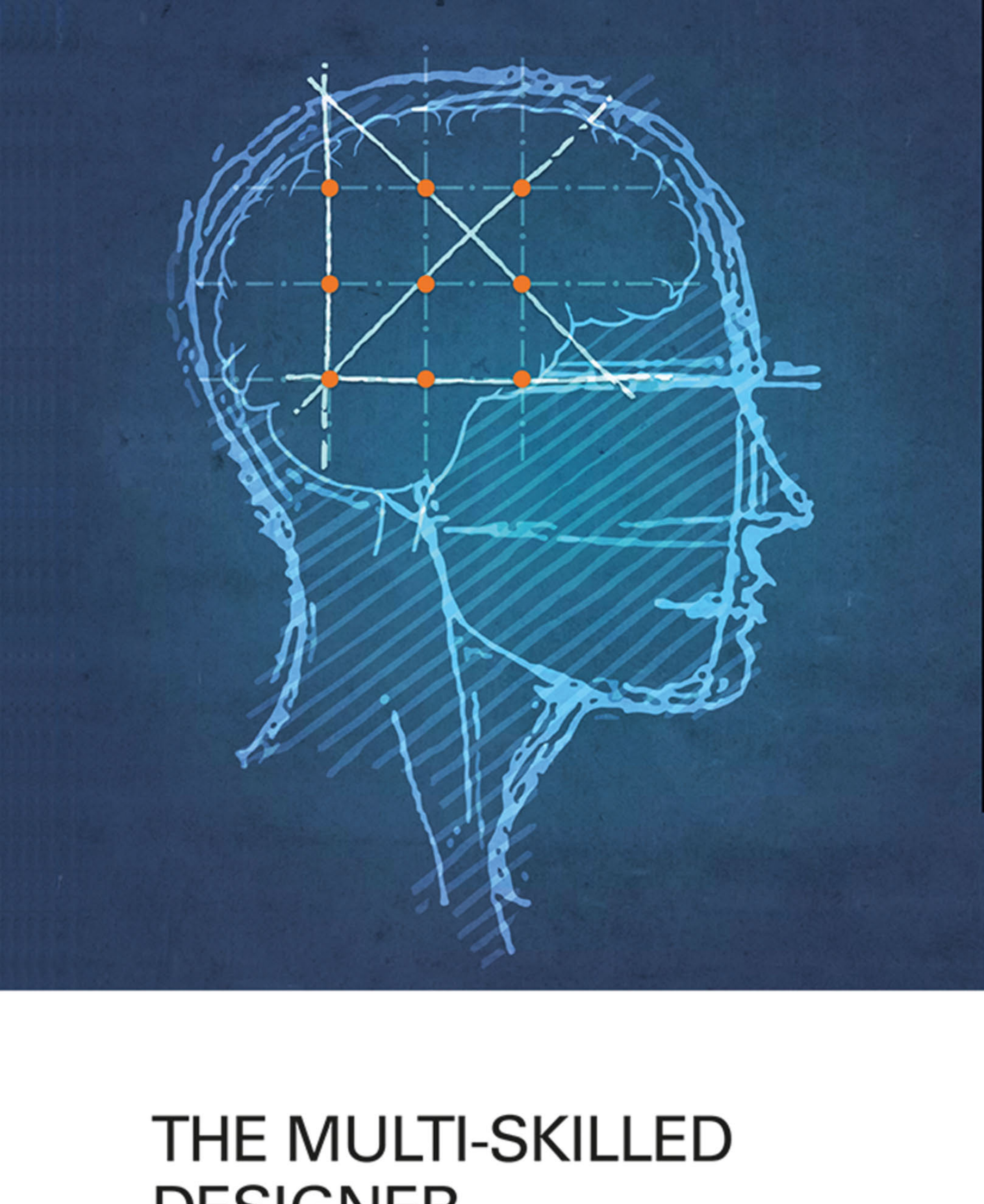

ROUTLEDGE RESEARCH IN ARCHITECTURE

THE MULTI-SKILLED DESIGNER

A Cognitive Foundation for Inclusive Architectural Thinking

NEWTON D'SOUZA

ROUTLEDGE

The Multi-Skilled Designer

The Multi-Skilled Designer presents and analyzes diverse approaches to contemporary architectural design and interprets them through the theory of multiple intelligences. The book establishes a systematic framework that uses the lens of cognitive psychology and developments in psychometric and brain research to analyze the unique cognitive thought processes of architectural designers and compiles design projects that could serve as a pedagogical companion for the reader. The book is aimed at design practitioners and students interested in examining their own thinking styles as well as those involved in design cognition research.

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A Cognitive Foundation for Inclusive Architectural Thinking

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To my parents, for giving me the gift of education

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1 The multi-skilled designer

Introduction

Nearly 20 years ago, I left behind a position with a burgeoning architectural firm and returned to graduate school out of an earnest yearning to explore better ways of design. Dissatisfied with my own design process and quickly on my way to becoming a young burnout, I found myself seeking answers to essential questions of design. *What do designers really do? What are the attributes of a good designer? How do designers achieve their highest creative potential?* What began initially as a quest for better ways of designing, which sometimes lead beyond design, took me to the realization that I was missing *the* central question. This central question, one that seems deceptively simple as posed by one of my graduate school professors and yet is anything but, is: *Ultimately, what is design?*

Even as an undergraduate design student, I have been long interested in the intellectual epiphany that a designer experiences in design conceptualization. Figure 1.1 is a sketch of mine during those years for a design proposal for a Center for Oceanography, one that a jury member commented as being "sketchy" and not developed enough. It was true that I enjoyed conceptualizing design projects more than the grind of "well-developed" solutions. As designers, it is an experience none too familiar when confronted with a new design project that we encounter a feeling of "stuckness" (a mental block of feeling stuck in the middle of design process), whether due to lack of information, uncertainty of how to proceed, or simply feeling lost from information overload.[1] If and when design ideas emerge, it is usually at the threat of an impending deadline, at which time we launch into a flurry of design ideations. During these initial stages, I often found myself venturing into new creative realms – which partly explains the "sketchy" forms during my jury reviews. I often wondered whether and how I could be more efficient and disciplined in my conceptual thinking. My pursuit of design thinking as graduate student was therefore, in part, motivated by my desire to investigate better ways of thinking about design and, ultimately, optimize my design process.

