THE ROLE OF CONCEPTUAL DIAGRAMS IN THE ARCHITECTURAL DESIGN PROCESS:
Case Studies of the First Unitarian Church by Louis Kahn, the Staatsgalerie by Stirling & Wilford Associates, and the Jewish Museum by Daniel Libeskind

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To my father and mother.
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This thesis investigates the conceptual phases of design during which designers formulate new ideas, develop them, and often change them, and the role of conceptual diagrams in the evolution of these ideas. The thesis poses three questions. First, what is the nature of the initial phases of design? Second, what are the roles of conceptual diagrams in the initial phases? Third, how to study the initial phases of design?

Expert architects' accounts of their design process often describes the initial phases of design as a period of incubation at the end of which they achieve a complete understanding of their design situation and a full-fledged design. In contrast to these accounts, historical materials from architectural archives portray rather a more complex process during which design proceeds through several iterations and changes. Research in the area of design studies has also corroborated these expert designers' accounts by investigating the design process. Research in this area, however, has been inconclusive in providing a rich understanding of the initial phases of design. First, researchers in design have described the initial phases of design differently. Koed and Piroli (1992) claim that design evolve in two distinct and sequential phases, i.e., problem structuring and problem solving. Schön (1988) characterizes design as construction of a framework rather than a sequential process from problem structuring to problem solving. Maher et al. (2003) describe design as a co-evolutionary process during which problem structuring and problem solving evolve interactively. Second, researchers in the area of design studies have often investigated design processes through simplified design tasks by using the protocol analysis method.

This thesis addresses some of the discrepancies between expert architects' accounts and historical documents and among researchers in design studies about the nature of initial phases of design. It does this through offering a methodology thus far not used in design studies: the cognitive-historical analysis method. The method has been proven to be effective in describing cognitive processes in scientific discovery and has potential to
provide a richer and contextually embedded understanding of the design process also. In this thesis, the method is applied to three cases from architectural design: the First Unitarian Church by Louis Kahn, the Staatsgalerie by Stirling and Wilford Associates, and the Jewish Museum by Daniel Libeskind. The archival research for these case studies, indeed, uncovered one particular kind of representation, *conceptual diagrams*, that designers use in the initial phases of design to explore design ideas and design schemes. The results from the case studies indicate that conceptual diagrams mediate the exploration in two spaces in design: the problem structuring space and the solution space. The former is characterized by conceptualization of design situations, whereas the latter is characterized by a search for a meaningful spatial configuration corresponding to the conceptualization. In the three design processes that were studied, the two phases of design are coalesced through conceptual diagrams which mediate the dual exploration in the problem space and the solution space. The proposal of this thesis is that conceptual diagrams are double-referential, thus through their structural correspondence to their target domains, they align the structures of their respective target domains.
CHAPTER 1

EARLY PHASES OF DESIGN

Expert Designers’ Accounts

Some expert designers, in their retrospective accounts of their design processes and in their writings on design, suggest that they first acquire a full understanding of the design situation and then start translating their ideas onto paper (Le Corbusier et al., 1981; Freifeld & Wright, 1990). If this were an accurate account of expert designers’ processes, one would expect them to spend a limited amount of time in concept development and to see few sketches from their conceptual design phases. Moreover, these sketches would be well-thought out and would only be translations of ideas rather than tools for idea exploration. These claims are testable through an investigation of early drawings, notes, and additional documents in an archival research.

This thesis presents the findings of three such case studies, conducted in the Louis Kahn Archives of the University of Pennsylvania, the Canadian Center for Architecture, and the Getty Research Institute. The projects studied were: Louis Kahn’s First Unitarian Church project at the Louis Kahn Archives; James Stirling and Michael Wilford’s Staatsgalerie project at the Canadian Center for Architecture; and Daniel Libeskind’s Jewish Museum project at the Getty Institute. Historical materials from the archives constituted the primary documents of investigation and facilitated the construction of detailed accounts of the conceptual phases of their respective projects.

These archival investigations and additional review of the literature cast doubt on the expert designers’ accounts. The research conducted at the archives uncovered often unpublished material illustrative of the depth and intensity of the effort that the designers made during the initial phases of their design processes. The results of some research in the area of design cognition, with a focus on the nature of conceptualizations in design increase the doubts about the designers’ accounts, as does a wide range of research in cognitive science viewed more broadly. Indeed, the archival research into the nature of
early phases of design for this thesis have uncovered a particular category of architectural representation especially significant for the conceptual phases of design, here called conceptual diagrams.

The discrepancies between the expert designers' accounts and initial observations at the archives, together with the findings of the design cognition studies, beg a central question about the nature of early phases of design, often characterized as a period of significant discovery. This constitutes the first question of this thesis: What do designers do in the early phases of design? The second question relates to the role of conceptual diagrams as a particular representational system in the early phases of design: How do conceptual diagrams facilitate exploration in the early phases of design? The two questions are closely related in the sense that the study of the second question provides an answer for the first. The results of this thesis, therefore, improve our understanding of the salient features of the conceptual design phase with reference to the role of conceptual diagrams.

At least three architects from architectural history have described their process during the early design phases: Frank Lloyd Wright, Le Corbusier, and Louis I. Kahn. A more detailed historical research would uncover additional examples, yet for the purposes of this research these three architects' accounts suffice to illustrate the argument.

Bruce Brooks Pfeifer, one of Frank Lloyd Wright's students, reports that Wright taught his students to complete their designs in their mind, before putting them down on paper (Pfeifer & Wright, 1990). Pfeifer quotes Wright as follows:

You all want to design things. You want to learn how to design things. Well, you don't learn how to design things by sitting at a drafting board with a pencil in your hand, and with T-square and triangle. That's what this talk this morning chiefly means, and that's why I'm giving it to you. I never sit down to a drawing board—and this has been a lifelong practice of mine—until I have the whole thing in my mind. I may alter it substantially, I may throw it away, I may find I'm up a blind alley; but unless I have the idea of the thing pretty well in shape, you won't see me at a drawing board with it. But all the time I have it it's germinating, between three o'clock and four o'clock in the morning—somehow nature has provided me with an hour or more of what might be called insight.... So this design manner is not something to do with a drawing board. It is something that you do as you work, as you play. You may get it in the middle of the tennis court and drop
your rocket and run off and put it down. That is the kind of thing that it is. It is fleeting, it is evanescent. It’s up there where you have to be quick and take it (Pfeiffer & Wright, 1990, pp. 7-8).

A widely cited account of Wright’s design for Fallingwater is an illustration of the statement above (Tafel, 1979). This is an almost mythical story about how an expert designer sketched out his complete design from scratch in a couple of hours after he learned that his client was on his way to the office. According to the story, Wright didn’t have any drawings prepared when he received the call from the client, and that by the time the client arrived he had the preliminary drawings and the design ready (Tafel, 1979). Pfeiffer also reports that in Frank Lloyd Wright’s mature period his initial drawings became more and more simplified, to the extent that they were just conceptual schemes.

Another significant figure whose account parallels Wright’s is Le Corbusier. Le Corbusier described his process of idea generation as follows:

> When a task is entrusted to me, it is my habit to put it in the interior of my memory, that is to say, to permit myself no sketch for some months. The human head is so made that it possesses a certain independence: it is a box into which one can toss the elements of a problem. Let them ‘float,’ ‘sourcer,’ ‘ferment.’ The one day, out of spontaneous initiative of the inner being, it clicks: one takes a pencil, a piece of charcoal, colored crayons (color is the key to the proceedings), and one gives birth on the paper: the idea comes out—the child is delivered, it has come out into the work, it is born. (Le Corbusier et al., 1981, p. 13)

We also know, however, that Le Corbusier often produced several diagrams, which he called ideograms, that were simple, yet representative of salient features of his design conceptualization.

Louis I. Kahn’s theory of design is a similar account of the design process in architecture. In writings in which he speculates on the essentials of architecture (Kahn, 1960, 1961a, 1961b), Kahn suggests that design proceeds from “Form” to “Design” in a linear way. He describes “Form” as the realization of the essentials of a design situation and “Design” as the implementation of that realization according to the circumstantial needs. Kahn’s account suggests that what is crucial in design is the realization of essentials, that the rest follows easily, and that once designers have this realization, the difficult part of design is more or less taken care of. Along with his theory of design, Kahn highlighted the
significance of what he called a "form drawing", a simple graphical representation of the design realization.

The accounts of Wright, Le Corbusier, and Kahn seem to be in agreement regarding speculations on the nature of creativity and that creativity requires a period of incubation followed by a period of implementation. According to this view, the period of incubation is a near mystical time interval during which the creative genius receives inspiration (Božen, 1991), constructs a complete understanding of the design situation, and configures a fully-fledged design scheme. Also, drawings from the early phase of design would have commonalties in being concise and representative of salient features of the design ideas.

Contrary to the accounts of Wright, Le Corbusier, and Kahn, there are detailed historical accounts of each architect's design process, which suggest different views of their initial design phases. Hoffmann (1978) reports that Edgar Kaufmann, Wright's client for the Fallingwater, actually notified Wright about his upcoming visit about a month before he came to the office. Besides, Hoffmann states that others' accounts of the day when Wright drew the whole scheme are varied and conflicting. For some other projects Wright made an intense effort to conceive a satisfactory design scheme. He worked through four different schemes to finalize his initial design for the Guggenheim Museum of New York, NY, and he made fifty studies for his Unity Temple in Oak Park, Chicago (b.B. Pfeiffer, personal communication, May 3, 2002). A detailed history of Le Corbusier's design (Le Corbusier et al., 1981) for the Firminy Church in Firminy, France, describes the initial phases of the design including the first day Le Corbusier visited the town of Firminy. During his visit Le Corbusier spent the day talking to the client and to the residents of the town, and analyzing the site. Throughout the day he produced a series of drawings in which he sketched out his first ideas. He produced his preliminary scheme for the church after four and a half months. Detailed historical accounts of Kahn's design process for the First Unitarian Church project (Dogan & Zimringer, 2002; Williams, 1991) discredit Kahn's accounts as well, even though Kahn (1960) reports that the design progressed in a linear and straightforward way from his design idea to the final realization. During his design for the church, which did not have a complex architectural
program, Kahn developed five different volumes in the design process. It took him three years to complete the design.

Views from Design Studies

Some studies that have focused on designers’ behaviors in the early stages of design cast doubt on expert architects’ accounts also. These studies indicate the significance of early stages of design during when designers construct a better understanding of the design situation. However, they often provide conflicting results about the nature of the early phases of design. Schön (1984; 1988) highlighted the importance of what he calls “problem framing” in initial phases of design from a constructivist perspective. According to Schön, design situations are complex and, as such, require framing in the initial phases of design by way of setting boundaries, selecting “particular things and relations for attention”, and imposing “a coherence that guides subsequent moves” (1988, p. 182). Goel and Piroli (1992) suggest that problem solving in design starts only after the problem structuring phase. Earlier studies in design have characterized design as ill-defined (Eastman, 1969; Simon, 1973) or ill-structured (Reitman, 1964). According to these studies, in the initial phases of design design structure problems through extensive information transfer, because initially much is unknown to designers either about their goal state, their initial state, or the means to go from an initial state to a goal state. Simon (1973) and Eastman (1969) suggest that ill-defined problems, e.g., design, are not so different from well-defined problems once they are structured. They also indicate that the nature of problems depends on the expertise of the problem solver and the availability of information in the initial phase. This implies that if designers have enough expertise in a particular design task they may not have to go through problem structuring prior to design solution, hence supporting experts’ accounts of their design processes. Some research (Lawson, 1979; Lloyd & Scott, 1994) has provided evidence for experts’ accounts by suggesting that designers start by focusing on solutions first (Lawson, 1979), or that designers with experience in a particular design task start with a solution (Lloyd & Scott, 1994). Other views, such as co-evolutionary views of design (Dorst & Cross, 2001; Grass et al., 1987; Maher & Tang, 2003; Suwa, Gero, & Purcell, 2005; Gero, 2006; Baker, 2008; Baker & Fields, 2008), suggest that designers are not restricted to focusing on solutions first.
2000), suggest a process in which problem solution and problem structuring evolve simultaneously; these views are not conclusive in resolving the discrepancies between studies in design and expert architects' accounts and between views suggesting the primacy of problem structuring and views suggesting the primacy of solutions.

The views above, regardless of their differences, seem to agree on the dual nature of exploration in design: be it in the problem definition space, i.e., problem structuring, or in the solution space, i.e., the problem solution. Exploration in the problem space leads to a better understanding and more informed definition of design tasks sometimes accompanied with a change in the representation of the task. Exploration in the solution space examines different design alternatives.

The notion of dual search was first introduced by Simon and Lea (1954) and was later adapted by Klahr and Dunbar (1988) for describing hypothesis generation and hypothesis testing in scientific discoveries. In describing the nature of design exploration the dual search paradigm has been useful, yet the views which adapted this paradigm have not provided a satisfying answer to how the explorations in the problem space and the solution space are coordinated. Goel and Yirrelli (1992) suggest a linear relationship; the co-evolutionary views of design suggest a continuous interaction between the two exploration spaces; and Schön (1988) suggest that the two are constructed in reference to a framework within constantly changing situations.

Archival Research

Historical documents, particularly from architectural archives, may provide some answers to the controversy among researchers in design studies. Such documents may also clarify the disparities between views from design studies and the experts' own accounts, because these documents provide a rich body of material from the initial phases of the design process. The archival material studied for this thesis indicates a rather more complex and less straightforward progression. In two of the case studies, the First Unitarian Church and the Jewish Museum, the design process started with problem structuring in the form of conceptualizations of design situations. In the First Unitarian Church study, this process was accompanied by problem solution in the form of a generic
design scheme. In the Jewish Museum study, problem structuring was accompanied by a specific design solution. In the other case study, the Staatsgalerie, the design started with a solution, yet occasionally went through a process of structuring. In all three case studies what is apparent is the intense and concentrated exploration, regardless of whether design started with problem structuring or with problem solution, suggesting that the experts' accounts are at best incomplete in describing the early phases of design.

Furthermore, the three case studies demonstrate the importance of representations produced earlier in the design, e.g., sketches and diagrams. Researchers in the area of design studies agree that sketching plays a crucial role in the early phases of design (Cross, 1999; Geel, 1995; Goldschmidt, 1991; Schön, 1992; Suwa & Tversky, 1997). However, these accounts fail to note that there are other kinds of representations that expert designers use in their design process and identify as significant among numerous other drawing types, i.e., conceptual diagrams, for example, Wright’s simplified drawings for conceptual schemes, Le Corbusier’s ideograms, and Kahn’s form drawings. These drawings are representative of core conceptualizations, are often simple, and seem to fixate meaning rather than be ambiguous (Goei, 1995). These drawings also appear to support more structured exploration in design, as opposed to serendipitous discoveries facilitated by sketches (Suwa et al., 2000).

Expert architects often use this kind of diagram to represent and communicate their conceptualizations. It is argued in this thesis that, in instances where they are used, conceptual diagrams become central components of the design process and that a study into their significance will increase understanding of early phases of design and the use of diagrammatic representations in rich domains. Hence, the objective of this investigation is to understand the role of conceptual diagrams in the early phases of design and the nature of the early phases of design themselves.

The particular diagrams studied in this thesis are examples of conceptual diagrams in design. Kahn’s diagram played a central role in the design process, informing the way Kahn represented the salient features of and the relationships within his conceptualization, the way he explored several design schemes during the early phases, and the way he communicated his conceptualization to his client. It represented the core
of Kahn's generic understanding of what the design solution should be for that particular design task. In the other two case studies there are representations equivalent to Kahn's conceptual diagram in terms of their significance for the design process. In the Staatsgalerie project Stirling identified one of his drawings as representative of the project and called it the "conceptual sketch". In the Jewish Museum project Libeskind drew a diagram of the Star of David, which he referred to as the "Star Matrix", as the illustration of his conceptualization.

The conceptual diagrams of Kahn, Stirling, and Libeskind provide clues to a resolution of the dichotomy between the expert architects' accounts mentioned above and the historical documents, as well as to different views of the initial design phases, coming from the field of design studies. The proposition of this thesis is that in the early phases of design some expert designers construct a design concept instead of developing a complete understanding of the design problem or a fully-fledged design solution, as some expert designers claim. The design concept helps the designer determine a set of related constraints, which he or she uses to explore a family of design solutions. The process of constructing a conceptualization is sometimes accompanied by a spatial configuration in the form of a conceptual diagram. This might lead some architects to believe that they have a full understanding or realization of the design problem. It is more reasonable, however, to think of this conceptual diagram as the formulation of a promising departure for design, by providing an abstract and generic conceptualization of the design situation. Furthermore, these conceptualizations, when accompanied by conceptual diagrams, represent generic spatial configurations of possible solutions, suggesting that problem structuring in the early phases of design may coalesce with problem solution.

Studies of diagrammatic reasoning substantiate these initial observations about the nature of conceptual diagrams as well. Researchers in this area often characterize the advantage of diagrammatic representations over other types of representations in terms of their structural correspondence to their represented domains. Shimejiama (2001) describes this correspondence in relation to the presence of iconic constraints in the representational system. Stenning and Lemon (2001) suggest that these constraints make the representations more directly interpretable; hence they can be more easily available to cognizing agents. Stenning and Lemon define an effective diagrammatic representation...
for an agent as "...a system in which graphical and spatial relations between representational tokens are directly semantically interpreted as relations between objects in the target domain" (2001, p. 47). However, with the exception of detailed research in scientific discovery, studies in this area are confined to the use of diagrams in impoverished domains. In the area of scientific studies, researchers have illustrated how diagrams are "ineliminable" components of scientific reasoning (Cheng, 1996; Griesemer, 1991; Nersessian, 1999). A study of diagrams in an rich domain a design could potentially bring new insights into our understanding of diagrams in general and further our knowledge of diagrams in the process of discovery.

**Contributions of this Research**

**Theory of Architectural Design**

This study of conceptual diagrams can make four potential contributions. Its main contribution is specific to the theory of architectural design in that it emphasizes an inquiry of the process of design as opposed to the product of design. This research specifically investigates how novel design ideas are generated and how they are elaborated, through an exposition of the early phases of design in three case studies significant to the history and practice of architecture. It also provides an alternative account to some expert architects' reports about the initial phases of design and resolves the discrepancies related to the nature of dual exploration in design.

This research proposes that as a unit of analysis conceptual diagrams will provide a more accurate account of the "a-ha experience" of some expert designers and of their early phases of design during which they report constructing a full understanding of the design problem and a full-grown solution. Similar research on scientific discovery has been successful in tracing the evolution of scientific concepts (Griesemer & Wimsatt, 1989).

Previous research on creativity in design has often considered sketches a unit of analysis and has focused mainly on the intensive process between sketching and reflection during an intense session of working out different ideas (Akin & Akir, 1996; Akin & Lin, 1996; Goldschmidt, 1994). These studies investigated designers involved in design
tasks for short periods. From expert designers’ accounts, however, we learn that at least some architects take time in developing their ideas. The process of evolution of design ideas seems to be more elongated and interrupted than researchers in design cognition shown. A study which uses conceptual diagrams as a unit of analysis, therefore, is more appropriate for investigating this elongated and sometimes interrupted period and for tracing the emergence of design ideas and their evolution, modification, and elaboration.

This research also expands our understanding of the design process by emphasizing the changing nature of design situations and the distributed nature of cognitive tasks in a design environment. The case studies illustrate why design must be understood as a coordinated effort among different participants within a changing environment and not as a solitary act of idea generation. The changing nature of situations and their significance in cognition and action has been a focus of research in situated studies of problem solving (Lave, 1988) and in action planning (Suchman, 1987). Research in this area has shown the specific importance of the structure in the environment and of external representations for cognition. Hutchins (1995a) and Zhang (1997b), for instance, have detailed how cognitive tasks are distributed across agents and external representations of the environment. Hutchins also introduced the notion of cognitive systems in which cognition is studied neither in the head nor in the environment but in the interaction of the two. This thesis takes a similar view of design situations, in which tasks are often distributed across different stakeholders and in which requirements often change.

Diagrammatic Reasoning and Cognitive Science

Secondly, this research contributes to diagrammatic reasoning studies and cognitive science in that it inquires into the relationship between conceptualizations, i.e., problem structuring, and their implementations through spatial configurations in design, i.e., solutions and how conceptual diagrams facilitate the dual exploration in design. Conceptual diagrams seem to play an important role in mediating between conceptualizations and spatial configurations. This is a crucial task because architectural design is about arranging spaces in a meaningful way through manipulations of spatial representation such as sketches, renderings, and diagrams. In other words, conceptual diagrams mediate the dual exploration in design by their simultaneous correspondence to
the structure of conceptualizations and to generic structure of design schemes. A more informed understanding of how architects bring meaning into their configurations through spatial representations, therefore, could provide significant insight into our understanding of how problem structuring and problem solution are coalesced in design tasks. Furthermore, the study of diagrams in design expands the findings and concepts of studies in diagrammatic reasoning, which have been confined to impoverished domains thus far.

**Design Methodology**

The third contribution of this research is a methodological contribution to the area of design cognition, proposing a new research method. Any study of design cognition faces methodological problems with collecting and analyzing data. Researchers in the area of design studies have often conducted design protocols during which designers are given relatively simple design tasks and expected to be creative in a limited amount of time. Using this particular method, researchers observe and record designers' behaviors, to trace the generation and evolution of design ideas. These studies, however, fall short of capturing the prolonged processes of design cognition. This thesis instead uses the cognitive-historical analysis method (Nersessian, 1992b, 1995), which studies richer and potentially more authentic sources of data to understand the cognitive processes involved in design. The authenticity of data and documents from the experts' design processes allow the cognitive-historical method to avoid the problem of ecological validity, which constitutes a major drawback for design protocols in which settings and tasks are partially representative of the design domain.

One research area in which cognitive-historical analysis has proven to be effective is studies of scientific discovery. Researchers in this area study the cognitive processes of scientists and their discovery process, with the help of findings from research in cognitive science. They then formulate hypotheses about the complex cognitive processes exemplified in cases of scientific discovery. The conventional accounts of discovery in science bear similarities to accounts of creativity in design. Both ignore the cognitive processes involved in discovery and creativity. According to these accounts, novel ideas and scientific discoveries spring fully-formed, like Athena from the head of Zeus.
Cognitive historical analysis has been successful in debunking conventional accounts of scientific discovery and creativity and constructing more viable accounts grounded in historical records and in what we know about cognitive processes in problem solving.

Few in architectural history and design studies have undertaken such an approach to the history of design. Hewitt (1985) made a call for a similar approach in architectural history, by which historical research on representational systems could be enriched by studies of cognition and perception. Rose (1987), in his book Design Thinking, partially attempted to undertake research along these lines, at one point studying Le Corbusier's thinking processes used in designing the Venice Hospital and basing his study on historical documents.

Architectural History

Some findings of this research may have relevance for architectural history too, yet this was not the primary objective of this study. For the purposes of this study, historical analysis was limited to periods in which the architects were involved in idea generation. Other historical developments outside this period were studied in less detail, not because these developments were considered less relevant, but because of the specific questions being asked and because of time limitations. This does not, however, mean that the research was less concerned about the authenticity and consistency of the historical material. Interesting historical questions emerged throughout the research, e.g., the connections that existed between the three architects studied in this thesis. Stirling and Kahn were at different times both Davenport professors at Yale University. Stirling was one of the first students of Colin Rowe, who worked with John Hejduk. Daniel Libeskind was a student of John Hejduk at Cooper Union. These questions among several others need to be pursued in subsequent studies.

It is hoped that the findings of this research will corroborate and enrich other historical research in the area of creativity and discovery in design. Pai's work (Pai, 2002) on the emergence of diagrammatic discourse within modernism, for instance, provides a rich historical background for the discussions in this thesis.

In summation, the research issues that set the boundaries of this thesis are as follows:
1) About the different accounts of the early phases of design:
   a) The discrepancies between expert architects' accounts of their design process and archival historical material,
   b) The discrepancies between experts' accounts and commonly held views about the nature of design exploration from design studies,
   c) The differences among views in design studies on the nature of early phases of design, i.e., how design starts and what the interaction between problem structuring and problem solution is,

2) About conceptual diagrams:
   a) The significance of diagrams in conceptual phases of design to facilitation of a dual exploration in problem space and solution space,
   b) The nature of relatively structured changes in design, as supported by conceptual diagrams, and
   c) The significance of diagrams as used in a rich domain rather than in an impoverished domain.

In the upcoming chapters I will first explain what a conceptual diagram means in this thesis in reference to research in architecture, design studies, and cognitive science (Chapter 2). In Chapter 3 I will introduce the cognitive historical analysis method. Chapters 4, 5, and 6 are detailed discussions of the three case studies. Finally, in the Conclusion I will present the commonalities and differences in the three case studies and the relevance of this thesis for design cognition, cognitive science, and architectural theory.
CHAPTER 2

CONCEPTUAL DIAGRAMS IN DESIGN

The case studies in the upcoming chapters will discuss the role of conceptual diagrams in the design process. Of the three cases, the First Unitarian Church was the first studied and it provided an initial set of preliminary ideas about the nature of conceptual diagrams. This set of ideas together with what design studies and cognitive science offer for explaining diagrams and the nature of design, defines the theoretical framework of this thesis.

For the purposes of this dissertation, a conceptual diagram is defined as a visual/spatial configuration representative of the core of a design conceptualization; i.e., conceptual diagrams highlight the structure of their corresponding design conceptualizations through their spatial configurations. Conceptual diagrams are concise, yet powerful, aids in design. First, they provide high-level commitments that define a family of design schemes yet prevent early commitment to a specific scheme. Second, conceptual diagrams represent complex ideas in a simple, easily communicable, and retainable form through their spatial characteristics. Their capacity to communicate these complex relationships makes them crucial for collaboration and communication in design. Third, conceptual diagrams are easier to transform into formal design schemes that are conceptualizations represented verbally. This is so partially because both conceptual diagrams and design schemes are spatial configurations. The correspondence between modes of representations allows conceptual diagrams to mediate between conceptualizations and design schemes by encapsulating generic characteristics and conveying the form of possible specific solutions. Fourth, conceptual diagrams are likely to facilitate more structured changes in design. Because they refer to fixed conceptual and spatial entities and relationships, a structured manipulation of their components is likely to result in significant shifts in the corresponding entities and relationships.

This chapter will:
Differentiate the use of the term conceptual diagram from other similar terms, e.g., conceptual sketches, esquisse, and figural concepts, and form other representational systems, e.g., sketches;

- Provide examples of conceptual diagrams from architectural design;
- Provide a working definition of the term conceptual diagram in reference to architectural drawing literature and to studies in diagrammatic reasoning;
- Differentiate potential significances of conceptual diagrams from the significance of other types of representations, first in reference to diagrammatic reasoning studies and second in reference to design studies.

Other Similar Representations

In this thesis the term conceptual diagram is deliberately chosen to define one particular type of drawing. The term is used similarly in only a few other instances in architectural studies and there are even fewer studies about the role of conceptual diagrams in design. In these studies the focus of the research has been on diagrams as a generic class of representation (Clayton, 2000; Do & Gross, 2001; Ervin, 1990; Graf, 1986; Oxnard, 1997). The focus of this thesis is on a subset of this generic class, which contains those diagrammatic representations that are related to design conceptualizations.

Ching and Juroszek (1998), from the architectural drawing literature, are one of the few who specifically wrote about diagramming concepts in architecture. They provide a definition which is used as a starting point for this thesis and define the act of diagramming concepts as a way to "...quickly and efficiently investigate the overall nature and organization of a scheme" and defines concept diagrams as focusing "on the key structural and relational features of an idea" rather than "...concentrating on how a design might appear" (Ching & Juroszek, 1998, p. 296). Laseau (1980; 1986) wrote extensively about the use of diagrams in architecture. He introduced the notion of abstract diagrams to denote those drawings that are "simple and clear" and that "provide enough information to form a distinct idea" (Laseau, 1988, p. 65).

In the architectural drawing literature the term sketch, in contrast, almost exclusively is used to describe quick, freehand representations of entities in the world (Ching, 2003;
Laseau, 1980). The tentative distinction between diagrams and sketches to be proposed here, as suggested by Ching and Laseau, is the difference in their target domains. Sketches are "realistic" representations of physical entities, whereas diagrams are representations of mental abstractions about the structure of physical entities. Structure here refers to underlying relationships between constituting components of represented entities. The difference between the two, therefore, suggests that diagrams are more about maintaining structural relationships, whereas sketches are more about maintaining resemblance to the physical objects that are represented.

Sketches and Conceptual Sketches
A more conventional term in architectural literature, i.e., conceptual sketch, seems (at least at first) to be close in meaning to what is defined by conceptual diagram in this thesis. The term conceptual sketch is widely used in design literature. Both terms define graphical representations of conceptualizations. The difference between these terms stems from the distinction between diagrams and sketches. Research in the area of diagrammatic reasoning has shown that diagrammatic representations, different from other kinds of representations, directly represent the structure of their target domain (Shiramjima, 2001; Sterning & Lemon, 2001), and thus simplify the complexity of conceptual domains (Baer & Johnson-Laird, 1993; Gattis & Holyoak, 1996; Gobert & Clement, 1999). In design studies researchers have focused mainly on sketches and the openness of sketches to multiple interpretations. Sketches are described as facilitators of dialectic thinking (Goel, 1995; Giddschmidt, 1991, 1994; Sowa & Tversky, 1997). Goel (1995) provided the most detailed study of sketches; he identified them as facilitating creative transformations in design.

In architecture and design studies other researchers have distinguished diagrams from sketches. According to Vidler (2000a), for instance, a diagram is not a sketch, which means "it evokes nothing, points to nothing," nor a plan, which means "it cannot be built;" instead diagrams are "a kind of 'neither/or' of delineation, a neutral zone, where certain relations are mapped precisely but without affect, with no qualitative information: there is, one might say, nothing superfluous in the diagram" (2000a, p. 6). Ervin (1990) and Do and Gross (2001) suggest a similar distinction between diagrams and sketches.
Ervin proposes that sketches are "literally data" and that their perceptual features, such as shape, color, curvature, are their important characteristics. He suggests that diagrams are about form, abstraction, and topological relationships. Do and Gross (2001) also state that in sketches shape attributes are an important part of the representational system, whereas in diagrams abstractions are often represented. Do and Gross state that the diagram "explores, explains, demonstrates, or clarifies relationships among parts of a whole, or it illustrates how something works (a sequence of events, movement, or a process)" (2001, p. 136).

The descriptions above provide the background for the difference between sketches and diagrams offered herein. In this thesis, sketches are described as a category of representations that are relatively more realistic representations of their represented counterparts, whereas diagrams often highlight abstract relationships between entities that are represented. Following this distinction, a representation is more of a sketch if it can maintain its meaning when some number of its constituting components is removed. If the removal of components of a graphical representation is likely to cause significant change in meaning, then it is considered to be more of a diagram. The distinctions imply that a sketch has more redundant features; therefore, to cause a significant change in its meaning, there needs to be a substantial modification of its components. The reverse is true for a diagram. In diagrams, a significant shift in meaning can be caused by minor modification to its components.

A thought experiment may help clarify the distinct nature of diagrams. Consider a map of North America with clearly defined borders between Canada, the U.S., and Mexico. The map represents each country as well as the continent of North America. If we erase the borders between the three countries, the meaning of the new representation would radically change. The map would cease to be a representation of each individual country and would only be the map of North America. Similarly, in diagrams systematic removal of components is likely to produce shifts in meaning; hence, changes in diagrammatic representations may have significant power to affect conceptual changes. The reverse is true for a sketch. Think of a sketch of a tree; for that sketch to cease to be a representation of a tree there must be substantial modification to the drawing.
In contrast to the distinction proposed above, others have either characterized abstraction as a salient feature of sketches (Smith, 1992) or have pointed out that sketches may highlight important features of their target domains (Laseau, 1980). The classification distinction that this thesis proposes acknowledges a continuity between classes of graphical representations rather than a clear-cut separation of them. However, there are more prototypical instances of the categories. The differences between prototypical instances of diagrams and of sketches would be greater whereas the differences between less prototypical instances would be smaller.

An example of a conceptual sketch from a study in design further illustrates why the term conceptual diagram is preferred in this study. This particular drawing (Figure 1) is from an ethnographic observational study of design students (McGown, Green, & Rodgers, 1998).

Figure 1: An example of a conceptual sketch (Top). The bottom drawing is the final drawing, which is a more detailed and refined version of the top drawing. From (McGown et al., 1998).
The authors labeled the top drawing a conceptual sketch and the bottom drawing a presentation drawing. They suggested that the presentation drawing is a more refined version of the conceptual sketch. The main distinction between the two is that the conceptual sketch is only a simpler version of the other; i.e., with less detail and less specific information, yet it remains a realistic representation of the designed object. In contrast, the use of the term conceptual diagram in this thesis suggests not a differentiation based on simplicity or refinement but rather based on representations of underlying relationships between components that are highlighted through abstractions.

Most research in the area of design has focused on the role of sketches. This is understandable given that designers spent a significant amount of time for sketching, especially during the early phases of design. What makes sketches significant for idea generation is their dense structure and their capacity to facilitate exploration and multiple interpretations, due to their ambiguous and open nature (Goel, 1995).

Sketches are especially well-suited to be players in unstructured processes of discovery. Goel (1995) and Suva and his colleagues (2000; 1997) argue that the ambiguous nature of sketches makes them almost indispensable for lateral translations in design, changes through which breakthroughs are achieved, as opposed to vertical translations through which ideas are detailed rather than changed. Conceptual diagrams, however, are less ambiguous and less open to multiple interpretations because they fixate conceptualization. Goldschmidt (1991; 1994; 1997) and Schön (1987; 1992) have also highlighted the importance of sketches for the dialectic interaction between thoughts and marks on the paper. Goldschmidt (1997) found that when design proposals are generated the frequency of switches between figural arguments and conceptual arguments is higher than the other design episodes, which suggests during those moments of discovery there is a high interaction between sketches and ideas about those sketches.

Schön (1992) proposes a similar dialectic interaction in design but more between seeing and drawing and describes design drawing as an example of reflective conversation. Schön presents data from design protocols in which students changed their conceptualizations through an interactive process of sketching, inspecting the sketches, and re-sketching. What is common in Goldschmidt and in Schön is the idea that design
evolves incrementally through local moves towards a Gestalt shift. In other words, although changes are local and incremental they lead cumulatively towards a holistic change, which Schön describes as a discovery of unintended consequences. Schön gives an example of this kind of change from a protocol study in which students suddenly shifted their "reading" of the footprint of a building given to them, which led to a creative solution. These kinds of changes are unexpected in design in the sense that the designing stumble upon the discoveries. With both incremental changes and sudden changes, discovery appears to be accompanied by a sense of surprise. Others have also underlined the unexpected aspect of discoveries in design and how sketches support unstructured discovery (Suwa et al., 2000).

Esquisse

Another term, from the Ecole des Beaux-Arts tradition, comes closer to what is meant by conceptual diagrams in this thesis. In the Beaux-Arts tradition, students were given a building programme and expected to develop a rough plan of a solution in a short period of time without any outside consultation. The rough plan was called an esquisse, "a rapid sketch, in preliminary form, the essence of the idea in the mind of the designer" (Fuglert & Van Zanten, 1980, p. 115). The students were also required to decide en a parti, a formal composition appropriate for their particular idea (Lampugnani et al., 1986, p. 86). At the end of a short period of work, the students would turn in their first drawings, which were used to assess their design development. In subsequent phases, the students were to develop final schemes absolutely in the spirit of their first idea.

The term conceptual diagram and the Beaux-Arts' notion of esquisse both refer to the embodiment of a conceptualization about a design situation through a graphic representation. There are, however, significant differences between the two. First, the Beaux-Arts school fostered a process of discovery that is strictly based on intuition (Pai, 2002). Second, the Beaux-Arts tradition imposed a linear and rigid process in design, proceeding from the first idea to the final design. Third, it presupposed the necessity of a set of formal compositional rules, usually in the form of typologies, for instrumentalization of the same conceptualizations in design.
Figural concept

In contemporary design studies Goldschmidt's notion of figural concept comes closest to what conceptual diagrams refer to in his research. Goldschmidt's use of the term figural concept relates to debates in the imagery literature about whether imagery is pictorial or descriptive. Goldschmidt argues that the distinction is irrelevant because picture and description "are so hopelessly intertwined in imagery" (1994, p. 156). In a case study of a novice architectural student, Goldschmidt detailed an interactive process in which the student discovered emerging patterns through sketching. She reports that after an unsatisfying design scheme, the student started doodling his signature on a blank sheet of paper and eventually discovered that the problem with his first scheme (Figure 2).

Figure 2: An example of a figural concept. The signature drawings of the student from (Goldschmidt, 1994) are the drawings in the right column and the subsequent plan configured based on student's signature is on the left column.

From then on, he started playing with curved lines instead of straight ones and he transformed his signature into a plan for a building that satisfied him. In his retrospective account of his design process, the student reported that he wanted to have a building that suited better to the users of the building, which was a kindergarten, and that curved lines were more appropriate for children. This account did not mention anything about the urge
to produce something different from his classmates or anything about the significance of his signature is getting intrigued by curved lines. Goldschmidt concludes that this is a post-rationalization of a design process and is not necessarily an accurate representation. Instead, she claims it was through the interaction between sketching and thinking that the designer brought incomplete concepts and figures together and reached a more satisfactory solution.

The student's signature, although significant in the evolution of the design, cannot be considered a conceptual diagram because it does not embody a conceptualization of a design situation. The emphasis on curved lines rather than straight lines stems from an urge to differentiate the design from others' and not because of a particular understanding of what the design scheme should be in relation to the design situation. As Goldschmidt reports, the rationale comes later in the design process, which implies that the signature had no conceptual meaning at the beginning. Its significance derived only from its formal characteristics. The signature, or the curved lines of the signature, remained figural throughout the process. As Goldschmidt suggests, the signature only triggered the designer's desire to abandon the straight lines and the rigid geometry of his first design.

This process was interactive, but only in the sense that sketches facilitated exploration and generation of a new formal configuration, and not in the sense of formulation of a better conceptualization. That is why the spatial configuration, both in the unsatisfactory rigid scheme and in the satisfactory curvy scheme, remained the same without any substantial changes.

Based on the discussion above, conceptual diagrams are not simplified drawings of presentation drawings (e.g., the conceptual sketch in Lloyd and Scott's study), neither are they just sketches that trigger significant changes in conceptualizations (e.g., the figural concept in Goldschmidt's study). Rather, conceptual diagrams are concrete, abstract representations that fixate meaning in design and their manipulations could facilitate more structure changes in design. The preliminary conjecture about conceptual diagrams is that they are significantly different from sketches and support different exploration strategies.
Examples of Conceptual Diagrams in Design

In the upcoming case studies three conceptual diagrams will be discussed in detail, yet it is necessary to briefly show other examples of conceptual diagrams to illustrate the pervasiveness of this drawing type in architectural practice. These examples were drawn by Jorn Utzon for his Sydney Opera House project, Steven Hoh for his Het Oksen project, and an architectural student for a school project.

Since the early years of his architectural career Utzon was fascinated with the idea of vast platforms, as expressed in Mayan and Aztec architecture, and with dynamic roofs over platforms, as illustrated in Japanese architecture (Giedion, 1964-1965). Utzon represented his fascination in a series of drawings (Figure 3), one of which became the initial inspiration for his Sydney Opera House project (Drew, 1995). The dramatic roof over a vast horizontal platform found in his competition entry for the Opera House was shaped around this conceptualization.

Figure 3: Section diagram of a Japanese house by Utzon (Left). Utzon’s preliminary sketch for the Sydney Opera House (Right).

In his subsequent projects Utzon used the same idea, to the extent that it became one of the main themes of his architecture. These projects include the Banque Melli, Teheran, Iran and the Church at Bagsvaerd, Copenhagen, Denmark, among others. For the Church project Utzon drew two preliminary sketches that are variations of the same idea (Figure 4). The first sketch shows a group of worshippers facing the horizon, topped by imposing clouds. The second sketch translates this idea into an architectural scheme in which the earth becomes the floor of the church, the horizon becomes the altar, and the clouds become the roof of the sanctuary.

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Utzon's drawings are clear illustrations of the continuity between sketches and diagrams and of the difficulty in categorizing representations in architecture. What is interesting in Utzon's drawings is that they are realistic representations of physical objects (e.g., roofs and clouds), yet they are also abstract representations of conceptualizations.

A second significant example is Steven Holl's diagram for his design for the headquarters of Het Oosten, a Dutch social housing company. The project consisted of renovation of an old building and a new addition to include a conference/dining hall. Holl (2000) states that he used a Menger sponge, a formation in which the removal of parts of its volume increases its area, as a starting point for his design. In an axonometric sketch Holl represented how he used the Menger sponge analogy to describe the relationship between the old and the new buildings (Figure 5). In the same drawing he showed the relationship between the old and new buildings using a conceptual diagram. This diagram shows a curved line that has two parts (Figure 6). The first part represents the old building and the second represents the new building. The left portion of the line forms a closed shape with arrows directed inward and the right portion forms an open curve terminating in arrows that extend outwards. This diagram shows Holl's conceptualization of both continuity and discontinuity between the buildings. Continuity between the buildings is represented by a continuous, yet changing line. Discontinuity is represented by the differentiation of the first and second halves of the line; the former standing for the old, introverted building and the latter denoting the new, extroverted building. Holl described his diagram as an.

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expression of turning inside-out the spatial character of the old building in the new one (Russell, 2000, p. 130).

Figure 5: Holl's axonometric sketch which shows the old building and the new building. The conceptual diagram is at the top of the drawing. From (Holl, 2000).

Figure 6: Holl's conceptual diagram.

The previous two examples are from expert architects. The next example is from a second year student's design project, at the College of Architecture, Georgia Institute of Technology. This eight-week-long project asked students to design a scheme that would integrate a leftover space on the Georgia Institute of Technology campus into its surroundings. The student's final presentation included a conceptual diagram and two photographs that represented his conceptualization of the design situation (Figure 7). The top photograph shows an outdoor theater structure representing a precedent solution. The bottom photograph shows a group of people sitting around a circle, illustrating that the student viewed the problem as a problem of generating people around a common focus. His conceptual diagram was composed of a central circle and several lines tangent to the circle. The circle represents a central area and the tangent lines represent lines of flow that connect the area of focus to its immediate surroundings on the campus (Figure 7).
Figure 7: Student conceptual diagram. The diagram on the right represents the design concept.

