1				1	2				
wood pieces, fabricated				1							1															
model parts	1	1	1	1		1	1	3		3	1	1									1	1				
partial model	1	1																								
model	1	2	5	3		1	4	2	1		5		1	5		2	2	5								2
xerox, graphic	1							1			1	1				1										
xerox, mixed text/graphics											2						3						22			
xerox, text						1												1								
xerox, sketch								1																		
xerox, map								3	1	1																
xerox, blueprint									1																	
xerox, journal article												1														
map, topoographical								1	1																	
color print		2																								
photograph		1							1	3		3					4					5				5
slide																										
box of photographic slides			1									1										1				
negatives														1												
cartoon												2					1									
diskettes																						3				
books		10							1					5							1	1				2
library book									1	1	2	1	2			1	2			9	3					
dictionary												1									1					
class notes						1		1																		
notebook						1					1	3	1								1					
binder with notes	1								1			4					1	1			1					1
Post-it™ note										3																
calendar							1																			
notes		1			10		1	8									1	1								
newspaper																										1
miscellaneous items	2	2	1			1																				

Design tools

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
pencil	8							1	10	1	2	1				4	15	8	1	2	5	3	11		17
box of colored pencils														1				2			1				
colored pencils																				38	17		3		
colored markers																			13	18		9			
pens	4		4						10			1	3			4		8				9	6		15
mechanical pen set (Rapidograph)			1																		1	1			
brush			1															1	1		1		1		
ink												1									1	1			
eraser								1				1						1			1			2	
eraser shield																				1			1		
electric eraser																1									
liquid eraser																								1	
parallel bar	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
drafting template			1															1							
adjustable triangle			1																						
triangle			1															2	3		4	5		4	1
protractor																		2							
compass																					1		1		1
scale ruler	1		1				1							1				3	2		2	1	2		1
flat ruler												1						1	2	1	1	1			1
drafting set	1							1																	
pounce																						1		1	
knives, cutting tools	1		1						1	1								1			1	1	1	3	
scissors									1																
stapler																1									
push pins																								1	
box of drafting dots	1		1					1	1									1		1		1			
drafting tape										1								1	1						
pencil sharpener	1				1			1	1			1				1		1	1	2	1		1		
electric pencil sharpener																1							2		
glue, glue sticks, spray adhesive								1		1		1					1				1	1	1		1
cutting board, self-healing								1				1							1		1				
silk screen						1																			
tape measure										1															
soldering iron											1														
spray paint								4				1													1
alcohol											1														
pliers																		1							
mitre box																									1
hammer																									1

General tools and equipment

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
lamp		1	2	1	1	1	1		2		1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1
fan																1										
roll of toilet paper				1	1								1				1	3	1	1						
wastebasket									1																	
refrigerator													1													
trash can																1										
box of light bulbs																							1			
unused lamp	1																									

Drawing and design supplies

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
stack of blank paper	1																									
roll of paper	1		9							3	1					4		4			2			2	1	
roll of vellum	1			1			1		2		1		1	2	1				1	1	1	1	1	1	1	1
roll of tracing paper					1			1				1														
pad of paper	1							1									1									
stack of paper, cardboard												1														
foam core												1		1												
loose paper scraps			1																							
scrap paper			2	1																						
stack of loose paper			5				1								1											
stack of loose cardboard			5	1	1		1							2	1	1		2		1	1			3	1	
homosote								1																		
glass plates																							6			
developer fluid, various																		3			1					
misc. wood pieces		1			1				2			2	2					1			1					

Storage systems

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
foot locker		1	1	1	1	1	1	1	2		1	1		1	1			1	1				1	1	1	1
cabinet				1		1							1													
box						1																				
pencil box																					1					
cup									1				1			1										
toolbox											1				1	1			1	1						
briefcase											1															
portfolio																				1						
paper storage roll																1										
drawing tube carrier																						1	1		1	

Personal items

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
cassette player	1																				1				
cassette tapes			4						1												2	4			
drink cup		1				1	2	2			1		1			2	1	1							1
greeting card		1							2																
coffee cup			1			1			1			1			1	1			1		1	1			
soda can			2																						
radio									1																
bowl, handmade									1																
wine bottle, empty									1																
painting									1																
stuffed animal									1																
tea, coffee												1									2				
nuts												1													
headphones																					1	1			
candy																						1			

Appendix B

Professional raw data

Category	Item	Daniel	Louise	Kevin	Thom	Michael	Larry	Phillip	David
	Drawing	25		1	25	3	7		1
	Stack of drawings							4	4
	Roll of drawings	1						9	36
	Sketches	11	17			1	6		
	Stack of sketches					2			
	Blueprint		1				3	1	
	Stack of blueprints		1						
	Roll of blueprints	1	1	1		1			
	Model			2					
	Photograph	11		2					
	Stack of photos				4			1	3
	Slide			3					
	Box of slides	1		2	8			48	
	Notebook				1				
	Job quote/specs							2	6
	Client design specs	1		1					
	Client contract			1					
	AIA budget sheet			1					
	AIA brochure					1			
Work in progress									
	Specs and standards	1	2	1	5				2
	Product catalogues	1		5	6	5		1	5
	Product specs					1		3	
	Product samples				40			5	9
	Vendor price list		1						
	Magazines		1	15	1				
	Stack of magazines					1			
	Books				5				9
	Transmittal	1	1						
	Time/job sheet	1		5					
	Work schedule		1						
	Note	1	1	7	2	6	1	2	2
	Stack of notes	1	1	3		2			
	Letter	1				1	3	2	
	Stack of letters			1				1	
	Folder		6		2	7		2	2
	Stack of folders	1							
	Xeroxes	2	1		6				
	Faxes			1				8	
	Phone notes	10	2	8	16	5	2		
	Post-it note			1			2	15	2
	Stack of papers			3	2			1	7
	Unopened mail							1	