When I first began this quest, the extant literature on design process and psychological attributes of design were loosely compiled under the area of

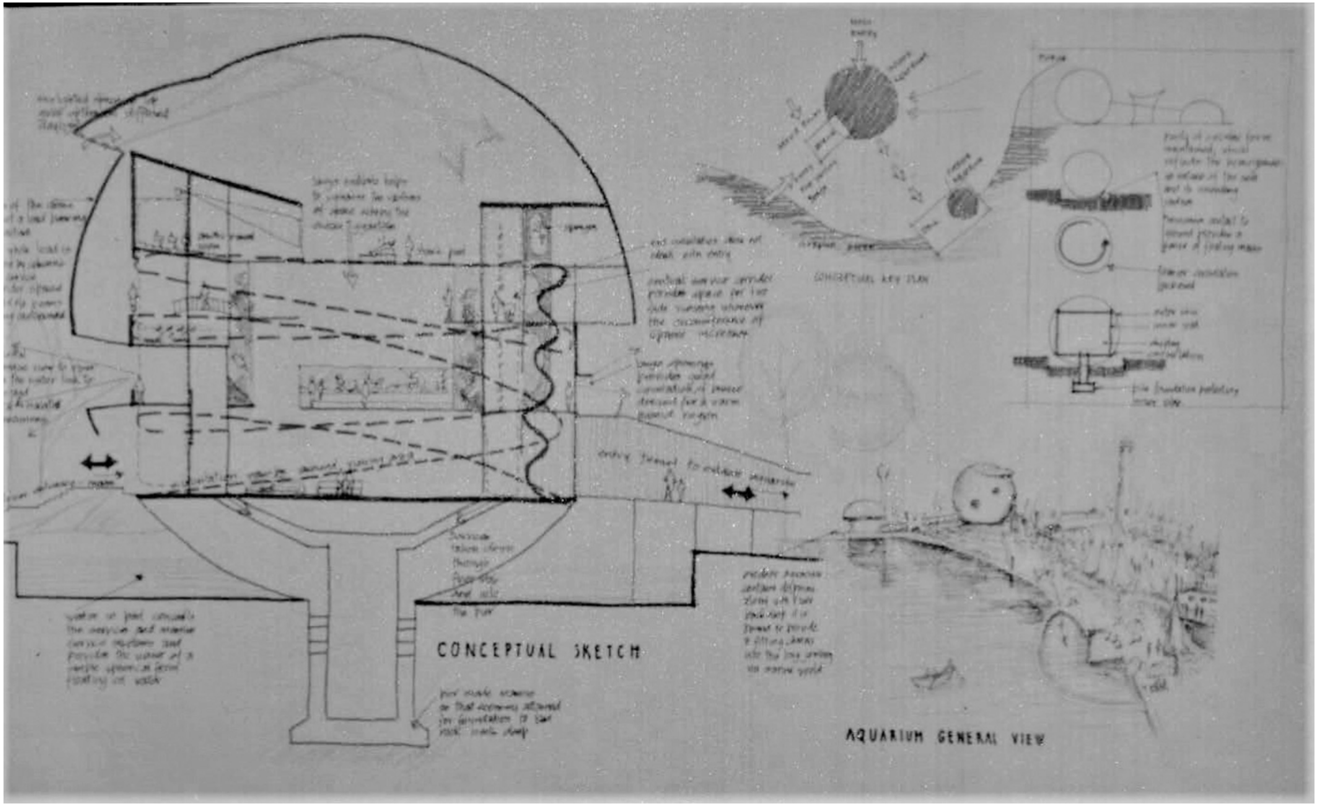

Figure 1.1 Author's thesis proposal for a Center for Oceanography (1993) that the reviewers found too "sketchy"

design cognition, which involves how designers think and solve problems. As my interest in design thinking endured, I decided not to return to my design practice as originally planned but instead continued in the pursuit of this research inquiry, which expanded to several other domains, including architectural theory, cognitive psychology, design computation, and environment-behavior, among others. This book is an attempt to synthesize these different strands of design thinking – drawing on an academic perspective but also reflecting on my own tacit experiences as both a practicing architect and interior designer.

Indeed, the world of design is changing dramatically due to advances in technology and the distributed nature of practice. For instance, speaking from personal experience, I was schooled in the modernist paradigm, practiced in the post-modernist paradigm, and currently teach in a parametric era. However, some of the questions raised by this book are fundamental to the way we learn, teach, and communicate design. In the current era of design described in terms of "blobs" and "force fields," we might wonder whether past compositional sensitivities are becoming obsolete. Have design skills changed so radically that we need to rethink how design is taught and learned? In the face of ever-changing systems of paradigms, it is a daunting task to maintain a strong foothold on time-honored design principles, much less conceive of a set of design skills to apply or teach. However, it is a critical point of departure that only reinforces my belief that designers today need multiple skillsets to negotiate the complex design issues emerging in this 21st-century design context. Design problems of today vary far too greatly – in terms of their content, scale, and complexity and demand a repertoire of mental representations (e.g., spatial visualization, problem-solving, verbal skills, communication skills, interpersonal skills) – to be limited by notions of paradigm and associated skillsets.

In making a case for the multi-skilled designer, this book explores design skills, the processes by which design skills are implemented, and the extent to which these skills can be described within current design works. By "design skills," I mean those skills that are most relevant to design. I first proposed a multiple skills framework in my doctoral dissertation entitled *Design Intelligence: A Case for Multiple Intelligences in Design*, which was based on ideas popularized by cognitive psychologist Howard Gardner. Gardner's multiple intelligences framework consists of eight forms of intelligences: verbal/linguistic, logical/mathematical, spatial, bodily-kinesthetic, musical, interpersonal, intrapersonal, and naturalistic intelligences. The conclusion of my dissertation was that architectural designers were more likely than other disciplines to use all their design skills in some threshold capacity, although they excelled in specific disciplinary skills (such as spatial skills). However, I also concluded that merely possessing multiple skills in design is insufficient. Designers need to blend these skills meaningfully in order to successfully and consistently apply them to design problems. Ultimately, I found that both the conception and application of design skills must be conducted in a situated and dynamic manner, rather than universally applied.

This book is the culmination of the lessons learned during my studies of architectural pedagogy, through my 18 years of teaching experience as a design professor, and through vibrant discussions and interactions with my professional practice colleagues. The book is structured to benefit a variety of audiences at different levels. The primary audience are those involved in design cognition research, an area that overlaps with the psychology of design thinking, and includes practitioners of design, design theorists, computer scientists interested in design, and neuroscientists interested in how the design mind works. While the book is presented as a cognitive-historical project, it might also be used by design practitioners and students interested in examining their own thinking styles. Although the examples are mostly derived from architectural discourse, the book can be useful to a wide continuum of design disciplines, including architecture, interior, design, urban design, and industrial/product design.