In all three of these examples the conceptual diagrams represent first what their respective designers considered to be the main aspects of their design and second a generic spatial configuration. None of the three diagrams is a simpler version of the final design scheme, nor are they arbitrary sketches which triggered some changes in design, nor "realistic" representations of buildings. Utzon did not design a roof of clouds for his Opera House and Holl did not design a continuous line with arrows pointing out of it.

Rather, the conceptual diagrams mediate between abstract conceptualizations and generic spatial configurations.

What is a Conceptual Diagram?

It has been as problematic to formulate a distinction between diagrammatic representations and linguistic representations, as it has been to distinguish between sketches and diagrams. Shimozuma (2001) discusses the major attempts to distinguish between diagrammatic and linguistic representations. He concludes that the main determining factor of diagrammatic representations is the existence of iconic constraints, which establishes correspondences between the representation and the represented. The iconic constraint hypothesis suggests that in any diagrammatic representation there needs to be at least one characteristic of the target domain present. The correspondence, therefore, between the representation and the represented is based on the commonality of at least one of their characteristics.

In Peirce's classification of representational systems (Peirce & Hoopes, 1991), diagrams are considered to be prime examples of icons. Icons, according to Peirce, are
representations of entities by virtue of structural similarity to what they represent. In other types of representations, i.e., indices and symbols, the representational system is established according to different correspondence rules. In the case of indices, there is a physical connection between what is represented and its representation. In the case of symbols, conventions establish the correspondence between the representation and the represented. Johnson-Laird (2002) highlights Peirce's emphasis of the structural correspondence in diagrammatic representations and notes a similarity between diagrams and mental models. Others have related the significance of diagrammatic representations for reasoning to the structural correspondence that they maintain in representing their target domain. Stenning and Lemon (2001), for instance, describe diagrammatic representations as "...plane structure[s] in which representing tokens are objects whose mutual spatial and graphical relations are directly interpreted as relations in the target structure" (Stenning & Lemon, 2001, p. 36).

Based on Peirce, Johnson-Laird and Stenning and Lemon's characterizations of diagrams, the distinction to be made between sketches and diagrams is that diagrams highlight and represent only structural relationships of their target domains, whereas sketches may represent these relationships but do not directly highlight them. The structural correspondence aspect of diagrammatic representations is accepted as their determining factor. Based on the discussion above, a conceptual diagram in design is:

A visual/spatial configuration representative of the core of a design conceptualization; i.e., conceptual diagrams highlight the structure of their corresponding design conceptualizations through their spatial configurations.

Different from sketches:

Conceptual diagrams do not have to be realistic representations of physical objects; they are, rather, representations of abstractions.

Different from other descriptions of diagrams in design or other types of diagrams in design:

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Conceptual diagrams are double-referential in the sense that they correspond to abstract design ideas and to generic spatial configurations, both of which are components of design conceptualizations.

As such:

Conceptual diagrams are conjectured to be mediating representations between abstract concepts and specific spatial configurations.

Why are Diagrams Helpful for Design?

There has been a growing interest in diagrams in architecture within the last two decades. Architectural theoreticians such as Vidler (2000a, 2000b), Eisenman (1999), and Somol (1999) have written about diagrams as an emerging concept in architecture. In their writings, interest in diagrams is the common theoretical concept in the work of contemporary architects such as Peter Eisenman, Bernard Tschumi, Rem Koolhaas, Gregg Lynn, and Kazuo Sejima, among others. The works of these authors, although related to diagrams in architecture, represent a different approach than the one taken in this study.

Another view in architectural research stemming from design studies takes a rather different approach from that of the theoreticians mentioned above. Whereas, for the former, diagram is a descriptive concept of architectural theory, for the latter, diagrams are external representations that facilitate reasoning in design. The focus of the latter has been more on the instrumentality of diagrams in the design process, which this thesis deals with, also. Different from the latter, however, this thesis investigates only one particular kind of diagrams in architecture, i.e., conceptual diagrams.

Christopher Alexander's seminal work Notes on the Synthesis of Form (1964) is a forerunner in diagrammatic reasoning research in design studies. Alexander introduced diagrams as a structuring tool to decompose design problems into manageable sub-problems. He called the diagrammatic decomposition of problems "patterns": this is the fundamental component of his design theory of pattern language. In his theory, patterns structure the design problem and do not dictate the formal characteristics of the end
product of design *per se*. Alexander introduced yet another type of diagram, which he called *constructive diagrams*. These diagrams entify functional requirements with formal requirements (Alexander, 1964, p. 88); in other words, they established a fit between function and form. Alexander's pattern language, even though well-respected in the 1970's, came under attack as a limiting methodology in design by architectural circles under the influence of recent development in post-structuralist philosophy in the 1980's and 1990's. His views became associated with over-rationalization of design at the expense of diminishing the importance of creativity.

Following Alexander's work there are few systematic studies of diagrams in architectural design. Some of these studies argue that diagrams are useful as analytical tools to understand buildings (Clayton, 2000; Graf, 1986; Oxman, 1997). Others showed that diagrams are pervasive among architects (Do & Gross, 2001). Still others (Ervin, 1990) suggest that diagrams are useful in design because they facilitate translation of ideas to final design schemes.

Clayton (Clayton, 2000) used diagrams as analytical tools in his teaching to increase students' awareness and understanding of architectural concepts. Clayton asked his students to investigate and compare houses designed by modern architects through a series of diagrammatic analyses. He reported an increased quality in the students' projects; however, it is hard to determine how the use of diagrams helped the students. Oxman (1997) studied the role of diagrammatic representations in eliciting levels of abstractions in design. Her study investigated the effect of re-representation in design by asking 15 designers to find underlying representational abstractions of a given pin using a particular diagram, such as diagonal axis system or grid system for a square plan.

Students were then asked to select one of the representational abstractions and modify the given plan according to a given constraint. She concluded that designers were able to extract different underlying representational abstractions of existing designs and use them in their own design manipulations as guiding principles.

Do's work (Do, 1998; Do & Gross, 2001) is so far the most systematic study of diagrams in architecture and puts forth the beginnings of a cognitive theory of diagrams in design. In a series of controlled studies Do looked at how designers use diagrams. In her 1998
study she asked architectural students to perform four tasks: making diagrams from stories, writing stories from diagrams, pairing diagrams and stories, and commenting on given diagram-story pairs. Her studies showed that diagrams are used extensively by architectural students and that students share a common understanding and knowledge of diagrammatic conventions. In a pretext to one of her experimental studies the architectural students reported that they use diagrams in their design processes. Twenty-six students said they use them moderately, nineteen often, four always; as opposed to thirteen who said they used them seldom or never. The same students also reported that they use diagrams mainly for communicative purposes. In a subsequent study, Do (1998) conducted four protocol studies of design in which she specifically studied the sketching behavior of subjects and whether they were using the same sketching conventions. In the first two protocol analyses, Do gave subjects five tasks: a conceptual schematic design for the given program, a spatial arrangement task, a lighting study, a study of visibility and privacy, and placement of furniture within the layout. Subjects had 30 minutes but could work longer if they required more time. Sketches from the first two design protocols showed that subjects did not really produce any conceptual diagrams even though they were asked to produce conceptual schematic designs. They began, rather, by simply laying out spatial components in a rectangular area, which could be described as a partitioning task rather than a conceptual scheme. The other two subjects did not produce conceptual drawings either. They started by thinking of either partitioning the rectangle or by drawing bubble diagrams, which were then translated into formal configurations.

What is puzzling about these design protocols is that the kind of sketches that subjects produced for the conceptual schematic design task and the spatial arrangement task were more or less the same. They were simply drawings that allocated space to particular functions. The reason subjects may not have come up with conceptual schemes may be diverse: level of expertise, time constraints, or the nature of the design task. It is also possible that the given design task was too detailed and may not have required subjects to produce a conceptual scheme.

The results and findings of the studies above support the idea that designers extensively use diagrams and that diagrams are helpful in architectural design. According to Alexander (1964) they are helpful because they structure the design problem into sub-
components. Although insightful, this does not illustrate how actual designers work; rather, it offers a strategy for designers. Cayton's (2000) and Oxman's (1997) works suggest that diagrams help analyze the structure and characteristics of existing buildings, yet they do not show how diagrams can be used as a tool of exploration. Do's work (Do, 1998; Do & Gross, 2001) shows that diagrams are extensively used by designers, yet her design protocols do not clearly support this argument. Participants in her protocols did not produce conceptual schematic designs even when asked to do so. Above all, however, none of the above researchers has specifically studied how diagrams embody conceptualizations and why these representations are significant to architectural design.

One exception is Ervin (1990), who suggests that diagrams are intermediary representations between initial concepts and final detailed drawings. Ervin also created a computational model of a diagrammatic reasoner in the act of design; his model converted verbal design descriptions into diagrammatic representations. In this model, each component in the design descriptions is represented by a component in the diagrammatic representation. The representation is a word-to-word translation of the verbal description; hence, it does not include any abstraction in the sense of setting priorities among requirements and establishing relationships between them. Furthermore, the model is only a computational model and has not been tested against real human designers.

**Why are Diagrams helpful for Cognition?**

The studies above do not provide an answer to the central question of this thesis: how conceptual diagrams facilitate exploration in the early phases of design. One area of research that could provide some answers to the question is studies in diagrammatic reasoning. Studies of diagrammatic reasoning are replete with research findings showing the effectiveness of diagrams in different cognitive tasks. The following review of diagrammatic reasoning studies provides ample evidence for the significance of diagrams in general, and in some specific cognitive tasks. Results of these studies support the conjecture that diagrams are potentially useful in design.
Research on the role of diagrams covers a wide range of topics, from deductive reasoning to qualitative reasoning to education. A strong consensus among researchers who study diagrams is that the perceptual characteristics of diagrams facilitate abstract reasoning. These perceptual characteristics may be spatial, formal, or other properties of diagrammatic representations that correspond to conceptualizations in a domain.

The main contribution of studies of diagrammatic reasoning to cognitive science has been in broadening the range of representational systems considered significant for cognition. Results and findings from the diagrammatic reasoning studies have shown the effectiveness of visual/spatial representations in various complex cognitive tasks. Chandrasekaran et al. (1995) summarizes why diagrams are helpful in solving spatial problems, as follows. First, diagrams preserve and represent locality information directly, such as neighborhood relations, relative size, intersections, etc. Second, diagrams provide a working environment through which one can explore emerging patterns. Third, diagrams can be used to represent non-spatial problems, such as spatial representation of temporal phenomena. Fourth, diagrams may help in the organization of cognitive activity, especially in the selection of problem-solving methods. Finally, diagrams are mental models and concrete representations.

Researchers in this area have explored the effectiveness of diagrammatic representations in terms of their differences from other types of representational representations. Shimozuma (2001) describes the efficiency of diagrams in terms of nomic constraints that govern the correspondence between diagrams and their target domains. Shimozuma claims that because nomic constraints keep at least some aspect of the target domain "as is" in the structure of the diagrammatic representation, we can make sound and direct inferences based on what we know from diagrams without knowing too much about the target domain. Shimozuma calls this a "free ride." Stenning and Lemon (2001) describe the direct availability of inferences through diagrams in terms of the lack of an abstract syntax that governs the interpretations of the representations. They extend Shimozuma's nomic constraint hypothesis by suggesting that the directness of interpretation depends on the availability of the constraints to the reasoning agents. In other words, nomic constraints are important for the efficiency of diagrams but also important is the easy availability of these constraints to an interpreting agent. Shimozuma's (2001) and Stenning
and Lemon's (2001) proposals together suggest that a correspondence between a diagrammatic representation and its target domain is easily available to its interpreter as opposed to other representation systems where an extrinsic syntax is required for interpretation.

Johnson-Laird (2002) characterized diagrammatic representations and their target domains in terms of a correspondence to a target domain, wherein the structure of the two domains remains the same. The correspondence between diagrams and their target domains, according to Johnson-Laird, is about structure and not any other arbitrary feature. Johnson-Laird also points to an important similarity between mental models and diagrams in the sense that they both maintain structural correspondences to their represented domains. The distinction between the two, however, is that mental models are internal representations whereas diagrams are external representations which in turn correspond to a mental model. As such, diagrams are what Gráeno (1989) considered to be physical models of structured mental representations. The significance of a physical model of correspondence to a mental model is that it literally can be simulated and inspected for inferences.

Based on the discussions above, in this thesis the following is conjectured about the significance of conceptual diagrams:

*Conceptual diagrams are physical instantiations of mental models, whose correspondence to their target domain is governed by nomic constraints that are “easily” available to agents. Therefore, manipulations of their components are likely to change the structure of their corresponding mental models.*

**Diagrams and Conceptual/Abstract Domains**

Several researchers in the area of diagrammatic reasoning studied how diagrams come to represent non-spatial domains and facilitate reasoning in those non-spatial domains ranging from problem-solving to scientific discovery. Gattis (1996) investigated how people use spatial relations to reason about non-spatial, or abstract, relations and make inferences about non-spatial relationships. She suggested that diagrams mediate the mapping between spatial and non-spatial relationships. In her experimental study Gattis
manipulated the graphics given to subjects in a task for which they were asked to infer the temperature changes in relation to altitude changes. Subjects performed better when they received a graph that made the conceptual relationships explicit than when they received a graph that emphasized the perceptual similarities between the represented domain and the representing medium. Her results strongly suggest that if there is a coherent mapping between a diagram and the represented conceptual domain, reasoning is enhanced through the use of diagrams. Gobert and Clement (1995) investigated how diagrams enhance conceptual understanding. They compared the benefit of student-generated diagrams over student-generated summaries in conceptual understanding of plate tectonics. Their results showed that although the summaries contained more information than the diagrams, students who generated diagrams were more successful in understanding the static and dynamic properties of plate tectonics. Gobert and Clement concluded that the task of generating summaries created a rich text-based memory yet failed in creating a sophisticated conceptual model of the study domain. Drawing diagrams, they hypothesized, helped students construct a richer mental model of plate tectonics. The conceptual structure of the domain and the relationships between components of the conceptual domain were represented by spatial adjacency between different plate tectonics and the causal relationships between them.

Diagrams are shown to be effective in more complex cognitive tasks such as scientific discoveries also. Cheng and Simen (1995) documented significant examples of the use of diagrams from scientific discovery, illustrating how diagrams enhance scientific reasoning. They detailed Galileo's use of a diagrammatic solution instead of more conventional mathematical approaches for a physics problem (the quickest decent problem), and they studied Huygens and Wren's use of diagrams in describing the law of conservation of momentum. Cheng, in his subsequent work with his colleagues studied how different-diagrammatic representations might facilitate reasoning and problem solving in different areas and introduced the notion of Law Encoding Diagrams (LED) (Cheng, 1995, 1999a, 1999b; Cheng, Lowe, & Scaife, 2001; Lane, Cheng, & Gobet, 1999; Lane, Cheng, & Gobet, 2000). Cheng and his colleagues described LED as those diagrams which "...capture the important laws or relations of a domain in the structure of
a diagram using geometrical, spatial and topological constraints, such that a single instantiation of a diagram represents one instance of phenomenon" (Cheng, 1995, p. 2).

As argued by Gattis, Gobert and Clement, and Cheng et al., diagrammatic representations foster exploration by way of highlighting the salient features and relationships of a conceptual domain through a coherent and consistent representation. Along the same lines, one would expect that diagrams would be more suited to represent conceptual relationships in architecture than other kinds of representations, such as sketches or pictures.

One area of controversy among researchers in the studies of diagrammatic reasoning has been the extent to which diagrams are effective in cognition. Some (Larkin & Simon, 1987) have shown that diagrams are effective representations in cognitive tasks such as information search and recognition. Others (Bauer & Johnson-Laird, 1993) have argued that diagrams are useful in deductive reasoning and inference-making also. Larkin and Simon (1987) found that search for required information in problem-solving is easier in diagrammatic representation because related pieces of information are spatially adjacent, therefore, easily accessible. This eliminates the necessity of an exhaustive serial search. They also found that recognition in diagrammatic representations is easier because when data structures need to be enhanced the processes involved in enhancement are computationally economical and recognition comes with no cost. The ease in enhancement suggests that fewer interventions in diagrammatic representations may change the structure of the representations radically, thus, may facilitate and enrich mappings between conceptual domain and the perceptual domain. Notwithstanding the benefits for search and recognition, Larkin and Simon concluded that diagrams had no advantages for inferences over sentential representations. In contrast to Larkin and Simon's conclusions, Bauer and Johnson-Laird (1993) showed the significance of diagrams for deductive reasoning. Adopting the mental model theory of representations, they claimed that difficulty in inferences is determined by the number of mental models that one has to consider, and they hypothesized that those diagrams that can make alternative possibilities explicit would help. In their first experiment subjects received either verbal or diagrammatic premises and either inclusive or exclusive disjunctions. Diagrams in this experiment did not improve the performance; however, when diagrams
were designed to make alternative states of affairs explicit in their topographical relationships they helped the reasons both in accuracy and time over verbal premises.

Diagrams and Expertise

The studies above show together that diagrams can be helpful to either search, recognition, or inferences, if the diagrams illustrate the significant aspects of a conceptual domain through their spatial configurations and/or shape properties. The main conclusion of these studies is that if there is a match between the task characteristics and the characteristics of the representational system, the diagrammatic representations are helpful. However, as Stenning and Lemon (2001) implied, diagrammatic representations can only be helpful if one can benefit from their representational characteristics. Experts seem to benefit more from these representational advantages through chunking, or diagram configurations. Tabachneck-Schijf et al. (1997) found that experts have an integrated system of multiple representations in which verbal and visual representations are linked to each other; i.e., experts know the meaning of visual information, whereas novices cannot link the two representations to each other. Koedinger and Anderson (1995) found that experts in geometry problem-solving construct an abstract plan and cluster relevant geometric information through diagrammatic chunking. They conclude that diagram configurations are more like mental models that make important features or relationships explicit.

The studies above investigate the differences between novices and experts in their use of diagrams; the conclusions are likely to apply to expert and novice designers too. In a preliminary study to this thesis, it was found that novice student designers' conceptual diagrams represent a formal similarity to their designs whereas expert designers' conceptual diagrams tend to investigate spatial relationships in designs. Here it is proposed that expert designers benefit from diagrams because they have a richer knowledge of the conceptual domain of architecture and of the formal vocabulary (Tabachneck-Schijf et al., 1997) and because of the integratedness of their conceptual knowledge through chunking (Koedinger & Anderson, 1995).

Another area of research in diagrammatic reasoning is related to the benefits of diagrammatic representations for facilitating inferences involving dynamic systems.
Research in this area (Hegarty, 1995; Narayanan, Suwa, & Motoda, 1995) has successfully shown that diagrammatic representations, which are static in nature, embody causal and temporal relationships of dynamic systems. The studies reviewed above point out several roles of diagrams in cognition. One issue that is substantiated repeatedly is that the perceptual properties of diagrams, their spatial characteristics foremost, facilitate cognitive processes in different tasks (Bauer & Johnson-Laird, 1993; Cheng, 1996; Larkin & Simon, 1987). The perceptual properties, however, are mostly useful if they correspond to the conceptual properties of a task domain.

The results from research in diagrammatic reasoning, however, need to be qualified with respect to the nature of design situations. The studies above are confined to domains that pose relatively well-defined problems, such as the problems in geometry (Koedinger & Anderson, 1995; McDougall & Hammond, 1995) and physics (Larkin & Simon, 1987; Novak, 1995); therefore, there may be an intrinsic difficulty in conjecturing about diagrams in design simply based only findings from other domains.

Conceptual diagrams in design potentially differ from other diagrammatic representations studied thus far in the following ways:

They are double-referential; i.e., they represent abstract design ideas and generic design schemes.

Their correspondence to their target domains is a constructed one; in other words, the nomic constraints governing the correspondence between representation and the represented are determined by the designer.

A review of what is known about design from design studies will further advance the propositions above with regard to the characteristics of design explorations.

Why are Diagrams Well Suited for Design?

In the literature on design cognition and problem solving, design problems are held to be ill-defined (Reitman, 1964). In ill-defined problems, the initial state, goal state, and operators require further "definition" or elaboration. In contrast, in well-defined problems
The initial state, goal state, and the operators are well-specified in these problems requires only the selection of appropriate operators to go from the initial state to the goal state. Search in these problems is confined to identifying the operators, whereas in ill-defined problems search includes both an alternative structuring of the problem statement and determining operators. In problem-solving literature, the former is known as problem structuring, whereas the latter as problem solution (Newell & Simon, 1972).

Further definition is possible in two ways: either by information transfer during the design process or by experience in a particular design domain. Eastman (1969) and Simon (1973) independently argued that once further definition is performed design problems cease to be different from other kinds of problems.

The distinction between problem structuring and problem solution has often been cited as a distinguishing factor of design problems (Goel & Pirolli, 1992) and design problem solving is considered to progress in two search spaces, problem structuring and problem solution, as opposed to a single search from an initial state to a goal state. The notion of dual search was first introduced by Simon and Lea (1974) and later adopted by Kühr and Dunbar (1988) to explain scientific reasoning in terms of a search in the hypothesis space and a search in the experiments space. The studies of insight problems have also shown the necessity of dual search in insight problem solving for which solutions are achieved often after re-representation of problem statements (Kaplan, 1990; Knoblich, 1999).

In design the notion of dual search has also been adopted to explain cognitive processes. The main controversy in design studies, however, has been about the nature of the interaction between the two searches. Some have argued that there is a linear progression from problem structuring to problem solution (Goel & Pirolli, 1992); others have suggested a reverse linear progression (Lawson, 1979; Lloyd & Scott, 1994), yet others have claimed that the interaction between the two is dialectic rather than linear (Maher & Tang, 2003; Schön, 1987).

In their study on the differences between design task environments and other problem task environments, Goel and Pirolli (Goel & Pirolli, 1992) suggest that the problem structuring and problem solution processes in design are clearly distinguishable in terms of the issues that are considered in each and in terms of their sequence. In three design
protocol studies that lasted between 95 minutes and 115 minutes, they found that design in the protocols began with problem structuring and was followed by preliminary design. Problem structuring occasionally reoccurred later in the process, yet the main structuring phase always happened at the beginning of design. Problem solution, however, never occurred in the first approximately 20 minutes of the three protocols. The researchers found that statements made during the problem structuring phase were associated with use and to how to build the artifact, whereas statements from the problem solution phase were associated with specifications for the function and form. There was a higher percentage of verbal statements during problem structuring during problem solving.

Others, however, have questioned the linear evolution of design from problem structuring to problem solving. Archea (1987), criticized the problem solving view of design and instead proposed that design is similar to puzzle-making because different pieces are assembled simultaneously while searching for a consistent fit among the pieces. Contrary to Goel and Pirelli, Archea suggests that design starts with either a precedent, with symbols, or with metaphors, rather than with problem structuring.

Schön (1987) criticized the problem solving view of design from a constructivist perspective also. He suggested that design is more of a making process that starts with the construction of a framework. This framework more often invokes a particular type in architecture or precedents that are exemplary for the design problem. More importantly, Schön suggested that design situations are complex and more dynamic than presumed in Goel and Pirelli's description. The linearity of Goel and Pirelli's model, from Schön's perspective, is unrealistic, because design problems cannot be sufficiently structured at any point so that problem solution linearly follows problem structuring. Others who have subscribed to the problem solving view have also acknowledged that the relationship between problem structuring and problem-solving in design is not deterministic but rather is a dialectic relationship (Akin, 1986). This explains why in Goel and Pirelli's protocols problem structuring occasionally reappeared during the design process.

The main distinction between Goel and Pirelli and Schön relates to the sequence of problem structuring and problem solution. Goel and Pirelli assume that designers would begin working on a solution only after problem structuring, whereas Schön does not
make this assumption. The difference, therefore, is not so much in whether design situations go through two phases, which look like problem structuring and problem solving, but rather in the sequence and the interaction of these phases. Problem solution, according to the Schön and Archea, could occur in the early phases of design and could be useful in structuring of problem as well. In Schön’s and in Archea’s views the use of type, which in Goel and Pirolli’s model would be associated with problem solving because it is about form specification, is also a way of problem structuring.

Two studies support views that a designer could start with a specific solution without going through a problem structuring phase (Lawson, 1979; Lloyd & Scott, 1994). The first (Lawson, 1979) studied the difference in problem solving behavior in science students and architecture students. The study indicated that designees started with solutions whereas scientists went through a problem structuring phase. The second study (Lloyd & Scott, 1994) illustrated the significance of the designers’ level of experience. The results of this study showed that designees with more experience in a particular design task tended to start with solutions, whereas designees with less experience tended to start with problem structuring. These studies seem to discount both Goel and Pirolli’s view. The designees in these studies did not start with problem structuring. Instead, the studies support the view that there is no intrinsic distinction between well-defined problems and ill-defined problems, and that ill-defined problems could be solved as well-defined problems if their structure were detailed enough for immediate solution (Eastman, 1969; Simon, 1973).

Most recent characterizations of design, while adopting the problem structuring and problem solving distinction, propose more interactive, co-evolutionary models of the process (Dorst & Cross, 2001; Gross et al., 1987; Maher & Tang, 2003; Sewa et al., 2000). Maher and Tang (2003) introduced a co-evolutionary computational model of design in which problem structuring and problem solution changed interactively through a series of operators in a cyclic fashion until a convergence between them is achieved. They also proposed to describe design situations as explorations rather than search. The behavior of the model in the two exploration spaces was symmetrical in the sense that the model spent equal amount of time in each. In two protocol studies Maher and Tang tested the behavior of their model against data from the protocols. In the first protocol study, a
product design task, they found that the design process evolved towards a more solvent exploration in the solution space, as was suggested by Goel and Pirolli. However, they also found that there were more interactions between the two exploration spaces throughout the design process. This second observation supports Schön's view of a process in which there is continuous interaction between solutions and problem structuring. In their second protocol study, an architectural design task, Maher and Tang again found a co-evolutionary process of problem structuring and solution. Results from this protocol also showed that even during the early phases designers spent more time on solutions, suggesting an asymmetry of exploration in the two spaces. Taken together, the two protocol studies confirmed the initial assumption about the co-evolutionary nature of design yet showed the incompleteness of their computational model to simulate human designers' behaviors. This study has two shortcomings. First, for both design tasks, the time given to the designers was only 45 minutes, which suggests that the results could hardly be representative of real design tasks. Second, the assumption of the study is that through constant cyclic interactions designers will eventually reach a satisfactory solution, suggesting an incremental design process. Yet, this view fails to explain how radical shifts in design occur.

Studies on creativity show evidence that designers often change their problem representation radically in a way which is reminiscent of problem re-representation in insight problems (Kaplan, 1990; Knoblich, 1999). Akin and Akin (1996) describe such changes as shifts in the frame of reference within which a designer works. In a protocol study, they compared a novice designer's behavior to an expert designer's behavior in designing a façade for a simple structure. The expert designer went through six shifts during the design process, whereas the novice designer went through four shifts. This suggests that radical shifts are pervasive among both novice and expert designers.

Following a break from their current frame of reference both expert designers and novice designers adopted new strategies, suggesting that moves in the solution space were triggered by shifts in the problem space. They found that problem re-structuring accompanied by necessary procedural knowledge led the expert designer to a more creative design scheme.
The above studies have four implications for this thesis. First, they show that design is sufficiently different from other types of problems. Second, they show that the notions of exploration space and dual exploration are useful in describing the nature of design. Third, they are inconclusive in describing the following:

1) The sequence of exploration in problem space and in solution space:
   a) Whether designers start from problem space or solution space, or whether they start from either space with regard to the nature of design tasks and their expertise;
   b) Whether there is a linear progression from problem structuring to problem solution, as suggested by Goel and Pirolli, which would fail to explain why changes happen in the design.

2) The nature of the relationship between exploration in problem space and exploration in solution space:
   a) Whether this relationship is highly interactive and constant, as suggested by co-evolutionary views of design, which would fail to explain why sometimes design change does not occur;
   b) Or whether there are interactions between exploration in problem space and solution space happening only at times when there is a shift in either space.

The fourth implication for this thesis is that the notion of exploration in dual spaces may relate to double-referentiality of the conceptual diagrams. If so, an inquiry into the role of conceptual diagrams may provide some answers to the questions above. Earlier, it was suggested that conceptual diagrams are double-referential; their structure corresponds to the structure of conceptualizations and to the structure of generic spatial configurations. Whereas conceptualizations correspond to problem structuring, generic spatial configurations correspond to problem solutions. Through conceptualizations design situations are given focus, whereas through generic design schemes a family of design schemes is defined that makes design situations more manageable (Gross et al., 1987).

Conceptual diagrams, therefore, are important to both problem structuring and problem solution. In this thesis, it is proposed that the structure of conceptual diagrams correspond
to both of the represented domains, as such they align the structure of problem space with the structure of solution space. Because conceptual diagrams are physical models of corresponding mental models of conceptualizations and spatial configurations, manipulations of the diagrams are propagated to both spaces whenever there is a structural change, suggesting that if there is a structural change in the conceptual diagram it directly changes the structure of both conceptualizations and spatial configurations simultaneously. When conceptual diagrams are constructed in the design process, therefore, problem structuring and problem solution are coalesced and exploration in the dual space is aligned.

This chapter first identified a significant class of representations in design, i.e., conceptual diagrams, and second inquired why they are useful in design. It characterized diagrams as fixing meaning and conceptualizations as opposed to sketches that are ambiguous. It differentiated conceptual diagrams from other seemingly similar classes of representations, such as conceptual sketches, esquisse, and figural concept. In discussing their usefulness in design, the chapter referred to the studies of diagrammatic reasoning and proposed that diagrams by way of structural correspondence elucidate complex relationships in their target domains. Finally, in reference to the dual exploration views of design, this chapter proposed that conceptual diagrams, because they are double-referential, are significant in mediating the dual exploration in design.
CHAPTER 3

THE COGNITIVE-HISTORICAL METHOD IN DESIGN STUDIES

To briefly recap, the central questions of this thesis are:
- What do designers do in the early phases of design?
- How do conceptual diagrams facilitate exploration in the early phases of design?

The thesis proposes to investigate these questions through case studies from architectural history. There are two reasons why a case study approach is adopted. First, the early phases of design last for an elongated period of time. Second, design is a complex cognitive act that evolves within a dynamic cognitive system with various cognizing agents, representative systems, and tools. A case study approach puts emphasis on the contextual aspects of design and studies a rich body of historical materials from contextually embedded design episodes. Other research methods in design, such as protocol studies, fall short to capture the contextual aspects of design and the elongated processes of creativity.

The underlying premise of this thesis is that design is an evolving process where the emergence and elaboration of novel ideas occur over time. This claim holds true for both those expert architects who claim that creativity and discovery in design follow a period of incubation (Le Corbusier et al., 1981; Pfeiffer & Wright, 1990) and those who suggest that creativity and discovery come through an intense effort of exploration (Cross, 1997). According to both groups, generation and elaboration of novel ideas evolve over time. According to the first group, this period is a passive anticipation for a moment of insight, whereas for the second, this period is an intense exploration.

Research into the emergence and elaboration of novel ideas in design needs to consider an appropriate research method to investigate the lengthy and complex processes of design. One research method that is particularly well-suited to study such processes is the cognitive-historical analysis method (Nercessian, 1995). This method has been influential in understanding the process of discovery in science and has potential for studying the
discovery and elaboration processes in design. There are similarities between scientific discovery and discovery in design that it is conceivable to use the studies of scientific discovery as a model for the design studies. The similarities that are relevant to this thesis are the following. First, both research in scientific discovery and research in design can benefit from the methods and findings of cognitive science in describing the cognitive processes involved in creativity. Second, discovery in science and design prolong over elongated periods of time. Third, both science and design evolve in cognitive systems. Fourth, findings from both areas of research can be employed in formulating new hypotheses about the nature of cognition.

**Cognitive-Historical Analysis Method**

The cognitive-historical analysis method studies cognitive processes in periods of discoveries in science based on available historical documents and in reference to related findings from cognitive science, an interdisciplinary research field with contributions from cognitive psychology, artificial intelligence, cognitive neuroscience, linguistics, philosophy, and cognitive anthropology. The method provides explanations of complex cognitive processes observed in scientific discovery and formulates new hypotheses about complex cognitive processes, as exemplified in cases of scientific discoveries. These complex processes are derivatives of everyday cognitive processes. Cognitive-historical analysis extrapolates what we know about everyday cognition to understand complex cognitive processes. Ideas such as concept formation and categorization and different kinds of reasoning methods provide working tools for philosophers and psychologists to understand the nature of scientific discovery. In turn, the findings from cognitive historical analysis bring new insights not only to our understanding of the process of scientific discovery but also to our understanding of everyday cognition. Philosophers and cognitive scientists who study scientific discovery via the cognitive-historical method employ the findings of cognitive science and reciprocally contribute to the advancement of cognitive science in areas such as conceptual change (Nersessian, 1985, 1992b), the use of imagistic reasoning (Giere, 1999), and diagrammatic reasoning (Cheng, 1996). This exchange of results and findings provides a model for design studies.
A cognitive approach to the study of design can use the findings of cognitive science to describe the design process and could be complementary to the fields above, by providing new insights into our understanding of the process of creativity and discovery.

The cognitive-historical analysis method differs from other studies in scientific discovery, such as controlled studies, by investigating contextually embedded cases that are relatively well-documented and thus conducive to detailed inquiry. The contextual embeddedness of these cases allows research in this field to avoid the problem of ecological validity, which is one of the main drawbacks of experimental studies.

The cognitive-historical analysis method represents a new approach to the history and philosophy of science. This method of analysis emphasizes the role of the cognizing individual embedded in complex problem-solving situations as opposed to traditional approaches to the history of science that consider scientists to be gifted geniuses and view scientific discoveries as flashes of insight. Cognitive historical analysis also differs from social historical methods that tend to ignore the role of individual scientist and instead, focus attention on the cultural and social context of historical phenomena more than on the individual scientist. In the study of the history of science both the traditional and socio-historical approaches do not emphasize the process of discovery as a cognitive process. A similar attitude toward design is common in architectural circles. Creativity in architectural design has been thought to be inexplicable and designers are regarded as gifted individuals whose creative abilities are not understandable.

Nersessian (1999) describes five characteristics of the cognitive-historical analysis method as it is used in the history of science. First, cognitive-historical analysis studies the reasoning processes of scientists through an examination of the cognitive tools and artifacts that they construct. Second, the method tries to reconstruct scientists' thinking processes, articulating speculations and replacing existing representations. Third, the method aims to bring new insights into our understanding of history. Fourth, the method attempts to provide working hypotheses that should be further explored in cognitive science. Finally, cognitive-historical analysis does not try to fit cases from the history of science to the findings of cognitive science but rather to establish a reflexive interaction between analysis of historical cases and cognitive science research.

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The five characteristics of the method apply to design studies as well. First, in the case of architectural design, the products that lend themselves to a cognitive analysis are representations of buildings, such as drawings and sketches, and additional documents, such as publications, speeches, and correspondence. These representations constitute the cognitive tools employed by designers to explore and communicate design ideas. These kinds of historical documents are the primary sources of the case studies in this thesis, too. Second, design evolves in ways similar to science, through generation, articulation, communication, and finalization of alternatives, and, to the extent that a case is well documented, it is possible to present a rich account of the thinking processes of design, too. The case studies in this research are well documented and thus conducive to detailed study. Third, for those cases from the history of scientific discovery and design in which conventional analysis of historical documents will not yield satisfying answers to historical questions cognitive-historical analysis may provide answers. Fourth, design studies should focus on individual cases to infer generalizations, in addition to controlled and field studies. Fifth, in a similar way to studies of scientific discovery, design studies have the potential to bring new insights into our understanding of cognitive processes, also.

Research Issues in Design Studies

In the last thirty years design studies have simultaneously explored several research questions related to the nature of design and formulated several research methods appropriate to the study of design. A quick overview of research in this domain will reveal a multiplicity of findings and methods, for several reasons. First, design studies are in an early stage of development. Second, design does not lend itself to straightforward observation, as do some other human activities, such as analytical problem solving. Among different research methods used in design studies, protocol analysis is the most prevalent (Cross, Christiansen, & Deet, 1996). This analysis consists of recording a designer's behavior while he or she is undertaking a design task for a short time and analyzing the recorded behavior in the light of what is known about cognition. This method has been widely used by researchers interested in problem solving, as detailed by
Ericsson and Simon (1992) in their book titled *Protocol Analysis: Verbal Reports as Data*. Protocol analysis considers concurrent and retrospective verbal reports of the participants of design protocols to be legitimate sources for use in tracing the underlying cognitive processes of activities. Emphasis in protocol analysis is placed on capturing thought processes through concurrent verbalizations, which are considered to be indicative of the information used by cognitive processes but not of the cognitive processes directly. The participant of a protocol study reports and then the experimenter uses that report to deduce the cognitive processes of the subject in reference to an a priori hypothetical model of reasoning in which particular pieces of information are associated with particular cognitive processes.

Several researchers in design studies have used protocol analysis, beginning with the early work of Eastman (1969). A review of this research reveals much variety in the use of the protocol analysis method in design studies. Some researchers' work, such as Eastman (1969), Akin (1978), Baykan (1996), and Ullman et al. (1996) has been more along the lines of Ericsson and Simon's view of protocol analysis, while others have been more flexible (Schön, 1988; Sawa & Tverský, 1997). Furthermore, there is a variety in the employed coding schemes and diversity in the research focus. Akin's work (1978), for instance, emphasized the role of computational models and simulation of human behavior using computational models. Gero and McNiill's work (1998) emphasized the importance of developing a model for a coding scheme. Other researchers used the protocol analysis method only for data collection, such as Schön (1988). Some researchers used participants' retrospective accounts instead of concurrent verbalizations, such as Sawa and Tverský (1997). Others posed hypotheses and tested them by manipulating variables in the task environment, such as Goel (1995), or testing them between group comparisons, as did Atman (1999).

Protocol analysis has been criticized from two perspectives. First, criticism of protocol analysis focuses on the inappropriateness of using concurrent verbalization to express the design situation. The second criticism focuses on the experimental set-up of protocol analysis, which lacks the richness of real design situations (Lloyd, Lawson, & Scott, 1996). This second criticism partially stems from a "phenomenological" stance that emphasizes the unity of experience, as opposed to an "analytical" approach (Janis, 1993).
Design tasks given in protocol analysis are often relatively simple and the time allocated is short. This runs counter to the premise of this research, i.e., that novel ideas are generated and elaborated during prolonged design processes. The lack of richness in protocol studies relates to the discussion of ecological validity in general, to the issue of context, and the realistic definition of tasks specifically. Some who have employed the protocol analysis have acknowledged the importance of context in relation to design task definition in protocol studies (Oost, 1996). Concerns about task definition are considerable, yet any task definition in a protocol study will fall short of representing the real context of design practice, which involves the social dynamics between different stakeholders of the design process and what evolves over prolonged periods of time. In this thesis it is assumed that idea generation in design takes time, that design is a collaborative endeavor, and that context in design is important because it provides both cognitive resources and constraints, such as social preferences, technological possibilities, and material artifacts, whose impact on cognitive processes in design needs to be considered also. It is these weaknesses that any new methodology in design studies should respond to if it claims to complement the existing body of findings in design studies.

The strength of a historical case study is its emphasis on contextual aspects of the design process and its capacity to analyze elongated processes of idea generation. These are the two areas in which the cognitive-historical method may play a crucial role in studying design cognition and complement the findings of protocol studies. However, in comparison to studies of protocol analysis the data in cognitive-historical analysis is coarser in detail because of the scarcity of available historical sources and the difficulty of undertaking a very detailed analysis of the whole process of design.

Generalizations from Case Studies

One of the main drawbacks of case studies has been the difficulty of generalizing, inductively, from individual cases. Generalizations about scientific reasoning in cognitive-historical analysis are actually possible if the findings of case studies are substantiated by cognitive science research findings. The basic assumption in cognitive-historical analysis is that scientific cognition is not different in kind from everyday
cognition but that its practices are extrapolations and refinements of everyday cognitive processes; this makes generalizations based on single case studies conceivable. In cognitive-historical analysis, working hypotheses provided by cognitive science are employed in historical cases and are modified with respect to the peculiarities of scientific reasoning.

Some researchers in design studies have pointed to a similar problem concerning the generalizability of findings from case studies when discussing recent views in design studies (Dorst & Dijkhuis, 1996). Dorst and Dijkhuis (1996), in their discussions of recent views, introduce two main research paradigms in design studies, herein called the "analytical" approach and the "phenomenological" approach. Dorst and Dijkhuis consider Herbert Simon's rationalist, positivist, technical view to be an example of the analytical approach and the constructionist and reflection-in-action view of Schön to be an example of the phenomenological approach. The analytical view considers design problems to be ill-structured problems that can be partitioned into smaller, well-structured units (Simon, 1973, p. 183), whereas the phenomenological view considers design to be making and not a tightly-structured problem solving activity (Schön, 1988, p. 182). In their comparison of the analytical view of Simon to the reflection-in-action view of Schön, Dorst and Dijkhuis claim that the Schönian view emphasizes singularities that are difficult to generalize across several cases, whereas the analytical view abstracts design activity to the extent that it loses its relevance to design in practice. Cognitive historical analysis, through the nature of its reflexive relationship with cognitive science, provides a resolution for the dilemma between abstraction and over-specification. This dilemma can be resolved by comparing the findings of experimental studies and case studies simultaneously, in order to achieve a complementary relationship between them. From studies of scientific discovery, Klahr and Simon (1998) provide a framework for achieving such a complementary relationship between different research methods.

Researchers in the area of social science methodology suggest a similar complementary relationship among different methods (Brinberg & McGrath, 1985). According to Brinberg and McGrath, a complementary relationship between different research methods is a natural result of these mutually incompatible desiderata that a researcher wants to maximize methodologically: generalizability (Criterion A), precision (Criterion B), and
**realism** (Criterion C) (p. 43). Generalizability determines the boundaries of the population to which the information acquired relates. Precision is related to accuracy of measurements, control of behavior variables, and level of detail. Realism is related to the degree of representativeness of the research phenomenon in the domain of research.