Category	Item	Daniel	Louise	Kevin	Thomas	Michael	Larry	Phillip	David
Business information	Phone book					1		2	1
	Phone number list	1	2	1	2	2			
	Calendar	1	1	2	1				
	Business card	5	1	1					
	Cheat sheet for computer	3		3					
	Software			5					
	Contractor list	2							
	Miscellaneous papers			3		1		3	
	Resume			3					

Category	Item	Daniel	Louise	Kevin	Thomas	Michael	Larry	Phillip	David
Drawing and design tools	Calculator	1			1			1	1
	Pens								3
	Pencils	10	3	7	4	4	15	1	10
	Pencil sharpener			1	1		2		
	Pencil lead							1	
	Lead cleaner							1	
	Colored pencils							2	
	Box of colored pencils					1			
	Template					7	6		10
	French curve						1	1	1
	Triangle					4	5		2
	Parallel bar	1	1	1	1	1	1	1	1
	Scale ruler					4	1	1	1
	Ruler						1		1
	Eraser						1	1	
	Electric eraser								1
	Eraser guide								1
	Brush					1	1	1	1
	Drafting tape					1		1	2
	Set of ink pens					1			
	Colored markers						30		
	Box of colored markers						2		
	Compass set					1			
	Knife								1
	Camera								1

Office supplies and equipment	Item	Daniel	Louise	Kevin	Thom	Michael	Larry	Phillip	David
	Film mailer	3							
	Adhesive labels		1						
	Post-it note pad	1		1					
	Phone note pad		1			2	1	1	
	Note pad			2	1	6		1	7
	Pad of unruled paper			2	2				
	Manila pad				1			4	1
	Columnar pad								2
	Transmittal pad	1							
	Lamp	1	1	1	1	1	1	1	1
	Stapler					1			1
	Telephone	1		1		1		1	1
	Correction fluid							1	
	Tape								1
	3-hole punch								1

Drawing and design supplies	Item	Daniel	Louise	Kevin	Thom	Michael	Larry	Phillip	David
	Tracing paper	2	1				1		
	35 mm film							4	
	press-on letter sheets						8		

Storage systems	Item	Daniel	Louise	Kevin	Thom	Michael	Larry	Phillip	David
	Clipboard		1					1	
	2 drawer filing cabinet	1	1	1	1			1	2
	Paper roll	1	1	1	1				
	Small cabinet				1				
	Rolodex							1	1
	Wastebasket							1	1
	Tape dispenser								2
	Pencil box								1
	Drawing basket			1				1	2
	Cardboard box								1
	Drawer							1	

Personal Items	Item	Daniel	Louise	Kevin	Thom	Michael	Larry	Phillip	David
	Clock			1					
	Cartoon				1				
	Photo			1	1				
	Coffee cup							3	1
	Bottle of aspirin								2

Appendix C

Project summary data

Design documents

	New Design					Design Future				
	A	B	C	D	E	F	G	H	I	J
Sketches						19	8	46	23	13
Drawings	135	6	3	3	2	39	8	33	39	9
Engineering documents					10					
Program notes	150									
Product catalogues	270	12			34	56			201	
Product specifications	100			6		66			39	2
Photographs	216					54	18			
Product samples						1				
Materials investigation					10					
Beam deflection data						2	5		13	5
Topo. site maps								2	5	

Business documents

	New Design					Design Future				
	A	B	C	D	E	F	G	H	I	J
Transmittals in						19	0		0	0
Transmittals out	540	1	2		27	68	4	12	25	6
Letters/memos in						23	8	5	3	2
Letters/memos out	108	5			27	33	1	2	6	6
Faxes in						162			3	
Faxes out						92		6	0	
Notes	432	17	4	4	65	35	5	19	28	1
Xeroxes			1	12	22	45		3	44	72
Phone notes						33			19	9
Post-its™										
Site visit notes						28	5			
Meeting notes					10		2			
Account audit forms						3				
Application for payment	54					14				
Bid log						6				
Bid proposals									7	
Bid summary						1				
Building permit data										
Change orders	108					2				
Contract addendum						5				
Contractor bid									3	
Contractor info						20				
Contracts					4	12			31	14
Cost estimates	15								13	2
Fee estimates						5				
Gov't forms, applications				1	5	5		1		
Invoices	54	3	1	1	54			11	5	
Job specifications					35	23		2		26
Magazine article										
Misellaneous documents	105				50				2	
Plats				2				1		
Preliminary job specs									13	
Punch list	54								10	
Release waivers						2				
Request for Information	20									
Request for Proposal	12									
Time line						1				
Time sheets	75									
Weather data						10				
Work guarantees						3				

Vita

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Andrew Cohill is an information architect with a diverse background in architecture, ergonomics, and computer science. He has seventeen years experience in software applications development in industry with both large and small firms, including several years at AT&T Technology Systems and AT&T Bell Laboratories. He has worked as a graphic arts and industrial designer, and has additional experience with computer systems development, document design, training design, and training delivery. He has worked as a consultant, doing both software development and human factors work. He currently works at Virginia Tech on the design and development of campus-wide information systems.

He is active professionally as well. He is a member of the ACM and Human Factors and Ergonomics Society, and has served as Chair of the HFES Computer Systems Technical Group. He has been a member of the HFS/ANSI Committee on HCI Standards since its founding in 1985, and is primary author of the "Design Process" section of the draft HCI standard. He is an associate editor of *Ergonomics in Design*, and is also on the editorial staff of the *International Journal of Human-Computer Interaction*.

His current research work is based on design activities of architects in professional practice, and in the articulation of a theory of information systems development based on design sensibility.