The theoretical contributions of the book are: first, to provide a cognitive explanation for multiple approaches in architecture design thinking; second, to describe attributes of specific design skills; third, to outline how these skills function in a design process; and, fourth, to outline its practical and pedagogical implications. The goal of the book is not to debate how design ought to be performed but to understand how specific skills might make specific designs possible – hence, the book does not intend to make value judgments on specific paradigms, such as modernist versus parametric styles of thinking. Rather, the paradigms used here are intended to provide context as to why certain skills might be disposed to those ways of thinking. In a sense, this book could also be used as a self-diagnostic tool to examine one's own skills. For example, a designer with a limited skillset might want to expand his/her repertoire of skills or sharpen the skills s/he does have. Furthermore, increasing self-awareness of our own skills not only helps us to better understand and move ourselves along in the design process but lends to our ability to empathize with other designs' strengths and weaknesses. In this respect, it should be no surprise that the multiple intelligences framework is often used as a career-advising tool in educational circles and may have some utility for careers in design as well.[2]

Hence, the goals of the book are:

- To establish a systematic framework that uses the lens of cognitive psychology and developments in psychometric and brain research to analyze the unique cognitive thought processes of architectural designers;
- To highlight skills diversity demonstrated in unique design approaches using examples from iconic design work as well as alternative practices;
- To compile design projects that could serve as a pedagogical companion for design studio instructors, design reviewers, practitioners, and students;

- To synthesize literature from architectural theory, practice, and design cognition;
- To explain tacit design processes from an architectural practitioner's point of view.

Using the multiple intelligences framework as a broad template, the book explores archival resources and documentation of practicing architects not typically captured in popular magazines or mainstream design discourse. Examples include iconic design works but also alternative design practices. The use of iconic design works familiar to the larger design community provide an anchor to start the conversation on multiple intelligences in design. On the other hand, alternative design practices, although less frequently discussed in the design literature, are essential to making the area of design cognition inclusive. Lauri Baker, for instance, designed spaces using local wisdom, cost-effective strategies, community stewardship, and local craftsman culture, among other elements.

In a way, the book is also a cathartic exercise. As I elaborate on multiple skills – some of which are not necessarily strengths of mine – they provide me with multiple vantage points from which to examine the design process, nevertheless. The intention is to identify, describe, and present a matrix of individual approaches so practitioners and educators can appreciate the validity of each in their own right.

In order to understand the scope of the book, it is also worth mentioning what the book *is* not. While the book identifies design styles, it is not about styles. Indeed, each designer featured operates under different design paradigms, and I deliberately highlight their individual biases to demonstrate certain tendencies of architects toward design. However, the intention is not to pigeonhole individual architects based on these biases nor to make an argument as to why we should favor some designers over the others. Instead, different styles are highlighted to make the case that the practice of architecture can be approached in a variety of ways.

The book is also more about the process of architecture and less about the products of design. Whether sound processes lead to sound products is certainly debatable, but one can identify a certain level of consistency and a dominant way of thinking in each designer's body of work, which itself implies a certain successful method of doing design. Additionally, since the focus is on the conceptual design process, rather than the product itself, no illustrations of finished design products are presented in this book. The focus is instead on design representations manifested when a building is merely a seed in the designer's mind.

This book is largely about how designers think – or, more importantly, it is a speculation into why they think the way they do. In recent years, considerable interest has been generated in design thinking, deriving from cognition, neuroscience, design computation, and Artificial Intelligence in design. Although domains outside of design have provided substantial insight into design thinking, these insights have often been fragmented and riddled with misperceptions about the domain of design. For instance, professional architects attending conferences on design computation have complained about how simplistically the architectural domain is presented and perceived at these conferences. Intrigued by this same issue, I attempt to highlight the complexity of the architect's mind in hopes of opening up the possibilities for discussion and transfer between related domains. In essence, I propose a multiple intelligences view of architectural design – one that is inclusive of various modes of thinking.

Navigating the book

In making a case for the multi-skilled designer, the introductory chapter outlines the author's journey in writing the book and lays a road map for navigating the chapters. It makes a case for valuing the practice of multiple skills among designers in order to nurture diversity in design thought, empathize with variations in individual strengths, and implement diagnostic tools for design thinking. The multiple intelligences framework from cognitive psychology is introduced as an explanatory framework for skill diversity in design.

The second chapter introduces the subject of design cognition and its relevance to archival and empirical studies conducted on design thinking. It contextualizes design thinking in terms of the unique nature of design problems, design creativity, design representations, digital technology, and collaborative design thinking.

The third chapter outlines the measurement and mapping of design skills using psychometric and neuroscience literature. The terminology of design skill is clarified in the context of cognitive-historical research in design. A rationale for multiple intelligences framework is presented along with a methodology to measure multiple skills in design.

The next eight chapters elaborate on specific skill categories in the context of architectural design (intrapersonal, interpersonal, suprapersonal, bodily-kinesthetic, naturalistic, spatial, linguistic, and logical-mathematical). Each chapter begins with a description of the specific design skill, followed by selective documentation demonstrating the practice of these skills in the works of iconic designers and alternative practitioners. The accompanying illustrations of work are not intended to represent a comprehensive catalog of the designer's body of work but instead to provide insight into particular processes used. The illustrations are also selected with a focus on the conceptual process rather than the end-product.

The fourth, fifth, and sixth chapters respectively address intrapersonal skills (involving personal emotions, as demonstrated by designers Daniel Libeskind and Peter Zumthor), interpersonal skills (empathizing with emotions of others, as demonstrated by designers Alejandro Aravena and university-based design centers), and suprapersonal skills (involving transcendental emotions, as demonstrated by designers Louis Kahn and Zaha Hadid).

The seventh and eight chapters address bodily-kinesthetic skills (visualizing or experiencing the movement of body in relation to the external environment, as demonstrated by designers Steven Holl and Herman Herzberger) and naturalistic skills (visualizing and experiencing nature and natural phenomenon, as demonstrated by designers such as Geoffrey Bawa and Chris Cornelius).

The ninth and tenth chapters address spatial skills (involving the ability to transform or modify one's own perceptions via mental imagery, as demonstrated by designers such as Frank Lloyd Wright and Tadao Ando) and linguistic/verbal skills (involving the ability to use language effectively or expressively to articulate design ideas, as demonstrated by designers Bernard Tschumi and Maya Lin).