Beinberg and McGrath suggest that maximization in any one of the three desiderata will eventually yield a low level in the other two; hence, research results cannot all be maximized at once. If generalizability is maximized, such as in a sample survey, the study will yield low contextual information and low control (precision) over the behavior. If precision is maximized, the research will take place in an artificial context and have "low generalizability with respect to populations outside the artificial laboratory conditions" (p. 44).

In design studies a cognitive-historical case study will provide a highly realistic substantive domain, yet the analysis will lead to low precision and low generalizability. In contrast, laboratory experiments or artificial design task analyses, such as protocol analysis, will produce high precision and control over data and behavior of the actors, however, a low rate of generalizability and low rate of realism. Rather than attempt to eliminate the inherent limitations of methods that favor different research paths, a better strategy would be to guarantee that a multiplicity of methods be used. Historical case studies can provide a high level of realism and experimental studies can provide a high level of precision. The findings from cognitive science can in both cases assure the generalizability of the findings. Figure 8 represents this complementary relationship between experimental studies, cognitive science, and case studies.

![Figure 8: The complementary relationship between case studies, experimental studies, and cognitive science.](image-url)
Data Type in CHA

Research methods need to be complementary because they investigate similar research questions at different scales. In design studies this difference becomes clearer in the nature of data analyzed in protocol analysis and cognitive-historical analysis. In protocol analysis data are collected in highly controlled settings. The verbal reports and other behaviors of the subjects are recorded, transcribed, segmented, encoded and then interpreted. Researchers define the tasks to be given to the subjects and the setup of the experiment. There may be some gaps in the data because of technical inefficiencies in recording and measurement, but the available data is used to give a complete idea about the task of the experiment. Furthermore, a task in such an experiment is at best a fragment of the real process of design. Tight control over the data and segmentation of the protocol provides a very detailed yet incomplete picture of design. Protocol analysis investigates only a small interval of time in the design process. A complete picture is possible only through accumulation of fragmented pieces from different design protocols.

Cognitive-historical analysis creates a more complete picture of the whole design process if there are enough quality archival documents. In cognitive-historical analysis, however, the data is not as detailed as in protocol analysis. Researchers who employ the cognitive-historical analysis method select the cases to be investigated, yet they cannot control the variables, as is possible in protocol analysis. The specificity of their research questions, therefore, cannot be as controlled as these questions in controlled studies.

What to Study with Cognitive-Historical Analysis?

A major question encountered with cognitive-historical studies is how to bring the hardly accessible aspects of cognition to the surface. From the perspective of cognition, the difficulty of data collection is tracing the cognitive processes, i.e., investigating cognitive phenomena quickly enough to access the processes involved. From the perspective of historiography, the difficulty lies in assuring the validity and relevance of the documents available for analysis.

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In conventional protocol analysis of problem-solving researchers have considered verbal reports of protocol participants as the primary data to investigate the cognitive processes. In design protocols, because of the nature of design, some researchers have instead considered designers' sketches and drawings as the primary sources of data to be investigated. This thesis accepts designers’ representations as the primary source of investigation. In the early phases, design primarily evolves through external representations and the use of other visual representations. These representations capture and store new ideas, function as an external memory that records fast and transient creative thinking. These external representations, along with other available sources such as written notes, publications, and correspondences are indicative of the thinking processes involved in design, and, as such, they are historical documents worth investigating.

Among the different types of external representations, conceptual diagrams play a significant role in the design process by way of embedding conceptualizations. This thesis accepts conceptual diagrams as the primary unit of analysis for studying elongated periods of idea generation and elaboration. A study of conceptual diagrams is especially appropriate to trace changes in design conceptualizations because easily traceable changes in conceptual diagrams reflect changes in conceptualizations. From studies of scientific discovery, Grissemer and Wimsatt (1989) used a similar approach in tracing the evolution of Weisssnnism in biology by identifying changes in published diagrammatic representations of the related scientific theory.

Selection of Case Studies

There were three criteria for the selection of case studies for this thesis:

- Presence of a representation which appears to be a conceptual diagram,
- Availability of and ease of accessibility of these representations and additional historical documents from the early phases of design, and
- Variety among the cases.

In the three cases studied as well as in other cases considered for detailed investigation, the architect had singled out one particular drawing from his design process as
representative of the project. These drawings are widely published and have become closely associated with the particular project they belong to. It is assumed the architect’s selection of one particular drawing signifies the importance of that particular representation to the project. This importance, however, was corroborated by archival research and by the reports of others involved in the design process whenever possible, helping authenticate the definition of the drawings as conceptual diagrams in this thesis. In the case of the Unitarian Church, members of the congregation present at the first meeting with Kahn confirmed the significance of Kahn’s form diagram. For the Staatsgalerie, the reports of two junior designers who collaborated with Stirling were crucial. Finally, in the case of the Jewish Museum, the jurors of the competition and one member of the design team confirmed the importance of Libeskind’s Star diagram.

The second criterion was the availability and ease of accessibility of the historical documents of the design process of the projects. For all three case studies extensive historical materials were available at major architectural archives. The Louis I. Kahn Archives at the University of Pennsylvania holds all the documents from Louis Kahn’s office; the Canadian Center for Architecture possesses all the documents from Stirling and Wilford Associates; and the Getty Research Institute houses all Libeskind documents up to the time he moved his office to Berlin.

Finally, case studies were chosen to provide variety. The first case study is from the late 1950’s and early 1960’s, the second is from the mid 1970’s, and the last is from the late 1980’s. Altogether, the three case studies are indicative of developments in architectural practice within the last 40 years. Each case study is characteristic of concurrent changes in architecture. Kahn’s project, one of his first, was a precursor of brutalism. Stirling and Wilford’s project was the realization of an alternative urban scheme following the modernist principles of city planning and emphasizing the role of historical references in architecture. Libeskind’s design for the Jewish Museum was one of the first major buildings of the so-called “deconstructivist” approach in architecture. All three cases, therefore, reflected changes in architectural practice and provoked discussions in architectural thinking. The buildings of Kahn and Libeskind marked the beginning of their internationally renowned careers, whereas for Stirling, the Staatsgalerie indicated a change in his architecture. Kahn and Libeskind wrote extensively about architecture,
whereas Stirling wrote little about architecture. The First Unitarian Church and the Jewish Museum had conceptually demanding design tasks because of their subject matter, whereas the Staatsgalerie was less demanding in this way. However, the progress of the Staatsgalerie was the most complex of the three. All three architects taught architecture for a period during their lives. Finally, the three architects each had a special interest in drawing. Kahn’s travel sketches and drawings for his projects have been widely published and exhibited. Stirling recognized the power of architectural drawing in communicating the essentials of architectural ideas, and he introduced what some have called the zip-a-tone technique in architectural technique (Bunham, 1974). Libeskind is the most radical of the three in the way he has explored the potential of architectural drawing, both in his projects and in his published work (Libeskind, Eisenman, & Architectural Association, 1983).

The three cases represent some differences in terms of their design process as well. The First Unitarian Church project started with a clear conceptualization that did not change for some time during the design process. The Staatsgalerie project started with a series of design precedents and a conceptualization of the design situation occurred sometime later in the process. The Jewish Museum project started with a clear conceptualization and a precedent, yet the conceptualization was continuously elaborated throughout the process.

In addition to the three cases studied, four other projects were also considered for detailed analysis: Frank Lloyd Wright’s Guggenheim Museum, Steven Holl’s MIT Dormitory project, Jorn Utzon’s Church at Bagsværd, Copenhagen, Denmark, and some projects of an Atlanta-based architectural firm. To get information on the Guggenheim Museum, the Frank Lloyd Wright Archives at Taliesin West was contacted. Even though there is evidence that Wright was imagining an inverted ziggurat for his museum, there was no clearly identifiable drawing, which was representative of the project. For the MIT Dormitory project there was a series of published conceptual diagrams, but a detailed study was not possible at that time although Steven Holl’s office was contacted about studying their documents of the dormitory project. There exists a series of drawings by Utzon that illustrate his initial design ideas, yet the historical documents about the project were not accessible. Finally, a preliminary archival research at an Atlanta-based firm was inconclusive in locating a project that would have been pertinent to this research.
In summation, this chapter outlined the reasons for which a cognitive-historical approach is adopted in this thesis. The cognitive-historical analysis method investigates contextually embedded cases and elongated periods of creative processes. In contrast, the protocol analysis method investigates rather short episodes of design in which it is harder to capture the elongated creative processes. The chapter also identified conceptual diagrams as the unit of analysis of this research, which are especially appropriate in tracing the changes in design conceptualizations.
CHAPTER 4

FIRST UNITARIAN CHURCH OF ROCHESTER, NEW YORK

I try to evolve a composition, and make every sketch count for as much value to me as may be gotten out of a design problem. To make a sketch of this sort requires, of course, the making of many impressions and notes "on the job". You must then get away from it all to work over and crystallize your thoughts in order to develop the picture in the form of a readable design." (Kahn, 1991, p. 11)

The First Unitarian Church case study is the first of the three case studies in which the significance of conceptual diagrams in design will be discussed. This case study was the first one to be completed among the three. It significantly shaped the initial research questions as well as research propositions about the nature of conceptual diagrams and their importance during the design process. The other two case studies were conducted in the light of the results and observations derived from the First Unitarian Church case. After the completion of the other two, this case study was revisited and its content and analysis changed.

The main argument in Chapter 4 is as follows. The conceptual diagram Kahn used in his design for the First Unitarian Church was significant in that it helped him structure the design situation and lay out the general characteristics of the design solution. Its significance in problem structuring and problem solution simultaneously facilitated the mediation between the exploration in the problem space and the exploration in the solution space. Furthermore, the conceptualization embodied in the diagram represented a shared understanding of the design situation for Kahn and his client who used the diagram to propagate common commitments in the design process.

The argument will unfold in the chapter along these lines. First, detailed information about the historical documents used in the case study will be provided. Second, the developments leading to the design will be described. Third, the building will be briefly explained to give an image of the final product. Fourth, the details of Kahn’s
conceptualization and his conceptual diagram will be introduced. Fifth, the evolution of the design ideas in the process will be described to illustrate the significance of the conceptual diagram. Finally, the salient features of the process will be discussed in reference to research in the area of design cognition and cognitive science.

The First Unitarian Church is an important building in Kahn's professional and intellectual career. The building is one of the significant early works of Kahn together with the Trenton Bathhouse, New Jersey, and the Richards Medical Research Building, Pennsylvania. Intellectually, the design process of the First Unitarian Church helped Kahn formulate his design theory, which he introduced in two articles and an interview published in 1960 and 1961 while he was still occupied with the design of the church (Kahn, 1960, 1961a, 1961b). In these publications, Kahn presented the design process of the church as a clear illustration of his design philosophy. Kahn's theory describes design as a linear progression from a conceptual, abstract realization, which he calls "Form" to a concrete expression of the same, realized according to circumstantial constraints, which he calls "Design". In simplified terms, the design process is a progression from "Form" to circumstantial "Design" in which "Form" is the realization of the essence of the thing to be designed.

In the case of the First Unitarian Church, Kahn expressed the underlying essence of the design through a drawing, which he calls the "Form drawing" and which I call the conceptual diagram (Figure 9), because:

- It is a visual/spatial configuration representative of the core of a design conceptualization: Kahn with this diagram emphasized the importance of questioning and the unity and libertarian aspect of the Unitarian belief system.

- It is double-referential: the spatial configuration represents a generic scheme of spatial arrangements and it highlights the main feature of the abstract conceptualization.

- It is a generic representation, i.e., it is not a plan configuration.

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Figure 9: The “Form” diagram of Kahn (published in Perspecta, 1961). The first ring (hatched) corresponds to the school, the second to the corridor, the third to the ambulatory, and the square to the sanctuary.

The design process for the First Unitarian Church (1959-1961) started with this drawing that Kahn drew on a blackboard at his first meeting with his client. This diagram is an abstraction of a church building consisting of a school and a sanctuary and of how they should be related. In his writings on the church, Kahn claims this particular drawing was significant in the way he communicated his design ideas to the congregation and in the way it encapsulated his design conceptualization and his formal compositional language.

The origins of Kahn’s emphasis on the first drawing encapsulating the design conceptualization may be traced back to his architectural education at the School of Architecture, the University of Pennsylvania, which at the time was ranked as the best Beaux-Arts school in the United States (Scully, 1962). In the Beaux-Arts tradition, the students were given a building programme and expected to develop a rough plan of a solution in a short period without any consultation. The rough plan is called an esquisse, a rapid sketch, in preliminary form, the essence of the idea in the mind of the designer (Eghert & Van Zanten, 1980, p. 115). The students were also required to decide on a formal compositional language (pantone) appropriate for their particular idea (Lampugnani et al., 1996). At the end of this short period, the students would turn in their first drawings, which would be later used to assess their design development. In the subsequent phases, the students were required to advance their final schemes absolutely in the spirit of their first idea.
The process as well as the elements of his Beaux-Arts education seems to have persisted in Kahn's practice even after 30 years. Kahn's form realization through "Form" drawing corresponds to esquisse and the linear process from "Form" to "Design" corresponds to the process from esquisse to the final project (projet rendu) at the Ecole des Beaux-Arts. The team conceptual diagram introduced in this thesis is similar to Kahn's notion of "Form" drawing and to the Beaux-Arts' notion of esquisse. All three refer to the embodiment of a conceptualization about a design situation in a graphic representation. This thesis, however, does not conjecture a linear process as it is implied in Kahn's writings and as it was practiced at the Ecole des Beaux-Arts (See Chapter 2).

Study of the Design Process

The analysis of Kahn's project is based on primary archival documents from the University of Pennsylvania's Kahn Collection, from the First Unitarian Church of Rochester, and from published materials.

After the sudden death of Kahn in 1974, all the materials from his office were transferred to the University of Pennsylvania's Architectural Archives. The transferred materials included everything from the office ranging from legal and business documents to detailed construction drawings and architectural models. The documents at the Archives are kept in their original boxes and order.

The material related to the First Unitarian Church includes: original sketches, drawings, notes, correspondence between the Unitarian congregation, Kahn and others, construction photos, and office documents. The wide range of documents from the design process made it possible for this research to establish a rich reconstruction of the process prior to the design and after the design. In addition, the Archives has several documents prepared by the client that clarify their intentions and preferences in preparation to the design process. These documents were crucial in identifying the events leading to the design.

1 For an exposition of Kahn's Beaux-Arts education see (Brownlee & De Long, 1991; Scully, 1962, 1976). For how Kahn describes his Beaux-Arts education see (Kahn, 1974).

2 See the following documents prepared by the Congregation: (What Can We Do About Growth/Fact-Finding Report on Four Courses of Action, ; Profile of the New Unitarian
and in contextualizing Kahn's design process. They were especially helpful in
determining the design challenge to which Kahn had to respond.

Sketches, drawings, and correspondence between Kahn and the Unitarian congregation
helped trace the evolution of events after the congregation commissioned Kahn with the
design task. This material was important in determining the way Kahn responded to the
design challenge. Additionally, all the renderings at the Archives from this project are
also published in a catalogue along with other drawings from the Archives (Kahn, University of Pennsylvania, & Pennsylvania Historical and Museum Commission, 1987). Among these renderings, one is a copy of the conceptual diagram Kahn drew at
his first meeting (Figure 10). It is without question that Kahn drew this diagram, yet it is
most likely that this particular diagram was drawn for publication purposes. We know,
however, that Kahn drew a very similar drawing on a blackboard when he first met with
the congregation based on the reports of the meeting's participants.

Figure 10: Another version of Kahn's form diagram housed at the Kahn Archives.
The form diagram is juxtaposed with a schematic drawing of the final design (©
1977 Louis I. Kahn Collection, University of Pennsylvania and Pennsylvania
Historical and Museum Commission).

Additional sketches from the early phases of design are housed at the Modern Museum of
Art, NY, which at the time of this research were not available for investigation. These
drawings stayed at the Museum after an exhibition on Kahn's work in 1966. They are,

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Church Building, ; Recommendations of Building Committee, ; Report to the
Congregation from the Fact-Finding Committee on Church Architecture.

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however, published in an extensive catalogue of Kahn's built and unbuilt work (Ronner, Jhaveri, & Vassell, 1977).

Letters from the Archives were instrumental in establishing an accurate timeline as well as in determining the interaction between the congregation and Kahn. This was crucial because the design went through a series of phases during which new requirements emerged or previous requirements were increasingly clarified. The letters helped formulate both the new and the old requirements.

The congregation provided an additional body of material, including audiotapes of retrospective accounts of the members of the congregation involved in the design and building of the church. The accounts give a detailed description of the period both before the selection of Kahn as the architect of the church and after his selection.

The secondary material used in this research consists of the writings of Kahn and of others on the First Unitarian Church. It is this group of material, Kahn's writings are of special importance because he referred to this particular project and to its design process several times when he wrote about his design philosophy. William Porter, who was involved in the project early in his career, provided some input, also. Porter's comments on a different version of this research were important in authenticating the historical reconstruction of the design process.

Design Situation

The story of the First Unitarian Church starts in 1850 with the rapid growth of the Unitarian congregation at Rochester. In the second half of the 1950's, the congregation's existing church building became too small for its growing needs. Their existing building was likely to be torn down because of new urban developments in downtown Rochester. As a first step, the congregation established a "Fact Finding Committee." This Committee was in charge of discussing the consequences of growth and alternative ways of dealing with growth. At the end of the fact-finding phase, the Committee decided to construct a new building. Following this decision, the Committee distributed questionnaires to
members of the congregation, to be returned by March 4, 1959. This questionnaire was intended to clarify the main concerns of the congregation in regards to the new building.

The major issue emerging out of the questionnaire results was how their new building was going to represent their belief system. The questionnaire asked the members whether "a church should reflect the belief of the people who worship in it" and if so to specify the relevant characteristics of the Unitarian faith and of a building that will reflect this belief by selecting appropriate adjectives from a given list of descriptors. The members affirmed that a church should reflect the Unitarian belief system, which was described as "searching, rational, democratic, non-dogmatic, tolerant, ethical, unity-in-diversity and dynamic." Members described a physical structure that would represent the Unitarian faith as: "functional, imaginative, plain and simple (beautiful in simplicity) dignified and harmonious (in itself and in relation to the site)." The primary design challenge for Kahn, hence, was to conceive a scheme that would be an embodiment of the democratic ideals of the Unitarian belief system. The results of this questionnaire were collected in a report entitled the Fact-finding Report (Fact-Finding Report on Four Courses of Action). The congregation provided this report as well as its summary to Kahn before the design process. Kahn's task involved the designing of a sanctuary and a school building in the spirit of the Unitarian faith.

The congregation provided Kahn with specific requirements in their invitation letter (Letter, Neman to Kahn, June 1, 1959). The requirements were a summary of the results of the questionnaire. The main issues in the summary described their preference for their building as follows (Profile of the New Unitarian Church Building):

1. A building of "contemporary or modern design, of permanent beauty and real artistic value rather than "exaggerated", "bizarre" or "oddish".

2. For 400-500 people and would NOT be enlarged. The growing needs of the congregation would be handled in other ways by two services and/or a daughter fellowship.

3. Built of stone or brick with glass and wood as the secondary materials.

4. Sparing use of symbols, and well-conceived, if any.
5. The Religious Education Building would be attached to the main building.

6. The whole plant should be planned for multi-purpose use.

7. Special care would be taken for the sanctuary.

8. No clear plan for the seating of the choir. An organ would be used for music, yet its type was not determined.

9. The upper limit of the budget was $505,000.

In addition to the documents provided to him by the congregation, we also know that Kahn talked to a minister about Unitarianism in Philadelphia before his meeting with the client (Williams, 1991). It is very likely that Kahn interpreted the "searching, rational, democratic, non-dogmatic, tolerant, ethical, unity-in-diversity and dynamic" aspects of the Unitarians faith as a belief system that emphasizes voluntary participation of churchgoers to the activities of their congregation, which would become the first aspect of his design conceptualization as materialized in his conceptual diagram. We also know that Kahn in his studio teachings prior to the First Unitarian Church asked his students to design a non-denominational chapel (Goldhagen & Kahn, 2001), during which he might have contemplated some of the issues he would deal with in designing the First Unitarian Church.

Among all the specifications above, the one about the relationship between the school building and the main church building would prove to be one of the main contentious aspects of the design and would constitute the second aspect of Kahn's conceptualization. The congregation's desire as described in their summary was in favor of a compound composed of two buildings. Kahn would modify this into a unified scheme with his conceptualization and would challenge it throughout the design process.

In April and May of 1959, a group of Church members contacted different architects, and Kahn was selected. The Committee officially notified Kahn on June 1, 1959 that he had been selected as the architect. The first design phase began with Kahn's first meeting with the congregation on the 17th of July and ended on the 13th of December 1959 when Kahn submitted his first set of final drawings. Responding to Kahn's first submittal, the Committee urged him to modify the first design and last asked him to explore a
completely different scheme (on January 8, 1960, February 28, 1960, and March 6, 1960). After April of 1950, Kahn stopped working on his first scheme, a symmetrical, square building with a circular sanctuary in the center. In the months that followed, Kahn explored different alternatives until his last scheme was approved by the Committee in June of 1961. Construction started on June 23, 1961 and was completed on January 30, 1963.

Building

The building consists of three series of concentric spaces, the sanctuary, the corridor, and other spaces, layered on two floors and clearly expressed on the outside. The sanctuary is centrally located around which other functions are assembled (Figure 11, Figure 12, Figure 13). The corridor, in the form of a ring, separates the sanctuary from other spaces. The other spaces surround the corridor in the form of a “U”. Each side of the U is dedicated to a different function: one side for the classrooms, one for the office spaces, and the other for the workshops and the kitchen. In the two diagonal corners, there are staircases leading to the second floor where there are additional classrooms and offices.

From the entrance hall, there are only two accessible spaces. The first is the library that is on axis with the entrance and the second is the sanctuary. On the left and right of the entrance to the sanctuary, there are passages to the corridor leading to other spaces.

The building lacks any literal symbolism. Instead it accentuates the natural qualities of its materials: wood, brick, and concrete (Figure 14). Another important feature of the building is the quality of the natural light both in the sanctuary and in the other spaces (Figure 15). In the sanctuary, natural light comes in through four light towers on each corner of the rectangular space. The roof of the sanctuary is in the form of a cross made by two foiled concrete planes. In the other rooms, Kahn especially deals with the problem of glare by putting the windows in recessed walls (Figure 16). Upon increasing space requirements, Kahn added a two-story addition, containing new offices, classrooms, a meeting room and a general purpose space, to his first building in 1969 (Figure 17).
Figure 11: The front view of the church (photo by Bülent Batuman).

Figure 12: The back view of the Church (photo by Bülent Batuman).
Figure 13: The back view of the Church (courtesy of Robert Craig).

Figure 14: The interior of the sanctuary has almost no decoration except wall hangings designed by Kahn and woven by Jack Lenore Larsen.
Figure 15: The balcony in the sanctuary with light coming down from the towers on its both sides.

Figure 16: Detail from the façade showing the recessed windows of the classrooms (photo by Bülent Batuman).
Figure 17: The side view of Kahn's extension to the Church (photo by Bülent Batuman).

The power of the spatial configuration together with the quality of the light and the nature of the materials made the First Unitarian Church building one of the most important pieces of Kahn's architecture. For Kahn, this was an important building because it represented an ideal example of his design philosophy. Others have argued that this building was the maturation of Kahn's investigations in architecture (Scully, 1976).

Kahn's Conceptualization and his Conceptual Diagram

We know that Kahn drew his "Form" diagram during his first meeting with the congregation between June 17 and 18, 1959 based on his account and the accounts of the members of the congregation. The "Form" diagram represented both the spatial

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3 Williams (1990), however, claims that the first dateable rendering of the "Form" diagram is an annotation in the top margin of Kahn's typescript of his speech entitled "The Difference between Form and Design." This speech was given at a meeting of the Southern California Chapter of American Institute of Architecture in October 1960, almost a year and a half later.
arrangement of the components and the significant conceptualization in Kahn's understanding of the design task (Figure 9). One member of the congregation reports that Kahn "impressed" and "mesmerized" the congregation both by his philosophy and by his concept (The First Unitarian Church of Rochester). Bob Jonas, another member of the Board, describes the design concept and Kahn's loyalty to the concept as follows:

From the very time he first came and presented this idea about the question surrounded by the other things that was the central theme of the building he was gone build regardless what the building committee might have in mind... He eventually built that concept but within a theme of very workable building. (The First Unitarian Church of Rochester)

Kahn's own description of what he conceived with this diagram provides significant clues about its importance and its meaning. Kahn states in September 1959 as follows:

So, what is a chapel really? A chapel, to me, is a space that one can be in, but must have excess of space around it, so that you don't have to go in. That means, it must have an ambulatory, so that you don't have to go into the chapel; and the ambulatory must have an arcade outside, so that you don't have to go into the ambulatory; and the object outside is a garden, so that you don't have to go into the arcade; and the garden has a wall, so that you can be outside of it or inside of it. The essential thing you see, is that the chapel is a personal ritual, and that it is not a set ritual, and it is from this that you get the form. (Kahn, 1961c)

What Kahn suggested here is a series of spaces and activities to which users can participate on a voluntary basis. The voluntary participation to activities is important because it emphasizes the liberal approach of the Unitarian belief. Semantically the diagram embodies the liberal approach of the Unitarian faith along the lines of a voluntary participation to different activities. These activities included study, circulation, and contemplation. One could be part of any of these activities. Participation, however, is not accidental or coincidental or forced, it is rather a deliberate choice and could be at different levels of intensity.

Formally the diagram consists of a series of concentric circles and a square in the center. The areas outlined by the circles and the square represent different activities and different spatial components. The outer circle represents the school building, the following circle the corridor, and the area between the innermost circle and the square represents the ambulatory. The components and the activities in them are in a hierarchical relationship that brings different permeability and accessibility to spaces. In other words the hierarchy
of spaces allows different patterns of participation to the ceremony, with the center being the least accessible from the outside and the school being the most accessible.

The sanctuary, which houses the question mark, is in the very center. To reach to the sanctuary one has to go through a series of spaces and make a conscious decision to participate in the religious ceremony in the sanctuary. The delay in entering the sanctuary makes the sanctuary a distinct place where one actually contemplates about questions related to existence. This is represented by the question mark, the only literal symbolic mark on the diagram. Participation to the ceremony could be realized at two levels, either by literally being part of the ceremony or by being an observer if one decides to stay in the ambulatory. The activity in the sanctuary leaks, therefore, to the rest of the complex through the ambulatory. The second major component of the project is the school building that surrounds the inner ring and the sanctuary. This is where Kahn imagines one would discuss and learn about the question being contemplated in the sanctuary.

By putting the school around the sanctuary, Kahn defied the congregation’s specific requirement for having two separate buildings for the school and the sanctuary. This scheme was contradictory to what the members specified in their responses to the survey and also to the ideal type of Unitarian church, whose general features date back to Frank Lloyd Wright's Unity Temple in Oak Park, Chicago (1906). Yet, early in the design process Kahn managed to convince his client to favor his conceptualization, at least in principle. The congregation was pleased with the conceptualization and endorsed his concept by hiring him.

Semantically, as well as formally, the diagram represents a distinction between the center and the periphery, or between the school and the sanctuary. These are, however, not opposite poles. On the contrary, they are complementary to each other as it is stated in the Unitarian belief system and as it is represented in the concentric arrangement of spaces. The concentric arrangement embodies a unity where components revolve around the center without sacrificing the distinction between the components. This is Kahn’s response to the “diversity in unity” principle of the congregation.

In summation, Kahn’s conceptualization consisted of two major principles: one about the liberal participation in the activities in the sanctuary and the second about the integrity of
the different functions in the complex, especially educational and religious activities. These two together helped Kahn transform an abstract design challenge into a design problem with relatively more specific requirements. In design cognition terms, this process can be characterized as "problem structuring" through which the designer formulated an alternative problem representation. With the conceptual diagram, Kahn managed to combine the two principles in a consistent way, which can be considered as a construction of problem structuring. Furthermore, Kahn defined a generic type in the form of a spatial configuration for possible solutions, which can be characterized as problem solution.

The diagram not only represents graphically this conceptualization but also expresses how this conceptualization is formulated in terms of spatial configuration. The liberal participation is conveyed through the hierarchical differentiation of spaces in the form of successive circles from the sanctuary, to the ambulatory, to the corridor, to the school.

The unity of the activities is expressed in the form of concentric circles. The two principles are brought together in one graphical representation by the conceptual diagram. Furthermore, the features of the diagram became the design constraints to which Kahn remained thoroughly committed throughout the first phase and some of which he dropped or changed in the second phase. The constraints embedded in the diagram consist of hierarchical succession of circles, differentiation of spatial components, centrality of the sanctuary, unity of the components, symmetry and uniformity of the perimeter (Table 1).
Table 1: A summary of the properties of Kahn's conceptual diagram.

<table>
<thead>
<tr>
<th>Design Challenge</th>
<th>Design Concept</th>
<th>Properties of the Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>A building that would embody the democratic ideals of the Unitarian belief system.</td>
<td>Hierarchical differentiation of spatial components to allow different levels of participation in different activities.</td>
<td>Hierarchical succession of circles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Differentiation between the square (the sanctuary) and the surrounding compound (the school)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Importance of the sanctuary: it is in the middle and it has a different form and it is where the question is asked.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unity among the different functional components of the building, especially between the school and the church.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unity among components: concentric circles and the square</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Symmetry</td>
</tr>
</tbody>
</table>

The following sections in this chapter describe how Kahn's conceptual diagram was influential in the design process. There are two major issues that will be discussed regarding the significance of the diagram: first, how the conceptualization facilitated Kahn's exploration for a design solution via commitment to family of design schemes; and second, how the congregation through Kahn's diagram and presentation shared this conceptualization and helped Kahn formulate a satisfying scheme. This investigation provides an alternative to Kahn's account of his design process, and allows a richer perspective about the collaborative and dynamic aspect of his design process. Foremost, it illustrates the instrumentality of the conceptual diagram in the design process.

Design Evolution

First Phase and Design Variations

The first design phase began when Kahn received a phone call on May 31, 1959 from the Unitarian congregation about their desire to hire him as the architect of their new church and ended on the 13th of December 1959 when Kahn submitted his first set of final drawings (which Kahn names the "first design"). After the phone call, Kahn received a
formal invitation letter on June 1, 1959 with a detailed summary of the congregation's ideas about the church (Letter, Jonas to Kahn, July 16, 1959). In his July 16th letter to Robert S. Jonas, who was collaborating with the congregation's Building Committee, Kahn wrote that he had started studying basic forms and spaces. He promised that he would present his ideas soon. Kahn's first meeting with the congregation occurred on the 18th of July 1959. After the first meeting, Kahn started working on the project in mid-July 1959. On August 8, 1959, the Committee expressed their frustration with the slowness of the progress and as early as September 11th, barely three months after his visit to Rochester, Kahn received the formal contract. However, the presentation was delayed until December 13, 1959.

From this first phase, there are six sets of drawings showing different plan configurations and section and elevation drawings which illustrate that Kahn remained within the solution space defined by his conceptual diagram. The following discussion intends to clarify this claim by highlighting the similarities between the design schemes from this period, the first design, and the conceptual diagram.

Kahn's first sketches date from mid-July to December 12, 1959. These sketches and diagrams are widely published, yet not very well dated. Williams (Williams, 1991) assembles these sketches into two groups: sketches from the period June-July 1959 and sketches from the period November-December 1959. The effort represented in these groups of sketches culminated in the first scheme presented to the client on December 13, 1959.

In the sketches from June-July, Kahn considered a hexagonal building with the sanctuary at the center and the smaller spaces at the periphery. Two of the three sets from this period are only massing studies looking at the overall composition of the building and the roof (Figure 18, Figure 19). In one of them the roof seems to be a uniform continuous surface and in the other the roof is fragmented. Each fragmented unit and the sanctuary in this scheme have a separate roofing structure. The small units on the periphery are clearly expressed in the elevation by the deep recesses between them.
Figure 18: One of the hexagonal schemes from June-July 1959. (© Collection, the Museum of Modern Art, New York, Gift of the Architect).

Figure 19: The second hexagonal scheme from June-July 1959. (© Collection, the Museum of Modern Art, New York, Gift of the Architect).

The third drawing set from this period (Figure 20) shows a preliminary interior plan with a square sanctuary at the center, an ambulatory around the sanctuary, a corridor-like space after the ambulatory, and finally a series of small rooms, probably classrooms.
around the corridor. With this drawing it becomes obvious that Kahn strictly converted his conceptual diagram into the spatial layout of the building.

Figure 20: The third hexagonal scheme from June-July 1959. (© Collection, the Museum of Modern Art, New York, Gift of the Architect).

In the second group of drawings from November-December 1959, Kahn continued to work on the same themes. In two sets of drawings from this group, Kahn considered a circular building instead of a hexagonal one, yet still with concentric circles. In the first one (Figure 21), there are a series of sections and plans, which are studies of the dome. The two relatively finished roof plans portray two similar alternatives. In both of them triangulation of the outer circle is dominant, wherein the roof of the outer circle is opened in an alternating pattern of light wells inside and outside the triangle. On the inside, the light towers, which Kahn calls "umbrellas" are visible, whereas from the outside they are covered with a shallow dome.
Figure 21: The circular scheme from November-December 1959. (© Collection, the Museum of Modern Art, New York, Gift of the Architect).

In the second set (Figure 22), Kahn studied a similar circular scheme in section and in elevation. There are also two small drawings in this set that show the circular sanctuary and surrounding rooms. In one of them the circular sanctuary is fit into a square. In the other one, each corner has a smaller circle to fill the gap between the surrounding square and the inner circle. Some have suggested that these drawings reflect the influence of Leonardo's circular church plans (Goldhagen & Kahn, 2001; Scully, 1962; Williams, 1990).

Figure 22: Sketch-diagram from November-December 1959. (© 1977 Louis I. Kahn Collection, University of Pennsylvania and Pennsylvania Historical and Museum Commission).
In the last set of drawings from the early phase (Figure 15), Kahn considered the hexagonal scheme two more times. He also introduced, for the first time, a third type with two plan drawings. In this type, Kahn kept concentric arrangement of spaces, yet he changed their geometries. With this scheme, the building became a square with a concentric circle and square inside. The space between the outer square and the inner circle is partitioned to accommodate other rooms in the program. This gives the scheme a character of modularity on the exterior. The corner pavilions on the plan are treated separately suggesting they will have staircases in their corners, close to the sanctuary. The two plans, illustrative of the third type are very diagrammatic, yet expressive of the conclusion that Kahn had reached at this moment in the design process. Based on this conclusion, he developed his first final scheme.

Figure 23: The scheme with a square building and a circular sanctuary inside from November-December 1959. (© 1977 Louis I. Kahn Collection, University of Pennsylvania and Pennsylvania Historical and Museum Commission).

In all the six sets of drawings from this phase, Kahn explored the same design configuration: the concentric arrangement of spatial components, with a sanctuary at the center, a school surrounding the sanctuary, and transition zones between them. This corroborates the claim that Kahn remained within the solution space defined by his conceptual diagram. The six sets also show Kahn’s attachment to a unified scheme where all the secondary components of the building program are laid out around the centrally located sanctuary. The unity of the scheme in all six variations is accentuated by the dominance of the center marked with a prominent roofing structure. The emphasis on the
sanctuary as the dominant feature of the plans, sections, and elevations relates strongly to Kahn's description of the ideal chapel. Studies of the roof for the sanctuary and the means for getting natural light into the sanctuary seem to constitute the major effort to emphasize the centrality of the sanctuary.

There are three plan schemes studied in this first phase of the design: concentric circles, hexagonal, and circle within a square. All three schemes consist of spaces in a concentric arrangement and are symmetrical in configurations similar to the conceptual diagram. In all but one plan studies, Kahn left the drawings unfinished because of their symmetry. The plan that was completed would become the first scheme presented to the client (Figure 24). The geometric organization, structural properties, and spatial relationships among individually committed features culminated in Kahn's first design. The design was a concentric symmetrical building with the sanctuary in the center and the school component on the periphery. Similarly, Kahn's conceptual diagram suggested a square building with four relatively differentiated zones in the form of concentric rings around a central space.

Figure 24: The first design.
(C) 1977 Louis I. Kahn Collection, University of Pennsylvania and Pennsylvania Historical and Museum Commission)

Kahn implemented all the properties of the conceptual diagram in his first design with few minor additions. He changed the geometric properties of the components, added a garde and wall around the gardens, and uniformly divided the perimeter of the building

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(Table 2). The overall building became a square instead of a circle and the sanctuary, while remaining a square, was topped with a circular shallow dome.

Table 2: Comparison between the properties of the first design and the conceptual diagram.

<table>
<thead>
<tr>
<th>Properties of the Diagram</th>
<th>The First Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Hierarchical succession of circles</td>
<td>• Hierarchical succession of clearly demarcated spaces</td>
</tr>
<tr>
<td>• Differentiation between the square (the sanctuary) and the circle (the school)</td>
<td>• Kahn reverses the geometry of the sanctuary (a square with a circular shallow) and the school (a circle), yet maintains the differentiation especially through his design for the roof.</td>
</tr>
<tr>
<td>• Importance of the sanctuary: it is in the middle and it has a different form and it is where the question is asked.</td>
<td>• Sanctuary is at the very center as it was shown in the diagram.</td>
</tr>
<tr>
<td>• Unity among components: concentric circles and the square</td>
<td>• The scheme maintains the concentric spatial arrangement of the diagram and the overall building represents a monumental uniformity especially strong in the model views.</td>
</tr>
<tr>
<td>• Symmetrical</td>
<td>• Almost absolute symmetry.</td>
</tr>
<tr>
<td>• Three concentric circles around a square</td>
<td>• Square building and sanctuary, circular ambulatory and corridor, a garden, a wall around the garden</td>
</tr>
<tr>
<td>• Modular, yet uniform periphery</td>
<td></td>
</tr>
</tbody>
</table>

The size layout and design of the main entrance in relation to the overall scheme are two additional significant features of this scheme (Figure 25). Kahn placed his building in a sunken garden away from the street on top of a gentle slope to emphasize the massive monumental character of his design. The main entrance to the building is through a bridge over the sunken garden right in the middle of the main façade facing the street. Neither the main façade nor the entrance is differentiated, which emphasized the uniformity of the overall scheme. Kahn uniformly fragmented the outer ring and de-emphasized the entrance, which accentuated the symmetry of the building and the equal importance of the whole perimeter. He may have thought of each gap, between the
fragmented rooms on the outer ring, as a potential entry point leading from the garden straight towards the center of the building. The garden around the building is surrounded by a wall on three sides exactly replicating the succession of spaces Kahn suggested in his Otterlo speech.

Figure 25: The site plan of the first design. (© 1977 Louis I. Kahn Collection, University of Pennsylvania and Pennsylvania Historical and Museum Commission)

The first set of sketches and finished drawings of the first design show a clear direction in Kahn's exploration of basic forms and spaces. At this stage, Kahn was preoccupied with a unified scheme of school and sanctuary, a hierarchical differentiation of spaces, and an undifferentiated exterior boundary to de-emphasize the significance of any single point on the perimeter of the building. The first design, as well as the six schemes from the first phase, illustrate that Kahn's concentric scheme embodied in his conceptual diagram, defined the boundaries of a solution space in which Kahn explored a satisfactory design scheme.

After the First Design

The period until the first design illustrates how the conceptual diagram mediated Kahn's dual exploration in the problem space and solution space. The conceptual diagram helped to convince the client by conveying his conceptualization. In the aftermath of the first
design, the client used Kahn's conceptualization as a tool to evaluate the subsequent design variations.

The congregation found several problems with the first design. The primary organizational problem was the arrangement of the rooms around the sanctuary and the placement of a circular sanctuary within a square plan. In Kahn's first design, the difficult geometry of embedding a circle within a square left him with unused corner spaces and irregular rooms on the perimeter. His strict commitment to a symmetrical arrangement resulted in unnecessary spaces. Altogether this added to the square footage of the building, resulting in a construction budget which was four times higher than the allocated budget.

Mindful of their concerns about space and budget, the congregation asked for variations of the first design within the spirit of Kahn's original design concept. Several letters later, they urged him to explore a completely different scheme (Letter, G.R. Williams to Kahn, February 28, 1960; Letter, G.R. Williams to Kahn, March 6, 1960; Letter, H.R. Williams to Kahn, January 8, 1960).

A close look at letters between the Building Committee and Kahn, especially those written after Kahn's first submission, reveals an evolving tension between the congregation and Kahn. What is significant about these letters is they confirm the congregation's dissatisfaction with specific design schemes as well as their commitment to Kahn's original conceptualization represented in his diagram. These letters illustrate how Kahn's original conceptual diagram facilitated communication and maintained collaboration between the client and Kahn, even when Kahn was not successful in delivering a satisfactory solution. Kahn's presentation in his first meeting with the congregation as well as his conceptual diagram became a shared external representation that constituted the backbone of a tense, yet, collaborative interaction between Kahn and the congregation.

In the the first of these three letters, dated January 8, 1960, Helen R. Williams informed Kahn of the Committee's comments. Williams wrote, "As individuals, the members liked your original, basic concept, but none of us was for your subsequent revision." She reported that the first scheme was too expensive and that it was not a flexible solution.
addition to the financial problem, the first scheme did not have enough classrooms and
the clients wanted the building to be more appropriately located on the site. Ms. Williams
reminded Kahn that time was running out. She wrote, “It is disappointing to realize that
some eight months have elapsed already and we have nothing to show.” She continued:

Under the circumstances we feel that further revision of your present plans
would be futile and that a brand new approach to the problem would be
preferable.

Upon seeing the revisions that Kahn produced between December of 1959 and January
1960, the Committee members may have realized the futility of further pursuing the first
scheme. At that moment, the client’s concern for flexibility and budget imposed definite
constraints on the design process. Kahn’s original concept, praised by the Committee,
still represented a shared vision of the problem and the solution. Both needed to be
worked out in the light of additional constraints imposed by the congregation.