The eleventh chapter addresses logical-mathematical skills (involving rational and systematic approaches to design, as demonstrated by designers Le Corbusier and Greg Lynn).

Presenting a taxonomy of multiple approaches, the concluding chapter presents an explanatory framework to evaluate individual approaches in design. Making sense of different designers and their skill affiliations/epistemologies, it describes the application of multiple skills in the context of Domain-Individual-Field Interaction model, the reciprocal priority of skill usage, and the conceptual blending of skills. The metaphor of ensemble is used to understand how multiple skills can be recombined in meaningful ways and allow for unique/creative design products. The chapter concludes by outlining the implications of multiple skills to practice, teach, and research.

Cognitive explanations of multiplicity

But first, let us consider a conceptual sketch by Steven Holl for the Nelson-Atkins Museum of Art (Figure 1.2). This sketch exemplifies the multiple ways of thinking in which designers often engage. I will demonstrate how multiple skillsets are employed by identifying the various mental representations used in this sketch. Holl creates an experiential architecture that unfolds as it is perceived through each individual visitor's movement through space and time. It presents a fusion of light, art, architecture, and landscape, experienced from various levels and from inside to outside.[3] In this sketch, one can observe the use of suprapersonal thinking (revealed in the ethereal character of light moving through glass lenses), kinesthetic thinking (how the bodily orientations and cone of visions are designed for changing views), as well as spatial thinking (demonstrated through the contrasting arrangement of spaces). Note that these multiple thoughts are intricately woven in the sketch, one informing the other, as Donald Schön describes, as almost in a designer's reflective conversation.[4]

Similarly, in a prior paper, I have indicated the use of multiple skillsets in the Fukuoka Bank design sketch by architect Kisho Kurokawa.[5] The bank rests on a slope, incorporating a semi-covered plaza enclosed by the

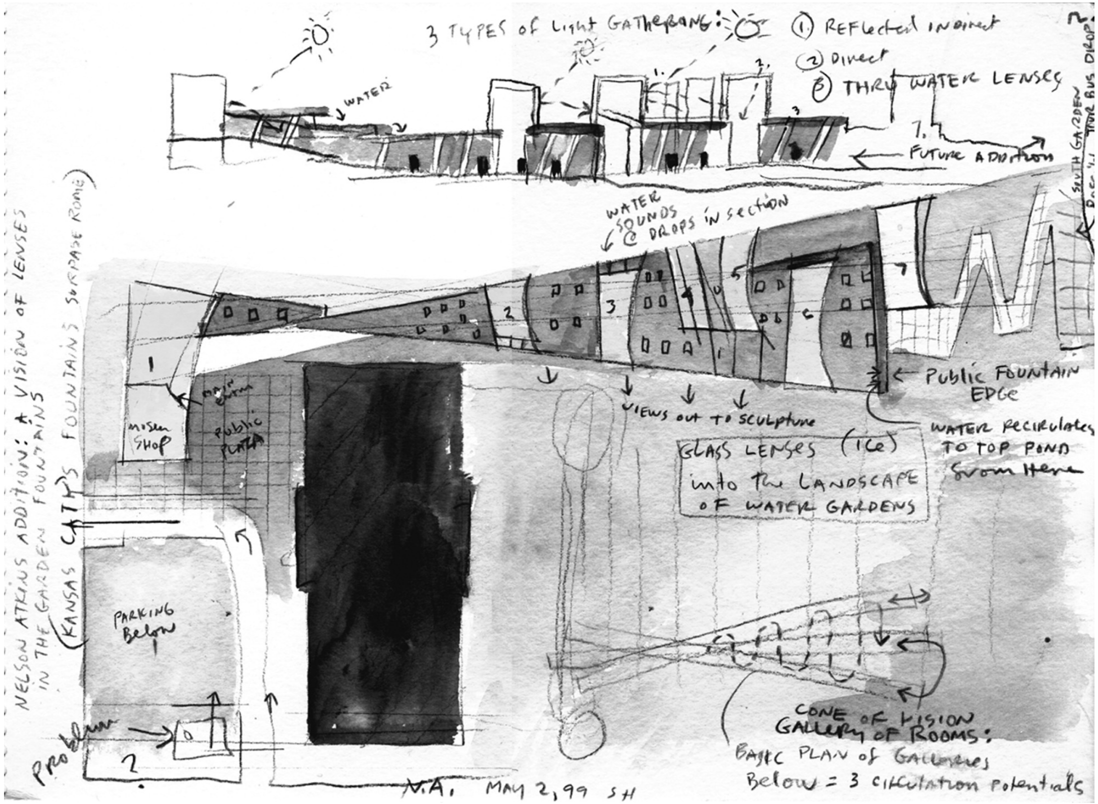

Figure 1.2 Steven Holl's concept sketches for Nelson-Atkins Museum of Art addition

Source: Steven Holl Architects

L-shaped parti of the bank and the large overhang on the ninth floor. This enclosure creates an intermediate space by merging private and public zones, functioning as an urban public space. Spatial thinking is represented through the application of spatial transition (open to close, large to small, etc.), while interpersonal thinking can be noted through the sensitivity to human behavior, namely the building as a refuge for urban workers (denoted by the words urban roof, public). Lastly, logical thinking is observed through the "putting-together" of the building in both plan and section in overlapping representations, which also indicate zoning and dimensions.

The above examples demonstrate only a small part of the cognitive process of a designer, and owing to the richness of these representations, it is easier to distinguish the presence of diverse set of skills. However, can we find evidence among other designers, who perhaps conduct similar mental operations but do not necessarily document it or resort to any explicit depictions? It might require more effort, but it is certainly possible because the complex design tasks of today require that individuals possess a wide array of skills. It should come as no surprise that we would find the use of multiple skills in much of contemporary work.

The idea of the multi-skilled designer is not new in design practice. In the time of Vitruvius, architecture was shaped by designers in the role of *master-builders*, who dealt with architectural design from the conceptual stage to construction. Vitruvius suggested that an architect must strive to be generally well informed in all the arts but "cannot hope to excel in each." In the preface of his *Ten Books on Architecture*, dating back to 1st century BCE, Vitruvius suggested that architects develop a generalized skillset, in the erstwhile role of master builders:

> An architect should be a good writer, a skillful draftsman, versed in geometry and optics, expert at figures, acquainted with history, informed on the principles of natural and moral philosophy, somewhat of a musician, not ignorant of the law and of physics, nor of the motions, laws, and relations to each other, of the heavenly bodies. … Those unto whom nature has been so bountiful that they are at once geometricians, astronomers, musicians, and skilled in many other arts, go beyond what is required of the architect, and may be properly called polymaths, in the extended sense of that word. Men so gifted, discriminate acutely, and are rare. … Since few men are thus gifted, an architect who must strive to be generally well informed in all the arts cannot hope to excel in each. Therefore, I beseech you, O Caesar, and those who read this my work, to pardon and overlook grammatical errors; for I write neither as an accomplished philosopher, an eloquent rhetorician, nor an expert grammarian, but as an architect.[6]

Vitruvius' conception of the architect aligns with mid-century views. For instance, as architect Buckminster Fuller once suggested, "a designer is an emerging synthesis of artist, inventor, mechanic, objective economist and evolutionary strategist."[7] Donald Mackinnon, a famous psychologist on creativity who undertook one of the most vigorous creative examinations of architects, found that architects generally share the characteristics of creative people and demonstrate multifarious expressions of creativity (i.e., "an effective architect must, with the skill of a juggler, combine, reconcile, and exercise the diverse skills of a businessman, lawyer, artist, engineer, and advertising man, as well as those of author and journalist, psychiatrist, educator and psychologist").[8] In a personal communication with architect James Cutler, he commented, "architecture is the last generalist professions."[9] Despite rapid growth of specializations, many architects in the US maintain that they are "generalists." Today, this means that architects try to reconcile the dispersed knowledge of many specialized designers.[10] Given all of this, we might conclude that the designer today is analogous to a decathlete, one who need not specialize in a particular track and field event but must perform consistently in a diverse set of events.

According to Barrow, the master-builder concept has reemerged in current day practice, albeit in a different way.[11] Although, in the early 20th century, there was proliferation of specialists such as engineers and design consultants for interiors, lighting, acoustics, fire prevention, code compliance, sustainability, etc., Barrow contends that the master-builder concept has re-emerged in the form of a dynamically networked team of design and consultants in the architectural design process. As building design and construction have increased in complexity (e.g., multiple materials, products, and project participants to coordinate), designers are often expected to accomplish their work in shorter timeframes. The challenge of integrative project leadership has become more demanding. Consequently, designers increasingly fall back into the role of a master-builder, perhaps as an "integrator" of various skills and knowledge.

Technological advancements are also making the need for integration even more immediate. For instance, Computer Aided Three-Dimensional Interactive Application (CATIA), which is a multi-platform software suite consisting of computer aided design, manufacturing, and engineering, is now serving as a place where many different kinds of knowledge meet, as well as where the details of construction are discussed by different consultants.[12] For example, Loukissas describes how the architectural firm Ralph Jerome skillfully used CATIA digital platforms to bring the architect closer to the craftsperson who actually handles the materials of construction. The affordances provided by digital technology facilitate the "techie-enabled architect" who has the potential to crystallize a new kind of integration among members of the firm and external contractors.[13]

In their book *The Digital Turn in Architecture*, Hight, Perry, and Morel observe that the alchemy of collaboration does not blend the voices of the collaborators together to produce a single voice but rather proliferates their voices to create the chorus of a multitude.[14] Providing examples of firms, such as Open Source Architecture (OSA), they observe that in fact the models of distributed exchange and productions are reconfiguring the design offices of today by recasting practice as an international, intergeographic, inter-institutional, design-based file-sharing community. They observe that, collective intelligence requires a transdisciplinary approach to the built environment and a robust interaction between various disciplines, such as architectural design, interaction and information design, product design, sound design, software and interface design, motion graphic and typography design, set and exhibition design, and lighting design.

In summary, to consider multiple skillsets is to recognize the presence of individual differences, representations, and approaches in design. This allows a shift from an emphasis on graphical and formal logic skills (which to some extent produces the same type of design students or designers) to an emphasis on other equally valid skills, such as interpersonal communication, and situational problem-solving skills – all of which are critical in the 21st-century design context. Studying multiple approaches in design not only celebrates diversity in representations but also highlights vital design skills and how they manifest within the design process. Moreover, given today's multicultural design practice scenarios, multiple approaches are even more critical. In his address at the American Institute of Architects (AIA) 2016, the famed Dutch architect Rem Koolhaas affirmed this view as he said:

> We're working in a world where so many different cultures are operating at the same time, each with their own value system. . . . If you want to be relevant, you need to be open to an enormous multiplicity of values, interpretations, and readings.[15]

This book proposes that it is important to recognize multiple skills among designers in order to value and nurture diversity in design thought, empathize with variations to be found in individual strengths, and implement diverse tools to evaluate different areas of design thinking. This makes the conception and evaluation of design problems much more inclusive and helps us to better understand that architectural design problems can be solved in a variety of ways, thereby through alternative viewpoints. Studying individual differences may not lead to a resolution of differences but helps us account for diversity in representations and approaches: whether designers use certain skills more frequently; whether certain skills could be taught more effectively; and whether sufficient research is available on specific aspects of designing.

As we come to understand design as a composite of different approaches, we can develop more inclusive ways of thinking about design. In practice, design ideas may not be clearly communicated when there is a lack of awareness or an unwillingness to understand individual differences. This ultimately hampers communication in cases where collaboration is required. Ultimately, increased awareness of and empathy toward different approaches may improve communication and decision-making.

The Multiple Intelligences (MI) framework, first proposed by cognitive psychologist Howard Gardner, assumes the existence of diverse intelligences and suggests that individual mastery over specific domains can be attributed to individual mastery over specific forms of intelligences.[16] According to Gardner, everyone is intelligent in a variety of ways and can develop each aspect of intelligence to at least an average level of competency. Not only do individuals possess numerous mental representations and intellectual languages, but they also differ from one another in the forms of these representations, their relative strengths, and the ways in which these representations can be changed. The multiple intelligences framework is used in this book insofar as it helps to identify the differing nature of individual body of design work and the context in which these works function. It also provides methodologies for studying the complexity of the design process in a systematic way.

Design literature has provided us with numerous resources to understand design thinking in variety of ways, either through the documentation of design philosophies and normative theories (e.g., modernist, postmodernist), design guidelines (e.g., typological, behavioral), or archival sources (e.g., drawings and writings of designers). However, it is limiting to create normative models without incorporating explanatory theories of design thinking, i.e., on how designers actually accumulate information, solve problems, and create solutions, as well as the skills needed to do so.