In the second letter, dated February 28, 1960, O. R. Williams shared the Committee’s
frustration with the two proposed revisions to the first scheme as follows:

Two sketches dated February 16, 1960 represent a modification of your
original idea pared down to meet our conflicting space and budget
requirements.

...In modification most of the charm of the original concept has been lost.

...Our greatest concern is with the inherent “squareness” of the building.

...We would like to make a fresh approach and submit drawings of a more
flexible and less formal structure to suit the site.

This letter became the turning point in the course of the design. After Helen Williams’
January 8th letter, Williams restated their appreciation of Kahn’s original concept yet felt
that neither of the revised proposals submitted were in the spirit of the original mutually
accepted concept. A conflict had arisen from contradicting requirements of budget and
space. This letter is critical for our discussion because it clearly illustrates how the
congregation used Kahn’s own conceptualization to assess the quality of one of his
schemes. Williams basically admitted the Committee’s conflicting requirements about
space and budget, yet they hoped Kahn would find a solution to this conflict without
sacrificing his original concept. The letter conveys the congregation’s worry and
frustration about Kahn’s failure to provide a scheme that could respond to the conflicting requirements.

The third letter, dated March 6, 1960, C. R. Williams reminded Kahn of the need for an entirely new concept because the first proposal and its modifications were not satisfactory. By this time, the client must have already lost its hope about the “charm” of Kahn’s original concept. Williams urged Kahn to come and visit Rochester so that they could converge on a solution by discussing “how these requirements might be incorporated into a “concept” that they “could accept.”

These three letters illustrate a dynamic interaction between Kahn and the congregation. The Committee was as effective as Kahn in developing, maintaining, and transforming a shared concept. In a sense, through their letters and requests the client tried to restructure the problem by combining their new requirements and Kahn’s concept. The shared concept referred to by the Committee as Kahn’s “original concept” provided a criterion for the assessment of subsequent proposals. The interactive process also revealed additional constraints, such as budget and flexibility, in addition to the initial ones represented in Kahn’s Form diagram and evolved through a mutual exploration of alternatives and elimination of uncertainties in design.

At this juncture it became obvious that the congregation’s and Kahn’s commitment to the conceptual diagram were different. While Kahn’s commitment was thorough, the congregation’s commitment was partial, i.e., mostly to the hierarchical succession of spaces and not to the symmetry and uniformity of the diagram. The more Kahn produced further symmetrical and uniform schemes, e.g., the first scheme and the revisions afterwards, the more it became obvious to the congregation they needed a flexible design. They thought this could be achieved by separating the school building from the sanctuary, as voted upon in their survey prior to the selection of the architect. This, however, meant that Kahn had to drop some of the features of his conceptual diagram. Namely, he needed to give up the uniformity and symmetry, which would not have required a change in the hierarchical succession of spaces.
Two-Separate Building Scheme

Kahn was slow in responding to the congregation’s request. Finally, he yielded to their persistent objections to his first design. Afterwards, Kahn briefly considered the client’s expressed preference for a separate school and sanctuary buildings connected via an entrance hall (Figure 26), which was going to be less expensive and more efficient, yet not as compact as Kahn’s original conception. The strength of the two separate buildings scheme was that it allowed flexibility by fragmenting the two major components of the program, i.e., the school and the church. By separating these two components from each other, one could easily avoid the problem of responding to their conflicting spatial requirements. The school consisted of small offices and classrooms, whereas, the church consisted of a larger sanctuary hall.

Figure 26: The second stage daring when Kahn briefly considered a scheme with separate school and church buildings.

Kahn seriously considered this scheme for a brief period even though his accounts provide a different story (Kahn, 1960). Kahn states that he convinced the Committee at the very first meeting by testing the separate building scheme (Figure 27). He claims he drew the two separate buildings and then prompted the members to think about the way they would use the buildings and about the facilities they would use immediately after a congregation. The process of questioning, as he suggests, revealed to the Committee that the other rooms had to be placed around the sanctuary. One by one, rooms that were located in the school building were moved next to the sanctuary building. The result was
a single building still along the lines of the original "Form" diagram. According to historical documents, however, Kahn had to revisit the scheme. It was most likely at this moment that he convinced his client of the strength of a unified scheme. At the end of this brief period, Kahn found a way to make his original concept less rigid and compatible with his client's space and budget requirements. According to Kahn, his last scheme preserved the original "Form".

![Diagram](image)

Figure 27: The test validity of the "Form". The sketch on the right shows the way Kahn claims he convinced the members of the congregation. Published in Perspecta (1961).

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Kahn's exploration of different alternatives continued until the Committee approved his last scheme in June of 1961. In Figure 28, Kahn summarizes the evolution of his design process diagrammatically. Figures Figure 29 through Figure 32 represent the different schemes Kahn developed during this process.
Figure 28: Kahn's "Process" diagram.
The first sketch represents the "Form" concept, the second is the "first design", the third, the fourth, and the fifth are "tests of the form", and the sixth is the "second scheme." Published in Progressive Architecture (1961).
(© 1977 Louis I. Kahn Collection, University of Pennsylvania and Pennsylvania Historical and Museum Commission)
Figure 29: The Third Stage.  
(C) 1977 Louis I. Kahn Collection, University of Pennsylvania and Pennsylvania Historical and Museum Commission)

Figure 31: The Fifth Stage.  
(C) 1977 Louis I. Kahn Collection, University of Pennsylvania and Pennsylvania Historical and Museum Commission)

Figure 36: The Fourth Stage.  
(C) 1977 Louis I. Kahn Collection, University of Pennsylvania and Pennsylvania Historical and Museum Commission)

Figure 32: The Final Stage.  
(C) 1977 Louis I. Kahn Collection, University of Pennsylvania and Pennsylvania Historical and Museum Commission)
Kahn's Last Design Scheme

In successive schemes Kahn made changes to the form of the sanctuary, and, the way in which other parts of the building related to the sanctuary. In these schemes, the sanctuary became a longitudinal hall instead of a square hall. Other facilities of the building program, such as classrooms, offices, kitchen, library, and workroom, were grouped into differentiated fragments instead of being grouped in a continuous thing. The fragmentation allowed Kahn to avoid the problem of wasted corner areas and facilitated the configuration of the smaller units in relation to the sanctuary. In subsequent phases, the fragmented parts were moved around until a satisfactory solution was achieved.

The satisfactory solution was made possible through a shift which was provoked by the application of a second ordering device over the existing order. The second ordering device was to fragment the larger parts around the sanctuary into smaller chunks and to move them independently. The later phase of the design is significant for the emergence of this alternative strategy, which provided a way to deal with the problem of the client's preference for a two-building scheme versus Kahn's preference for a unified building. At this stage, the geometric relationships in the first design were changed from a strictly concentric scheme to a more flexible one. This resolved the seemingly incompatible requirements of budget, space, and Kahn's original "Form" concept.

Figure 33 represents this shift in comparing the first design to the final design. Diagram 1 of Figure 33 is a tentative illustration of Kahn's first design proposal, described by Kahn as the literal translation of his "Form" diagram. Diagram 3 represents the final design based on Kahn's final drawings. In diagrams 1 and 3 the concentric succession of spaces is evident. This demonstrates the continuity between these two schemes suggesting that Kahn tried to elaborate one design concept and remain in one solution space throughout the design process. However, the second scheme, (Diagram 2), represents the application of the second ordering device in conjunction with the first one. The continuity between the first and the final scheme underlines the significance of Kahn's initial conceptualization both at the beginning and throughout the design process.
Figure 33: The change in Kahn's original concentric configuration [drawn by the author].

Diagram 1 represents the first scheme, in which the corners and the irregular leftover spaces between the inner circle and the outer squares are a problem.

Diagram 2 shows the effect of fragmentation of the surrounding rooms on the first scheme. The outer square is fragmented and the inner circle is converted to a rectilinear form. The small arrows show potential directions of movement of the fragments of the outer ring.

Diagram 3 represents the end product of the transformation.

A feature-based comparison between the first design and the final design further illustrates the continuities as well as the shifts in Kahn's conceptualization (Table 3). In the first design, the building was symmetrical whereas in the final design it was not. The entrance to the building in the first was on the central axis of the main façade parallel to the street. The entrance to the sanctuary was aligned with the main entrance suggesting a processional axial approach from the street to the entrance lobby to the sanctuary. In the final design, the main entrance was shifted towards the west and rotated 90 degrees. The entrance to the sanctuary became perpendicular to the axis of entry breaking the processional approach to the sanctuary.

In the first design, the perimeter was uniformly fragmented emphasizing the compactness of the design. In the final scheme, the perimeter was fragmented into four bigger and dissimilar groupings which emphasized the flexibility of the design. In terms of geometry, the first design had two of the three concentric circles and the square from the conceptual diagram. In the final scheme, the whole geometry was changed into a strictly right-angle geometry.

Concerning the components, the first design had all the four components of the diagram with the addition of a garden and a wall around the building. In the final scheme, Kahn
dropped the ambulatory altogether. Notwithstanding all the differences, however, both schemes maintained the topological relationships between the spatial components: and the concentric arrangement of the sanctuary, the corridor, the school building, and the integrity of the two major components, i.e., the school and the sanctuary.

Table 3: A feature-based comparison between the conceptual diagram, the first design, and the final design. The changes from the diagram to the first design are all in the form of detailing whereas in the final design there are major shifts in some of the features of the conceptual diagram.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Conceptual Diagram</th>
<th>First Design</th>
<th>Final Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symmetry</td>
<td>Overall</td>
<td>Symmetrical</td>
<td>Symmetrical</td>
</tr>
<tr>
<td></td>
<td>Main Entrance</td>
<td>Not shown</td>
<td>Aligned with</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>axis</td>
</tr>
<tr>
<td></td>
<td>Main sanctuary</td>
<td>Not shown</td>
<td>Aligned with</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>the main</td>
</tr>
<tr>
<td>Uniformity</td>
<td>Overall</td>
<td>Uniform</td>
<td>Uniform</td>
</tr>
<tr>
<td></td>
<td>Perimeter</td>
<td>Uniform</td>
<td>Uniformly</td>
</tr>
<tr>
<td>Geometry</td>
<td>3 circles and</td>
<td>2 circles</td>
<td>No circles</td>
</tr>
<tr>
<td></td>
<td>1 square</td>
<td>and 2</td>
<td>and complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>squares</td>
<td>right-angle</td>
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<tr>
<td>Components</td>
<td>Four</td>
<td>Six (with the</td>
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<td></td>
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<td>addition of</td>
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<td></td>
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<td>a garden and</td>
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<td></td>
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<td>a wall)</td>
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<tr>
<td>Compactness</td>
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<td>Integrity of school</td>
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<td>Integrated</td>
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</tr>
<tr>
<td>and sanctuary</td>
<td></td>
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<tr>
<td>Topology</td>
<td>Concentric</td>
<td>Concentric</td>
<td>Concentric</td>
</tr>
</tbody>
</table>

A close look at the comparison illustrates that the first design almost absolutely emulated the features of the conceptual diagram. This strongly indicates the significance of the diagram in defining the solution space during the first design phase. At this stage, the
changes from the diagram to the first design were only in the form of detailing, e.g., the treatment of the main entrance and the entrance to the sanctuary to accentuate the overall symmetry. In contrast, few of the changes in the final design, i.e., components and compactness, are detailing changes. Only two features of the conceptual diagram, integrity and topology, were kept intact. Other features of the diagram, i.e., symmetry, uniformity, and geometry, however, were radically changed in the final design. These are considered radical because they are exact opposites of the corresponding properties of the conceptual diagram and the first design.

The primary objective behind the shift in the final design was to bring flexibility to the design, as required by the client, without compromising from the original conceptualization. Kahn’s conceptualization emphasized first the unity of the different activities and second the liberty offered to the occupants of the building. In the two-separate-buildings scheme, however, Kahn had to change not only the formal configuration of his diagram but he had to partially compromise from the unity component of his conceptualization to achieve flexibility. Such a change would have implied a radical shift not only in the spatial configuration of the building but also a radical shift in the original conceptualization, which Kahn realized was not acceptable to him. Therefore, Kahn had to find a way to accommodate the flexibility requirement without compromising the unity and liberty of his original conceptualization.

Discussion

The design process of the First Unitarian Church highlights the significance of the following issues in relation to design cognition:

- dual exploration in design,
- the role of conceptual diagrams in mediating dual exploration,
- fixation in design problems,
- the way conceptual shifts occur in the design process, and
- the role of conceptual diagrams in propagating design commitments in a cognitive system.
Dual Exploration

As described earlier, designers undertake a dual exploration in two spaces (Cross, 2001). The first exploration is for a more structured, informed, and consistent definition of a design problem, incorporating often seemingly inconsistent design requirements. The second is an exploration for a spatial configuration addressing those same requirements. The former relates to what is required, preferred, or intended in a design situation, while the latter relates to how what is required is to be achieved through a particular spatial configuration. In this thesis it is proposed that this dual exploration occurs simultaneously at a broader level and is mediated through conceptual diagrams. The first exploration space roughly corresponds to problem structuring, the second to problem solving as defined by Goel and Pirelli (1992).

In their analysis of the difference between design task environments and non-design environments, Goel and Pirelli (1992) proposed that design tasks evolve in distinct phases, starting with problem structuring and ending with problem solving. Goel and Pirelli proposed that problem structuring reoccurs occasionally during the problem solving phase. However, they failed to explain the mechanism through which these distinct phases relate to each other. Their model suggests a sequential process in which problem solution starts only after the problem is structured and develops incrementally with a steady increase of transferred knowledge. The design process of the First Unitarian Church appears to have evolved in two exploration spaces, as Goel and Pirelli suggest design occurs; yet Kahn's process also evokes two shortcomings of their model. First, Kahn's conceptual diagram, which was drawn at the beginning of the design process, was a structuring of the problem as well as the definition of a generic design solution. Second, as such, problem structuring and problem solving were coalesced at least for a period, rather than being distinct phases.

An alternative view to Goel and Pirelli's sequential model is the view that explorations in the problem and solution spaces co-evolve (Dorst & Cross, 2001; Cross et al., 1997; Maher & Tang, 2003; Suwa et al., 2000). According to the co-evolutionary views of design, explorations in both spaces evolve simultaneously and incrementally while changes in one space are concurrently propagated to the other, regardless of the
importance or scale of the changes. The main problem with the co-evolutionary views is that they do not distinguish between more important and less important changes, and thus they do not explain how and why radical changes occur in design other than those instances when such changes are prompted by surprise.

Kahn's response to the Unitarians' libertarian approach was to design a building that would enable voluntary participation in the activities of the church at different levels of involvement, while his interpretation of the Unitarians' focus on the central question led him to a unified scheme of different concentric components. These two faces of Kahn's conceptualization were brought together in the conceptual diagram, which suggests that the conception of the diagram was an effort to provide a reformulation of the design situation. Kahn's conceptualization corresponds to Goel and Piroli's (1992) problem structuring phase in design. What is different in the case of the First Unitarian Church, however, is that the reformulation of the design situation appears in the form of a spatial configuration descriptive of a family of design schemes as well, which is characteristic of the problem solution phase in design. Kahn's conceptualization of the design situation, therefore, came with the definition of a set of design schemes. The coexistence of problem structuring and problem solving in the design process of the First Unitarian Church differs from the general design process model introduced by Goel and Piroli. In subsequent phases of the design, however, unless there was a significant change either in the conceptualization or in the spatial configuration, problem structuring and problem solving remained separate phases, differing in this way from co-evolutionary views of design.

The previous discussion leads one to the proposal offered in this thesis: exploration in design evolves in two exploration spaces; however, it differs from other views in design studies in the way it explains the interaction between the two exploration spaces. What is proposed in this thesis is that because of their spatial and conceptual properties, conceptual diagrams help structure the problem by providing consistent and coherent conceptualizations of design situations and by defining a generic spatial configuration. In comparison to the view of Goel and Piroli, therefore, this view suggests relatively more integrand explorations for a design conceptualization and for a design scheme. In contrast to the co-evolutionary views of design, this thesis explains how radical changes
in design might occur and how changes in one exploration space affect exploration in the other.

**Conceptual Diagrams as Mediators**

Following the proposition above, this thesis suggests that conceptual diagrams mediate between abstract ideas evoked by design problem definitions and spatial configurations implied by design solutions. Furthermore, they represent the core of conceptualizations of design situations by addressing design challenges and responding to design requirements. Through conceptual diagrams designers respond to often contradictory requirements and reconcile complex challenges while simultaneously conceiving generic spatial configurations.

The mediating role of Kahn's conceptual diagram becomes apparent in the way it facilitated the coordination between the dual exploration in the design process and in the way it provided a shared, flexible framework with which design schemes were elaborated. Through a consistent conceptualization Kahn brought structure to the design problem, through a generic scheme he managed to define a set of related design solutions, and through a shared, flexible framework he managed to convey his conceptualization to the client. These features are significant for design cognition because design situations require a coordinated dual exploration and involve multiple stakeholders who need a common understanding of the design situation. During Phase 1 the conceptual diagram aligned the exploration in the problem space and in the solution space; during Phases 2 and 3 it acted as a framework for the assessment of various design schemes (Figure 34).
Figure 34: The three phases of the design process. Between Phase 1 and Phase 2, Kahn completely dropped his concentric scheme. In Phase 3, however, he managed to combine the flexibility of Phase 2 with the uniformity and hierarchy of Phase 1. In Phase 1 the conceptual diagram defined a set of design variations; in Phases 2 and 3, it was used either by Kahn or by the client to evaluate subsequent design schemes.

During Phase 1 the conceptual diagram represented a structured generic understanding of the design problem as well as the generic spatial characteristics of a satisfactory design configuration. The structure of the conceptual diagram corresponded to the generic structure of Kahn’s conceptualization and to the generic structure of spatial configurations. The structural correspondence between the diagram and the represented domains suggests that Kahn's diagrammatic representation was a generic model (Nersessian, 1999). Nersessian (1999) states the benefits of visual representations to the formation of generic models in scientific discovery and in constructing mental models.

The proposition of this thesis follows Nersessian's analysis of generic models that are in the form of external representations and studies conceptual diagrams as examples of structured representations in design. Whereas Nersessian explained some advantages of
structured external representations for reasoning and constructing a mental model, this thesis looks at their specific role in design, proposing that, as a generic model, the diagram represents the salient features and relations in the design situation (problem structuring), resolves inconsistencies in these relations (problem structuring), and defines a generic spatial configuration (design solution).

In his conceptual diagram Kahn transformed a conceptualization into a formal/spatial configuration. This formal/spatial configuration consisted of a concentric arrangement of program components, a hierarchical spatial configuration, uniformity in the design, the importance of the sanctuary and school building, and symmetrical composition. In the first phase of the design Kahn produced several variations of this configuration, all of which closely followed the specifications of the original conceptual diagram, with the exception of fragmenting the outer ring into uniform modular rooms. Kahn remained within the problem space and within the solution space defined by the generic model.

In Phase 2 the initial conceptualization, as the client understood it, was a tool for evaluating the validity of design schemes and for shaping the exploration for a satisfactory design scheme. In this sense Phase 2 illustrates how design commitments were propagated in the design process and how different agents in the cognitive system advocated these commitments at different times as it became necessary. The client's use of Kahn's conceptualization was significant because it shaped the exploration within the solution space. When it became apparent to the client that Kahn would fail to provide a satisfactory scheme within the initial solution space, they asked for changes first in the solution space and later in the conceptualization space. During this phase, the client used the agreed-upon initial conceptualization in appraising the first design and its subsequent variations. Later the client imposed new requirements, such as flexibility, yet urged Kahn to incorporate these requirements into his initial conceptualization.

The problem throughout Phase 2 was that Kahn appeared indifferent to his client's requests. When Kahn's unwillingness to cooperate was recognized, the client felt the need to completely drop Kahn's original concept, including the idea of liberal participation in the activities of the sanctuary, in favor of a more conventional scheme with two buildings, following the example of the Unity Temple building by Frank Lloyd Wright.

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At this stage it became clear to the client that there needed to be a shift in structuring the design problem to incorporate the flexibility requirement. This shift in the problem space not only necessitated a new conceptualization of the design task but also determined a new solution space through the proposal of a precedent, i.e., the Unity Temple. Midway through Phase 2, Kahn had to completely abandon his conceptualization in favor of an asymmetrical, non-uniform, polar arrangement, following his client's demands for a more flexible design.

**Fixation in Design**

Kahn's resistance to incorporating the client's new requirements suggests that he was fixated and his commitment to the components of his diagram was different from the client's commitment. Kahn never mentioned anything about symmetry and uniformity to his client, yet both were implied in his diagram. In fact, Kahn only considered symmetrical and uniform schemes, both during and after the first design phase, at the risk of losing the commission. The controversy over uniformity versus flexibility suggests that for Kahn the formal characteristics were as important as the spatial ones, however, the formal characteristics were not initially discussed with the client at the beginning of the design process. If they had been discussed the client could have specified immediately that symmetry and uniformity needed to be considered together with flexibility. The discrepancy between the client's and Kahn's interpretations of the initial conceptualization became apparent when the client expressed its dislike for the symmetry, rigidity, and squareness of the first design. Although the client had approved Kahn's initial conceptualization and urged him to work within it, they did not think the shape and geometric properties of the diagram were essential. The client was happy with the conceptualization but only partially happy with the generic design scheme, approving the spatial configuration but not the implied geometric properties.

To Kahn, however, the geometric properties were equally important. In a sense, the client's interpretation of the diagram was more abstract and generic than Kahn's, interpreting it as a "type" diagram (Howse et al., 2002). For Kahn the diagram was relatively more specific and its interpretation was inflexible (Stenning & Oberlander, 1995), making inferences from the initial conceptualization more available and tractable.
(Stenning & Lemon, 2001). The over-specificity of Kahn’s interpretation suggests that to Kahn the diagram was closer to being a token (an instance of a generic type) than a type (a generic conceptualization). This would also explain the literal translation of the diagram into a design scheme at the end of the first stage. The process of translation of the initial conceptualization into a design scheme can be characterized as almost a “free ride” (Shimozuma, 2001), in which the features of the diagram were inflexibly converted into the features of the design.

One reason why Kahn may have been over-committed to the features of his diagram is that through the diagram he managed to achieve multiple goals simultaneously. First, through the formulation of the conceptual diagram Kahn structured the design situation in the space of conceptualizations (problem structuring) while defining a set of design schemes in the space of spatial configurations (problem solution). Second, Kahn incorporated two components of his conceptualization in this conceptual diagram at once: a scheme that unified the school and sanctuary and a hierarchical scheme that accommodated different levels of participation in activities. It is likely that by overlapping different ideas into one relatively simple representation designers efficiently establish meaningful connections among these ideas. This, however, may make it harder for designers to separate these ideas when necessary, as in the First Unitarian Church project, or harder for them to drop one of the ideas because the combined representation has become too important to them.

This last point indicates why certain conceptual diagrams become more important to designers than others. It also provides a detailed illustration of how an expert designer’s commitment to a generic concept and a generic spatial configuration became fixation when he did not change his conceptualization although change was necessary. Research in the area of fixation in design has studied designers’ fixations on design solutions (Jansson & Smith, 1991) and on their initial concepts (Cras & Cross, 1995). Results from this body of research show either the shortcomings or the benefits of fixation to a solution or to a concept. The First Unitarian Church case study, however, presents an example in which fixation was both disadvantageous (in the early phases) and beneficial (in the later phases, when Kahn reformulated his initial conceptualization in the light of emerging requirements).

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One explanation of commitment to initial conceptualizations has been that designers are emotionally attached to them (Cross & Cross, 1995). In the case of the First Unitarian Church emotional attachment was definitely at work; however, there was more to the commitment than emotional attachment. It is likely that when multiple design ideas are conflated into a single representation, designers are more likely to commit to that representation and the ideas embodied therein. The representation becomes richer in meaning and integral to establishing relationships between different ideas, yet it becomes harder to modify, even when necessary. Knebelich et al. (1999), studying insight problem solving, described the difficulty involved in changing problem representations in terms of the scope of a constraint. They found that constraints with a wider scope, i.e., a higher degree of influence on problem representations, are harder to relax. Following their description, it is plausible that Kahn resisted modifying the components of his conceptualizations because of their wider scope. A shift in the initial conceptualization would have required numerous changes in the solution space.

Another reason for Kahn's fixation to his initial concept may relate to his over-commitment to the formal vocabulary inherent in his conceptual diagram, i.e., to his interpretation of his diagram as a token in which almost all the features became significant. In this instance, the perceptual features of the diagram suggested a particular formal vocabulary that was representative of both the important conceptual ideas and the spatial configuration. The unity of the scheme corresponded to compact and uniform designs and different levels of participation in activities corresponded to a concentric arrangement of spaces. Kahn did not seem to consider that it was possible to change the formal vocabulary, i.e., symmetry and uniformity, to achieve a more flexible scheme without having to alter his conceptualization. Kahn was not able to divorce the perceptual features of his diagram from their conceptual counterparts.

Another potential explanation for Kahn's over-commitment may relate to the significance of the spatial typology of symmetrical, centralized plan schemes in his architecture. The symmetrical centralized plan by itself may have been Kahn's primary concern, placed over concerns related to function, budget, or space. In two of his realized projects, the Bangladesh Assembly building in Dhaka, Bangladesh, and the Exeter Library in Exeter, New Hampshire, Kahn conceived almost perfect centralized buildings. In both instances,
however, the program was conducive to a centralized scheme. In projects for which the program was not conducive to this type of scheme, such as the unbuilt Goldenberg House in Rydal, Pennsylvania, Kahn managed to mutate the centralized scheme in accordance with the specific requirements of the project. Kahn finished the project for the Goldenberg House at about the same time that he received the invitation letter from the Unitarian congregation (Kahn, 1961b). This indicates he could have loosened the rigidity of his design for the First Unitarian Church as well.

One other possible reason for Kahn's over-commitment might relate to his Beaux-Arts education, which emphasized designers' absolute commitment to their initial conceptualizations as expressed in their esquisse. As described earlier, Kahn's education was influential in formulating his design theory. His education was apparently also important to the way the initial stages of the First Unitarian project evolved. It is conceivable that Kahn might have broken away from his Beaux-Arts education during the design process of the Unitarian Church, to a certain extent, by recognizing the importance of circumspect requirements as much as the initial conceptualization.

**Conceptual Change**

During Phase 2, when Kahn abandoned his initial conceptualization he also began meeting individually with different sub-committees representing different program components of the building (Kahn, 1961b). Kahn reports that during these meetings he realized that his initial conceptualization was the right structuring of the design because all the activities in the building revolved around the sanctuary. These meetings might have helped him realize the subtle differences between as well as the natural fragmentation among activities in the building. The two realizations together may have prompted Kahn to reconsider his original conceptualization and realize that he could actually devise a scheme which would be both flexible and retain some of the features of his initial scheme. This necessitated, however, a conceptual shift in his understanding of the design situation by way of incorporating his client's emerging requirements and dropping some of his own requirements. The shift occurred after Kahn considered the scheme with two buildings, which he thought was not appropriate because of how the building would be used and because of the radical shift from his initial conceptualization.
It was, however, a flexible scheme that consisted of two components. Towards the end of Phase 2 it was Kahn's turn to use his initial conceptualization to evaluate the design schemes, in a way similar to the client's use of the initial conceptualization to evaluate earlier design schemes. Once more the initial conceptualization was used to determine acceptable design schemes in the solution space and was a mediating factor in design selection; however, this time it was not the only factor. Kahn also had to incorporate emerging requirements that led to a conceptual shift.

This conceptual shift was in essence a restructuring of the design problem definition with significant implications in the exploration space as well. The conceptual shift and its implications in the solution space, however, were less radical when compared to the shift necessitated by the two-separate-buildings scheme, because some commitments from earlier phases of design were propagated into the final phase.

The conceptual shift in the design process of the First Unitarian Church illustrates a significant change in conceptualization of the design situation. Researchers in the area of design cognition have often characterized significant changes in design as insights or illuminations, in reference to the literature of insight problems. In insight problems, impasses are broken by restructuring the problem representation, thus bringing about a sudden realization of what a solution could be (Kaplan, 1990; Knoblich, 1999). Akin and Akin (1996), for instance, described the moment of insight as a change in a designer's frame of reference, operational in a particular design situation. They suggested that shifts in the problem space are indicators of creativity in design. Accordingly, shifts in a frame of reference help break an impasse only if they are accompanied by appropriate procedural knowledge, which Akin and Akin observed in expert designers but not in novice designers. Others, such as Sewa et al. (2000), characterized this shift in terms of a sudden realization marked by surprise, suggesting that such changes are random and serendipitous (Thagard, 2002). In contrast, Cross (1997) described these shifts as bridging between the problem space and solution space rather than suddenly leaping from problem to solution. Dorst and Cross (2001), using Cross's notion of creative leap, however, put the emphasis again on the significance of surprise in bridging between problems and solutions. Views emphasizing the significance of surprise in design tend to corroborate views which describe designers' behaviors as opportunistic (Cross, 2001; 102
Cross & Cross, 1995), at the expense of minimizing the role of designers' more structured and deliberate efforts in creativity.

In the case of the First Unitarian Church what is observed is, at first, a resistance to change on the part of the designer and, second, a gradual change triggered by constant and deliberate pressure from the client. The conceptual diagram was instrumental both during the period when Kahn resisted changing his conceptualization and during the period when he realized the need for change. The gradual as well as radical changes that occurred during the design process of the First Unitarian Church suggest that a deliberate, structured process of change can be as significant in design as an incremental process of development triggered mostly by surprise.

Cognitive System

Finally, changes in the problem space and solution space were determined primarily by the architect, but the client's feedback was important, also. As described earlier, the conceptual diagram played a crucial role in facilitating the client's feedback to the design, establishing the design constraints and commitments, and propagating these constraints and commitments throughout the process. Following Hutchins' definition of a cognitive system (Hutchins, 1995a), internal, external, and shared representations in the First Unitarian Church design process were constructed, propagated, and modified according to emerging circumstances through complementary contributions of the client and the architect.

Kahn's conceptual diagram first conveyed a generic understanding of a design situation, i.e., an appropriate conceptualization of the design task and a corresponding family of design schemes, and then facilitated the construction of a shared mental model. In subsequent phases the client used the diagram to evaluate design schemes and suggest precedents for the design of their church; thus, they shaped the spatial configurations space. When the client concluded that there was not going to be a satisfactory scheme using the initial spatial configuration, they decided to drop Kahn's initial conceptualization; thus, they changed the problem space. The change in the conceptualization triggered Kahn to reconsider his initial conceptualization and led him
to incorporate the emerging requirements, thus changing the conceptualization space again.

In the cognitive system of the design of the First Unitarian Church, moves in the exploration spaces could be triggered or performed by either the architect or the client. The client's contribution, relative to the architect's, was limited, yet, when the client intervened there was a substantial change in the exploration, such as during Phase 2, when they rejected Kahn's first design, introduced the requirement of flexibility, and proposed a precedent for the church.

In the process, the conceptual diagram maintained the genericity of a shared understanding, which at times of tension became crucial in determining an acceptable set of design solutions. This suggests that the design process was the product of an integrated system in which the participants were involved in coordinated explorations, both in the problem space and in the solution space. Throughout the process neither the boundaries of the problem space nor the solution space were fixed and complete in the minds of either the client or the architect. The boundaries were, rather, changing and distributed across the system. In this system Kahn's conceptualization, the conceptual diagram, and the client's understanding of Kahn's conceptualization, together with their requirements, constituted the determining factors.
CHAPTER 5

STAATSGALERIE, STUTTGART

If you structure the process properly you don’t have to concern yourself with extraneous matters or details until an appropriate time. You prioritize the issues under consideration and begin work with the fundamentals. This is a bare bones method of designing in which the brief is always distilled to a simple graphic representation in order to establish connections between the spaces the building has to accommodate and the site on which they are to be situated—a diagrammatic comparison. (Wilford, 1993)

In the First Unitarian Church, the design process evolved from a distinct conceptual diagram towards the final design scheme with variations and modifications along the way. Kahn’s diagram embodied the abstract conceptualization of the design situation and determined those constraints to which he and his client remained committed throughout the process.

The second case study, Staatsgalerie portrays a similar process. The design, in this case, evolved within a restricted solution space. There was, however, no clear diagrammatic representation of one single design conceptualization until a later period during the process. Furthermore, some other constraints emerged along the way. They became constructive as a whole only after a series of conceptual diagrams were produced. From then on the process was further restricted with fewer variations and modifications. In this sense, the case of Staatsgalerie portrays a different trajectory during which a generic abstract conceptualization emerged out of variations.

For the First Unitarian Church, Kahn remained the leading designer. There were others who were part of the project development as well, such as William Porter, yet, Kahn himself was primarily in charge of the conceptual design phase. The conceptual diagram during this process sustained the collaboration between the architect and the client.
In the case of Staatsgalerie, there was more than one leading designer involved in the conceptual design phase: James Stirling, as the primary designer, Ulrich Schaud and Russell Bunting as the junior designers. Their primary medium of communication was sketches and diagrams. In the process of exchanging ideas, the representations were simplified and abstracted through re-sketching, allowing them to identify the salient features of their schemes and formulate them in abstract and generic diagrammatic representations. Abstraction through diagrams facilitated the determination of important features, propagated design comments in the collaborative cognitive system of Stirling and Wilford's office, and sustained collaboration among the designers.

During one particular re-sketching phase, Stirling abstracted Schaud's and Bunting's design schemes using diagrams. Diagrams from this set were integrative of the major design issues and elements by way of combining them in one single conceptualization. The isolation of major issues was significant during the design process because afterwards the subsequent schemes followed the newly emerged conceptualization. Stirling picked one of the diagrams from this set for publication and labeled it later as the conceptual sketch for Staatsgalerie.

This case study will highlight the salient features of the process of abstraction in Stirling's diagrams. The abstraction process was sustained through a collaborative effort within a cognitive system (Hutchins, 1995b) that consisted of a senior designer, two junior designers, and architectural representations in the form of sketches and diagrams. The study will emphasize the distinct roles of each component of this cognitive system and how the junior and senior designers took advantage of different but complementary attributes of architectural sketches and diagrams.

Study of the Design Process

The Staatsgalerie case study is based on an investigation of archival materials from the Stirling Collection at the Canadian Center for Architecture, a literature survey of materials about Staatsgalerie, and the correspondence with the surviving members of the design team.
The archival materials include approximately 505 graphical materials such as sketches, study, presentation, publication, construction, and detail drawings, additional textual materials such as correspondence, minutes from meetings, and expenditure documents.

Each of the graphical material at the Archives was documented according to the following categories: type of representation, type of paper, pen/pencil, pen/pencil color, the use of scale, and number of drawings. The drawings that introduced new ideas and new design features were analyzed carefully with the author’s annotations and diagrammatic abstractions. Sixteen sets of sketches from the conceptual design phase were reproduced as high resolution slides. The reproduced sketches were of crucial importance for tracking the evolution of the design ideas. Five additional sets of sketches from the early phases were published in different journals. The published sketches together with the reproduced ones add up to 21 sets of sketches. Each of the 21 sets has a number of small and large sketches, which were studied further for tracking the emergence and evolution of the design ideas.

There are few textual materials available at the Archives and these are of secondary importance. However, they were helpful in consolidating the timeline of the design process and its aftermath. One reason why there are limited numbers of textual material is because the design evolved in approximately five months almost without any interaction with the client. The client's requirements were specified in the competition brief and the designers were expected to proceed based on this document. In addition the client requested almost no changes after the design scheme was selected, hence little documentation was created.

In addition to the archival documents, published material about the significance of the Staegalerie provides substantial amount of information about the design situation and the impact of the building on architectural theory and practice. The building, when it was finished and opened to the public, was so successful that it was widely published in the architectural journals and stimulated discussions about monumentality, symbolism, and historicism. The published material contained additional information about the important issues addressed in the competition brief and by the design team.
The writings of Stirling and Wilford on the work dynamics of their office, their philosophy of design, and their way of working with different architectural representations provided a second body of important documentation. Neither Stirling nor Wilford were theoreticians, and their writings are concise, yet to the point. Wilford's writings especially were significant because after Stirling's sudden death, the architectural media had consulted Wilford to explain in detail what Stirling, Wilford and Associates' architecture was about.

The final body of material were the reports of Schaad and Bevington, the surviving members of the design team. Schaad and Bevington made significant contributions to the design. They are currently practicing architects, the former in Switzerland and the latter in the UK. They responded to 27 questions about the design process. Their responses were of crucial importance in determining the nature of the collaboration among them and in authenticating the set of sketches.

**Design Situation**

In April 1977, the state of Baden-Württemberg, Germany, announced an invited competition for the extension of the Staatsgalerie and the redevelopment of its close vicinity in Stuttgart. This was an international and restricted competition to which only eleven architectural offices were invited. Among the eleven architectural offices, four were foreign and seven were German. The foreign invitees included Bo and Wohltert (Copenhagen), Powell, Moz and Partners (London), Zoelly (Zurich), and Sirling and Wilford (London).

This was a second competition administered by the state of Baden-Württemberg for the development of this area. The first competition, organized in 1974, asked architects to develop only conceptual schemes for this site, which the city authorities decided would house new buildings for the Parliament, administrative buildings, a new theater, and an extension to the Staatsgalerie (Rodiek & Stirling, 1984). None of the foreign invitees of the second competition, including Sirling and Wilford's office, participated in this first competition.
The results of the first competition were announced on June 10, 1974. Three schemes were given first prizes in this competition, yet, none was realized. The jury thought it would be futile to expect a concrete project from an idea competition. The subsequent competition was announced three years after the first one.

Both the first and the second competition emphasized the urgency of restoring the spatial and historical continuity of the urban fabric by establishing relationships between the new structures and the existing urban structure and by enhancing pedestrian movement. This became the central focus of the competition organizers and the competition brief.

A vast majority of the historical fabric of the area was destroyed during the Second World War with few remaining buildings, including The Staatstheater (1912), the Parliament of Württemberg (Werner, 1984, p. 23), the Museum of Natural Sciences and the State Archive (1833-1840) and the old Staatsgalerie (1838 - 1843) (Figure 35). After the war the opening of new roads and highways further increased the problems in the area, resulting in a fragmented urban fabric (Rodick & Stirling, 1984).

Figure 35: The site of Staatsgalerie and its close vicinity.
The loss of the original fabric of the city created a historical and spatial discontinuity. Historically, the new buildings had very little connection with the existing buildings. Spatially, the new urban environment and the new traffic arteries created a fragmented urban fabric where old buildings were disconnected from each other and the pedestrian movement was cut off between different zones of the city.

The competition brief given to the architectural offices addressed these issues in specific terms and made some explicit suggestions about how the urban character of this area could be restored. The central issue addressed in the competition was the restoration of the integrity and continuity of this area, whereas the specific requirements of the competition brief were as follows (Filler, 1984):

- Pedestrian path: A pedestrian path across the site should create a link between the residential neighborhood behind the Staatsgalerie and the more civic district in front of the Museum.
- Historical continuity: The new building should contribute to the historical significance of the area by way of establishing relationships with other historical buildings around the site.
- Highway: The new design should improve the discontinuity caused by the harsh presence of a major highway, the Konrad Adenauer Strasse, on the west of the building.
- Scale: The new building should respect the small scale of buildings on the site.
- Terrace: A ten-foot-high terrace is suggested along the main façade of the building for the passage of pedestrians via a bridge to be built over Eugenstrasse to connect the site with the areas in the south of the building.
- Parts and whole: The unity of the overall composition and the excellence of the constituting parts should be of equal importance.
- The gallery spaces: The exhibition spaces should be in a sequence of well-defined and well-proportioned rooms.

In addition to the specific requirements, the competition brief provided detailed information about the three components of the building program: an expansion to the
Stratstgalerie, a new theater building, and a music school building. Among all the three parts, the extension of the Stratstgalerie was the major component of the scheme with an approximate area of 12,400 sq.m. compared to 2,400 sq.m. for the Theater and 500 sq.m. for the Music School (Rodek & Stirling. 1984, p. 52).

In early April 1977, Stirling and Wilford’s office received the second competition brief, which was in German. The document was later translated by Schaad who was the first to start working on the design (Ulrich Schaad, personal communication, 2002). Stirling asked him to start thinking about the project before leaving for Yale University for a brief period. After Stirling came back from the States he became involved in the design process and collaborated closely with Schaad and Berington. Stirling might have visited Stuttgart during this period.

The participants were given about five months with August 30, 1977 as the deadline for the submissions. The final drawings for the Stirling and Wilford entry were ready in

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4 Schaad remembers that the first time he went to Stuttgart was sometime during the Fall 1977, after the competition results were announced. However, in the Architectural Archives of the Canadian Center for Architecture (hereafter abbreviated as the Stirling Archives) there is a roundtrip airline ticket between London and Stuttgart issued on the name of Schaad for the date of March 28, 1977. It is likely that he went and received the brief for the competition as well as visited the site.

5 Mark Girouard reports that Stirling left for Yale right after they received the competition brief. Stirling taught at Yale for a period of time during the Fall semester as the Davenport Professor of Architecture. During the Spring Semester of 1977, however, he visited Yale for a series of seminars briefly (personal communication with Grazyna Kirsch, Registrar and Admissions Administrator School of Architecture, Yale University, October 30, 2002). He was not away from the office for a long time and became involved in the design as soon as he got back from the States. Girouard’s report seems to suggest that Stirling was away for longer and that during his absence the scheme was almost resolved and complete.

6 This is not conclusive. Schaad reports that nobody from the office visited the site during the competition phase, yet, the Stirling Archives has a roundtrip ticket between London and Stuttgart issued on the name of James Stirling for May 17-18, 1977.
August and an architectural model weighting about 87 kg was sent to Stuttgart on the 31st of August via airmail.1

Stirling and Wilford's scheme was especially significant for its urban characteristics, which included the provision of urban plazas at different sizes and of a public path in response to one of the specific competition requirements. In his competition report, Stirling describes the major site layout and town planning elements of their scheme as follows:

- A diagonal public path neither subdividing the new building nor forcing people to pass along the back of the building.
- A new urban square on Eugenstrasse by setting-off the theater-wing.
- Respect for the traditional relationship of buildings to streets by retaining all the buildings on Eugenstrasse and Urbanstrasse.
- A public square on Urban Platz.
- A three-meter high terrace, allowing a footbridge across Eugenstrasse and providing an uninterrupted pedestrian flow.

Among the site layout elements, the configuration of the public path and of the public plazas became the major design intervention in response to the fragmented character of the site. The central issue for the team was to configure a scheme that would accommodate the public circulation through the building without disrupting the integrity and wholesomeness of the Museum, yet allowing the public a true experience of the activities in the Museum. This became the main challenge of the designers involved in the process because they potentially represented two contradictory objectives of the design task. The study of the design process will clarify how these issues came up in the design, how they were handled, and how they were integrated in a unified scheme.

The jury deliberations of the second competition continued for two days on September 14-15, 1977.5 The results were announced on September 14. Stirling and Wilford's

1 This is documented by an air express receipt slip for an architectural model from Stirling to Mr. Birlton Stulli Hochaulum.
scheme was selected unanimously by the jury as the winner, followed by the signing of a contract on September 20 and the design phase continued without major modifications after that. The final building was much the same as their competition entry. The only minor changes included changes in the columns in the temporary exhibition and in the lecture hall, at some places stucco or precast concrete were used instead of masonry veneer, and the openings in the sculpture court were changed from Gothic to classical (Doubitet, 1984, p. 78). The groundbreaking was held on September 6, 1979, the topping-out ceremony on February 12, 1982, and the building was opened on March 9, 1984 with a total construction cost of 89 million Deutsche Mark (Rodiek & Stirling, 1984, p. 52). Stirling describes the process of construction and design as smooth. He states "the budget seemed reasonable and the standards of workmanship have been of the highest. We have been able to use fine materials and achieve complex detailing; and we were not subject to contractual hostilities" (Doubitet, 1984, p. 78).

Building

The building was a great success from the perspective of the role of museums in civic life and the architectural practice. Within six months after its opening, the Museum became the third most visited museum of Germany with 900,000 visitors (Doubilet, 1984, p. 76). Before the new extension, the Museum was only the fifty-second among all the German museums.

From the perspective of architectural practice, the building became one of the influential buildings of the 1980's and 1990's because of its much discussed references to historical

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8 The jury members were as follows (Rodiek & Stirling, 1984, p. 48):
- Prof. Werner Düttman, Chairman, Akademie der Künste, Berlin,
- Prof. Fred Angerer, Universität München, Munich,
- Alexander Freiherr von Branca, Architect, Munich,
- Prof. Hans-Martin Brochmann, Bürgermeister, Stuttgart,
- Gabriel Epstein, Architect, London,
- Ministerial Director Prof. Herbert Pecker, Director of State Construction Office, Ministry of Finance, Baden-Württemberg, Stuttgart,
styles. Its urban design features illustrated an alternative to city planning principles of modernism. The project for Staatsgalerie coincided with discussions on the merits of modernist principles of city planning and with search for alternative paradigms in urban planning. The same year when the Stirling and Wilford Associates entered the Staatsgalerie competition, they had submitted a scheme for the competition of the Revisions of the Nolli Plan for Rome too. Within this context, the Staatsgalerie project was widely published in architectural journals and praised by the jury even when there was a general concern among some German architects about its appropriateness for their country. Mr. Fecker, the Ministerial Director of the Jury, wrote an appraisal of Stirling’s scheme in response to criticisms from the German architects (Fecker, 1978). He praised the project as creative, sensitive to its context and stated its major strengths, and described why the jury selected the project. The jury’s thoughts about the project were as follows:

- The project fits well into its context and is not a tabula rasa.
- Takes into consideration the Konrad-Adenauer Strasse.
- Contributes to the Urbanstrasse by creating a public plaza.
- Deals successfully with the circa 10 meter level difference between Konrad-Adenauer and Urbanstrasse in three levels.
- Enriches its context by its public path and the sculpture court.

The Staatsgalerie is located on the skirts of a hill that is a residential neighborhood (Figure 36). Down the hill, the site borders Konrad-Adenauer Strasse, a highway beyond which there are other public buildings. The residential area has a web of stairs that helps pedestrian circulation up and down the hill. The new extension continues this web of vertical circulation via a public path which runs through the building, and, which can be used independently of the Museum (Figure 37). The path divides the building above the Gallery level into two L-shaped wings, wraps a circular courtyard, and lands diagonally

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Prof. Dr. H. C. Horst Linde, Freiburg.
onto a lower terrace. The second urban feature of the scheme is the layers of terraces that provide a variety of public spaces. The terraces are at two levels, gently spreading the building on the skirts of the hill.

Figure 36: The surroundings of the Staatsgalerie. The State Theater is in the foreground and the residential areas are in the background.

Figure 37: The aerial view of the Old and the New Staatsgalerie. The red dashed line shows the public path.

9 Girouard (1998a, p. 204) mentions that Frei Otto wrote to Stirling why they were reacting against the project in a letter (20 July 1979). A piece by Behnisch critical of Stirling’s scheme was published in Betelmann fachzeitschriften GMBH (Fecker, 1978).
The building has four distinct components: the Museum (Figure 38), the Administrative Building (Figure 39), the Theater building (Figure 40), and the Music School (Figure 41). The upper level of the museum includes permanent gallery spaces in the form of a sequence of rooms in different sizes (Figure 42). The entrance level houses a temporary exhibition space, a foyer with a bookstore, a lecture hall, a cafeteria, and a foyer for the Theater (Figure 43). On the lower level, there are auxiliary spaces with a street level covered garage.

Figure 38: The Museum entrance.  Figure 39: Administrative Building.

Figure 40: Entrance to the theater (Photograph by Virginia Couch).  Figure 41: Music School.
Conceptual Diagram

One month after the completion of the competition, the Staatsgalerie project was published in the September/October issue of Architectural Design Magazine (“British architecture,” 1977). Stirling picked one drawing from the design process to represent the whole scheme. This drawing was printed on the cover of the magazine and labeled as the “conceptual sketch” by Stirling (Figure 44), herein referred to as the published...
conceptual diagram. This diagram fits the definition of conceptual diagram provided in Chapter 1:

- It is a visual/spatial configuration representative of the core of a design conceptualization: this diagram emphasized the importance of continuity between the building and its surrounding and the unity within the building.
- It is double-referential: the spatial configuration represents a generic scheme of the integration between a circulation path cutting through the building and an axis defining the center of building.
- It is a generic representation and a specific configuration. The base drawing shows a relatively specific plan configuration, yet other features of the drawing, e.g., axial and circulation lines, represent generic features.

The same conceptual diagram was again printed on the cover of a German book about the Staatsgalerie published in 1984 (Baden-Württemberg, Finanzministerium & Staatliches Hochbouamt Stuttgart., 1984).

Figure 44: Stirling's published conceptual diagram for the Staatsgalerie (Architectural Design 1977).

The published diagram portrays the overall footprint of the building without any information about its interior arrangement. Along with the footprint, it also illustrates the major elements of the project. A red dashed line stands for the public path with arrows representing entry and exit to the building. Two yellow zones mark the sculpture terraces.
Finally, a green amorphous shape indicates the rows of trees in front of the building to block the traffic of Konrad-Adenauer Strasse.

The published diagram was a modified, re-sketched version of an earlier one (Figure 45), herein referred to as the original conceptual diagram. In its published version, there were three additions to the original diagram: a green area in front of the building, the yellow hatching, and the red dashed line (Figure 46).

Figure 45: The conceptual diagram drawn at an earlier stage. Published in A+U (1989).

Figure 46: The elements added to the original diagram [Produced by the author to show how Stirling used the earlier diagram as the basis of his published sketch].

These additions were redundant for the design team, yet they were essential for an audience unfamiliar with the basics of the project. For the design team, the abstract perceptual features of the original conceptual diagram were sufficient in distinguishing the significant features of Stirling's generic conceptualization. Whereas, for the general architectural public, Stirling emphasizes the same features by additional elements such as coloring and hatching. Both the original and the published diagrams embody the generic features of Stirling's conceptualization. Yet, they differ from each other in terms of the number and nature of perceptual features they use to communicate the same conceptualization. The original diagram was intended to be an abstract representation with few details, whereas, the published diagram needed to be more explicit. As opposed
to abstract lines, in his published diagram Stirling draws lines that have literal associations with features of the scheme.

Stirling underlined the significance of the original diagram in the design process by selecting it as the basis of his published diagram. The significance of the original diagram relates to how and when it was drawn. Stirling drew the original diagram based on previous sketches of Schaad and Bunting while he was trying to understand and integrate their various schemes. He managed this by way of abstracting the different elements in their schemes.

The original diagram represents the core of the design team's conceptualization in dealing with the design challenge: to configure a scheme that would accommodate the public circulation through the building without disrupting the integrity and wholeness of the Museum, yet allowing the public a true experience of the activities in the Museum. This conceptualization was realized in a satisfactory scheme only after the ideas and elements of different previous variations were abstracted and integrated in a unified organization. The architectural elements represented in the diagram were public terraces, a public path, and a central circular courtyard along with the footprint of the overall complex. The path was intended to accommodate the public circulation through the building while the terraces and the courtyard were intended to allow the public to become acquainted with the activities in the Museum. The two aspects of the design conceptualization, i.e. movement and the pace of the public, are represented by abstract graphic features. The diagonal axial line in the diagram represents the entry of public to the building while the thickened contour lines of the museum block and the hatched zone stand for the public zones that are conducive for pauses. The two aspects are linked two each other by two axial lines: the diagonal line representative of the movement and the vertical representative of the pause.

A set of drawing by Stirling (Figure 47), to which the original diagram belongs, illustrates the process of abstraction through which Stirling conceived of an integrated generic scheme. A study of each drawing of this set reveals the trajectory of the abstraction. The set starts with a plan drawing showing the configuration of the lecture
hall, temporary exhibition space, and the court (Figure 47.1). They are all lined up on a linear axis. In two partial plan drawings, Stirling studied first the alignment of the court in relation to the museum block. The court is moved up and down within a vertical band (Figure 47.2, Figure 47.3).

Figure 47: Progressive abstraction in Stirling’s diagrams. Figure 13.7 is the original conceptual diagram. Published in A+U (1989).

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In the second complete plan drawing (Figure 47.4), Stirling introduced an abstract diagonal axial line representative of the public path going through the center of the sculpture court. This shows an effort to integrate the path and the court. In two small sections, Stirling sketched how the integration would work between the different levels of the upper terrace, the courtyard floor, and the lower terrace (Figure 47.5, Figure 47.6).

In the third complete plan drawing (Figure 47.7), which is the original conceptual diagram, the diagonal axial line becomes a dashed line, which intersects with a vertical axial line. Here, the path and the court are defined according to an integrated set of axial lines. The vertical axial lines determine the positioning of the court while the horizontal band indicates the horizontal positioning of the court. Another important feature of this drawing is the differentiation of line thickness for different areas of the building complex. The interior contour lines of the building are thickened as opposed to the outer contour lines. This marks an emphasis on the in-between space defined by the building blocks.

In the following three partial plan drawings, Stirling studied this in-between space (Figure 47.8, Figure 47.9, Figure 47.10). In two of them (Figure 47.8, Figure 47.9), he investigated the relationship between four spaces on the entrance floor: the foyer, the lecture hall, the court, the temporary exhibition space, and the path's entry point to the court. All these spaces are arranged according to the center of the circular court through a second set of axial lines. At this stage, Stirling considered the sculpture court as the central element of the scheme. In the third drawing of this series (Figure 47.10), Stirling studied only the upper terrace floor of the scheme. Here, the void, composed of terraces and the courtyard, becomes an element in itself. At this stage, a negative space becomes not only a positive constitutive element of the scheme but also the core of the composition. This indicates how the central court became a focal area in the overall scheme when compared to the first plan drawing of this set in which the court is only one of the three equal spatial components of the scheme. In the next drawing, Stirling showed only the Old Museum Building and the new gallery wing with the theater building, which is an abstraction of the surrounding block (Figure 47.11). This drawing corresponds to the previous abstraction of the in-between space.
Until now, each drawing furthers the abstraction process. In the last drawing, Stirling drew a final complete drawing that is a re-configured arrangement of the interior spaces (Figure 47.12). This is equivalent to the first plan drawing. Throughout the set, therefore, Stirling proceeded from a relatively detailed drawing to more and more abstract drawings and finally to a re-configured detailed scheme. The process of abstraction allowed Stirling to distill the detailed scheme to its basics, which in turn helped him to reconfigure the overall composition of the path, the sculpture court, and the major spatial components. Among all the drawings, the third complete diagram summarizes the process and represents the basic features of Stirling's emergent conceptualization.

Stirling produced this series of drawings during a process of getting to the basics of earlier schemes produced by Schaad and Bevington. At this stage, Stirling was trying to understand, integrate, and enhance the previous schemes of Schaad and Bevington, which were variations on the public path and the sculpture court. Stirling's diagrams were in a sense cumulative summaries of other sketches with further elaboration. This elaboration was in the form of abstraction to produce a generic conceptualization and not in the form of introducing more details. The production of the generic conceptualization emerged by the use of abstract diagrammatic elements representative of the relationship between design elements and significant design features. What remained to be resolved was the establishment of a meaningful connection between them with respect to the specifics of the urban context and of the building program. Stirling's generic conceptualization provided the meaningful connection.

This process was a collaborative effort sustained through abstraction of design representations in a cognitive system. During this process, the significant collaborative effort evolved mainly through sketches and diagrams with few discussions and conversations, which was the preferred medium of communication in the office. Wilford describes this collaboration in terms of successive stages. First, the brief or the program document was placed on the desk of everybody who was involved in the design. From then on, Wilford reports "a wide-ranging diagrammatic exercise [was] carried out to establish all possible ways of configuring the building." The alternatives produced at the end of this stage would then be presented to Stirling who would work on these sketches
to "select, edit, alter, add." He would do this by "taking the A4 photocopied clip and putting an A4 tracing paper on top and doodling." The members of the team would create photocopies of their sketches and Stirling would take them as the basis of his own sketches. In this way, "the concept thereby results from a myriad of ideas" (Wilford, 1996, p. 14).

Wilford characterizes Stirling's manipulation of others' sketches as a process of simplification of the complexity of the design situation. The drawings are reduced to their basics and essentials, which Wilford describes as follows:

Stripping away extraneous information is done by overlaying tracing paper on an under drawing and redrawing it, often many times, until the scope and detail are pared down as required (Wilford, 1994, p. 5).

During the design process, abstraction followed a period of exploration of different variations of design themes. Variations consisted of explorations of the idea of a diagonal path and the idea of a sculpture court. Exploring variations, the team focused on detailing and comparing alternatives, whereas during the period of abstraction, alternatives were simplified and their details were removed until a generic integrative conceptual scheme was achieved, which in turn became an organizing principle to simplify exploration.

The strategy of simplifying the exploration space by way of reducing the set of available design solutions was a conscious effort on the part of the designers. Wilford expresses this as follows:

Not big on words, he (Stirling) explored ideas in diagrammatic sketches. The office was a searching factory: it was not a pick-and-choose operation but an elaboration of an agreed-upon set of ideas, a sequence of sketches rather than 25 alternatives.

If you structure the process properly you don't have to concern yourself with extraneous matters or details until an appropriate time. You prioritize the issues under consideration and begin work with the fundamentals. This is a bare bones method of designing in which the brief is always distilled to a simple graphic representation [italics added] in order to establish connections between the spaces the building has to accommodate and the site on which they are to be situated—a diagrammatic comparison.

(Wilford, 1993)
Wilford, here, introduces two strategies about how they simplified the design situation. The strategy is the simplification of the brief through graphic representation to study the relationships among different elements of the design. It is through a graphic representation that complexity is reduced. At least two diagrams are representative of how the team distilled the program to a simple graphic representation. The first is a conventional program diagram where only the relationship between different functional components of the program is laid out (Figure 48). These relationships show only dependency relationships. The second is a bubble diagram which investigates spatial relationships and the hierarchy in the configuration (Figure 49).

Figure 48: A programmatic diagram.
(© James Stirling/Michael Wilford Archive, Centre Canadien d’Architecture/Canadian Centre for Architecture, Montréal)

The second strategy is comparisons by diagrammatic representations. The sketches from the early phases of Staatsgalerie validate Wilford’s statements. The sketches are small, simple, and drawn on standard, small size sketching papers. This is partially because these sketches are abstraction: without any details and they are easier to be studied,
inspected, and reproduced. Furthermore, there are usually several of them on a set of sketches suggesting that designers were comparing different schemes. These sketches are often clear and concise representations of design ideas that are compared to each other.

Among the early sketches of Staatsgalerie, there are several indicative of how the schemes are compared through re-sketching by superimposed papers or by tracing over the sketches. One such drawing is of particular importance. It shows how the team proceeded from a specific scheme to a more generic one through diagrammatic abstraction (Figure 50). This particular drawing is an early version of the original conceptual diagram that represents the path and its relation to the sculpture court suggestive of the upcoming conception in the original diagram. With this early diagram, the team configured a generic scheme regarding the nature of the path and the court through a superimposed diagonal line and a circle.

**Figure 50:** The earlier version of Stirling's conceptual diagram. The blown up portion shows the superimposition of the three levels of abstractions. The first represents the path, while the second the trajectory of movement, and the third the axis of movement.

(© James Stirling/Michael Wilford Archive, Centre Canadien d'Architecture/Canadian Centre for Architecture, Montréal)

In this drawing, the superimposed lines show three phases of abstraction on the idea of path. The path is indicated by three elements: the blue dashed lines, the red dashed line, and the diagonal line. The blue dashed line is probably drawn at the same time as the overall layout. Here, two parallel broken blue lines at the entrance of the site and at the exit of the site literally correspond to a path with a certain width. The superimposed red dashed line, however, is more abstract. Here, the line represents the movement and not a
particular path with a particular width. With this line, the path is abstracted to become a circulation line, which only shows the trajectory of the movement and the turns along this trajectory. With the third superimposed line, i.e., the gray ghost-like line, abstraction is advanced one more step. Here the line does not have a thickness and it does not denote the trajectory of the movement either. Rather it denotes an abstract circulation axis going through the building and establishes a relation with the sculpture court.

The difference in the colors confirms that the abstraction evolved in three phases from path to movement to axis. We also know that, in the office, Stirling was the designer who used red pen to edit and comment on others' drawings (Girouard, 1998a, p. 248; Wilford, 1994, p. 5). This suggests the red dashed line was drawn by Stirling during studying an earlier drawing. Again, what is significant about this process is that collaboration evolved through abstraction and through a series of m-sketching among the team members. Abstraction, in turn, helped Stirling in establishing a meaningful relationship between the path and the court.

After the emergence of the conceptualization, the team concentrated more on details such as whether the path would wrap the court from its left or right side, the shape of the foyer, the configuration of major spatial components, i.e., the lecture hall, the foyer, the sculpture court, and the temporary exhibition hall. After such details were resolved, the design team went on to finalize the interior configuration of each component. In the final scheme, the path enters the building parallel to the gallery block, while it wraps the court from the left, the foyer is flipped on its vertical axis, and the major spatial components are aligned along two perpendicular axes.

Why was one particular diagram, among all the others, probably more than hundreds, picked as the one to represent the whole project? There are several potential reasons. First, this diagram was drawn at a crucial stage during the design process, when Stirling conceived the unifying concept of the scheme. Second, because it is instructive by way of conveying the essentials of the project in one single, small drawing. Third, it is a

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10 Bevington's report validates this claim.
complete diagram as opposed to a partial diagram. Fourth, it might well be picked for pure aesthetic reasons. It has fewer, definite lines as opposed to some others from the same set with less definite contour lines implying indecisiveness. From the perspective of design cognition this diagram played a crucial role in the design process in the way it oriented the exploration. The diagram embodied the generic conceptualization of the basics of the different design schemes, by integrating design ideas, elements, and features.

Design Evolution

The significance of the particular diagram unfolds in the description and analysis of the design evolution. With respect to the design process of the Staatsgalerie project, there are two important issues to be raised: first, the specific reason why there was a need for a unifying organizing system and second, once it was decided that this system would be related to the path and the court why it was crucial to integrate them. The design ideas and elements needed to be integrated through an organizing system because they had at least three different sources of origin. The path and the court needed to be integrated because of the contradictory objectives of the competition brief.

The different sources of origin for the design ideas and elements were the competition brief, design precedents that became models for the Staatsgalerie project, and the design philosophy of Stirling and Wilford Architects. The design brief and its significance for Stirling’s project were introduced at length in the Design Situation section. What follows is an account of the importance of two precedents for the Staatsgalerie project and of a particular design strategy, i.e., fragmentation of the program, that Stirling’s team used in dealing with the complex design situation. The team transferred different elements from the precedents to the Staatsgalerie project and identified almost independent building components by fragmenting the complex program into sub-components. Both the elements and the fragmented components, however, needed to be integrated into a unified whole as dictated in the competition brief.
Scholars claim that the Altes Museum designed by the 19th century German architect Schinkel was of crucial importance for the Staatsgalerie design project (Blundell-Jones, 1985; Grouard, 1998a, p. 200; Lemas, 1985; Waterfield, 1987). In some of his articles on Staatsgalerie Stirling mentioned the importance of Schinkel’s museum for his scheme also (Stirling & Wilford, 1984, p. 5). However, the sketches and other documents at the Stirling Archives do not in any ways support this claim. In the Stirling Archives, there is only one item that points to some connection with the Altes Museum, which consists of a pair of renderings on a sketch paper with two slides taped underneath showing respectively the elevation and plan views of Altes Museum. The sketch, however, is so vague that it is hard to tell whether it was ever instrumental during the design process.

There are formal similarities between Stirling’s museum and Schinkel’s. In both schemes, the gallery spaces are in the form of a sequence of rooms that surround a central circular court in a “U” form. In the Altes Museum, the central zone is a rotunda in the form of an enclosed circular space, whereas in the Staatsgalerie, the central zone is an open circular courtyard. The formal similarities alone, however, are not sufficient to claim that the Altes Museum was instrumental in specific ways as it was argued by Stirling and by other scholars.

Stirling and scholars also discuss the importance of an earlier project of Stirling’s office for a museum competition in Düsseldorf, the Kunstsammlung Nordrhein-Westfalen, 1975 (Rodiek & Stirling, 1984; Stirling, 1984) (Figure 51). Schaad also acknowledges that Düsseldorf was definitely in their mind when they designed the Staatsgalerie (Schaad, 2002). This becomes apparent when one studies both schemes carefully. Overall, both buildings are composed of fragments. Fragmentation in Düsseldorf, however, is more obvious, whereas in Staatsgalerie the overall composition looks as one unified whole. In both schemes, a pedestrian path and a circular courtyard are the two significant elements of the design. At the level of single components the similarity becomes further evident. The internal ramp system and the elevator in the foyer of the Staatsgalerie are the same as it is in the Düsseldorf scheme. These components were transferred, as is, from the Düsseldorf to the Staatsgalerie scheme.
One particular early plan drawing for Staatsgalerie (Figure 52), which belongs to a set of drawings where all the other schemes are without a court, especially confirms this. The plan is a simple scheme drawn in red pen, probably by Stirling. It illustrates a squarish building with a circular court and a path, the configuration that is similar to the Düsseldorf scheme. This indicates that the idea of a sculpture was probably transferred from the Düsseldorf scheme. The configuration of the path and the court in Staatsgalerie, however, did not remain the same as in the Düsseldorf scheme.

Figure 51: Museum for Northraine Westphalia (Düsseldorf, 1975).

Figure 52: A schematic plan drawing for the Staatsgalerie showing a striking similarity to the path/court configuration of the Düsseldorf scheme (Left). (© James Stirling/Michael Wilford Archive, Centre Canadian d'Architecture/Canadian Centre for Architecture, Montréal)

In addition to the two buildings above, Schaad reports another building was crucial in the design process (Ulrich Schaad, personal communication, 2002), the Temple of Fortuna. He recounts the image of this Temple was in his mind when he started working on Staatsgalerie, which he saw in Christian Norberg-Schulz’s book, Meaning is Western Architecture (1975). The building, which is a Roman temple, was built on a series of terraces, ending with a semi-circular amphitheater on the skirts of a hill, and accessed through a sequence of ramps (Figure 53 and Figure 54). Topographically, the site of the new Staatsgalerie is similar to the site of the Temple of Fortuna. In a way similar to the
Temple of Fortuna, the architects for the Staatsgalerie layered the building on different terraces and used ramps to connect the different levels.

Figure 54: A perspective from the Stirling Collection showing the use of ramps in the new Staatsgalerie with the Old Staatsgalerie in the background. (© Janets Stirling/Michael Wilford Archive, Centre Canadien d'Architecture/Canadian Centre for Architecture, Montréal)

Figure 53: Temple of Fortuna at Praeneuste.

In summation, among the three precedents, the Düsseldorf Museum and the Temple of Fortuna had directly influenced the design of the Staatsgalerie, while the influence of the Altes Museum is more debatable or at least indirect. Different elements were transferred to the Staatsgalerie project from the two precedents. From the Düsseldorf, the architects took the idea of path and the idea of circular open space. Whereas from the Temple of Fortuna they took the idea of layering the building on different levels of terraces connected to each other through a series of ramps. These became significant elements to which designers remained committed during the design process. They also corresponded to some of the requirements specifically mentioned in the competition brief, such as the requirement of a pedestrian path crossing the building, open spaces for a sculpture garden, and a terrace.
In addition to the precedents, the design team used fragmentation as a strategy to deal with the complexity of their design situation. Wilford describes this strategy as one "of breaking down each building into a number of discrete parts, each expressed separately and clearly" (Stirling & Wilford, 1984, p. 5) to counter "the risk of producing amorphous, inappropriately scaled buildings" (Wilford, 1996, p. 12).

The design team for the Staatsgalerie followed a similar strategy by dividing the program into sub-components: a museum, an administrative building, a music school, and a theater building (Figure 55).

![Figure 55: Fragmented building components in two drawings.](Left: © James Stirling/Michael Wilford Archive, Centre Canadien d'Architecture/Canadian Centre for Architecture, Montreal. Right: A+U 1989)

The fragmentation strategy was about dividing a complex program into relatively manageable independent chunks to look for a unifying structure. The first phase was about fragmentation while the second was about continuity and integrity. The evolution of the design traced in the drawings confirms this observation. During the early stages of design for Staatsgalerie, once the program was divided into sub-component and significant design elements were identified through precedents, the team focused on working how to bring these pieces together. At this stage, their efforts concentrated on an overall meaningful composition by using "supplementary organizing elements".

Unifying Theme: Circulation and Public Realm

Among the different features transferred from the precedents and the fragmented components, the team emphasized the configuration of the circulation patterns and of the
public areas as potential organizing principles. It appears this strategy was a conscious effort on the part of the design team too. Again, it is Wilford who explains how the office emphasized circulation, especially pedestrian circulation, to achieve unity and harmony in their designs. He states two major themes of their design philosophy to achieve unity:

- Clarity and dramatization of pedestrian circulation within and between these separate parts
- Articulation of spaces in and around the building to enhance the public realm

(Wilford, 1994, p. 5)

By way of providing a public path through the site, the design team responded to one of the requirements of the competition: to improve the fragmented nature of the neighborhood by establishing connections. This would enable the public to indirectly enjoy the Museum while they are passing through the building, by making them spend as much time as possible in the Museum site. This decision, however, could result in dividing the building into fragmented components at the expense of lessening the overall integrity of the building, which was stated to be avoided in the competition brief. The two requirements, hence, presented contradictory challenges that needed to be resolved. This is the reason why Stirling searched for an integration of the idea of path and the court, in other words, to introduce the public circulation to the building without sacrificing its uniformity.

The path, the first important feature of the scheme, was worked out in numerous circulation diagrams as well as other sketches. There are no schemes without some sort of a path crossing the building. In all schemes the path starts from the corner closest to the old Staatsgalerie building and ends in the diagonally opposite corner. The reason why it is diagonal most likely relates to the fact that a diagonal path across the site would increase the time spent within the building while providing the shortest connection between the northwest corner and southeast corner of the site. The northwest corner of

\[11\] Others have also written about the role of circulation, especially of promenade architectural, in Stirling's architecture (Baker, 1992a, 1992b; Wilson, 1992).
the site opens up to a junction of three roads whereas the southeast corner of the site would be adjacent to a public plaza once the nearby site was developed, as was prescribed in the competition brief.

The shape and configuration of this path, though, changed throughout the exploration. The team considered five variations of the idea of path, two of which are the main variations: paths with no turns and paths with turns (Table 4). The basic example of the first is the straight path scheme. The example for the second is a zigzag path where the public circulation makes several turns through the building. There are two further variations of each of these categories. The large curved path is a variation of the scheme with no turns, whereas the meandering path is a variation on the zigzag path scheme. A category of variation is a hybrid of schemes with no turns and schemes with turns. This variation includes those schemes with partially straight and partially meandering paths. In this category, the path enters the site directly, makes half a circle around the sculpture courtyard, and then proceeds directly to outside of the site.
Table 4: Different variations of the path element. The schemes are categorized according to whether they have any turns and whether they provide an opportunity for pause for pedestrians passing through the building or not.

Keeping the primary challenge of their design situation in mind, the team tried to achieve a scheme where the public would use the path as a shortcut and still enjoy the building as much as possible. This translated into how much time pedestrians would spend on the site. With the number of turns on the path, the time to cross the site increases. In straight paths, the public circulation is fast and direct with less chance of becoming acquainted with museum life. In zigzag paths, the chance increases, yet one has to spend more time crossing the building. In the hybrid schemes, there is a compromise. The time is relatively elongated and the passers-by are given a chance of a momentary pause to enjoy the sculpture court.
The second important theme in the design was the idea of a centrally-located sculpture court. While the path entailed public circulation through the site, the court was a focal point in the scheme that would unify the fragmented components. An outdoor sculpture garden was mentioned in the competition brief, yet, the brief did not specify how it should be configured in relation to the rest of building. The court emerged very early during the design process, most likely in reference to the Düsseldorf competition entry described above. There were only 13 schemes without a court as opposed to 228 schemes with a court among all the sketches investigated in detail. Once it emerged, the idea was studied in several variations. The variations, when sorted according to their shapes, are grouped under six headings. The categories with their respective numbers of occurrence are as follows: triangle (2), rectangle (11), square (13), ellipse (6), circle (105), and semi-circle (1).

The team apparently considered numerous schemes that were variations of few categories both for the public path and the sculpture court. This confirms Wilford's statement about how the office structured the exploration along few themes and considered different variations of each idea. Neither the path nor the court, however, was studied independently. Their elaboration actually went hand-in-hand and interactively. The trajectory of the path determined the shape of the court and the shape of the court determined the configuration of the path. Through this interactive process, the designers searched for a unifying design principle for their schemes that would also respond to the primary challenge of the competition: to configure a scheme that would accommodate the public circulation through the building without disrupting the integrity and wholeness of the Museum, yet while allowing the public a true experience of the activities in the Museum. In the design process of Staatsgalerie, this would be possible only through a series of abstractions with which Stirling first conceived the path and court in terms of their basics, then established a meaningful connection between them, and finally, modified their meaning to achieve a new satisfying scheme. At this stage in the design, Stirling shifted the focus of their exploration from seeking a design solution to formulating a consistent conceptualization of the potentially contradictory objectives of their design task.

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Integration of Path and Court

In terms of the configuration of the path and court, there are five categories, with their respective numbers of occurrence: Path without a court (19), Path without connection to court (17), Path tangent to the court (10), Path intersecting the court (24), Path around the court (95) (Figure 56).

<table>
<thead>
<tr>
<th>Focal space</th>
<th>Focal + pause space</th>
</tr>
</thead>
<tbody>
<tr>
<td>I No court</td>
<td>II No connection</td>
</tr>
<tr>
<td>(19)</td>
<td>(17)</td>
</tr>
<tr>
<td>III Tangent</td>
<td>IV Fragmented</td>
</tr>
<tr>
<td>(10)</td>
<td>(24)</td>
</tr>
<tr>
<td></td>
<td>V Visual</td>
</tr>
<tr>
<td></td>
<td>(95)</td>
</tr>
<tr>
<td></td>
<td>VI Final</td>
</tr>
</tbody>
</table>

Figure 56: The graph above shows a categorization of path/court configurations according to their integration and the time it takes to cross the building with the last column showing the final solution. The "Y" Axis shows the time spent in the building while the "X" Axis shows integration between the path and the court. The dashed line in the middle indicates the shift in the conception of the court idea.

In those schemes without a court, the path dissects the building into disconnected fragments. In the schemes with a court, there is a central focal element, the court, which dominates the composition by providing a point of gravity. Where the court is disconnected or tangent to the path, the building remains somewhat fragmented. When the path diagonally exits the courtyard, it is either the path which is divided into two parts or the court which is dissected by the path into two half circles. In either case, the continuity of either the path or the courtyard is disrupted.

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in the last category, i.e., when the path wraps around the court, there is a compromise. Neither the path nor the court is fragmented. The path retains its integrity while providing enough exposure to the museum. When the section sketches and the axonometric drawings are studied, we see two sub-categories of this variation, of which one is the final scheme. In the first sub-category the path wraps around the courtyard yet stays at a different level, i.e., the path never reaches down to the courtyard floor. The movement across the site, therefore, remains unconnected to the focal point of the scheme except visually. In the final scheme, the path proceeds downward to the floor of the court along the curvilinear wall of the courtyard (Figure 57). It is with this scheme the team responded to the challenge. They acquired a configuration in which neither the continuity of the path, nor the integrity of the courtyard was compromised. Furthermore, with the integration of path and court, the court acquired a new function, in addition to its centrality. In its new configuration, the court became a place of pause for the pedestrians. This suggests a shift in the conception of the court element from being solely a central place for the building to becoming a center of focus for both museum visitors as well as the residents of the neighborhood using the path.
Conceptual Diagrams and Shifts in the Design

Figure 56 shows a categorical classification of generic schemes that the design team considered throughout the process. Each category in the figure corresponds to a family of design schemes; to different but related solution spaces and to states within those spaces. The moves across different categories of generic design schemes are controlled by the amount of the time one spends crossing the building and the integrity of the building components within themselves and with the path. Shifts along the two dimensions of the solution space modify the generic schemes from each other. The fourth and fifth categories, beyond the line of conceptual shift, indicate a radically different solution space in which the two elements became one integrated element. The central claim of this case study is that the shifts in the solution space and in the conceptualization space occurred during the construction of conceptual diagrams and mediated through them.
A detailed study of the drawings illustrates the mechanism involved in these shifts. There are four important stages in the evolution of the court idea and its relation to the path: first when the idea of a court emerged, second when its form was decided, third when the path and court were integrated, and fourth when the public space defined by the court became a positive defining space (Table 5). All four stages mark crucial decisions along the design process in the way they resulted in shifts in the solution and the problem space.

In the early schemes, in which there was no central court (Phase 1), the complex was fragmented and the path remained more like an urban street going through the building. A sculpture court was introduced most probably when the team considered possible similarities between their schemes for Düsseldorf and for Stuttgart, which also corresponds to the time when the first conceptual diagram was drawn. Compared to early schemes, in later sketches the court became first an additional spatial component (Phase 2), second an element around which other fragments of the building gathered (Phase 3), and finally both a focal point and place for pause (Phase 4).

Table 5: Four schemes showing four stages of the integration between path and court. The first illustrates a scheme without a court, the second with a court yet with no integration, and the third with integration.
(The three images on left: © James Stirling/Michael Wilford Archive, Centre Canadien d'Architecture/Canadian Centre for Architecture, Montreal. Right: A+U 1989)

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Phase 4</th>
</tr>
</thead>
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After the emergence of the court as a focal and potentially unifying element (Phase 2), the idea went through several variations. Difficult to trace an accurate trajectory of the variations, it is likely that the circular court emerged later. There are two sketches indicative of a trajectory towards a circular path from other variations. The first instance is on a set of sketches with different variations of the court. In a program diagram from this act, in the upper left corner of the page (Figure 58), the sculpture court is drawn in the shape of a square, and a circle is drawn over the square with an annotated question, "Circular?"

![Figure 58: The superimposed circle on the square and the related annotation.](image)

![Figure 59: The superimposed circle over the square court.](image)

The second drawing that presents a circular court is the early version of the conceptual diagram (Figure 59). The court is in the shape of a square with a path around it. This is one of the early diagrams where the designer considered the relationship between the path and the court. The movement through the path is represented with a red and blue dashed line. A more careful investigation reveals yet another diagonal line and a circle drawn with a very light pencil. The lines resemble ghost-like traces over the blue pen.
drawing. The diagonal line represents a diagonal path crossing the building. The court is in the shape of a circle that fits exactly into the central void.

During this phase, however, the court and the path were only visually connected and still not totally integrated with each other. This becomes apparent when studying a section drawing linked to the earlier version of the conceptual diagram (Figure 60). Here the path wraps the court, yet it continues on a different level.

Figure 60: The sectional drawing of the scheme introduced with the early conceptual diagram. The space in the middle with columns is the court flanked by galleries on four sides. The section does not show the path, which suggests that at this stage the path had not been integrated with the court yet.

(© James Stirling/Michael Wilford Archive, Centre Canadien d'Architecture/Canadian Centre for Architecture, Montréal)

During Phase 3, the team tried to integrate the circular court and the path. In some of the sketches this connection is only a visual one (Figure 61). In these sketches, the path circles around the circular court after it dissects the building and continues as a ramp down the first terrace. In later sketches, especially in sectional and axonometric sketches, the ramp goes around only one-half of the court. It descends towards the courtyard floor, and becomes a stopping point on the continuous path. Thereafter, the ramp exits the court and continues to the second terrace. The series of drawings, to which the second conceptual diagram belongs, are significant because they proposed an integration of the elements.
Figure 61: One of the schemes in which the path circles around the court. However, their relationship remains only visual. (© James Stirling/Michael Wilford Archive, Centre Canadien d’Architecture/Canadian Centre for Architecture, Montréal)

Figure 62: A scheme where the path circles down towards the floor of the courtyard. (Published in A+U 1989)

During Phase 4, which coincides with the integration of the path and the court, the space defined by the building boundaries becomes an entity independent of the surrounding buildings. In a sense, Stirling recognized the "court" as a defining feature of the scheme. This was achieved again through the original conceptual diagram.

All the important shifts, except the emergence of the idea of court, appear to have occurred through a process of abstraction by way of simplifying the relatively detailed variation drawings. In the first conceptual diagram, while the red dashed line and the
superimposed ghost-like diagonal line abstracted the idea of path, the diagonal line together with the circle paved the way towards an integration between them. The scheme represented by the second conceptual diagram accommodates both passers-by and those who would like to pause momentarily. A satisfying integration between the path and the court was achieved without compromising either the continuity of the path or the building. This required a conceptual change in the way the nature of the court and the path were conceived. Furthermore, it helped the designers to emphasize the significance of the open spaces as a positive component of their scheme.

Discussion

The case study of the First Unitarian Church detailed a design process during which the conceptual diagram emerged at the beginning of the design, mediated exploration in the conceptualization space and in the solution space throughout the process, and sustained the collaboration between the client and the architect. The Staatsgalerie case study reveals further characteristics of conceptual diagrams and the nature of dual exploration in design. The salient features of the design process of this case study will be discussed under the following headings:

- the nature of the dual exploration,
- exploration strategies,
- construction of conceptual diagrams and conceptual shifts in the structuring of the design situation, and
- the nature of distributed cognition sustained by external representations.

Dual Exploration

The design for the Staatsgalerie started with definite objectives as well; however, they were not integrated into one single representation at the beginning of the design process as in the case of the First Unitarian Church. A unified conceptualization for the Staatsgalerie project emerged only after a period of exploring different design variations. Table 6 summarizes this design process from the early stages to the configuration of final elements.
<table>
<thead>
<tr>
<th>Design challenge</th>
<th>Specific features of the competition brief</th>
<th>Specifics (Principles)</th>
<th>Strategies (Design Philosophy)</th>
<th>Conceptual Diagram</th>
<th>Elements of the final scheme</th>
</tr>
</thead>
</table>
| Restoring the spatial and temporal continuity of the urban fabric via establishing relationships between the new structures and the existing urban structure and via enhancing pedestrian movement. | • Pedestrian path • Historical continuity • Highway • Scale • A terrace • Unity of the overall composition • Well-defined and well-proportioned gallery spaces | Issue of tournament: Kunstraum erstattung Norddeutche- Westfalen: the path and the 
   circular central open space.
   Temple of Fortuna: leaping the building on different levels of terraces and using ramps extensively. | • Fragmentation of the building program • Configuration of circulation patterns and of public areas as a potential organizing principle | Path: • Continuity with the surrounding circulation patterns • Monastery pause Court: • Unity between the building and its environment • Integrity within the building | ¿A diagonal public path, neither subdividing the new building nor forcing people to pass along the back of the building. 
¿A new urban square on Eugenstrasse created by off-setting the theater-wing. 
• Respect for the traditional relationship of buildings to streets, retaining all buildings on Eugenstrasse and Urbanstrasse. 
• A public square on Urban Platz. 
• A three-meter high terrace, allowing a footbridge across Eugenstrasse and providing uninterrupted pedestrian flow. |
The major objectives of the design task for Staatstheater were to make the building an integral part of its close vicinity and to maintain a harmonious unity among its components. To achieve the former objective, the designers envisioned a series of public terraces and a diagonal public path cutting through the building site to accommodate public circulation, both of which were demanded in the competition brief. To achieve the latter objective, they introduced a circular sculpture courtyard that was conceived as a focal space that would unify the fragmented components of the building. However, the two objectives constituted a challenge because any exterior circulation system cutting through a building potentially would disrupt the integrity of the overall complex. Any design scheme that would address both of these objectives required some changes in the way the objectives were formulated.

Early in the design process, junior designers produced several schemes with different variations of the path and sculpture court, yet did not tackle the seemingly contradictory objectives of their design task. Instead, the beginning of design was marked by the identification of two precedents and significant design elements, the latter in response to the challenge presented in the competition brief. This indicates an exploration starting strictly in the solution space and not in the problem space, in contradiction to what Goel and Piozzi (1992) suggested in their descriptive model of design. Goel and Piozzi claimed that the early phases of design are dedicated to problem restructuring rather than problem solution; however, in the case of the Staatstheater, problem restructuring occurred later in the design process and the initial phase of design was mostly dedicated to generating specific design schemes comprised of variations of a few design elements. The two precedents that were identified highlighted a series of design features relevant to the issues discussed in the design challenge. However, at this stage, the designers did not restructure the problem definition or formulate a single conceptualization to restructure their problem representation so that the presumably contradictory objectives of their design tasks would be resolved.