Part of the difficulty in constructing theories of design thinking is that designers do not necessarily keep a paper trail of their entire process, so much is lost in the tacit nature of practice. Moreover, design projects are not exhaustively discussed but are instead fragmented and dispersed throughout professional organizations around the world. Much of the documentation that does exist comes from anecdotal writing of architects, which may or may not convey the cognitive aspects involved in the design process. Nonetheless, recent publications have begun to explore explanatory theories of design thinking through archival and empirical studies of design cognition. For example, Lawson utilized archival evidence and cognitive interpretations to analyze the design works of eleven distinguished architects.[17] Mallgrave used historical literature from neuroscience and creativity to make associations between brain faculty and architectural ways of thinking.[18] Even the classic work *Design Thinking* by Peter Rowe focused on the situational logic and decision-making processes of designers, with most of the concepts reflecting the self-examination of the status of architectural inquiry in and of itself.[19]

This book will contribute to this body of knowledge by examining iconic design works and alternative approaches and interpreting them through the multiple intelligences framework. Ultimately, the goal of the book is to counter the emphasis on traditionally dominant approaches in design, such as spatial and form-making skills, by bringing attention to approaches that have been neglected in architectural discourse, such as interpersonal, kinesthetic, and narrative approaches.

Notes

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2 Design cognition

Ultimately, what is design?

I would like to begin by posing the same question that my graduate school professor once asked me decades ago: *Ultimately, what is design?*

Design has been described in many ways, ranging from a problem-solving activity[1] to a very complicated act of faith.[2] In order to understand what exactly constitutes design, perhaps we need to begin by clarifying what falls outside the limits of design. Cross suggests that, although professional designers are expected to have highly developed design abilities, even non-designers demonstrate some aspects or lower levels of design ability. For example, common folk of craft-based societies have created objects that are not only highly practical but also very beautiful.[3] They would therefore seem to possess high levels of design ability, which Christopher Alexander has referred to as "unconscious design," as opposed to a conscious design performed by a trained designer.[4]

In the debate over what is design, it is also useful to ask what constitutes "design proper," or the core of design, as its boundaries are less than clear. Schermer describes a continuum of design activities that start with pre-design activities, such as scenario planning (strategic activity) and programming (tactical activity), and end with post-design activities, such as post-occupancy evaluation.[5] Farbstein and Kantrowitz suggests that while a "hard dry ground" job description of an architect is clearly defined, design is ambiguous and functions more like a "swamp" with boundaries less delineated. Design is increasingly being viewed as a multidimensional, information-based activity that may start with initial feasibility study but continues through occupancy, perhaps even through the entire lifecycle of a building.[6]

While the definitions of design are certainly complex, the domain of design cognition sheds light on how designers think and to some extent how they define design and where they draw the line. According to Chiu-Shui Chan, cognition is the process of perceiving, receiving, analyzing, soring, retrieving, and utilizing information, and skillful designers have way of solving design problems that produce beautiful forms.[7] This may involve mental processes, such as strategy, methodology, reasoning, logic, and representation, which span the entire thinking process completion of the design. Design thinking is hence different from other thinking processes that are applied to solving problems of accounting, finances, statistics, software engineering, and medicine.[8]

In the scope of this book, I bring specific attention to the conceptual phase of design cognition, assuming most cognitive evidence is available. "Conceptual design" is the early phase of design ideation, where the designer lays out the initial parti through sketching, study models, or even programming and research applications, as compared to more detailed design development. Heylighen and Martin observe that during the design process, designers try to find a concept that will give meaning to their design.[9] Even with incomplete information, designers adeptly form concepts based on highly personal sensations, which they use to guide their decision-making throughout the design process. Heylighen and Martin also chart the phases of conceptual design, such as comprehension of the problem (program), representation of the problem (space), inductive reasoning (fuzzy concept), and deductive reasoning (precedent). In particular, they highlight the importance of the designer's "gazing point," which is a unique way of choosing to examine a problem informed by personal experience and memories.

Attempts to build explanatory theories about design cognition is hence challenging because of the complexity of design activities. Material related to design cognition is dispersed and fragmented throughout the writings of architectural practitioners, psychological studies conducted on architectural designers, as well as in writings on the worldviews that have influenced architectural design. For example, design cognition is addressed implicitly within studies that have examined personality traits of architects,[10] studies conducted on design process and methods[11] or the nature of design,[12] and writings from well-known architectural practitioners.[13] Furthermore, studies in design thinking literature have also been influenced by epistemological and theoretical discussions in philosophy and social sciences[14] and normative theories of design.[15]

Initial reflections on design thinking emerged with the functionalist movement of the 1930s. It was believed that tradition and intuition were able to generate successful designs in the past because the problems of the past were simple.[16] Armed with a new scientific outlook toward design, however, the functionalists argued that tangible tools and description of the design process were necessary to counter the disorder and irrationality associated with traditional architecture. Functionalists, such as Corbusier, asserted the primacy of design rules to emphasize the machine-like functioning buildings.[17]

With the advances of functionalism and technology came the advent of the "design methods movement" that advanced planned decision-making and replaced the ancient process of trial and error as well as unconscious design. The emphasis was on efficiency and the belief that design problems could be quantifiable in stage phase models such as analysis, synthesis, and evaluation. Another line of inquiry that influenced design during this time was cybernetics and systems theory. Here, design problems were seen as an organization or system rather than individual components.[18] In architectural design, Alexander (1964) and later Bijl (1989) have given much attention to systems theory and explored implications to design inquiry.[19]

While the aforementioned approaches sought to break down the complexity of design into quantifiable logic and functional aspects, the organic style, mainly propagated by the works of Frank Lloyd Wright, propelled the rigid functionalist dictum of "form follows function" into a new philosophy that considered form and function as one.[20] There was also a renewed attention given to the complexity of architectural spaces. For instance, Rowe and Slutzky showed much interest in visual ambiguity and inverted spatial effects that were influenced by the gestalt studies of visual perception.[21] Subsequent research by Schön also showed that spatial gestalts are an important part of the design process.[22]

Other design researchers have understood design as a form of language or discourse consisting of a definitive underlying structure.[23] This notion of an underlying structure, with elements that must be combined through geometric and visual logic, was first promoted by linguists such as Chomsky, whose work became a basis for formal rules.[24] Other linguists such as Barthes and Eco have suggested that design has a formal structure (syntactic and semantic) much like any other language.[25] Language narration has also been used as an analogy in design[26] or to bring a fictive quality to design inquiry.[27] Dong has advocated a view of the role of language in design as one of "becoming" design, rather than one as "facilitating" design.[28] He describes the role of language as "performatory" in that designing is a language itself that performs what cannot be spoken or said. Instead, this language is enacted through designing, where linguistic descriptions are not mere bystanders but become an active functional instrument of design.

Assuming a choreographic view of design, Tschumi proposes a view in which architecture can be explored as an instrument to express the body's experience of order, movement, and temporal dimension.[29] The recent trend in design inquiry explores the value of meaning and pluralistic opinions in design inquiry, which includes phenomenological and pragmatic approaches. Phenomenological approaches invoke personal and subjective experiences in design,[30] while pragmatist approaches emphasize a more collaborative and critical role for the designer, one in which empathy and empowerment of society are considered important.[31]

While these multiple paradigms have influenced design thinking, the long-standing debate concerns whether design is a unidisciplinary domain consisting of its own set of rules or a multidisciplinary domain borrowed from various disciplines. The view that architecture is a unidisciplinary domain emphasizes the unique nature of architecture discipline, one that possesses its own subjects and skills and must establish its own niche in the pursuit of intellectual clarity and professional responsibility. For instance, Leatherbarrow argues that one characteristic distinguishing architecture from other applied arts or engineering is that architects rarely make buildings as artists make paintings. Rather, architects produce mediating artifacts that make buildings possible.[32] In contrast, proponents of the multidisciplinary view suggest that architectural design is a complex process of working with diverse domains and performance criteria[33] as design problems are multidimensional and highly interactive.[34] For example, Robinson proposes a new paradigm in which architecture is viewed as a cultural medium that integrates technology, sociocultural issues, history and theory, and representational disciplines that define what architecture ought to be.[35]

Regardless of which side of the debate one falls on, it has been revealed that design schools (specifically of architecture) tend to privilege a narrow group of designers with limited skillsets, neglecting individual differences. Garry Stevens, in his book *The Favored Circle*, reveals how a certain habitus is being inculcated in architectural schools today based on a cultural capital that favors the privileged and has very little to do with native talent.[36] In this sense, the question of inclusivity within the design world is an ethical one, regardless of whether design is unidisciplinary or multidisciplinary, conscious or unconscious, with clear or blurred professional boundaries.

Archival and empirical studies

While it might be difficult to completely unlock the "mysterious" and subjective nature of the design process, we know more about design thinking today than ever before. Archival literature on the design process are available in many forms, including documentation of a specific designer's work, ethnographic studies of design firm practices, architectural critics who have followed specific architectural work, and reflective writings of architects. However, design cognition as a specific subject matter has only recently attracted interest. These studies consist of understanding the design process either retrospectively (after the design process is completed) or concurrently (during the design process).[37]

Bryan Lawson, for example, examines archival evidence of 11 distinguished architects with retrospective interviews.[38] The design processes are illustrated by original design drawings. Lawson provides a macro-level examination of the context in which the designer operates, including their philosophy of practice, relationships with clients, and attitudes toward technology, among others. This work is interesting from a cognitive perspective as Lawson captures how designers examine the brief, how they work with alternatives, their speed of work, and use of drawing, among other aspects. For example, while some architects (e.g., Eva Jiricna) deliberately use a number of alternatives, others (e.g., Santiago Calatrava) avoid doing so altogether. Lawson also demonstrates how a big idea is necessary to nourish and sustain a design process for some successful designers, such as Richard MacCormac. Moreover, the ability to incorporate parallel processes of thought are crucial in the development of idea for an architect, such as Robert Venturi. Lastly, Lawson demonstrates the importance of drawing among these designers as a communicative tool, not so much as a work of art in and of itself.

Examining the relationship between design thinking and construction, Suckle examines and compiles the works of ten designers into biographical pieces that highlight their different approaches.[39] He analyzes design thinking with respect to each designer's personal affinity toward design construction, such as structural expressions of Arthur Erikson, the influence of tradition in Kisho Kurukawa's work, or the technological innovations of Norman Foster. The book therefore highlights a range and multiplicity of approaches. For instance, architects who limit the scope of construction to simply that of making the building, to those who view the building object in terms of sculptural sensitivity.

In Brawne's book *Architectural Thought*, he documents the thought process of prominent designers through the lens of visual thinking and non-verbal thought.[40] The focus is on what the eye sees and the extent to which memories of seeing influence concept making. The book draws on Karl Popper's falsification principle as a basis to analyze the design works. In several examples, Brawne claims that while architecture as a totality is not falsifiable, the sequence of scientific research and the sequence of design process share many similarities. For example, Brawne observes the same underlying intention in Le Corbusier's Ville Radieuse and Frank Lloyd Wright's Broadacre City and yet sees variation in the design works of Kahn and Scarpa, who were contemporaries and admired one another's works. Kahn's architecture was of simplicity and mass (Greco-Roman influence), while Scarpa's focused on craftsmanship and detail (Venetian influence). Brawne argues that the presence of similarity *and* variation is the result of long-standing experimentation of designers, which ultimately mirrors the experimentation in scientific research processes.

Drawing on literature from neuroscience and creativity, Mallgrave investigates the relationship between architectural ways of thinking and the faculties of the brain.[41] However, given the complexity of such a one-to-one mapping, Mallgrave attempts to bridge the relationship in a more speculative fashion, with a focus on historical evidence and general philosophies. He categorizes architectural thinking in terms of historical antecedents, as well as how the brain views and ponders the design world. Examples include Alberti's "humanist brain," which views architecture as a metaphor for human body, and Pallasmaa's "phenomenological brain," characterized by an aversion to highly rationalized formalism that led to architecture as a multisensory experience. In conclusion, Mallgrave alludes to how neural plasticity contributes to the potential of designers to constantly learn from their design experiences.

Others have highlighted the procedural aspects of design. Rowe used design protocols to examine decision-making processes of designers.[42] While the focus is on the procedural aspects of designing, he also describes normative positions. Moreover, his book avoids content knowledge outside design domain and instead offers a general explanation of the decision-making processes of designers. Most of his research reflects on the role of self-examination within architectural inquiry itself. Based on his findings, Rowe outlines three different styles of design thinking: first, style constrained by information derived from the immediate context of the design problem; second, style dominated by the a priori use of a particular building type as a model for resolving the problem at hand; and lastly, style that manifests as a dialectic through the use of two dominant ideas, which advances the design process.