An emphasis on solution in the initial phases of design has also been well documented in the literature of design cognition. Lawson (1979) compared science students to architecture students and found that architecture students began with solutions...
immediately. Lloyd and Scott (1994) showed that expert designers, when they have enough experience in a particular design task, start with solutions rather than with problem definition. The Staatsgalerie project is a clear illustration of a group of designers with substantial prior experience in their particular design task starting the design process with a solution scheme rather than with a problem definition. When Stirling stated that this project was going to be Phase 2 of the Düsseldorf Museum project this was an indication that design would begin with an exploration in the solution space. The design task of the Staatsgalerie was familiar to the design team. Three members of the Düsseldorf project constituted the core team for the Staatsgalerie. The same team had worked on the Wallraf-Richartz Museum project two years before the Staatsgalerie project began. Furthermore, there were enough overlaps between the Düsseldorf and Stuttgart projects, e.g., program, client, context, scale, and a relatively short time gap between the two projects (two years), that the office did not have to go through a thorough problem definition process and did not concur with a single conceptualization identifying the salient features of their design scheme, as was the case for Kahn with the First Unitarian Church. This last point corroborates views that characterize the nature of design problems in terms of the depth of expertise of a designer in a particular design task (Eaton, 1969; Simon, 1972). According to these views, the shallowness of a problem depends on problem solvers' knowledge in that domain and on the information transfer that is required for problem solution. Once design problems are better defined by information transfer they cease to be different from well-defined problems. The initial phases of the design process for the Staatsgalerie project confirm these views. In the initial phases the junior designers were mainly involved with considering variations, i.e., they remained within a solution space defined by precedents and elements identified in the competition brief. Some of these elements remained the same in the final competition entry. Although the design challenge included contradictory objectives in the initial phases, the team did not restructure their representation and there was no need for mediation between exploration in the problem space and solution space.
On different occasions, however, especially when Stirling participated in the design, the nature of the exploration changed significantly. When Stirling was involved in the design he was mainly in charge of identifying the underlying ideas of the variations generated by the junior designers, looking for generic features that were shared by them, and establishing consistent relationships among them. It was during this process that new ideas were formulated, previous ideas were modified and, above all, the contradictory objectives of the design challenge were studied. This process is best characterized as problem structuring through conceptual changes.

In the design process of the Staatsgalerie problem structuring happened repeatedly, yet not in the initial phases. When it happened, Stirling ended up with a new problem conceptualization, such as when the path and court were superimposed in the first conceptual diagram and when the axial lines representative of the court and the path were integrated. In the former, the two elements were identified as linked to each other; in the latter, the nature of the court changed from being only a focal point to being a place of pause. These changes are significant in the way they responded to the seemingly contradictory objectives of the design challenge: emphasis on the continuity of the urban fabric and integrity of the overall composition. Reconciliation between the two objectives could happen only when the problem had been restructured. In the restructured design task, the building was defined not only as a passageway for the public but also as a stopping point. During the periods when Stirling was involved in the design, therefore, the nature of the exploration changed from a single exploration in one space to a dual exploration in both the problem space and the solution space.

**Exploration Strategies**

The Staatsgalerie design team considered a vast number of variations in the initial phases of design while they remained strictly within one solution space, yet this was neither an exhaustive search nor a linear search. It did not need to be exhaustive because the variations generated by the junior designers were occasionally summarized into generic schemes by Stirling, and they generated further, related alternatives. The generic schemes that Stirling produced were in the form of conceptual diagrams, and these facilitated
exploration. First, because the number of potential generic schemes to be considered was limited compared to the number of potential detailed schemes, i.e., it was more feasible to consider a few generic schemes than numerous detailed alternatives. Second, because each generic scheme potentially stood for several related alternatives, with the elimination of one generic scheme several alternatives were eliminated also. The conceptual diagrams dealt with problems created by the sheer size of the exploration space, especially of the solution space. The design team chunked potential solutions according to the generic schemes that described them and eliminated chunks by eliminating generic schemes.

The exploration was not linear because the team considered several alternatives more or less at the same time, which facilitated comparisons of different schemes. Some sets of sketches for the Staatsgalerie project, for instance, show a vast number of alternatives studied together. Others, which show a detailed rendering of one alternative, have smaller sketches accompanying them, suggesting that the designers were considering related alternatives simultaneously and sometimes going back to a previous alternative. In other sketches drawings and layers are superimposed again suggesting an iterative rather than linear exploration. The designers considered several different schemes, compared them to each other, and sometimes jumped back and forth between schemes. They remained, however, within a well-defined solution space. After the conceptual diagram was formed, however, exploration shifted to another solution space and became hierarchical, in the sense that the schemes became more and more detailed at every stage.

The team employed two other strategies for dealing with the vast number of alternative schemes, both determined by the general design philosophy of Stirling's architectural office. The first was simplifying the complex task by fragmenting the program into semi-independent components. The second was searching for a unifying structure that would integrate the different sub-components into a harmonious whole. The unifying structure emerged within the conceptual diagrams that defined the relationship between building components as well as the connection of the building to its surroundings. The new conceptualization outlined the central open space as a positive space around which the other components of the building were gathered.
Construction of Conceptual Diagrams and Conceptual Shifts

Unlike with the First Unitarian Church project, in the Staatsgalerie the process of formulation of the conceptual diagrams is traceable, which helps identify the role of the diagram in the design conceptualization. In the Staatsgalerie, once design ideas were abstracted and associated with perceptual features of diagrams, manipulation of the perceptual features helped designers manipulate features of the conceptual domain. Manipulation of the perceptual features can be considered both moves within the problem structuring space and moves within the solution space.

The restructuring of the design problem in the design of the Staatsgalerie is similar to re-representation of problems in insight problems in order to break an impasse (Knoblich, 1999). In both instances, there is a need for a problem restructuring because no operators are available to solve the problem. The difference between moments of illumination in insight problems and the shift in problem representation in the Staatsgalerie design task is that the former is a sudden and momentary realization of a new dimension of the problem whereas in the latter the shift occurred through a structured process, herein called progressive abstraction. In the design of the Staatsgalerie, Stirling used the technique of progressive abstraction on at least two occasions. This occurred when he conceived the early and late versions of his conceptual diagram (Figure 47, Figure 50).

Abstracting through the perceptual features of the conceptual diagram allowed Stirling to isolate only the necessary, basic elements. Once the basics were isolated, Stirling was better able to manipulate the elements to search for a meaningful relationship between them. In both instances, progressive abstraction evolved through construction and manipulation of a conceptual diagram. In the second conceptual diagram (Figure 45) the centrality of the court was emphasized by a vertical axis through its center and a diagonal axis delineated the public circulation. Manipulating these two axial lines, Stirling finally superimposed them and made them intersect at the center of the sculpture court. This is a generic conceptualization in the sense that the two basic elements, which had remained relatively independent of each other until then, became integrated. The significance of this shift was that by conceiving the two objectives of the competition as integrated components of one single scheme, Stirling succeeded in resolving the contradictory
demands of the design situation. With this newly emerged conception the sculpture court became the focal element of the overall complex and the path became subordinate to the court. Furthermore, the court acquired a new function when it was linked to the path: it became a potential pause place for the public and allowed the public to enjoy the sculpture courtyard of the Museum.

Two important aspects of the process of progressive abstraction traceable in Stirling's conceptual diagrams are the gradual simplification of the drawings and the gradual evolution of the abstraction. Gattis and Holyoak's research on graphs (1996) provides one explanation for why abstraction could be important. In their research, Gattis and Holyoak compared the effectiveness of graphs that have a higher pictorial correspondence with what is represented to graphs that preserve the correspondence at a more abstract level. They found that when abstract correspondence was higher subjects were better at making correct inferences based on the represented graphs. Their results suggest that explicit representations of conceptually important features may have significant advantages for making inferences.

In Stirling's first conceptual diagram (Figure 50), for instance, the progression from a relatively more realistic representation of the path to a more and more abstract representation of the idea of movement indicates an effort to emphasize the conceptually important features and to leave out features that are considered to be details. A reverse process is observable in the published diagram (Figure 44), in which Stirling increased the specificity of the drawing.

An additional reason for simplification and for the gradual progressive abstraction might relate to the ease of manipulation of the perceptual features of diagrams when they are simplified. This is similar to the piecemeal animation of diagrams of complex mechanical systems, in which only parts of the system are animated at any given time (Hegarty, 1995). It is possible that through step-by-step abstraction Stirling was not only reducing the details of the drawings but also animating a series of complex connected spaces. This is clearer in the series of diagrams to which the original conceptual diagram belongs. In this series Stirling abstracted elements of the design one at a time, as if he were animating each element of the scheme, hence, a different part of the building, individually at each stage of abstraction. Narayanan (1995) and Qin and Sirazon (1995) suggested that
animations of diagrams are important because they facilitate inferences. Qin and Simon found in their study that the complexity of the phenomenon to be mentally simulated determined the pace with which subjects undertook the simulation. For instance, one subject who was simulating the trajectory of light managed this only through a step-by-step animation. Their conclusion was that for making inferences subjects use a piecemeal process of imagery to construct and simulate complex mental models. Gobert and Clement (1999), in their comparison between subjects who drew diagrams and subjects who wrote summaries in studying a text on plate tectonics, demonstrated that diagrams are better than summaries for constructing mental models of plate tectonics. Subjects who drew diagrams had a better understanding of causal and dynamic relationships between tectonics, whereas subjects in the summary group understood less of these relationships, although they had a better recollection of the text. Their hypothesis was that the spatial properties of the student-generated diagrams provided cues for causal and dynamic understanding of plate tectonics. Their results suggest that diagrams highlight relationships between objects and entities through properties of their spatial configurations, such as adjacency. In Stirling's abstractions one can trace a similar emphasis on the relationships among elements.

Greeno (1989) provides a theoretical basis for understanding how diagrams are helpful in simulation of mental models. He introduces a view of semantics in which structured systems of symbolic notations are mapped to structured systems of objects and events, and he suggests that inferences are possible through manipulation of either one of the systems. In Greeno's view, mental models are structured systems of symbolic notations and correspond to structured systems of objects and events in the form of physical models. Any transformation in the physical model, therefore, has a corresponding transformation in the mental model. In other words, transformations of structured systems of external representations facilitate transformations, hence simulation, of mental models.

The core proposal of this thesis, that conceptual diagrams mediate between abstractions and specifics, advances an argument similar to Greeno's: manipulation of components of an external system of representations triggers transformations in the components of conceptualizations, as exemplified in the way the meaning of the central sculpture court

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changed through manipulation of components of the diagrams. Furthermore, this thesis extrapolates Greeno’s argument about the relationship between mental models and their corresponding physical models to those representations that are double referential. In the case of conceptual diagrams in design, the structure of the diagram corresponds both to generic conceptualization and generic spatial configurations. Nersessian (1999) explains the role of generic abstraction in building mental models that embody commonalities across seemingly dissimilar domains in scientific reasoning. She presents two examples from the history of scientific discovery in which the use of visual representations for constructing mental models is evident. The first is Maxwell’s use of a diagram to explain his theory of electromagnetic forces (Nersessian, 1992a). The second is Faraday’s diagram of lines of force surrounding a magnetic bar, which became a visual model for the dynamical theory of forces (Nersessian, 1992a). In both instances, visual representations provide a structured domain representative of core relationships in the conceptual domain.

Through simplification and manipulation of the diagrams, Stirling had managed to simulate a mental model, to manipulate components of the design schemes, i.e., the path and the court, as well as manipulate the corresponding components of their conceptualizations, i.e., the public circulation and the centrality of the court. In the case of the Staatsgalerie, construction of the conceptual diagram through progressive abstraction helped change physical features of the design scheme as well as change components of the conceptualization. The construction of the diagram, therefore, facilitated conceptual change and mediated the exploration in both the solution space and problem space. Such a shift exemplifies a conceptual change in the design process and illustrates how new concepts arise through manipulation of visual representations.

Stirling’s office appears to have used abstraction and abstract renderings deliberately in their exploration. The office devised procedures that would facilitate the abstraction process. These procedures related to the nature of the renderings they produced. These renderings, especially ones from the early phases of design, were usually small so that they could easily be “inspected by the eye.” They were on standard, semi-transparent sketch paper, to facilitate comparison through superimposition. Different types of lines in
the renderings appear to have had specific meanings, making communication efficient and the renderings less ambiguous. The basic line types consisted of dashed lines indicating circulation; continuous lines indicating spatial boundaries; axial lines, for spatial configuration; and thicker lines for emphasizing spaces. The office also limited the color range in their drawings. Conventional black ink was assigned to all designers, except the senior designer, who used red to mark others’ drawings, especially when trying to reduce sketches to their “barebones”. All of the above indicate a deliberate effort to facilitate conceptual changes. This case represents an alternative view to explanations of change and discovery in design that emphasize the importance of surprise, sudden illuminations, or insights, or sudden discoveries. In the case of the First Unitarian Church the process of structured change in conceptualization unfolded through the interaction between the client and architect, whereas, in the case of the Staatsgalerie, this process evolved in the structured environment of the architectural office.

Views that emphasize the role of surprise and sudden discovery of emerging elements also emphasize the centrality of sketches as the primary architectural representations in the process of discovery (Goel, 1995; Goldschmidt, 1991; Schön, 1992). These views describe the discovery process almost exclusively in terms of serendipity (Zwicky et al., 2000) or of piecemeal evolution of design ideas through localized changes (Maher & Tang, 2003). In the area of scientific discovery, Thagard (2002) has recently advanced a similar position by emphasizing the significance of serendipitous discovery in science. In his work, Thagard portrays the complexity of cognitive processes in scientific reasoning by suggesting that serendipity, along with emotions, is as instrumental in discovery as more conventional scientific methods. Thagard’s proposal, in a sense, tries to bring a balance between those aspects of scientific reasoning such as serendipity that are considered “non-rational” and more conventional scientific methods.

Views from design cognition, however, often single out the serendipity of the discovery process in design and the role of sketches at the expense of ignoring the more structured processes of discovery in design. Researchers in design studies have suggested that designers almost stumble upon new things while manipulating sketches, and benefit from them opportunistically (Cross, 2001; Cross & Cross, 1995). This may be the case among
both expert and novice designers, however this fosters a view of designers as frantically doodling in hopes of suddenly discovering satisfying schemes. The case of the Staatsgalerie, in contrast, illustrates that designers used sketches and diagrams for different but complementary purposes. They used sketches for variations and detailing and used diagrams for abstraction and conceptual change. The conceptual shifts which occurred through progressive abstractions were more than serendipitous discoveries triggered by surprise.

Cognitive System

Hutchins' (1995) description of a cognitive system is helpful in describing the process of conceptual change in the Staatsgalerie project. In Hutchins' studies of cognitive systems cognition evolves in real-time, for a relatively shorter period, in constant interaction with a structured environment, and with constant feedback from the environment. Different from the systems Hutchins studied, the cognitive systems in design prolong over a period of time and feedback from the environment is delayed, which increases the significance of external representations for such systems. The changes in the Staatsgalerie in related stages were made possible by a cognitive system consisting of junior designers, a senior designer, a structured office environment, and external representations in the form of sketches and diagrams. In this system, first the junior designers produced variations of a few design elements. These variations, in the form of sketches, were propagated in the system to the senior designer. Then, the senior designer abstracted the variations and the abstracted elements were manipulated and combined to achieve a generic conceptualization. Changes were then again propagated in the system through conceptual diagrams.

The emergence of the conceptualization progressed in a distributed fashion with the contributions of both junior and senior designers. Within the cognitive system junior and senior designers, as well as architectural representations in the form of sketches and diagrams, had distinct roles. The senior designer was in charge of leading the team by providing direction and integrating the various ideas of junior designers. In this process, a well-defined representational system structured the collaboration. Sketches were assigned
to junior designers for exploration of detailed variations, and diagrams were assigned to the senior designer for exploration of generic conceptualizations. Through abstraction the senior designer could integrate the various ideas of the junior designers and communicate the resulting generic conceptualization to them.

The syntax and semantics of architectural representations were also relatively unambiguous to the members of the design team. The junior designers' drawings were in black ink, whereas the senior designer's were in red. Axial lines, hatching, and dashed lines designated specific abstractions. When these were in red they specified a clear direction to the exploration given by the senior designer. This structured representational system assured effective collaboration even when members of the design team were not working together or when tasks needed to be distributed through time.

The shared representational system and the structure of the office created an efficient environment for communication, in which detailed discussions were redundant. Architectural representations in this system sustained communication and collaboration by conveying shared meanings and facilitating exploration through promoting conceptual change. Stirling's abstract diagrams conveyed the maximum information with the minimum lines to reduce the memory and processing load. Verbal explanations were secondary to the exchange of ideas through drawings. It was through re-sketching that peers understood each other's ideas and elaborated on them.

Re-sketching was the mechanism through which distributed cognition evolved within the collaborative cognitive system and, when accompanied with progressive abstraction, the graphical representations were simplified to their bare bones. These representations were "cognitive artifacts" in the sense that they were generic abstractions and they propagated design commitments (Nersessian et al., 2003). Re-sketching in the design process of the Staatsgalerie occurred at three levels when designers employed re-sketching for reflection, as exemplified by the use of superimposed drawings on transparent media, when designers communicated through sketches and understood each other through re-sketching, and when the designers communicated to a general public.
The characterization of the design process of the Staatsgalerie as a cognitive system helps us understand the changes in the solution space and in the problem space as a whole. Whereas exploration in the solution space was mainly the junior designers' task, exploration in the problem space was almost exclusively the senior designer's task. Any changes in either space were propagated through sketches and diagrams to the other space. A more conventional description of the collaboration among the members of the design team and their interaction with the architectural representational systems would fail to depict how exploration in both the problem space and the solution space evolved through the contributions of the senior and junior designers and would rather describe the design as an individual act.
CHAPTER 6

JEISH MUSEUM OF BERLIN

Most of all, however, I am a fascinated observer and a perplexed participant of that mysterious desire which seeks a radical elucidation of the original precomprehension of forms—an ambition which I think is implicit in all architecture. If there is true abstraction here (as opposed to generalization) it is not achieved by the elimination of context through a gradual deployment of an increasing emptiness, but is rather an isolation of structural essence, whose manifestation in two dimensions illuminates all the sub-systems of projection (for example, three-dimensional space).

(Libeskind, 1981, p. 81)

The third case study in this thesis is the Jewish Museum designed by Daniel Libeskind as an extension to the Berlin Museum. This particular project was Libeskind's first architectural commission following several years of teaching and theorizing in architecture. Prior to the Jewish Museum, Libeskind had widely published his drawings as well as his writings about architecture. His architectural projects, drawings, and writings are marked by an interest in the theoretical and conceptual underpinnings of architecture and of architectural representations. His drawings were unique in the architectural arena, his writings were critical of the establishment in architecture, and his projects for different competitions often questioned the competition briefs. The Jewish Museum competition provided an opportunity for Libeskind to implement these ideas in an architectural project.

In addition, the subject matter of the competition required a thorough understanding of the Jewish history and its relation to the German history and to the history of Berlin. It is the objective of this chapter to explore how Libeskind responded to this challenge through an investigation of his drawings from the conceptual design phase.

Libeskind's previous work on architectural drawing, e.g., 'Chamberworks' (1983) and 'Macrospaces', explored and pushed the potentials of drawing in architecture, yet they were mostly theoretical, abstract exercises without any constraints imposed by the
requirements of a particular project. Libeskind (1981, p. 81) reports that Edmund
Husserl's *The Origin of Geometry* has been the main source of inspiration for his
exercises in architectural representations. In *The Origin of Geometry*, Husserl discussed
those sources of geometry that are independent of history and historical developments. In
his *Chamberworks*, Libeskind explored a related idea with which he mused on the origins
and variations of an initial idea in architecture, i.e., straight line (Kipnis, 2000). Husserl's
ideas on phenomenology were influential for Libeskind's architectural thinking also
(Hays, 1990). John Hejduk, his mentor at the Cooper Union, was a second important
figure in Libeskind's intellectual development.

In his *Chamberworks*, Libeskind investigated the relationship between the musical ideas
and architecture (Libeskind, 2000, p. 52). In the *Macromegas*, he explored the
relationship between the process of construction and the process of drawing (Libeskind,
2000, p. 51). Drawings in *Chamberworks* and *Macromegas* are devoid of any direct and
literal semantic meanings (Taylor, 1997, p. 129). Rather, they are products of physical
acts of drawing, which Libeskind thinks cannot "be simulated on the computer screen"
(Bruns, 2001, p. 74).

Libeskind's drawings for the Jewish Museum project differ to a certain extent from his
drawings for *Chamberworks* and *Macromegas*. The drawings for this project while a
continuation of his exercises on architectural drawings were a departure from an abstract
investigation of the potentials of a particular system of architectural representation. They
were Libeskind's responses to a conceptual problem and differed from his previous
published drawings. As Kurt W. Foster suggests they carry the "double burden of
representing both actual buildings and mental structures" (Foster, 1997, p. 7).

Libeskind drew upon different domains and works for his Jewish Museum project:
Walter Benjamin's essay *One Way Street*, Schönberg's opera *Moses and Aaron*, and the
Star of David. Among the three main ideas, the Star of David is of particular interest for
this research as it encapsulates the core of Libeskind's conceptualization. Libeskind for
this project created a distorted version of the Star, which he calls the "Star Matrix,"
during the early stages of the design. He drew many variations of the star throughout the process, and drafted a final version for his competition entry, which was published in numerous publications about the Jewish Museum (Figure 63). Herein this drawing will be referred to as a conceptual diagram of the Jewish Museum project, because the drawing is:

- A visual/spatial configuration representative of the core of a design conceptualization: Libeskind with this diagram emphasized the pervasiveness, yet, invisibility of the Jewish presence in Berlin and the intertwined histories of Jews and Germans.
- Double-referential: the spatial configuration represents a generic scheme of spatial arrangement at a very abstract level (cf. Kahn’s diagram and Stirling’s diagram) and highlights the main features of the abstract conceptualization.
- A generic representation, i.e., it is not a plan configuration.

The drawing was produced in the last few weeks of the competition (Donald Bates, personal communication, 2003). In the sketchbooks of Libeskind, there are numerous drawings of stars produced at different stages of the early phase of design.13

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12 Libeskind, criticizing Durand’s technical approach to architectural education, rejects views of design as problem solving (Libeskind, 1981, p. 27).
13 Bates reports that Libeskind did not express the star idea to the design team until late in the design process although he might have had it in his mind for a long time during the early phases (Donald Bates, personal communication, 2003).
Figure 63: Star Matrix: a distorted version of Star of David drawn by Libeskind. The Jewish Museum building is in the middle of the three buildings blacked out on the map. The names on the drawing are historical Jewish and German figures who lived in Berlin. The edges of the Star connect the names to each other. The upper zigzag line is the Berlin wall, whereas the lower curvilinear line is the canal Landwehrkanal. The base drawing is the city plan of Berlin which is visible only through the edges of the Star. In the drawing, other parts of the city, which do not overlap with the Star, remain invisible. (© Research Library, The Getty Research Institute, Los Angeles, 920061).
The first instance of a star drawing is a series of stars (Figure 64) that Libeskind drew on the Berlin Museum pamphlet he received with the competition invitation letter on November 29, 1988 (Letter, Keller to Libeskind, November 29, 1988). Along with the invitation, Libeskind received a site plan printed on a letter-size paper where he recorded his first ideas about the museum. In his initial marks, Libeskind drew a dissected star on the site plan and individual additional stars on the margins of the pamphlet (Figure 65). In addition to the star drawings on the Berlin Museum pamphlet, Libeskind had few plan and axonometric sketches of a building in the form of a zigzag also (Figure 66).

The dissected star is of significance for Libeskind’s project first, because of its meaning in the contemporary Jewish culture as a symbol of Jews14 and second, because Libeskind modified the geometry of the Star to connect the addresses of historical German and Jewish Berliners plotted on the map of Berlin. Through the configuration of the Star, Libeskind was responding to the relationship between the history of Jews and the history of Berlin as well as to that between the Jewish and German population of the city. The distorted Star of David, therefore, has a double semantic meaning: one derived from the Jewish cultural literature and the other imposed by Libeskind. The latter originates from the formal configuration of the star as well as from the role of the German and Jewish historical figures whose addresses are plotted on the Star. The Jewish Museum is part of this star. The footprint of the Museum is plotted on the lower base of the upward triangle of the Star and is very small in comparison to the scale of the Star.

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14 Several theology books on Jews state that the Star emerged as a symbol of Jewish belief as late as in the 17th century (Werblowsky, Wiegler, & NetLibrary inc., 1997). In the original Jewish theology, there are no references to the Star and in the archaeological artifacts there is hardly any evidence that the Star was a symbol of the Jewish belief as cross has been for Christianity and crescent for Islam.
Figure 64: The distorted star that Libeskind drew on a plan sent to him with the invitation letter to the competition.
(© Research Library, The Getty Research Institute, Los Angeles, 920061)

Figure 65: The stars on the Berlin Museum pamphlet that Libeskind received with the invitation letter to the competition.
(© Research Library, The Getty Research Institute, Los Angeles, 920061)

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Study of the Design Process

The Jewish Museum case study is based primarily on an investigation of archival materials at the Getty Research Institute, which houses sketchbooks, final competition drawings and other drawings, letters, and additional textual materials from Libeskind's office before he moved to Berlin. Other investigated materials contain published writings of Libeskind and of others on the Jewish Museum and on Libeskind's architecture. In addition, a member of the design team, Donald Bates, was contacted to provide information about the design process. Bates was the associate designer to Libeskind during the Jewish Museum project.

For this thesis research, in total 19 sketchbooks (twelve are 23 x 23 cm, six are 15 x 21.5 cm, and one is 15.5 x 20.5 cm), 55 rolls of architectural drawings, seven flat files of drawings, and six boxes from the competition phase were studied. All these documents were inspected at the Special Collection of the Getty Research Institute. The most important set of documents from the Archives for this research is Libeskind's sketchbooks, which portray the evolution of design in the initial phases of design. The Institute houses a substantial amount of additional documents from subsequent phases of design and construction in addition to the documents investigated. These materials were
not studied in detail for the purpose of this research. It is without question these documents include very important information, yet their content is beyond the scope of this research.

All documents in the Archives, textual as well as visual, are carefully documented, including their dates when available, by the Archives' researchers and hence further cataloguing was not necessary. Dates for the pages of the sketchbooks or the sketchbooks themselves, however, are not available. The sketchbooks are numbered and stored in five boxes, yet it is difficult to establish an exact chronology across different sketchbooks while it is relatively easier to determine a chronology within each sketchbook following the natural sequence of its pages.

All sets of sketches together with additional drawings were inspected and annotated for this research with diagrammatic abstractions, sketches, and notes. During the archival research, 154 diagrams and sketches were drawn as memory aids and as investigative representations. An additional 25 set of drawings from different sketchbooks were reproduced in the form of high quality slides. Most of the reproduced sets pertain to the significance of the conceptual diagram, i.e., the Star of David. Others deal with additional important themes in the design.

Similar to the Staatsgalerie case study, the design was the product of a competition, and there are only a few explanatory textual documents illustrative of the interaction between the client and the architect. The Archives include three textual documents crucial to identifying the requirements of the client, the history of the competition, the design, and the major themes of the architect. The first document is the original competition brief that was provided to Libeskind. The brief describes the objective of the competition, the design task and other requirements, and includes additional information of the design situation. Libeskind's original copy has marks and annotations along the text, which are helpful in identifying those issues from the brief on which Libeskind put more emphasis.

The second document, Libeskind's architectural report, summarizes the main conceptual issues addressed in Libeskind's scheme and the major features of the design. The final document is a book published in commemoration of the competition. The book includes
parts of the competition brief, the architect’s report, as well as other writings detailing the important developments leading to the competition and after the competition.

In addition, to the archival documents, there is an extensive literature on the Jewish Museum. The architectural critics hailed the design as an example of deconstructivism architecture when it was first published. The building was also the first Libeskind project to be realized. This increased the general interest in the building. Furthermore, the subject matter of the competition and the events after the competition kept the project on the architectural agenda as well as general public.

An important body of additional writing is Libeskind’s publications about this particular project as well as others and his general architectural investigations. Libeskind, as opposed to Stirling, is very explicit and detailed in describing the conceptual underpinnings of his project. Until his early forties, Libeskind’s architectural work consisted of conceptual investigations, both in text and drawing of architecture, and projects for competitions.

Donald Bates’s responses, Libeskind’s associate architect for this project, to a 24-item long questionnaire constitute the last piece of material inquired in this case study. Bates’s answers were important in understanding the work dynamics of the design team and the principal components of the design scheme.

Design Situation

The design task, as well as detailed information about the history of the site and the neighborhood was provided in the competition brief entitled Competition for an extension to the Berlin Museum to include the Jewish Museum (project to be built): invitation to compete. The competition was organized by the Land of Berlin represented by the Department of Cultural Affairs (Department of Cultural Affairs, 1988, p. 1). It was open to architects in the Federal Republic of Germany with an additional twelve invited foreign architects (“Between the lines: extension to the Berlin Museum, with the Jewish Museum,” 1990, p. 1(2)). The competition book included four major sections:

1. Background to an aim of competition

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2. Situation and planning parameters
3. Competition brief
4. Annexes

Additional documents given to the designers consisted of a programme and annexes, guide to the Berlin Museum, replies to questions, plans and maps, and a base for the architectural model.

The competition brief formulated the design task as offering alternatives for an extension to the Berlin Museum that would house its Jewish Collection as well as support services including a lecture hall, cafeteria, and restaurant. Prior to the planning and construction of its extension the Museum was organized chronologically in two major sections: the period before 1870, i.e., the year when the German Reich was established, and the period after 1870 to which the Jewish Museum was originally planned to be integrated (Department of Cultural Affairs, 1988, p. 68).

The aim of the competition was twofold. First, the Jewish Museum Department, which was part of the Berlin Museum, had “to be enlarged and fully integrated into the Berlin Museum.” Second, the Berlin Museum itself needed more space (Department of Cultural Affairs, 1988, p. 1). The former, however, was the crucial and the main task of the competition. As it is stated in the competition brief, this was “the most urgent reason” why the competition was held (Department of Cultural Affairs, 1985, p. 15). Prior to the construction of the Jewish Museum, part of the Jewish collection was housed in the first floor of the existing structure and part in the Martin-Gropius-Bau building (Bothe, 1992, p. 33).

The first independent Jewish Museum in Berlin was established on January 24, 1933 just a week before the Nazis assumed the power in Germany (Braun, 1999, p. 104). Eventually, the Nazis closed down the museum. After the erection of the Berlin Wall on August 13, 1961, the existing city museum remained in East Berlin (Braun, 1999, p. 107). Soon after the West Berliners founded a new city museum with a Jewish Department. In 1969, the Berlin Museum moved into the historical Baroque Collegienhaus building (Figure 67), designed by Philipp Gerlach (1735) (“Between the lines: extension to the
Berlin Museum, with the Jewish Museum," 1990, p. 158). Originally, there were plans to establish as independent museum for the Jewish Department. The city, in those days, decided to rebuild a historical building torn down in 1935 for the new Jewish Museum. In March 1988 the city changed its original decision and approved the construction of a Jewish Museum as part of the existing Berlin Museum. The new building was to be called Berlin Museum-Jewish Museum (Braun, 1999, p. 110). In 1998, close to the completion of the building, the decision was changed yet another time and the Museum became "conceptually and institutionally" as independent entity (Schneider & Libeskind, 1999, p. 24).

Figure 67: The front facade of the Berlin Museum (Left) and the rear (Right).

As this brief history of the idea of a Jewish Museum suggests the important issue outlined in the competition brief was the nature of the relationship between the Jewish Department of the Museum and the Museum itself. The brief describes the Department "as an autonomous department" of the Berlin Museum, yet also integrated with it. It explains this as follow:

The extension should be planned in such a way that the Jewish Museum is fully integrated into the Berlin Museum and that Jewish History can be seen as an integral part of the history of Berlin. (Department of Cultural Affairs, 1988, p. 16)

The discussions on the nature of the relationship between the Jewish department and the main department date back as early as to 1982 (Young, 2000, p. 7). Heinz Gaenski, leader of the Berlin Jewish Community and of the Central Council of Jews in Germany, during the early years of the conception of Jewish department underlined the importance
of an integrated relationship (Young, 2000, p. 6). Some local politicians voiced the same concern as follows:

We must make it quite clear that the creators and the products of this culture were not something "exotic", not something alienated from this city and its cultural life, but that they were and still are a part of its history... (Young, 2000, p. 7)

The dilemma for the competing architects was to find a scheme in which the two main departments of the Museum, the Jewish and the city of Berlin departments, are housed to remain integrated to each other while the Jewish Department keeps its autonomy. This presents itself as a dilemma and a challenge because autonomy and integratedness at least at first seem to be incompatible with each other. The nature of the relationship between the two departments as described in the document would, in theory, reflect the interaction between Jews and the City of Berlin throughout its history. At times this interaction became a constructive relation and at other times it became very destructive.

Libeskind related to the dilemma of the competition as it was described in the brief. He underlined those lines of his copy of the competition brief, where the nature of the relationship between the departments and the history of Jews in Berlin and Berlin itself were described. His copy of the document has a good amount of underlining that provide clues about what he found important and what became influential in the way he conceptualized the design situation.

In another section of the same document the connection between the Jewish and the Berlin departments is spelled out more in detail. Here the zone between the two parts is described as an intermediate one where the contributions of Jews to the society would be emphasized. This would ensure the integrity of the two parts. The book states as follow:

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15 The competition book uses the term dilemma to describe the challenge introduced by the competition. It describes the dilemma as "the autonomy and linkage to the existing Museum" ("Between the lines: extension to the Berlin Museum, with the Jewish Museum," 1998, p. 158).

16 From now on the quotations from the competition brief wherever Libeskind underlined his copy will be underlined here too.

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Between the sections dealing with general history of Berlin from 1870 to the present day and the Jewish Museum Department there is an "intermediate area" devoted to the topic of "Jews in Society" (working title). Here the Jewish part of the museum will open onto the part dealing with the general history of Berlin and show the necessary cross-references. (Department of Cultural Affairs, 1988, p. 68) [Underlined by Libeskind]

The autonomy of the Jewish department was partially dictated by the requirements imposed by the Society for a Jewish Museum in Berlin. It underlined the importance of "the independence of a series of rooms which does not correspond to the section dealing with the general history of the city" (Department of Cultural Affairs, 1988, p. 87).

Following the suggestion, the brief formulated the relationship as "autonomous but simultaneously associated" (Department of Cultural Affairs, 1988, p. 88). The brief makes the following specific suggestions about this relationship (Department of Cultural Affairs, 1988, pp. 70-71):

- The access level of the extension must link to the first floor of the existing building.
- There must be connections between the two buildings at least at one level, preferably at two levels. If there is only one, it must be on the first floor.
- Above all, however, what is most important is to have innovative suggestions about how to connect the two departments.
- Following the city commissioner for historic monuments, the extension should not result in any changes in the old Baroque building of the Museum, e.g., by way of proposing either extensions or bridges to the old building. The commissioner recommends an underground passage between the two buildings.

Libeskind apparently found this last suggestion of special importance. He put an exclamation mark on its side and in his competition entry proposed a dramatic underground connection between the two parts.

The brief suggests the followings in regard to the autonomy of the Jewish Department (Department of Cultural Affairs, 1988, p. 70):

- The Jewish sections should be identifiable both from inside and outside.
— However, the existing entrance at the main building must be kept as the main entrance.

— Though a second independent entrance should be provided for the Jewish Exhibition for direct access.

The dedicated site for the project offered significant challenges as well (Figure 68). The site of the Museum is located in the Kreuzberg district of Berlin approximately a kilometer south of the now collapsed Berlin Wall (Figure 69) and about a block north of Erich Mendelsohn’s Metal Workers’ Union Building. It stretches between Lindeistraße and Alte Jacobstrasse. The area was called Southern Friedrichstadt, the only section in West Berlin that used to be part of the old center of the city (Department of Cultural Affairs, 1988, p. 17).

Figure 68: The Museum site.
Figure 69: Berlin with the Berlin Wall before its collapse. The dotted circle points Kreuzberg.

The building site and the close vicinity were heavily destroyed during the Second World War. Although damaged heavily, the Berlin Museum was one of the few buildings in the area that survived the bombings. The Collegienhaus was originally built as a judicetial building where E.T.A. Hoffmann worked as a judge (Schneider & Libeskind, 1999, p.17). For a long time after the war the area was scarcely populated by buildings. The urban interventions in the sixties and seventies further erased the historical traces in the area by changing the street patterns (Department of Cultural Affairs, 1988, p. 17). From 1979 to 1988, the close vicinity of the site became the site of the International Building Exhibition, which aimed at the “re-establishment of the inner city as a place to live by adding public amenities” (Department of Cultural Affairs, 1988, p. 1). In addition, the master plan of the site included a green and fresh air corridor on its south side (Department of Cultural Affairs, 1988, p. 1).

In the light of the peculiarities of the site, the brief spelled out specific and generic suggestions for site planning. The urban design features of the competition dictated an utmost concern for the following (Department of Cultural Affairs, 1988, p. 67).
- "The historical street pattern, in particular the original course of Lindenstrasse which has now become unclear" and which was historically an important axis. [Underlined by Libeskind]
- The setbacks from the street on Lindenstrasse.
- The urban corridors between Oranienstrasse and the green zone is the south of the site. [Underlined by Libeskind]
- Different urban planning paradigms in and around the site changing from city blocks in the north to freestanding apartment buildings in the south.
- The historical baroque building that houses the Berlin Museum. [Underlined by Libeskind]
- The green zone in the south of the site that also includes a children playground. [Underlined by Libeskind]
- "The necessity to minimize the volume of the building above ground." [Underlined by Libeskind]

The competition brief also emphasized the problem of missing materials because of the systematic elimination of Jewish artifacts after 1933 (Department of Cultural Affairs, 1988, p. 87). The brief suggested a flexible chronological organization for the available materials, instead of an absolute linear one (Department of Cultural Affairs, 1988, p. 69). Libeskind specifically addressed both issues by providing a voided space cutting through the proposed museum block to underline the non-replaceability of the missing materials and by proposing a linear organization in the form of a zigzag with a series of connecting bridges between different parts of the museum.

The proposed museum was planned to include three major sections. The content of the first section was to be about Jewish religion and customs, the history of the Jewish community in Berlin, and the family history of Jews. The second section was to address the contributions of Jews to the economic, cultural, and political life of Berlin. Finally, the last section was to depict the persecution of Jews between 1933 and 1945 during the reign of Nazis.

The competition documents were issued on December 27, 1988. Libeskind received an invitation letter from the Berlin Senate Department for Building and Housing on
November 29th of the same year (26.2. Libeskind. Correspondence, 1988). The organizers accepted questions in writing by January 20, 1989 and arranged an inquiry colloquium on February 6, 1989 to which Daniel Libeskind attended with Donald Bates (26.3 - L, corres. 1989 A - Risk). The deadline for 1:200 and 1:500 architectural drawings submissions was April 28, 1989 and for the model was May 12, 1989 (Department of Cultural Affairs, 1988, p. 14). The competition jury deliberations continued from May 2 to June 15 in 1989 and the jury announced the results on June 25 (Bothe, 1992, p. 35).

There were 89 entries to the competition ("Between the lines: extension to the Berlin Museum, with the Jewish Museum," 1990, p. 158), and Libeskind's entry was given the first prize. The second prize was given to Raimund Abraham and the third to Lange, Ullrich, and Meschele.

The jury was especially excited by Libeskind's interpretation of the Star. They thought Libeskind's project "developed a spatial and kinetic concept of interpenetration, refraction, superimposition, and temporary division" (Libeskind & Binet, 1999, p. 112). Ralf Bothe, director of the Berlin Museum, reports that Libeskind's scheme was picked "...because its design corresponded in an unexpected, but exemplary fashion to the integrated model demanded in the invitation for tenders" (Bothe, 1992, p. 43). Martin Filler claims that the non-obvious and invisible connection between the Berlin Museum and the Jewish Museum was of particular interest to the jury members (Filler, 2001, p. 27). Heinz Galiński, the chair of the Jewish congregation of Berlin, thought of the building as a testimony to the achievements and fate of the Jewish citizens of this city.

17 The jury members included architects as well as others: Architectural assessors: - Harold Dülßmann, Munster - Dr. Christoff Hackelsberger, Munich - Heinz W. Hofman, Landscape Architect, Aachen - Herrian Hertzberger, Amsterdam Others: - Klaus Humpert, Freiburg - Josef Paul Kieslhuber, Berlin - Isaac Luxemburg, Tel Aviv
with the history of Berlin in an inescapable way" (Libeskind & Bitet, 1999, p. 112). Several other architectural scholars have commented on the significance of Libeskind's use of the Star (Betsky, 1998; Foster, 1992; "Record readers were asked: What do you think of Daniel Libeskind's new Jewish Museum in Berlin?"; Rybczynski, 2002; Schneider, 1997; Schneider & Libeskind, 1999; Spenn, 1999).

A few months following the announcement, the Berlin Wall collapsed on November 10, 1989. The project was put on hold for several reasons for about two years until November 6, 1992 when the cornerstone was finally laid (Libeskind & Bitet, 1999, p. 112). In the meantime, Libeskind made several changes to his competition entry to reduce the final cost of the building (Russell, 1999). The first cost estimate was about DM 178.5 million, which was significantly higher than the original dedicated budget of DM 77 million (Russell, 1999). After revisions, the competition budget was reduced down to DM 117 million (Bothe, 1994, p. 36). There were three major changes to the original scheme:

- Tilted walls were straightened.
- The lower floor was simplified.
- All the separate towers except the Holocaust tower were excluded.

The construction finished in 1999 and the formal inauguration could happen only two years later on January 25, 2001 (Spenn, 1999, p. 40). The building was a big success, even before its collection was put on display. It attracted enough visitors to become the second most visited museum in Berlin only after the Pergamon Alter (Patterson, 2000, p. 70).

Building

The Jewish Museum building is in the form of a zigzag, 27 meters high and 150 meters long, stretching between Lindenstrasse and Alte Jacobstrasse (Figure 70, Figure 71). Visitors to the building get a limited view of the building from Lindenstrasse, to which the main façade of the Berlin Museum is oriented. The only view the block offers is its

-- Peter P. Schwengr, Hamburg

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narrow end on Lindenstrasse. The Museum consists of four levels and one basement level (Figure 72, Figure 73, Figure 74). The top floor includes office spaces and the first, second, and third floors are dedicated to exhibition spaces. The ground floor houses the main circulation axis in the building with some storage spaces as well as a learning center.

The Jewish Museum does not have a separate entrance except one which is provided to the special exhibition hall on the ground floor (Schneider & Libeskind, 1999, p. 48). The access to the building is from a staircase projecting to the main lobby of the Berlin Museum. The staircase leads to an underground corridor which gently slopes up towards a monumental staircase connecting the exhibition spaces on upper two levels (Figure 75). There are two corridors branching off of the main corridor. The first leads to an outdoor garden labeled as the F.T.A. Hoffman Garden. The second leads to the inside of a tower that Libeskind calls the Holocaust Tower. The garden is in the form of a checkerboard with a sloping floor plate and 49 inclined columns inside which rose bushes are planted. The tower is completely void in the height of the building with a slice of light coming from above.

The permanent exhibition halls are placed on the second and the third level. Visitors take the main staircase at the end of the underground corridor to the third level where the exhibition starts. The exhibition layout is linear and zigzags its way up and down a series of voided spaces slicing through the building from one end to the other (Figure 76). The void creates discontinuities in the linear layout. The fragmented parts are linked to each other through a series of bridges (Figure 77). The exhibition continues on the second floor following the reverse path. The exhibition spaces are organized chronologically, housing the following sections, among others, in a sequence: the origins of Jewish culture, the medieval times, the Enlightenment, the emergence of modern Judaism, German Jews – Jewish German, persecution, and the present.

The series of voided spaces are accessible at the ground floor. Some are visible from the interior of the building, and some are neither physically nor visually accessible. They align on a straight line cutting through the zigzagging exhibition spaces. At times when the void cuts through the exhibition block the interior spaces are disconnected from each
other and connectors to the form of bridges become necessary. The layout is in the form of a series of rooms connected to each other through bridges. When the void is adjacent to an exhibition space, its walls are painted black to differentiate between the exhibition spaces and the void enclosed inside the black walls.

Figure 70: The Jewish Museum with the Berlin Museum from the front and the back (Top). The I.T.A. Hoffman garden in the foreground (Bottom Left). Details from the façade (Bottom Right). (Courtesy of Michael Gamble)
Figure 71: The Celan Courtyard.  
(Courtesy of Michael Gamble)

Figure 72: Site plan (published in Architectural Review 1999).
Figure 73: Sections (published in Architectural Review 1999).

Figure 74: First floor plan (published in Architectural Review 1999).
Figure 75: The underground tunnel system (Top left). The staircase leading to the exhibition spaces (Top right). The E.T.A. Hoffman Garden (Bottom left). The Holocaust Tower (Bottom right).
(Courtesy of Michael Gamble)
Figure 76: Exhibition spaces. The voided spaces slicing through the exhibition galleries are painted in black.

Figure 77: Interior view of some of the voided spaces.
(Courtesy of Michael Gamble)
Design Conceptualization

Design Challenge

On several occasions, Libeskind elaborated on his design scheme for the Jewish Museum and its significance for his architectural career and for Berlin as a city. For him, this was the beginning of his architectural practice while "Berlin had become a beginner too; a beginner in approaching the ever-elusive question of its own relation to Jews—past, present, and future—toward traces of that which forever remains unborn, yet to be born" (Libeskind, 1999, 13).

Libeskind specifies four lines of thinking in his project in dealing with the conceptual challenge, each of which relates to one aspect of Jewish culture or Jews' position in Germany ("The Jewish extension to the German Museum in Berlin," 1999, p. 17-35; Libeskind, 1990; Libeskind, Berlin Museum Judische Abteilung, & Feireiss, 1992, p. 63-67; Libeskind & Binet, 1999, p. 9-15). The first is about the invisible Berlin of Jewish and German Berliners, which gets expressed in Libeskind's star diagram. The second relates to Schönberg's unfinished opera Moses and Aaron. The third relates to a lengthy list of names of all the Jews deported from Berlin. The fourth develops around Walter Benjamin's essay One Way Street. Libeskind summarizes the significance of the above as follows:

The first aspect is the invisible and irrationally connected star which shines with the absent light of individual address. The second one is the cat through Act II of Moses and Aaron which has to do with the not-musical fulfillment of the word. The third aspect is that of the deported or missing Berliners; the 4th aspect is Walter Benjamin's urban apocalypse along the One Way Street. (Libeskind et al., 1992, p. 65)

The competition posed a challenging task upon architects. It raised the difficult issue of the relationship between Jews and the city of Berlin, once the capital of Hitler's Germany which witnessed the near elimination of its Jewish population. The competition asked the participants to respond to this issue conceptually as well as architecturally. Conceptually, it urged the competitors to contemplate recent historical developments in Germany. Architecturally, it required them to spatially address the same conceptual issues. The first specific challenge for the architects was to propose a creative proposal for the
relationship between the old Baroque building, which housed the Berlin Museum, and the to-be-built extension which would house the Jewish Department of the Berlin Museum. The second specific challenge was to design the exhibition spaces that would bear testimony to the now invisible Jewish culture in Berlin. The design situation dictated conceptually intriguing proposals. In the case of Libeskind, there were emotional ties because 85 members of his family were killed during the Holocaust (Libeskind, 2001).

Libeskind in his writings acknowledges the challenge involved in the competition, which he interpreted as a task of building "a museum showing the Jewish dimension of Berlin's history" (Libeskind, 1999, p. 13). On another occasion, Libeskind reports that in his design he was concerned more with those who were "unborn" than the input from the environment of the building or the functions to be supported by the building ("The Jewish extension to the German Museum in Berlin," 1990, p. 24). In an interview, Libeskind further elaborates on the dilemma imposed by the design task. He says:

To extend this Modern relationship [between the Berlin Museum and the Jewish Museum] across a gap which would then constitute the Jewish museum is a fascinating idea. If you use the word 'extend' you are obviously not simply putting in another element, a foreign element, that could be grafted on. How can you extend Berlin history with Jewish history? It is a very provocative theme because you cannot extend simply by elaborating Berlin history to its tragic finale in the Holocaust, but neither can you extend it by creating the Jewish collection as if it were just another contribution beneath the umbrella of the Berlin museum.

Erweiterungsbau means extensions and it is the extension of both Berlin's history and Jewish history and not merely a building form. Rather it is the extension of both the program and the idea of extending Jewish heritage across the abyss created by the destruction of European Jewry." It is a new relationship to a history that can hardly be matched and pieced together into a whole. (The Jewish extension to the German Museum in Berlin,' 1990, pp. 17-19)

Bates describes the challenge of the competition as follows:

It was clear from the beginning that the competition presented a spatial/programmatic paradox: how to give presence and visibility to a Jewish collection, but also 'to see it as inextricably enmeshed with the history of Berlin itself—that is that Berlin history was only possible in the context of the Jews who were also Germans. (Donald Bates, personal communication, 2003)
Oneness

According to Libeskind, historically Jews had been part of the German culture for a long time although the events of the thirties and forties tried to eradicate them from history (Ladd, 1997). Libeskind considers Jews as "inseparably both German and Berliners" and their culture as "one". His extension to the Berlin Museum "would manifest that fact, clear across the abyss created by the Holocaust" (Libeskind, 2001). The conceptual dilemma for Libeskind was acknowledging the oneness of Jewish and German culture without diminishing the significance of the historical facts of the thirties and forties.

In a series of drawings, Libeskind specifically addresses this issue (Figure 78). With these drawings, he conceives the relationship between Jews and Germans in terms of a metaphor of two beams drifting apart from each other, which were once interlocked.

Figure 78: Study of the interaction between Jews and Germans each represented as one half of a beam.

Libeskind refers to one of the beams as Jewish, and the other beam as German in an annotation next to one of the drawings (Figure 79), with capital letters J and G on the side of the word "Interlocking", J standing for Jew and G for German. In the following pair of beams, he splits the two interlocking beams, which he identifies as the same, rotates them 180 degrees to form "reversed beams", and creates a gap in-between. He calls the space in-between as external and the space further away from the other as interior. It is almost as if
these two same elements are turning their backs against each other or they are pushing each other apart. In a force diagram Libeskind represents that idea (Figure 80). Here, two series of fractured lines pull apart each other only to converge at a central node.

"SPLIT FIBER
INTERLOCKING
NOTCHES
READING MACHINE"

German/Jewish History

With this series of drawings, Libeskind introduces new concepts such as gap, rift, interior and exterior spaces, pull and push to define the Jewish-German relationship. He also conceptualizes the historical evolution of the relationship between Jews and Germans which progressed from a pair of interlocking beams to a pair of reversed beams.

In another drawing, Libeskind’s conception of the historical evolution of this relationship becomes even clearer (Figure 81). In this drawing, the Jewish and German histories are depicted by two converging/diverging lines representative of their close interaction. The Jewish history line points into the past, whereas, the German history line branches out of the Jewish line and points up into the future. This suggests that Libeskind envisioned Jewish history as one that is rooted in the past from which the German history emerged. The gap between the two lines is filled with several successive layers labeled as wealth-economists, morals-moralists, politics-politicians, poetry-poets, and prophecy. Each layer respectively corresponds to a series of formal composition.

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Figure 81: The Jewish and German lines of history.
(© Research Library, The Getty Research Institute, Los Angeles, 920061)

With a smaller drawing in the same set, Libeskind abstracts the relationship in a
rudimentary force diagram where Jewish history becomes a downward line and the
German history a diagonal line branching off the Jewish line with a sinusoidal line, which
weaves a series of points (AA, BB) from each history line. Libeskind links two formal
configurations to this depiction of Jewish-German history. He calls one as "obscurantist
from" and the other as "expectant form". The former is a conventional grid layout that
Libeskind conceives as non-innovative whereas the latter is dynamic and Libeskind
labels it as the path.

Another series of drawings provides a different, related conception of German and Jewish
histories (Figure 82). Here, Libeskind draws numerous numbers of trajectories between
two points (AB), representing the individual biographical trajectories of citizens of
Berlin, which Libeskind refers to as histories.
Figure 82: Trajectories between points AB.
(© Research Library, The Getty Research Institute, Los Angeles, 920061)
None of these trajectories, however, is linear. They are all convoluted lines that crisscross each other and their sum is a complex network of lines rather than a single resultant of all different lines (Figure 83).

Figure 83: Detail from Figure 82 where Libeskind shows the sum of trajectories.
In the subsequent drawings (Figure 84), the line AB becomes the organizing feature of the façade design from which the openings on the façade are hung.
Figure 84: The journey from A to B becomes the organizing features of the façade design.
(C) Research Library, The Getty Research Institute, Los Angeles, 920061)
Here, the trajectory from A to B becomes a red line on the façade of the building running, from one corner of the building to the other (Figure 85).

Figure 85: Detail from Figure 84.
The trajectory lines on the façade drawings allude to two journeys which were crucial in Libeskind’s conception. The first is Moses and Aaron’s journey from Egypt back to Israel, without a definite end, which Libeskind reads from Schönberg’s opera. The second is Walter Benjamin’s journey in Berlin in his essay One Way Street, which wanders in the city without a definite target. In his façade drawings, Libeskind transcribes this on the exterior of his building making the elevations highly symbolic that could be read as pages of a book. Here, the building becomes a metaphorical book on the history of Jews and their relationship with the Germans. Several of Libeskind drawings illustrate his conception of folded and inclined walls of the Museum as half open pages of a book or as an unfolding scroll of Torah (Figure 86).
Figure 86: Inclined walls representative of half opened pages with people walking in and out of them [sketch drawn by the author based on a Libeskind drawing].

The conception of history in these drawings dictates a double helix-like historical progression of two intertwined lines rather than a linear one, which refers to the merging as well as parting of the two histories and which represents the complex and convoluted historical relationship between Jews and Germans.

The conceptual dimension of the design task, therefore, relates to history, to specific events in the Jewish and German history, and to the way the nature of this relationship changed. Libeskind underlines this by changing the title of the competition and the title of the new building. The original title was “Extension of the Berlin Museum with the Jewish Museum”, whereas Libeskind deliberately referred to the competition as “Between the lines,” i.e., two lines of thinking that are intertwined throughout history.

One line is straight yet broken while the other is continuous yet zigzaggy. As Libeskind puts it, one represents organization while the other represents relationship and they “seem apart, disengage, and separate” as similar to the history of Jews and Germans (Libeskind et al., 1992, p. 53). This is, however, not an attempt to bring a resolution between the two lines of thinking. It is more a testimony to history, which Libeskind interprets in two dimensions simultaneously: horizontal and vertical. The horizontal dimension of the history is the chronological succession of events while the vertical is the timeless struggle between the opposites such as light and darkness (“The Jewish extension to the German Museum in Berlin,” 1990, p. 28).

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In some of Libeskind's drawings, historical succession of events is plotted along a horizontal and a vertical axis, where horizontal axis is linear and continuous and the vertical tends to zigzag around the linear horizontal axis. Sometimes historical events or dates are plotted along the horizontal and vertical dimensions. In some other drawings, this configuration becomes a proper building with again historical dates and names inserted in several places.

Figure 87: The Jewish and German history lines crossing each other. (© Research Library, The Getty Research Institute, Los Angeles, 920061)

With this drawing (Figure 87), the analogy between the history of the interaction of Jews and Germans and the Jewish Museum Building becomes clearer. Libeskind labels the straight linear block cutting through the building as the Jewish history line whereas the zigzag block as the Berlin history line. He also adds dates to the zigzag substantiating the idea that the lines represent trajectories in history. In his final scheme, the straight line would become the series of voided spaces that cut across the exhibition spaces. The rhythm of the series and the idea of the voided spaces relates both to the missing Jewish artifacts and culture in Berlin and to Schöenberg's opera Moses and Aaron. Libeskind
summarizes the overall idea of missing materials and how it relates to his buildings as follows:

The new extension is conceived as an emblem where the not visible has made itself apparent as a void, an invisible. The idea is very simple: to build the museum around a void that runs through it, a void that is to be experienced by the public. (Libeskind et al., 1997, p. 67)

This understanding of the history of Jews and Germans, as Libeskind puts it, constitutes three fundamental ideas of Libeskind's design:

The impossibility of understanding the history of Berlin without understanding the enormous intellectual, economic, and cultural contribution made by its Jewish citizens;

The necessity to integrate the meaning of the Holocaust, both physically and spiritually, into the consciousness and memory of the city of Berlin;

That only through acknowledging and incorporating this eraure and void of Berlin's Jewish life can the history of Berlin and Europe have a human future (Libeskind & Binet, 1999, p. 965).

In other words, according to Libeskind the German-Jewish history is one which is complex and convoluted yet very creative and productive. This, however, remains obscure when one looks and walks in the streets of contemporary Berlin not only because Jews no more live in Berlin but also because their mutual artifacts were destroyed also.

The contemporary plan of Berlin, therefore, is an "obstructionist form" which renders invisible the Jewish material presence in Berlin.

Visible/invisible

Conceptually Libeskind makes the invisible visible by introducing the notion of Berliner Luft (Figure 88), "the air across Berlin which mixes with the air of history to shape the city" and employ a visual device, Star of David, representative of that notion ("The Jewish extension to the German Museum in Berlin," 1990, p. 20). The Berliner Luft invokes the Jewish presence in the air of Berlin while the Star of David materializes that or projects that on the map of contemporary Berlin. The Luft denotes what is reminiscent of both anonymous and historical Jewish Berliners and the Star surfaces only those who are historically significant. Libeskind's conception of the Berliner Luft and its materialization through the Star of David constitutes the embodiment of his design

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concept. The notion of Luft, therefore, designates the invisible yet pervasive presence of Jews in Berlin, while the Star visually depicts their presence. In his architectural report for the competition, Libeskind states the underlying idea of his project as one with which he tries to render visible what is invisible, i.e., "the past fatality of the German-Jewish Cultural relation in Berlin" ("Between the lines: extension to the Berlin Museum, with the Jewish Museum," 1990, p. 169).

Figure 88: The Berliner Luft—the air across Berlin—and the spiritual search for form within the Berliner Luft.

The notion of Berliner Luft evokes all those who disappeared in Berlin during between 1933 and 1945. These people are almost anonymous now. Nothing was left from them, nothing more than names, date of birth, date of deportation, and places of death. There is almost no physical testimony to their cultural existence in Berlin, not even their physical addresses. In addition to all those disappeared, Libeskind thought of other specific Jewish and non-Jewish historical figures who lived in Berlin. Berliner Luft, however, remains invisible both in history and in space and Libeskind traces it through a series of drawings where he plots imaginary points and connects them to form an incomplete Star of David.

Libeskind, with this set of drawings (Figure 88), depicts what he implies by an "invisible" order behind what is visible. Over a rendering suggestive of the Berlin Museum and labeled Berlin, Libeskind starts drawing a zigzag, which he calls "Luft".
This may suggest that Libeskind is trying to find an underlying pattern for the city of Berlin. On the facing page, Libeskind continues the zigzag line and forms an almost complete Star of David with plotted points. Libeskind calls this line as the “spiritual search for form”. In a sense, with this drawing, he explains how he conceives of the Star as an underlying pattern of structure over the city of Berlin which may not be visible yet traceable through plotting points and connecting them to each other. This is, to Libeskind, indicative of the “eye-mind despair”, i.e., the disjunction between what is visible and what is conceived. The Star is visible only through conception rather than being perceivable through vision. His building, hence, would be part of this overall underlying pattern of Berlin and it would bring that to visibility.

With the following set of drawings (Figure 89), Libeskind explains further how he employs the invisible “spiritual organization” in his building. The invisible organizational principle applies both to the plan configuration as well as to the façade. Its implementation is dramatic especially when it is applied to the conventional façade of the Berlin Museum. After the organizational principle is superimposed over the façade, it transforms the building into a “wounded” looking creature. This whole process explains how Libeskind conceived of the invisible pattern of Berliner Luft as an organizational principle in his design.

Figure 89: Spiritual organization is superimposed on a conventional façade.
(© Research Library, The Getty Research Institute, Los Angeles, 920061)
To trace the invisible pattern of the Luft, Libeskind introduces specific names of Jews and non-Jews from history in his architectural report for the competition. These historical names included people of significance for the cultural richness of Berlin. The ones that Libeskind includes in his report and the descriptions he used are as follows ("Between the lines: extension to the Berlin Museum, with the Jewish Museum," 1990, p. 169) 18:

- Heinrich von Kleist: tragic
  (Kleist (1777-1811), who committed suicide, was one of the first to attack the rationalism of Enlightenment in his plays and stories)

- Rahel Varnhagen: sublimated assimilation
  (Varnhagen (1771-1833), a literary hostess, felt for all her life the shame of being a Jew up until her death) (Arendt, 1974, p. 85).

- Walter Benjamin: inadequate ideology
  (Benjamin (1892-1940), who struggled between Zionism and socialism, had to commit suicide on the border of Spain and France while trying to escape from the Gestapo) (http://www.wbenjamin.org/bio.html).

- E.T.A. Hoffmann: mad science
  (Hoffman (1776-1822), who was jurist as well as a storywriter, died while he was tried for treason) (http://www.littleblueilight.com/lblphp/intro.php?name=Hoffmann).

- Friedrich Schleiermacher: displaced understanding
  (Schleiermacher (1768-1834), a philosopher and a liberal theologian, objected to the assimilation of Jews through baptism and argued for their civil liberties)
  (http://plato.stanford.edu/entries/schleiermacher/).

- Arnold Schönberg: inaudible music
  (Schönberg (1874-1951), the originator of atonal music, was brought up as a Catholic and became Protestant later even though he was Jewish. When Hitler came to power, he was forced to leave his position at the Berlin Academy and left for the US)

18 Parentheses are added by the author.
— Paul Celan: last words
(Celan (1920-1970), a Jewish poet, was raised to love German literature and culture, yet he was sent to the concentration camps with his parents where he lost them) (http://www.kirja.to.sci.fi/celan.htm).

The interesting aspect of these names is that they personally experienced the difficulties and richness of an integrated German-Jewish culture at a historical period when the project of Enlightenment emerged and evolved in Germany. The Jewish-German relations reached its peak during this period with at least some of the Jews of Germany embracing the German identity at the expense of avoiding their Jewishness.

The contemporary Berlin has almost nothing reminiscent of the anonymous Jews as well as historically more significant Jews, yet at least for the latter their addresses in Berlin may be available. In his star drawing, Libeskind plots a projection of the Berlin Luft over the Berlin plan by locating and connecting the addresses of famous Jews with German Berliners from the list above with the exception of Walter Benjamin and Arnold Schönberg. He also added to the list the names of Mies van der Rohe, who had to leave Germany a little after Nazis came to power, and of Heinrich Heine, a German poet with Jewish origins who converted to Protestantism to have a civil service career. In different ways, these names represented the integrated culture of Jews and Germans prior to Nazis. With Nuremberg Laws, however, the German-Jewish myth, as Derrida describes (Derrida, 1997, p. 111) reaches its ultimate opposite peak by declaring the Jews as non-German (Young, 2000, p. 4).

Conceptual Diagram

Daniel Libeskind received an invitation on December 20, 1988 from a Mr. Keller, of the Berlin Senate Department for Building and Housing, to participate to the competition. Along with general information about the competition and its deadlines, the letter included a 1:5000 site plan and brief information about the Berlin Museum.

On the back of the Berlin Museum pamphlet, attached to the competitive invitation letter, Libeskind drew six distorted and eight partial stars. On the second page of the same document, Libeskind had about 15 more stars (Figure 65) and on the back of the page he
drew a zigzag (Figure 66), which became the final form of his building. On the site plan, he sketched a preliminary layout for his building and its relation to a close-by public circle (Figure 64). The interesting issue about the initial stage of the Jewish Museum is that the distorted star on the site plan, and the zigzag lines, one of which shows a zigzag building adjacent to the Berlin Museum in an axonometric drawing, were conceived as generic spatial configurations for the Jewish Museum. The zigzag configuration was derived from an earlier project of Libeskind. In the subsequent stages, the design team looked at only variations of a zigzag configuration until when Libeskind merged the zigzag plan with the distorted star layout. At that point in the design process, the spatial configuration of the building became two intertwining-lines, one straight line defining the voids and one zigzag line housing the exhibition spaces.

The distorted star Libeskind drew on the site plan shows axial lines connecting the partial star to its neighboring elements. The sketchy plan together with the different kinds of stars on the invitation letter indicate that the Star of David emerged right at the very beginning of the design process. At this initial stage, the distorted version of the Star on the site indicated the footprint of the building, i.e., the Star became the building itself. In the subsequent phases, the distorted star was not used as a generic spatial configuration for the building. It was rather the zigzag that became the generic spatial configuration.

Bates reports that the design team searched through all of Libeskind’s previous projects including Chamberworks and Macromegas “at different scales,” “in different arrangements,” and decided on the zigzag of the Line of Fire project as the plan layout for the Jewish Museum. This project “made sense” and “worked on the site”. In the subsequent phases, the team changed the width of the zigzag and explored ways of making the zigzag more vertical (Donald Bates, personal communication, 2003).

The Line of Fire was designed for an exhibition held at the Centre d’art contemporain, Geneva (Libeskind, Centre d’art contemporain (Geneva Switzerland), & International Labour Organisation, 1988). The zigzag in this project was called Line of Fire and it was placed between the two rows of piers in the main hall of the International Labour Organization building. The exhibition was held on April 18–May 22 1988, about eight months before Libeskind received the invitation letter for the Jewish Museum.
In the final version of the Star, drawn as a presentation drawing for the competition (Figure 63), Libeskind introduced some changes to his initial conception of the star. The first major change is the relationship between the configuration of the building and the configuration of the Star. In the final version, the distorted Star is no longer the footprint of the building. It is a rather a non-physical entity, which extends across the cityscape of Berlin beyond the boundaries of the Museum and even the site. The Jewish Museum Building is only one of the elements of this star among several others. In a sense, Libeskind only changed the scale of the Star to cover a very large area in Berlin to establish a network of connections between different points of the city. Libeskind considers this as similar to "cyphering new stars" on the curtain of sky just like constructing constellations of stars at night (Figure 90).

![Figure 90: The cyphering of stars in the sky (sketch drawn by the author based on a Libeskind drawing).](image)

The major elements of this network, however, are neither buildings nor physical artifacts. The points in this Star designate rather the original addresses of historical Jews and non-Jews from the history of Berlin.

Libeskind explains this as follows:

At the same time, I felt that the physical trace of Berlin was not the only trace, but rather that there was an invisible matrix or amaness of connections in relationship. I found this connection between figures of Germans and Jews; between the particular history of Berlin, and between the Jewish history of Germany and of Berlin... So I found this connection...
and I plotted an irrational matrix which was in the form of system of
squared triangles which would yield some reference to the emblematics of
a compressed and distorted star; the yellow star that was so frequently
worn on this site, which today is green. (Libeskind et al., 1992, p. 63)

The invisible matrix or Libeskind’s Star demonstrates a network of social interactions
among Berliners that is invisible in nature, yet emergent in the physical urban fabric of
the city. Here the social network of interactions emerges out of the connections and
integration of Jewish and German Berliners. This is an invisible aspect of Berlin because
social interactions occur within a physical environment, however, they remain invisible.
They are traceable only through secondary signs in the physical environment.
Furthermore, the social interaction of Jews and Germans remains invisible because the
events between 1933 and 1945 eliminated the Jewish culture. Libeskind’s Star embodies
the duality of this invisibility and denotes furthermore, the near impossibility of social
interactions. The diagram embodies this conceptualization at several levels. It emphasizes
the importance of social interactions which gives the city its unique character. It
illustrates the seemingly close ties between Jews and Germans. Finally, it reminds us the
terrifying inability of changing what had happened.

In addition to the Star, several of Libeskind’s drawings depict the difference between
what is visible and invisible in these drawings. The invisible is complex, whereas, the
visible is seemingly orderly and simple, yet falls short in expressing the complexity of the
invisible underlying fabric of the city (Figure 91).

![Image](image_url)

**Figure 91: Invisible versus visible.**
(© Research Library, The Getty Research Institute, Los Angeles, 920061)

What is significant about the Star Diagram is that it reveals a legible pattern by
establishing meaningful connections within the chaotic fabric of the city between the city
and the Museum, or among places, or among people, or between the Berlin Museum and
the Jewish Museum. As Libeskind describes the mission of the Star is "to integrate the German and Jewish histories of Berlin" (Libeskind, 1997, p. 113).

City and Building

In a series of drawings (Figure 92, Figure 95, and Figure 96), Libeskind depicts the connection between architecture and city by using the Star as a mediator. The geometry of the Star in these drawings denotes an underlying structure that connects individual buildings to the overall city pattern. In the drawings below (Figure 92), Libeskind illustrates how he thinks of the mediating function of the Star between buildings of a city and the urban fabric of a city. This set is of particular importance because the star in this case establishes the relationship or the transition from the building to the city. The city is a continuation of buildings shaped according to an invisible pattern that Libeskind calls the Matrix (the Star).

Figure 92: Star as a mediating structure between the building and the city. (© Research Library, The Getty Research Institute, Los Angeles, 920061)

In one instance, Libeskind calls the star the "Matrix (invisible city)," further emphasizing its role as the underlying pattern of the visible city fabric (Figure 93, Figure 94). In another drawing (Figure 95), Libeskind puts his matrix between the city and architecture and labels it the "ghost" again emphasizing the invisible mediating nature of the star.

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Figure 93: Detail from Figure 92.

Figure 94: Detail from Figure 92.

Figure 95: The Star Matrix as a mediator between architecture and city [sketch drawn by the author based on a Libeskind drawing].

In yet another drawing, Libeskind further depicts the mediating role of the star (Figure 96). This time an incomplete star, labeled as "Jewish", first evolves into Berlin, and later evolves into Libeskind's final scheme with the linear void cutting through the zigzag. Here, Libeskind combines the two initial design ideas: the star and the zigzag. The star becomes the intertwined trajectory of Jews and Berliners, which eventually transforms into a zigzag.
Figure 96: Star mediating between the Jewish Museum Building and the history lines of Jews and Berlin [sketch drawn by the author based on a Libeskind drawing].

Places

In a second group of drawings, Libeskind uses the Star as a connecting element among places including his scheme for the Jewish Museum (Figure 97, Figure 98).

Figure 97: Star connecting places and people. The Jewish Museum Building is in the center.

(© Research Library, The Getty Research Institute, Los Angeles, 920661)
Figure 98: Stars in different positions.
(C) Research Library, The Getty Research Institute, Los Angeles, 920061)
In one particular drawing (Figure 99), Libeskind plots a star over and beyond the Berlin Wall connecting specific buildings and places including the Berlin Museum, Mendelssohn's Metal Worker's Union Building, Libeskind's City Edge Project, Oranienstrasse, and Mehringplatz. He also includes the names of Schinkel, Celan, Osietsky, and Hoffman on the drawing and an axis over the Star, which he labels as the "Jewish Cultural Intermarriage" to depict the integration between Jews and non-Jews.

Figure 99: The Intermarriage between Jews and Germans.
(C) Research Library, The Getty Research Institute, Los Angeles, 920061)
The position of the Jewish Museum building changes from one star configuration to another one. Sometimes the building is in the center, sometimes it is aligned along one of the edges of the star, and sometimes it is one of the corners of the star. In Figure 100, the museum building stretches from one edge of the Star to the other, as if the two sides of the star are held together with the Jewish Museum itself.

Figure 100: Jewish Museum stretching between the two edges of the Star.
(© Research Library, The Getty Research Institute, Los Angeles, 920061)

In other drawings, Lichnowsky increases the scale of the star to cover the whole of Europe. He substitutes the building with the city of Berlin (Figure 101). With this drawing, Lichnowsky places Berlin at the center of Europe and at the center of the star.

Figure 101: Star connecting cities and countries, with Berlin in the center.
(© Research Library, The Getty Research Institute, Los Angeles, 920061)
People

In a third group of drawings, Libeskind establishes connections between people rather than places (Figure 102). By coupling the Jews with the Germans, Libeskind wanted to underlie the "wedding of assimilation and disassimilation" between the Jewish culture and the German culture in the 19th and 20th century (Libeskind, 1997, p. 113). Anyone of the names in the Stars, according to Libeskind, "faced the duplicity, and themselves became duplicitous in both their conversions and in the impossibility of the conversion" (Libeskind, 1997, p. 113). Libeskind writes:

For example, I connected Varnhagen to Schleiermacher, and not arbitrarily, because one could find many Jews and Protestants buried in this particular track of Berlin. But to find a Jew who would convert to Protestantism and announce this conversion on her death bed and to connect her to a Protestant theologian, or to connect Celan to Mies Van der Rohe—here are some completely irreconcilable differences joined in a wedding. (Libeskind, 1997, p. 113)

Figure 102: Star connecting Mies to Celan and the zigzag building stretching between them.
(© Research Library, The Getty Research Institute, Los Angeles, 920061)
In other places, Libeskind calls this wedding as an “urban marriage” between Jews and non-Jews (Figure 103), and sometimes an “intermarriage” (Figure 104). He depicts this marriage as terms of invisible tunnels, much like the underground tunnel which connects his Jewish Museum to the Berlin Museum.

Figure 103: Tunnels connecting Jews and Germans.
(© Research Library, the Getty Research Institute, Los Angeles, 920061)

Figure 104: Intermarriage of Jews and Germans.
(© Research Library, the Getty Research Institute, Los Angeles, 920061)
In another drawing, Libeskind plotted a partial star with the names of Mendelsohn, Celan, and Hoffman (Figure 105). Along the edges of the star, he placed imaginary signatures, to substitute for the real signatures of the names that he used for the Star. In a letter to Kurt Foster written on December 12, 1989, Libeskind actually requested the signatures of Heine, Celan, Varnhagen, Schleiermacher, with the intention of including (by re-drawing) them in the drawings (re-signed). Again, a zigzag which stretches along one of the edges of the Star designates the footprint of the Jewish Museum building. This suggests that Libeskind was actually thinking of his building as a signature/mark equivalent to those of Jewish Berliners.

Figure 105: Star connecting people with their signatures. The Jewish Museum building is one among other signatures.
(© Research Library, the Getty Research Institute, Los Angeles, 920061)

Jewish Museum and Star

In a fourth group of drawings, Libeskind uses the Star as a connection between the two components of his conceptualization: the histories of Jews and Germans and the invisibility of Jewish presence (Figure 106). With this set of drawings, Libeskind connects the star imagery with the zigzag. In one of his set of drawings, he drew several
stars in different form and nature (Figure 107). Few of these stars are complete and most are either incomplete or distorted. What is interesting about these incomplete or distorted stars is that Libeskind explodes the two completely enclosed lines of the original star (Figure 108). In the original star, the two triangles are drawn by two lines making two 60 degree turns at equal distances from their starting points and turning points. The two lines finally complete the enclosed shape. In the exploded and distorted stars, the two lines never close and never complete the circle. Rather, they become two intertwined lines suggestive of the final zigzag footprint of the Museum building and the double-helix like histories of Jews and Berlin. In certain cases, the two lines start as the two triangles of the Star of David, yet they suddenly break the geometry of the star and become a zigzag. In these instances, there is a combination of an incomplete star and a zigzag. In other instances, there are so stars. The intertwining lines start as a zigzag and remain like that. In the majority of these cases, both lines make acute turns. In one case, however, one of the lines remains straight all the way through and the other makes up-and-down turns very similar to the overall composition of Libeskind’s competition entry.

Figure 106: Star and the zigzag are superimposed. (© Research Library, the Getty Research Institute, Los Angeles, 920061)
Figure 107: Star evolving into a zigzag. (© Research Library, the Getty Research Institute, Los Angeles, 90061)

Figure 108: Steps of the evolution. Detail from Figure 107.
With this set of drawings, Libeskind clearly links the two emerging themes in his design: the Star, i.e., the conceptual theme of his design, and the zigzag, i.e., the generic spatial scheme of the building. The zigzag in these drawings (Figure 108) is depicted as a derivation of the Star, or as Bates puts it the Star becomes a derivation of the zigzag.

In one particular drawing (Figure 109), Libeskind further elucidates how he conceived the relationship between the zigzag of his building and the Star. Libeskind annotates this drawing with the following statement: “Adjust all the angles to correspond to the star angle.” This explains how Libeskind manipulated the Star to form a shape that could be the plan of his building.

Figure 109: Libeskind adjusts his building according to the Star [sketch drawn by the author based on a Libeskind drawing].

In this drawing, Libeskind rotates the Star corners probably to achieve a desirable configuration as well as to denote that the placement of the star could change as well without losing its significance as a unifying order between Jews and Germans.

It is apparent that Libeskind, through this set of drawings, exploits the literal meaning of the Star of David as well as its formal potentials. There could not be a better representation, to capture the design idea for a Jewish Museum, than the most widespread contemporary symbol of the Jewish belief and culture, the Star of David. Libeskind extends the meaning of this representation by distorting and fragmenting the Star. He achieves a configuration in which two lines intertwine, cross each other, and fall apart from each other. Conceptually, the Star becomes the embodiment of the crossing of Jewish people and German people and the Jewish culture and German culture, in addition to being the icon of the Jewish culture proper.

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19 Bates confirms that through these drawings Libeskind combined the two themes.

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Berlin Museum and Jewish Museum

In the final group of drawings, the Star becomes the underlying invisible structure that unifies the old Berlin Museum with the new Jewish Museum. In Figure 110, Libeskind depicts how the old and the new buildings sit atop of this underground star. The fragment of the star in-between the two buildings becomes the underground circulation system that connects the two museums. This provides a satisfying solution to the challenge of the competition to make the extension as autonomous as possible and to leave the historical building as is. The two buildings would be connected with the underground passageway while from the outside they would give the impression that they are separate, hence autonomous.

Figure 110: An underground Star of David connects the new to the old.
(© Research Library, the Getty Research Institute, Los Angeles, 920061)

In this set of drawings, the Star is conceived as a horizontal element which is not even visible from up above. The Star is below the ground level and constitutes an underlying
pattern which connects structures that are above the ground level (Figure 111). The star, therefore, is invisible, yet it defines the relationship between the structures of the city and its buildings as well as the relationship between the Berlin Museum and the Jewish Museum.

Figure 111: Detail from Figure 110.

In Figure 112, Libeskind specifically studies the connection between the Berlin Museum building and the Jewish Museum building. The connection is represented in four sectional diagrams and one elevation. Libeskind conceives of the two buildings as connected to each other through an underground passage. From above ground, the two buildings look separate and seem to push away each other. The two buildings are actually depicted as the negative and positive poles of a magnet (Figure 113). From under the ground, one sees they are actually connected to each other.

Figure 112: The relationship between the Berlin Museum and the Jewish Museum. (© Research Library, The Getty Research Institute, Los Angeles, 920061)
In a simplified diagram (Figure 114), Libeskind plots the relationship between the two Museums in terms of the relationship between Jews and Germans, which he summarizes as a push and pull relationship. The relationship is designed as one which involves opposite forces of push and pull similar to positive and negative ends of a magnet. This is analagous to the historical relationship between Jews and Germans. There are two lines connecting the two polar opposites. The first is an arc which tries to close in order to bring the German and the Jew together. The second is a two-directional arrow which pulls apart the two.

It is significant that here a diagrammatic representation seems to resolve a seemingly paradoxical relationship, push and pull at the same time, which may otherwise remain as paradoxical.

Following his insights in this set of drawings, Libeskind envisioned inclined walls for his final scheme, which he needed to drop because of budgetary reasons.

Geometry

In addition to establishing connections, another aspect of the Star that corroborates its significance and meaning is its geometry and the dynamics of its production. Libeskind’s star (Figure 63) is a distorted version of the Star of David, which consists of two
superimposed equilateral triangles whose centers of gravity overlap and which are positioned in such a way that their bases are parallel to each other while their corners perpendicular to their bases point opposite directions. Libeskind modified this geometry by stretching the two triangles along their vertical axis, which connects the opposite corners of the triangles. With this transformation, the topological relationships were kept intact while the geometric relationships were modified. Each side of the distorted Star is a segment of a line passing through two points indicating the street addresses of two historical figures. The points are not necessarily part of the Star, yet they are aligned with at least one of the sides of the Star. Notwithstanding the distortion of the original Star, Libeskind considers his Star as identical to the original. At one point in his sketchbooks, he writes, "Any triangle still retains its identity if one or two of its points are INFINITELY distant!" (Research Library, The Getty Research Institute, Los Angeles, 923061, Box 7, Sketchbook 3). Libeskind clearly spells out the fact that even though one particular triangle might go through some sort of distortion it will still retain its identity. This is interesting because Libeskind apparently is not committed to the specifics of a geometry. Rather he thinks in terms of the basics of that geometry.

The six sides of Libeskind's Star are demarcated from the rest of the Berlin city map by an increased width that shows the partial pre-war urban fabric of Berlin, which had already became invisible. In a sense, the distorted star is like a mask in which the sides of the star are cut out and rendered transparent whereas the rest kept as opaque (Figure 115). This mask, with its perforation in the form of a distorted Star, is overlaid on top of an old street map of Berlin, whose urban fabric was heavily damaged in the War. The only visible streets and buildings on the map are those that overlap with the Star. The Star, therefore, renders visible only a certain part of the Old Berlin to which the Jewish Museum is a part along with few other, still-standing buildings such as the Berlin Museum and the Mendelsohn's Metal Worker's Union Building.

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Figure 115: The superimposition of Star over Berlin [The series is created by the author. Only the last drawing is original].
Figure 117: The combination of the idea of the current invisibility of the Jews and the integrated history lines of Jews and Germans [drawn by the author].

This manipulation of components of the two diagrammatic representations and their coalescence is an example of how changes in physical representational systems trigger changes in their corresponding structured conceptualizations. The change in the conceptualization, in turn, triggered a change in the spatial configuration of the building. The superimposition of meanings, therefore, was achieved through manipulation of the physical representational systems, and changes in the conceptualization and in the spatial configuration were mediated by the structure of the diagrammatic system. The emerging representation retained its structural correspondence to both of its corresponding conceptual domains and thus acquired double meaning. If we consider each source conceptualizations as a mental model, the example above could be described as the superimposition of two mental models through analogical mapping of their respective representations.

Libeskind drew this set of diagrams (Figure 107, Figure 108) sometime during design when the zigzag had already been determined as the generic spatial configuration. This combination of ideas was not triggered by an impasse encountered in the solution space, as the conceptual shift was in the Staatsgalerie and in the First Unitarian Church project. Rather, it was elicited by an attempt to align an ongoing exploration in the problem space with an ongoing exploration in the solution space. The two explorations remained
How the Star was Drawn

To plot the Star, Libeskind used only seven addresses. These seven addresses are significant, yet even more significant, is the ability to draw other Stars of David from a number of additional possible addresses of Jews and non-Jews in Berlin. Potentially there might be numerous combinations and sets of addresses of Jews and non-Jews different than the ones Libeskind used for his Star. From all the potential sets Libeskind chose only one.

In one particular drawing (Figure 116), Libeskind seems to depict the idea above by rotating the corners of his star. What he suggests with this drawing is that within a certain radius there are potentially several possible star combinations that would connect different names, which further emphasizes the social network between Jews and Germans.

![Rotated Star Diagram]

Figure 116: Rotating the corners of the Star [sketch drawn by the author based on a Libeskind drawing].

The dynamics of the Star, as well as its mechanics, embodies Libeskind's notion of an "invisible matrix", which one can transpose to different locations in Berlin. The potential of drawing a numerous quantity of such stars indicates the infusion of Jewish figures into the city culture of Berlin and how the social cultural network was woven among Jews and non-Jews.

Libeskind's diagram indicates an interesting feature of the conceptual diagrams. The meaning of Libeskind's Star is embedded as much in the perceptual features of its components as well as in the dynamics of its realization. The particular Star that

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Libeskind drew, is only one instantiation of connections between Jewish and German figures among possible other combinations, and illustrates the level at which Germans and Jews were integrated. At a certain level, this aspect of the diagram becomes as significant as its perceptual characteristics in establishing the mediation between the design concepts, the drawings, and the building itself.

Libeskind's Star evokes several meanings at different levels. At a pure semantic level it is a symbol of the Jewish belief system. At a conceptual level within the context of the Jewish Museum, it makes visible that which is invisible, i.e., integration of the Jews and non-Jews of Berlin through their patterns of social interaction, occurring within the physical fabric of the city. At the building level, this integration is symbolized by a pair of intertwining lines, one which represents Jewish history and the other the history of Berlin. Libeskind's drawings have this characteristic of condensed meaning at different levels. According to Bernhard Schneider, Libeskind's drawings superimpose different representational systems and lines carry conceptualizations while representing the formal configuration of the project. Schneider states that in Libeskind's work:

Diagrams of relationships, which create a context of topographical lines and points, are overlaid with the lines which mark the outer edges and internal articulation of a building and which define the physical form of the same space; or they incorporate graphic signs which convey other aspects of the object such as the characterization of surfaces, thereby introducing a further dimension to the graphic vocabulary, etc...

(Schneider, 1997, p. 124)

The Star Matrix for the Jewish Museum, through its multiple layers of meaning and its plain graphical configuration, captures the essential conceptualization behind Libeskind's project. In a sense, this is a continuation of Libeskind's fascination with "radical elucidation of the original preconception of form" which leads to "true abstraction" (Libeskind, 1981, p. 81), which, according to Libeskind, does not invoke removal of meaning but isolates the structural essence. What is clear is that through diagrammatic configurations Libeskind aimed at capturing the essentials of a design situation, which might be about either its conceptual underpinnings, its formal configuration, or both. In any case, the visual elements of his star diagram abstract the core of his essential understanding of his design situation and confine the different conceptualizations into one drawing.

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Discussion

The three case studies of this thesis present three different explorations during design. In the first case study a generic model was changed during design. In the second case study a generic model was constructed through a process of progressive abstraction. In the final case study conceptualization became more elaborate during the process although this was not specifically triggered either by changes in the problem space or in the solution space. This discussion will highlight the salient features of the design process of the Jewish Museum, often in comparison to the salient features of the other two case studies. The main points of the discussion are the following:

- the nature of exploration,
- the symbolic and iconic aspects of the Star imagery,
- conceptual diagram as a type and the tokens of this type, and
- conceptual elaboration.

Nature of Exploration

Libeskind's explorations within the problem space and solution space did not follow the general outlines of Coel and Pirolli's description of design or co-evolutionary views of design. The design for the Jewish Museum started with a powerful conceptualization, like the First Unitarian Church project, and with a specific spatial scheme, like the Staatsgalerie project. In its subsequent phases, however, the Jewish Museum design process differed substantially both from the First Unitarian Church and Staatsgalerie projects. Libeskind's exploration within the problem space continued throughout the initial period of design, even though the spatial configuration was determined early in the design process in reference to an earlier project of Libeskind and the same scheme remained the design solution throughout the process.

The idea of extending the Berlin Museum with a Jewish Department fascinated Libeskind, yet it involved a difficult challenge. At the conceptual level the project challenged designers to think about the difficult history of Jews in Germany and specifically in Berlin, to think about the Jewish-German interaction, and to consider
Jewish contributions to German culture. The project required designers to consider how to make the Jewish presence visible. At a practical level this had to be translated somehow to the configuration of the Berlin Museum and the Jewish Museum, which the competition brief described as autonomous, yet linked.

At the conceptual level, Libeskind considered the historical relationship between Jews and Berlin to be a form of intermarriage. Jews contributed to Berlin through their material culture as well as through their social interaction with other citizens of Berlin. Unfortunately, this contribution is not visible in the contemporary cityscape of Berlin because their material culture was eradicated, their social interaction was restricted, and ultimately they were massacred. This creates a dilemma, because the rich and integrated history of the Jews in Berlin ended tragically, and almost no physical testimonies to this history survive. To address the conceptual challenge Libeskind emphasized the pervasive yet invisible Jewish "presence" in the city and history of Berlin.

At a more pragmatic level, the competition brief for the design of the Jewish Museum framed the dilemma in terms of the nature of the institutional as well as the physical relationship between the old Berlin Museum and the new Jewish Department. In light of this formulation, the competition urged designers to propose innovative solutions for linking the old and new buildings and for how to establish the relationship between the two so that both departments retain a certain level of integration and do not lose their autonomy. Furthermore, it required designers to deal with the issue of the missing Jewish materials in Berlin, that is, the invisibility of Jews in Berlin and in the rest of Germany. To address the practical challenge Libeskind designed the new Jewish Museum as separate from the old Berlin Museum but with its entrance in the main lobby of the Berlin Museum and connected to the Berlin Museum through a system of underground tunnels invisible from the outside.

Libeskind’s conception of the design remained relatively constant throughout the design process, even though various sources influenced his conceptualization. Libeskind established links to these sources through instantiations of the star diagram. Each instantiation of the diagram can be characterized as a move within the problem space through which new relationships to other domains were established. As such, the
conceptualization became elaborated by including layers of meaning from different domains, yet the core conceptualization remained constant. Elaborations of the conceptualization did not result in changes in the solution space either. These elaborations were generally not propagated to the solution space because, in most cases, they were in the form of substantiations of an already committed conceptualization or because they were not triggered by changes in the solution space that would have otherwise necessitated propagation of changes between the two spaces.

In terms of the nature of the exploration within the solution space, Libeskind and the design team remained within the same space as well. Throughout the whole process the team only considered closely related schemes, all of which had similar spatial configurations. As with his Star conceptualization, Libeskind elaborated on the meaning of the spatial configuration of the zigzag. The design team took the zigzag form from his project, Line of Fire. In the subsequent phases, the zigzag transformed into two crisscrossing lines, a straight line representative of the Jewish history and a zigzag line representative of the German history. The crisscrossing lines of the zigzag were derivatives of the crisscrossing lines of the star also. The emergent configuration was representative of both the star and the zigzag. Therefore, the solution space acquired two specific conceptual source domains: the visibility of the Jewish presence, embodied in the Star imagery, and the intertwined histories of Jews and Germans, embodied in the intertwining lines.

What follows from this discussion is that initially, the process of the Jewish Museum did start with a focus on problem structuring, as Goel and Pirolli (1992) suggested, yet exploration in the problem space continued throughout the design process. Second, the zigzag provided a generic design scheme, right from the beginning of design. Different from Goel and Pirolli's description the initial phases of design were not only dedicated to problem structuring but also to problem solution. This last point seems to support co-evolutionary views of design (Maher & Tang, 2003) and solution-oriented views of design (Lawson, 1999; Lloyd & Scott, 1994). In contrast to co-evolutionary views of design, however, the explorations in the problem space and the solution space remained isolated and there was no need for constant interaction between the two exploration spaces. Often the implications of moves in one space did not get propagated into the
other, as is predicted by co-evolutionary views of design. Different from solution-oriented views of design, Libeskind thought and elaborated on a conceptualization while developing a satisfactory design scheme.

Exploration in the design process of the Jewish Museum can be best described as the construction and elaboration of a design concept, along the lines of Schön’s views about the nature of design. Schön (1987) characterized design in terms of a process of making, as an alternative to the description of design as problem-solving, introduced by the information processing theory (see Akin, 1986). Different from Schön’s view, however, the exploration in the solution space was not linked to the exploration in the problem space for a long period during the design process. In this case study, as well as in the two previous case studies, construction, modification, and elaboration of concepts emerge as salient features of the initial phases of design. When concepts were constructed, modified, or elaborated in the three case studies, this was often done in response to dilemmas (the Jewish Museum), contradictory requirements (the Staatsgalerie), or an impasse (the First Unitarian Church), and resulted in problem restructuring.

Symbolic and Iconic Aspects of the Star Imagery

Perhaps the most obvious difference between the case of the Jewish Museum and the other two is the nature of the visual/spatial configuration as representative of design conceptualization. The diagrammatic conceptualization in the Jewish Museum project, i.e., the Star of David, is a symbol, whereas the diagrammatic conceptualizations in the other case studies are not symbols. Furthermore, in the case of the Jewish Museum there were numerous different instances of the conceptual diagram, whereas in the First Unitarian Church project there was only one instance and in the Staatsgalerie there were only a few instances. The former difference will be discussed in this section, and the latter will be discussed in the following section.

The case study of the Jewish Museum invokes a discussion that began with Peirce’s classic work (1992) on the classification of systems of signs. Pierce proposed three classes of signs: icons, indices, and symbols (see Chapter 2). In Pierce’s discussion, diagrams are introduced as prime examples of icons. Based on Pierce’s categorization, Johnson-Laird (2002) emphasized the structural correspondence of diagrams and
suggested a similarity between mental models and diagrams in terms of their structural correspondence to their represented domains. According to Johnson-Laird, the iconicity of diagrams makes them examples of mental models, in which representations are constructed based on the correspondence between a set of mental tokens and a set of entities in the world. The importance of Johnson-Laird's argument to this thesis is that by virtue of corresponding to a mental model (a structured conceptualization) diagrams might facilitate otherwise difficult transformations in complex conceptual domain. Also, by virtue of their correspondence to generic models of spatial configurations, diagrams might mediate the relationship between mental models and spatial configurations.

The proposition of this chapter is that Libeskind's Star imagery was a symbol, yet it was also an icon in the form of a distorted star diagram. As such, the distorted star corresponded to components of the design conceptualization as well as to some components of the spatial configuration. This duality of the Star enriched the semantics of the representation through its symbolism and at the same time opened the possibility of manipulating components of the represented domain through its structural correspondence.

Libeskind's use of the Star as the initial conceptualization enriches the meaning of his scheme within the larger context of culture. This explains Libeskind's commitment to his design concept and the power of Star Matrix for communicating his design to others. Furthermore, Libeskind attributed specific additional meanings to the components of the Star, e.g., he interpreted two lines of the Star as the intertwining lines of Jewish and German history. More important, however, is that Libeskind established a structural correspondence between the Star and two domains: problem structuring and spatial configuration. By establishing these two structural correspondences Libeskind converted the star imagery into a diagram.

The structural correspondence between the visual imagery of the Star and the two domains is not due to a convention or to an intrinsic structural correspondence such as nomic constraints. In his discussion of the differences between graphical and linguistic representations, Shintomi (2001) proposes that in a representational system the existence of nomic constraints also known as intrinsic constraints are the determining
characteristic of graphical representations (see Chapter 2). In the case of the Jewish Museum there are structural correspondences between the representation and the represented; however, the correspondence is not based on intrinsic constraints. Rather, the correspondence is constructed spontaneously, during which both the structure of the representation as well as the structure of the represented change. In a sense, the system of diagrammatic representation in the Jewish Museum project is a constructed and imposed system of iconic constraints in which the consistency of the representational system assumes coherence between the conceptual domain and the spatial configuration domain.

The diagrams studied in this thesis, especially Libeskind's diagram, illustrate a type of diagram that has not been closely investigated in the area of diagrammatic reasoning. These diagrams are from semantically rich domains where the relationships among concepts are complex and flexible, and the diagrams differ from other diagrammatic systems studied thus far. In the case of Libeskind's diagram this richness was increased when he established links through the Star to other conceptual domains. The diagrams studied in this thesis are also double-referential and can mediate the correspondence between the domain of conceptualizations and the domain of spatial configurations. These diagrams are constructed, which suggests that their configurations and the constraints operating on them can change according to emerging circumstances.

The characteristics above are important because design evolves through a dual exploration in both a problem space and a solution space, and these need to be coordinated. Furthermore, design situations often involve changing requirements and constraints, and this necessitates adjustments to conceptualizations as well as to spatial configurations. In the course of design, changes in either space need to be propagated to the other space. Conceptual diagrams coordinate the explorations in two spaces because they are intermediary representations.

The Star imagery brings together the conceptual challenge of the design and the specific requirements of the competition in one framework of understanding. Components of this conceptual understanding, i.e., the invisible presence of Jews in Berlin and their integration into the culture and with the people of Berlin, are attributed to components of the Star Matrix. The Star depicts the Jewish-German integration by linking them to each
other through the intertwining lines and portrays the Jewish presence by becoming an imaginary topographic element of Berlin. The components of the Star diagram are in turn attributed to components of the spatial configurations, e.g., the zigzag exhibition building and the series of voided spaces that slice through the exhibition spaces. Intersections of the two lines in the diagram represent times when Jewish history became unified with German history. When the two lines separate they represent times when the histories were pulled away from each other. The overall configuration, hence, depicts both the engagement and disengagement of the two histories. Through the perceptual features of the diagram the challenge identified in the conceptual domain is captured and simplified to the extent that it became manageable through manipulation of the same features. In this way the conflicting conceptual issues, i.e., the integrity of the histories and the final tragedy, are made visible and legible.

**Conceptual Diagram as a Type and the Tokens of this Type**

Different from the diagrams in the previous two case studies, in Libeskind’s drawings there is a generic, diagrammatic conceptualization, i.e., a type, and several representations of it, i.e., tokens. The distorted Star of David is the type diagram and the different stars in Libeskind’s sketchbooks are tokens of the generic abstraction. These tokens, however, are not design schemes, as was the case in the previous two case studies.

The Star Matrix, which was the final diagram in a series of stars, is a culmination of the other tokens and represents a perfected conceptualization, which was drawn for the competition as a representation drawing. Through each instantiation of the type diagram in a new context the Star brought together various threads of ideas from different sources at different times and in different contexts either as a mediator or as a connecting device. As a mediator, it first defined the transition from the individual building to the city by becoming the underlying structure that feeds into the building as well as into the city.

Second, it mediated between the realm of ideas and the realm of spatial configurations.

One potential explanation for Libeskind’s repeated efforts at conceptual elaboration may relate to the major challenge of the competition. In each instantiation of the Star, while making connections between otherwise unconnected elements, Libeskind repeatedly...
represented and made visible the importance of the Jewish culture in Germany and also in Europe.

The numerous instances of the Star diagram involve a discussion on type diagrams and their token representations. Howse et al. (2002) initiated a discussion on the distinction between type and token diagrams. They argued that, unlike sentential systems of representations, diagrammatic representations require different syntaxes for type diagrams and token diagrams. Their analysis of the two-tiered syntax of diagrammatic representation, however, needs to be extended to domains that are semantically rich.

Conceptual Elaboration

Conceptual elaboration in the design process of the Jewish Museum is an example of how manipulation of the components of diagrams can mediate changes in the corresponding conceptual and spatial configuration domains.

During the design process, at least once a significant and traceable conceptual elaboration occurred when the idea of the intertwined histories of Jews and Germans was integrated with the idea of the significance of Jewish culture for the German culture. This happened when Libeskind modified the Star of David through a series of diagrams and mutated it into two zigzagging lines with which the two conceptual ideas were connected into a single representation (Figure 107, Figure 108).

The combination of the two conceptualizations might have been triggered by the perceptual similarities between the two diagrammatic representations, the zigzag and the star (Figure 117). The matching perceptual features were: crisscrossing lines, intersections, and corners. Once the two diagrammatic representations were combined the meanings of these perceptual features were superimposed. In the final configuration each element acquired a double meaning, at once designating the invisible nature of the Jewish culture and the integrated history of Jews and Germans. Furthermore, Libeskind managed to relate the two explorations in the problem space and in the solution space thus far isolated through mutating the star into two crisscrossing lines. In the final spatial configuration, Libeskind left a void where the lines crossed, symbolic of the invisibility of the Jewish presence in contemporary Berlin.

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separate for a period in the design process. Libeskind was focused on elaborating on the design concept through variations of the star and the intertwining lines, while others in the design team explored different variations of the zigzag configuration in reference to the Line of Fire project. The initial zigzag configurations of the design team did not have the straight line of voids. Then, Libeskind converted the star into a two-line configuration, with a straight line representative of the Jewish history and a zigzag line representative of the German history. The zigzag line corresponded to the spatial configuration explored earlier in the design also and the straight line became the line of voids in the subsequent design schemes. The change in the spatial configuration suggests that at this point in the design process Libeskind managed to combine his explorations of different concepts with the other members' exploration of spatial configurations.

As discussed in the First Unitarians Church case study, the coalescence of ideas into a single representation might have strengthened the commitment of the designer. This supports the proposition introduced in the related discussion regarding the commitments of designers to their initial concepts. However, as Cross and Cross (1995) suggest, Libeskind's commitment to the initial concept definitely had an emotional component as well.

As exemplified above, changes in the conceptual domain are facilitated by ease of manipulations in the conceptual diagram. The ease of manipulation of conceptual diagrams is underscored by the fact that Libeskind considered the Star diagram to be context-neutral. He used the Star in different contexts, e.g., below ground and above ground; in different scales. e.g., as topographical elements of Europe, the city of Berlin, and the site of the Berlin Museum; and in different positions, e.g., horizontal and vertical. He thus used the Star to draw upon different ideas and create a network of meaningful associations between otherwise unrelated ideas. The diagram, or parts of its perceptual features, was transposed literally. In each instance when it was used, however, the Star retained enough of its original formal configuration as well as semantic content that it helped create a family of ideas, which, in turn, facilitated comparisons between schemes. This is true of the use of diagrams in other fields as well. The basic features of the diagram remain constant through its different instantiations, even though the specific meaning may change. In Libeskind's design exploration, through each instantiation of the
Star, enough perceptual features were kept constant that one can actually trace the evolution of the ideas, track changes, evaluate progress, and backtrack through to previous schemes.
CHAPTER 7
CONCLUSION

This dissertation introduced two questions: what do designers do in the early phases of design and how do conceptual diagrams facilitate exploration in design? With regard to the first question, the dissertation reviewed different views from studies of design cognition and from some expert architects' accounts of their design processes, namely, F.L. Wright, Le Corbusier, and Louis Kahn. These investigations were inconclusive in describing the nature of early phases of design. Furthermore, studies of design cognition have often investigated design in controlled design task environments that fall short of capturing the complexity of real design situations. Instead, the dissertation proposed that the cognitive-historical analysis method is well-suited to investigation of design and the role of conceptual diagrams. With regard to the second question, the dissertation reviewed studies of diagrams and sketches used in design and studies in diagrammatic reasoning. The studies of diagrams used in design are limited and are not detailed enough to explain the role of conceptual diagrams. In contrast, the studies of sketches used in design are ample and provide substantial evidence for the significance of sketches, especially in unstructured and serendipitous discovery, yet these studies do not clarify the differences between diagrams and sketches. In contrast to studies of sketches, diagrammatic reasoning research provides sufficient findings that suggest potential differences between sketches and diagrams. Based on diagrammatic reasoning studies and the three case studies from architectural design, the dissertation conjectured that diagrams are of special importance in the relatively more structured processes of discovery and conceptual change in design.

In this dissertation, the cognitive-historical analysis method was applied to three cases: the First Unitarian Church of Rochester by Louis Kahn, the Staatsgalerie by Stirling and Wilford Associates, and the Jewish Museum by Daniel Libeskind. The findings of the
case studies support some generic conclusions about design and some specific conclusions about architectural design.

With regard to generic conclusions, each case exposed a different trajectory of exploration and underlined a different role of conceptual diagrams. Notwithstanding the differences among the three cases, the studies emphasize the importance of one generic aspect of design: the role of concept formation. In each case study, the designer formulated a concept containing various design ideas in response to a particular design challenge and often in reference to his own earlier projects. The concept formulation in the design process of the three case studies brought together different design ideas in a structured and consistent way. This structured concept formulation established priorities and relationships among design requirements, resolved controversies, and often led to a restructuring of a design situation accompanied by a change in the initial design problem.

What is significant about this process is the importance of restructuring the design situation through concept formulation. Others have also emphasized the role of structuring in design problems, especially in the initial phases of design (Goel & Proctor, 1992; Simon, 1973) but they have not characterized structuring of design situations in terms of concept formulation. According to these researchers, design problems are ill-defined problems (Simon, 1973) and are different from well-defined problems primarily because of lack of sufficient information in the task environment. These researchers suggest that ill-defined problems are converted into well-defined problems primarily through information transfer. In contrast, what is noteworthy in the three case studies is that structuring the design situation through concept formulation was, if not more important, at least as important in the design process as information transfer. Different from information transfer, restructuring entails changing the properties and relationships of already existing elements in the task environment. This constitutes a salient difference between ill-defined problems and design situations. Restructuring in design appears to be similar to problem re-representation in insight problems (Kaplan, 1990; Knoblich, 1999), however, in design situations restructuring is accomplished through concept formulation, that often progresses through time and involves conceptual changes. In contrast, re-representation in insight problems is, rather, a sudden illumination of an understanding of a new dimension of the problem space.
One primary reason why conceptual change is a significant characteristic of design is that design situations are complex problem spaces in which requirements, the relations among requirements, vital information, and implications of design decisions unfold only over time. Furthermore, design exploration evolves in multiple spaces, and that increases the complexity of design. The case studies suggest that the formulation and manipulation of conceptual diagrams facilitate restructuring of the design situation and help align the explorations evolving within the dual design space.

The saliency of concept formulation in providing a structure to design situations is common to other design domains as well. These domains share with architectural design the unstructured nature of the initial phases of design and the dual nature of exploration. In restructuring a design situation to suit different design practices, concept formulation is likely to serve a similar purpose to that which it serves in architectural design. The formulation of concepts and conceptual relationships through diagrams, however, may differ from one design practice to another. There is a natural correspondence between configurations of diagrams and the final spatial layout of buildings because they are both spatial in nature. In design practices in which the primary object of interest is spatial, conceptual diagrams will play a similar role in aligning the dual explorations in design; in other design practices the spatial configurations of diagrams may potentially be mapped onto the primary object of interest in each particular practice in mediating the explorations within different spaces.

This dissertation contributes to the study of design by proposing a new research methodology, and it contributes to our understanding of the early phases of design and the role of conceptual diagrams. The three case studies provide a detailed account of three expert architects' early phases of design. The studies offer a resolution to the discrepancies between expert architects, who describe their early design processes as a period of "incubation," and rich historical documents, which suggest otherwise. The case studies underline the significance of conceptual diagrams as simple, yet powerful representations in design. Herein it is proposed that conceptual diagrams are double-referential, in the sense that their structure corresponds to both the structure of abstract conceptualizations and generic spatial configurations. As such, conceptual diagrams are physical models that correspond to mental models. In the three case studies the double-
referred to conceptual diagrams is found to be important because, by using conceptual diagrams, the designers simultaneously structured problems and formulated generic spatial configurations. The simultaneous structuring of the problem space and formulation of generic design schemes offers an alternative account of design. This alternative account resolves the differences between views that describe design as evolving in two distinct exploration spaces and views that suggest a unified exploration. The proposal herein is a hybrid of the two views. Finally, the cognitive-historical analysis approach provided a rich investigation of contextually embedded cases from architectural design. This dissertation benefited from the findings of design studies and studies of diagrammatic reasoning. Findings in these studies were extended by exploring the significance of conceptual diagrams and by providing an alternative account of the nature of dual exploration in design.

With regard to its specific conclusions, this research makes two conclusions: first about the nature of conceptual diagrams and second about the nature of design exploration. The first conclusion relates to the double-referentiality of conceptual diagrams. The second relates to the mediating role of conceptual diagrams during the dual exploration of design situations.

**What is the role of conceptual diagrams?**

The central question of this dissertation is whether conceptual diagrams only reflect ideas or also advance thinking. The question is not as controversial in design studies as it is in some other domains. In studies of scientific discoveries, for instance, claims regarding the significance of visual representations faced significant challenges. Recently, however, research in this area has provided strong evidence for the essential nature of visual representations in the process of scientific discovery and conceptual change (Cheng, 1996; Giere, 1999; Griesemer & Wimsatt, 1989; Nersessian, 1999).

The diagrams in the three case studies differ from the representations studied in the diagrammatic reasoning literature in that they are examples of diagrams from rich domains. Studies of diagrammatic reasoning have thus far been confined to impoverished domains, with few exceptions (see Lowe, 2000). In the three case studies of this
dissertation the conceptual diagrams were rich in meaning, bringing different ideas together in a coherent and structured way. When the ideas were contradictory the diagram resolved the contradictions, e.g., in the Staatsgalerie project and in the First Unitarian Church project. When dilemmas existed they were resolved through the diagrams as well, e.g., in the Jewish Museum project. Furthermore, the diagrams represented both the domain of spatial configurations and the domain of conceptualization, thus increasing their richness.

A second difference between conceptual diagrams and diagrams studied in diagrammatic reasoning literature relates to the nature of the correspondence between diagrammatic representations and their target domains. In conceptual diagrams the correspondence between representations and the represented is not completely governed by a priori nomic constraints as is the case for diagrammatic representations in other domains. In conceptual diagrams some of the constraints are constructed "on the fly" during the design process yet remain to act as nomic constraints. In other words, the correspondence between the diagrammatic representations and their target domains is partially constructed during the design process.

In Peirce's terminology (1991) diagrams are "icons" and as such retain a structural correspondence to their target domain. Johnson-Laird (2002), based on Peirce's definition, argues that diagrams and mental models share several properties, but foremost they both maintain a structural correspondence to their target domains. The diagrams studied in this dissertation are considered to correspond to generic mental models. Diagrammatic representations in design are akin to physical models representative of these generic mental models (Greeno, 1989). Hence, manipulations of the components of these diagrammatic representations are likely to facilitate mental animation (Hezgarty, 1995; Narayanan et al., 1995) and have implications for the corresponding mental structures.

The structure of diagrams in design simultaneously corresponds to generic models of spatial configurations and generic conceptualizations. As such, diagrams in design are iconic for the structure of both domains. More interestingly, because they represent the
two domains simultaneously, they have to align the structures of both domains. Hence, they mediate the dual exploration of design.

Through their correspondence to design conceptualizations, conceptual diagrams first help highlight the salient features of the design situation, e.g., Kahn's emphasis on the tenets of the Unitarian beliefs, Stirling's focus on the continuity of the urban fabric and the integrity of the building form, Libeskind's focus on the Jewish-German history and the invisibility of the Jewish presence in Berlin. Furthermore, conceptual diagrams establish priorities among design requirements and constraints. They help formulate relationships among the salient features and facilitate resolution of inconsistencies among these relationships: e.g., Kahn's diagram embodied both unity and differentiation.

Through establishing relationships the conceptual diagrams become concise representations of the different features of the conceptual domain. In a way, the salient features of the conceptual domain are coalesced through the diagrams, e.g., in the case of the Jewish Museum, Jewish and German histories are combined with the Jewish presence in Berlin. Stirling's diagram defined the court as both a central space for the building and a central space for the neighborhood. This is of particular importance in conveying the core of design conceptualization, especially to those who are not familiar with conventional architectural representations, e.g., Kahn's diagram and Libeskind's Star Matrix were essential in explaining their intentions to larger audiences.

Through correspondence to generic spatial configurations, conceptual diagrams define a family of design schemes, hence layering the boundaries of the solution space. In each of the diagrams seen in the three case studies the properties of the diagram that are representative of the corresponding design schemes differ in terms of content. Stirling's diagram is more spatial; Kahn's is equally spatial and conceptual; and Libeskind's is more conceptual, even metaphorical. Yet, in all three studies, the spatial configuration was generic enough to define a family of design schemes that the designers explored. In the First Unitarian Church case study the spatial ordering of the circles as well as the shape and geometric properties of the diagram remained significant to Kahn during Phase 1 of his design. In the Staatsgalerie case study the spatial relationships of the components of the diagrams were essential in establishing a satisfactory scheme. In the Jewish
Museum case study both the shape and spatial properties of the diagram corresponded to the design scheme.

What is the nature of initial phases of design?

The primary contribution of this dissertation to design studies is the detailed exposition of three authentic creative processes from architecture. The lengthy and intensive processes seen in the three cases refute those views that describe design only in terms of sudden flashes of insight or an illumination of a complete design scheme.

This dissertation began with three expert architects' accounts of their design processes. Two of these architects, Wright and Le Corbusier, each claimed that when given a design problem he let the problem incubate in his mind until he reached a complete understanding of the problem and a complete design scheme. The third architect, Kahn, suggested that design evolves smoothly from the realization of the essence of the design task to final design. These accounts suggest that design evolves in a linear and straightforward manner.

Historical documents from the works of these architects as well as others, however, suggest that architects often go through an intensive exploration of alternatives and conceptualizations. It appears that there is truth in the architects' accounts; that they often formulate a conceptualization of the design situation in its generic form, and that this conceptualization may appear as a complete understanding of the design situation and a complete configuration of a design scheme. The alternative view advanced in this dissertation is that these conceptualizations are only generic formulations of design ideas, yet as such they become powerful representations.

The three case studies illustrate different processes of design. In the First Unitarian Church case study the initial generic model was first explored through different variations and then changed. In the Staatsgalerie case study a generic conceptualization was constructed out of many variations through a process of progressive abstraction. In the Jewish Museum case study the generic imagery of the Star was used repeatedly through the design process to enrich the meaning of the design. The view proposed in this
dissertation does not preclude the existence of sudden flashes of insight in design, such as Ulrich Schaes's realization of the similarities between the Staatsgalerie and the Temple of Fortuna or Libeskind's conception of the star, which he drew on the first leper he received from the competition organizers. The dissertation suggests that design includes both more structured and less structured processes of discovery; yet, even when there are sudden flashes of insight, the insights must be enriched and elaborated through further explorations.

Researchers who have studied the design process have often characterized design in terms of exploration in both a problem space and a solution space (Akin, 1986; Goel & Pirolli, 1992; Maher & Tang, 2003). Exploration in problem space corresponds to problem structuring, by way of information transfer. Exploration in solution space, in contrast, corresponds to exploration for a sufficiently specific design scheme. The notions of dual search, problem space, and solution space were accepted in this dissertation as descriptors of the design process, with some qualifications. The notion of search, first used by Simon (Simon, 1996) to describe design, was substituted by the term exploration, as suggested by others (Maher & Tang, 2003). The use of the term exploration differentiates design from problem solving in impoverished domains. Search implies the existence of one solution (the goal state), a priori determined ways of reaching that state (means and operators), and a well-defined initial state. In exploration, however, none of these is implied. In this dissertation the focus was on how expert designers coordinated exploration in two spaces, and the way they rendered their design situations more structured so that they could become manageable. These issues were found to be related, in the sense that the answer to the second determined the nature of the answer to first.

Furthermore, the design processes seen in the three case studies required a new understanding of design. What was seen in these studies necessitated describing the design process not so much in terms of a single individual undertaking a design task but in terms of a cognitive system in which cognitive processes are distributed across agents and external representations and in which representations are generated, modified, and transferred within a structured environment (Hutchins, 1995a; Lave, 1988). These studies also underlined the situatedness of design tasks, which is why the term design situation was used in this dissertation. The situatedness of design suggests that design is
constructed during a process (Schön, 1983; Suchman, 1987) and often exploits both the 
structure of the work environment and the external representations (Lave, 1988).

Description of the design process in terms of a cognitive system is important because it 
extends the boundaries of problem space and solution space beyond the individual 
 designer's mind. In the case of the First Unitarian Church the boundaries of the 
exploration space were shaped by interventions of both the architect and the client. In the 
case of the Staatsgalerie boundaries were shaped by interventions of junior and senior 
architects. In the case study of the Jewish Museum, junior designers were solely involved 
in an exploration in the solution space, while the senior designer was involved in a 
parallel exploration within the problem space. In these case studies the commitments in 
the system were propagated through conceptual diagrams and other external 
representations.

During discussion of the case studies four alternative positions for analyzing the design 
process were referred to. The first position is Goel and Pirolli's description of design 
(1992). Goel and Pirolli suggest that problem solving starts after problem structuring; i.e., 
designers invoke extensive invention in structuring the design situation and then start 
designing. The results of their three protocol analyses substantiated their argument; each 
designer in the protocol study started the design with problem structuring. The First 
Unitarian Church and the Jewish Museum case studies appear at first to confirm this 
view, because in both cases there was a strong conceptualization that gave extensive 
structure to the design. In the case of the First Unitarian Church, however, the design 
situation needed radical restructuring. In the case of the Jewish Museum, 
conceptualization remained a constant activity throughout the design process and in the 
early phase of design the designers identified a precedent design scheme as well.

Foremost, the conceptualization in both of these cases occurred simultaneously with the 
formulation of either a generic design scheme (First Unitarian Church) or a specific 
design scheme (Jewish Museum). The case of the Staatsgalerie, however, differed from 
the first two in that design started with specific solutions; as such, it does not follow the 
outlines of Goel and Pirolli's design model.
The Staatsgalerie and the Jewish Museum case studies appear to confirm the second alternative position, which suggests that designers start with a solution (Lawson, 1979; Lloyd & Scott, 1994). These cases also support views that suggest that when design tasks are familiar enough to designers, the designers' behavior does not differ from others involved in well-defined problem solving (Entman, 1968; Simon, 1973). In the Staatsgalerie design process, however, Stirling went through occasional yet significant periods of problem structuring, suggesting that even when design tasks are familiar or when design starts with a specific scheme there may still be a need for problem structuring. In the case of the Jewish Museum, problem structuring continued throughout the design process.

A more complex version of the second position is Gross et al.'s (1987) constraint-based approach to design, which describes the initial phases not so much as an exploration for the solution, but as an exploration for a solution within a bounded space of possible solutions. According to this view, designers deal with the enormous size of the solution space by formulating constraints that limit the number of available solutions. Generic spatial configurations defined by conceptual diagrams perform the same function as the constraints in Gross et al.'s view. They also define a family of design solutions that reduces the complexity of the solution space.

The third position referred to in his dissertation is a co-evolutionary view of design (Dorst & Cross, 2001; Maher & Tang, 2003; Sewa et al., 2000), which suggests that problem structuring and solution co-evolve in a system where changes in one space are propagated into the other. Observations from the three case studies confirm the general premise of this view in the sense that at times there is a close interaction, chronologically and in content, between moves in the problem space and moves in the solution space. However, observations from the case studies highlight a significant difference from this view. Not all changes in one exploration space were or needed to be propagated to the other space; e.g., Libeskind's enrichment of the conceptual domain was not constantly propagated to the solution space. The co-evolutionary view does not differentiate between more important and less important changes in one space, hence it does not explain why certain changes are not propagated in the other space. Furthermore, this
position assumes an incremental evolution which does not leave room for radical changes in the course of design.

The fourth position comes from Schön's proposal (1988) that designers build a framework and then work within it. According to this view, design schemes and concepts are constructed dynamically in changing design situations with reference to the initial framework. Schön's view suggests an alternative to the problem solving paradigm of the information processing theory (Akin, 1986) and highlights the complexity of design situations. Analysis of the case studies supports the ideas that design is complex and that the design process is more like a process of construction, however, the studies also suggest that exploration in design sometimes evolves in two distinct spaces. In the case of the Jewish Museum, for instance, the exploration within the problem space remained parallel to and isolated from the exploration within solution space for most of the design process. Notions of problem space and solution space (Newell & Simon, 1972), hence, are helpful in describing and thinking about the process of design.

Overall, the case studies show a mixture of different strategies in design as described in the views above. This corroborates those views which suggest that designers' behavior changes according to their experience as well as according to the design situation.

The proposal of this dissertation is that the interactions between the two exploration spaces of architectural design are mediated through conceptual diagrams, and that is why these diagrams are significant. In architectural design conceptual diagrams not only represent generic conceptualizations but also generic design schemes. In the case of the First Unitarian Church Kahn managed to use a diagram to structure the design situation and create a generic spatial configuration. In the Staatsgalerie case study progressive abstraction led to a new conceptualization and identified the spatial relationships between the court and the path. In the Jewish Museum case study the combination of the lines of history and the Star imagery in a series of diagrams was followed by the addition of a series of void spaces to the initial zigzag configuration. In the three cases at times problem structuring and problem solution coalesced through the mediation of conceptual diagrams the dual exploration, however, remain disengaged afterwards, more in lines of with the view Goel and Pirelli.
Using conceptual diagrams to mediate dual exploration spaces facilitates the mapping of constraints and requirements that are defined in problem space onto spatial configurations, e.g., Kahn's concentric scheme embodies the unity and libertarian aspects of the Unitarian belief system. Through conceptual diagrams changes in either space are directly propagated to both spaces; hence, coordination is ensured throughout the design process, e.g., Libeskind's superimposition of the intertwining lines and the star, and Stirling's progressive abstractions. Finally, because conceptual diagrams evoke generic models, manipulations of the diagrams may bring significant shifts, elaborations, and changes to the exploration spaces, e.g., conceptual shift in the Staatsgalerie project and conceptual elaboration in the Jewish Museum project.

How should the initial phases of design be studied?

In addition to contributing to the fields of diagrammatic reasoning and design cognition, the research has shown that the cognitive-historical analysis approach to design studies has much to offer in the way of understanding design situations.  

The case studies point out the significance of conceptual diagrams that is used in design and in diagrammatic reasoning. This particular representation has not been studied before. This dissertation proposes new hypotheses and explanations, primarily about the nature of dual exploration in design and how that exploration is mediated through double-referential diagrammatic representations. Additional secondary propositions are formulated about the nature of design commitments, and fixation, about the differences between sketches and diagrams, and about conceptual changes.

The possibility of driving several propositions at once reflects the richness of the primary research material studied in this dissertation. Archival historical research may provide undiscovered rich material that is open to reinvestigation from multiple perspectives.

20 After adapting this approach in this thesis, I identified an earlier attempt at proposing and outlining a similar research paradigm in architecture, combining historical research and research in the area of perception and cognition (Jewitt, 1985). However, since then not much progress has been made in this area, with the exception of Rowe's Design Thinking book (Rowe, 1987).
Furthermore, reconstructions of the design process based on historical materials provide
more realistic illustrations of the evolution of design, as opposed to controlled studies
such as protocol analysis. Hence, historical research avoids the problem of ecological
validity, often cited as the major problem with protocol studies.

In this dissertation the cognitive-historical method is proposed as a research method that
complements protocol studies in design (Cross et al., 1996). Problems related to protocol
studies were discussed in detail in Chapter 2. The major problem with protocol studies is
that design tasks given to protocol participants are often simple and fall short of
representing the studied domain. The tasks also need to be completed in a short period of
time, such as in two to three hours (Dorst & Cross, 2001; Goel, 1994) or 45 minutes
(Suwa et al., 2000). Protocol studies may be more appropriate for problem solving studies
investigating well-formulated questions regarding the nature of design cognition. In
controlled settings it is possible to collect precise results, yet such results would lack
realism (Brinberg & McGrath, 1985). In a coordinated research program it is possible to
achieve a complementary relationship between cognitive-historical analysis, which would
ensure realism, and protocol studies, which would ensure precision. Through protocol
studies and controlled experiments it would be possible to investigate in more detail the
propositions offered in this dissertation.

The unit of analysis in this dissertation was conceptual diagrams that were the primary
constructs used in tracing the evolution of design ideas. This has proven to be effective.
Conceptual diagrams are material artifacts which can be transferred, changed, and
modified. As such, changes in these diagrams are easily traceable. The changes in
diagrams can point to changes in conceptualizations and ideas; this suggests that the ideas
behind these representations can be recovered. Griesemer's (1989) use of diagrams in
tracing the evolution of Weismannism in biology is a precedent for this research.
Griesemer argued that diagrams are representations through which conceptual change in
scientific communities can be traced more accurately. Others in design studies used
sketches to trace the evolution of design ideas. McGown (1998), for instance, collected
sketchbooks that had been used by students for a period of 15 weeks and analyzed the
content of the sketches to trace the evolution of design ideas.

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This research does not presuppose to construct a complete picture of the creative process nor does it propose a substitute for conventional archival research in architecture. Rather, it aims to complement other historical research. The focus of other historical research has been on designers undertaking a design task in a structured environment. This research recognizes the significance of social, cultural, professional, and economic factors in the process of creativity and discovery. However, from the perspective of methodology, because it is practically impossible to convey an all-inclusive picture of the discovery process, it is assumed that a variety of research with different areas of focus be complementary. A recently published work by Pai (2002), for instance, puts discussions of diagrams into the larger context of representational changes in modernist architecture.

Finally, the rich body of material studied in this research provides significant insight into the specifics of the work of the architects studied. The case study of the First Unitarian Church showed Kahn's resistance to his client's suggestions and the significance of this project to the formulation of his design theory. The study of the Staatsgalerie indicated how the design office used the Düsseldorf scheme in the design process of the Staatsgalerie. Others have acknowledged the link between those two projects, yet this case study further details the connection. Furthermore, it has often been cited that Stirling was keen on redrawing and modifying earlier drawings for publications at the expense of distorting chronology or past events deliberately (Girouard, 1998b). The case study, however, shows that this was not always the case. During the design process, Stirling actually used re-drawing as an essential tool to understand the variations produced by other designers in his office. In the case of Libeskind, scholars have often focused on his experimentation in Macromegas and Chamberworks and have emphasized Libeskind's formal explorations in architectural representations (Kipnis, 2000). The Jewish Museum project, however, is a case in which the drawings from the design process were semantically rich and often representative of different metaphors that Libeskind was drawing upon.

There are various potential future studies that might be based on the findings and propositions of this research. The first study would be to further these propositions through additional archival research focused either on one of the architects studied, to advance a detailed understanding of the use and origins of diagrams, or on other
architects, for cross comparison. The second study would be to pursue a purely historical research, either to put the case studies into a larger context and study additional important factors in the design process or to study major shifts in representational systems in architectural history from the perspective of design cognition (see Evans, 1995, 1997; Hersey, 2000, Pérez-Gómez & Pelletier, 1997). A third study would be research that formulates well-defined, small scale, question-specific design tasks and related tasks to test specific hypotheses about the nature of the propositions advanced herein. A fourth study might relate to how conceptual diagrams are used in architectural education in order to foster conceptual understanding. The implications of this study for advancing design tools or for designing computational models might also be studied. A final category of research would be to study the pervasiveness of conceptual diagrams in other domains of design and reasoning.

This dissertation has been an attempt to address some issues related to the central question of how meaning is induced in the spatial configurations of buildings. Its results underline the cerebral tature of architecture which distinguishes it from other practices related to buildings and the built environment.
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