Schön also focuses on the procedural aspects of design.[43] He considers the emergence of design knowledge as a "knowing-in-action," suggesting that designers are in transaction with the design situation and that a designer's knowing-in-action involves sensory, bodily knowing, and the "seeing-moving-seeing" sequence of design thinking. He captures the intimate process of design as a reflective conversation between the studio master Quist and design student Petra.[44] In this example, he describes Petra's trouble with a classroom design plan in which she identifies a mismatch in scale and then changes the layout shape from linear to L-shaped. As Schön explains, this modification can be attributed to the way Petra "sees" her project, just as the designer sees what is "there" in some representation of a site, draws in relation to what is there, and then sees what is drawn, thereby informing further designing. The act of seeing not only allows us to visually register information but also to construct meaning, which makes design a reflective conversation with the materials of a situation. This unique type of seeing is what allows designers to recognize, detect, discover, and appreciate. It follows that master Quist does not try to solve student Petra's problem directly, as much as he reshapes it by restating the problem from its starting point.

More recent empirical studies on design processes are conducted through short and highly controlled experimental conditions, usually by recording a designer's overt behaviors, such as verbalization, sketches, and audio-visual recordings captured by cameras.[45] The assumption is that by capturing the design process as a sequence of events in time, one can make a reasonable judgment about design behaviors.[46] Borne out of Eastman's pioneering studies of design in the late 1960s, protocol analysis has become a well-established empirical research tool in the field of design research.[47] As Cross observes, of all the empirical research methods for the analysis of design activity, protocol analysis has received the most attention in recent years. It has quickly become regarded as the method most likely to shed light on the somewhat mysterious cognitive abilities of designers. Interestingly, most protocol analyses have focused on the disciplines of product design, industrial design, and mechanical engineering processes, although architectural design processes have also been analyzed.[48]

Protocol analysis gained attention in the 1990s due to the research of Nigel Cross, Norbert Roozenburg, and Kees Dorst at the Delft University of Technology.[49] At the Delft Protocols Workshop in 1994, a common dataset was shared with researchers around the world so they could conduct their own analyses. Many more protocol workshops have followed: in 1996 at Istanbul Technical University on the topic of descriptive models of design; in 1999 at the Massachusetts Institute of Technology, on the topic of design representation; in 2001 at the Delft University on the topic of design in context and developing an interdisciplinary approach to studying design; in 2003 at the University of Technology, Sydney, on the topic of nature and the nurture of expert performance in design; in 2007 at the University of Arts, London, on the topic of analyzing design meetings; in 2010 at the University of California, Irvine, on the topic of studying professional software design; in 2010 at the University of Sydney on the topic of interpreting design thinking; and in 2012 at the University of Northumbria on the topic of articulating design thinking related to inclusive design.[50]

Summarizing such protocol studies, Cross observes that design behavior is uniquely characterized by the production of novel and unexpected solutions, tolerance of uncertainty, access to incomplete information, application of imagination and constructive forethought to practical problems, and the use drawings and other modeling media as means of problem-solving. He also describes three major activities in which designers engage: problem formulation, solution generation, and process strategy. In *problem formulation*, designers conduct goal analysis, solution focusing, and problem framing. Interestingly, Dorst and Cross observe that there is a distinct co-evolution of the problem and solution in design. Elaborating on each of the design behaviors, they observe that designers seem to be "ill-behaved" problem-solvers in that they do not give enough time and attention to defining the problem.[51]

Cross observes that successful design behavior is based not on extensive problem analysis but on adequate problem scoping and problem framing, which are key features of design activity. The process of *problem scoping* involves a focused or directed approach to gathering problem information and prioritizing criteria, while *problem framing* is the process of structuring and formulating the problem. In various studies, successful, experienced, and outstanding designers are consistently found to be proactive in problem framing, actively imposing their view of the problem and directing the search for solution conjectures.[52] Similarly, Chen and Liu illustrate that, in the early stages of architectural design, creative designers take a more involved approach to problem finding than less creative designers, which demonstrates the critical role of problem finding in producing creativity.[53] Along these lines, Cardoso and colleagues find that high-level questioning plays a role in (re)framing problem definitions and the subsequent direction of idea generation.[54]

Cross further observes that while successful designers must commit time to problem framing, they tend to be more solution-focused than problem-focused due to their education and training.[55] Consequently, designers "co-evolve" the problem and solution together in the conceptual stages of the design process, which is a defining characteristic of the definition process. According to Cross, a designer's solution generation is characterized by periods of fixation, attachment to concepts, generation of alternatives, creative thinking, and sketching activity. Fixation can act as a double-edged sword within the design process in that it may lead to feeling stuck and yet can serve as an incubation period for creative activity. Designers will also readily attach themselves to single, early solution concepts, which they are reluctant to abandon even if this inhibits their ability to develop such concepts into satisfactory solutions. Yet, designers are also inclined to generate a wide range of alternative solutions given their divergent forms of thinking, which is a characteristic of creative behavior. Cross finds little evidence to accept the notion that the key feature of creative design is the intuitive, heroic "creative leap." Instead, he suggests that problem framing, co-evolution, and conceptual bridging between the problem space and the solution space are all better descriptions of what actually happens in creative design. Lastly, he suggests that the design sketch is fundamental to supporting and facilitating the uncertain, ambiguous, and exploratory nature of conceptual design activity.

Cross concludes his paper by describing the unique process strategy of designers, which includes the structuring of the design process, opportunism, and modal shifts. In terms of structuring, the key is to ensure the flexibility of one's approach that derives from a rather sophisticated understanding of process strategy. Through opportunistic behavior, expert designers are able to create space for finding creative solutions. Finally, productive design behavior is associated with frequent switching between types of cognitive activity, which Cross speculates enables the designer to deftly explore the problem and the solution in tandem.[56]

Framing design problems

Researchers on design often debate which features of design problems serve to distinguish them from other types of problem-solving. Interestingly, this debate raises questions as to whether design consists of a problem to be solved or is a pure creative expression in and of itself. While we will revisit this question in a later section, it important to know that the question of the nature of design problems has been a subject of immense interest among the design cognition community.

A witty illustration from architect Daniel Libeskind (Figure 2.1) depicts architecture as a pseudo chess game in which the designer is confronted with the impending choice of whether or not to eat the ripe fruit – a luxury only afforded to the rich man's architect. This is not a view of design as an exercise in problem-solving but rather a selection of impending choices. Similarly, Archea describes architecture as having more in common with puzzle making than problem-solving.[57] Puzzle making, according to Archea, is less about solving a specific problem and more about exploring a range of opportunities. Thus, a view of design as a puzzle-making activity allows a designer to compose, work in context, and assemble the situation in both time and space.

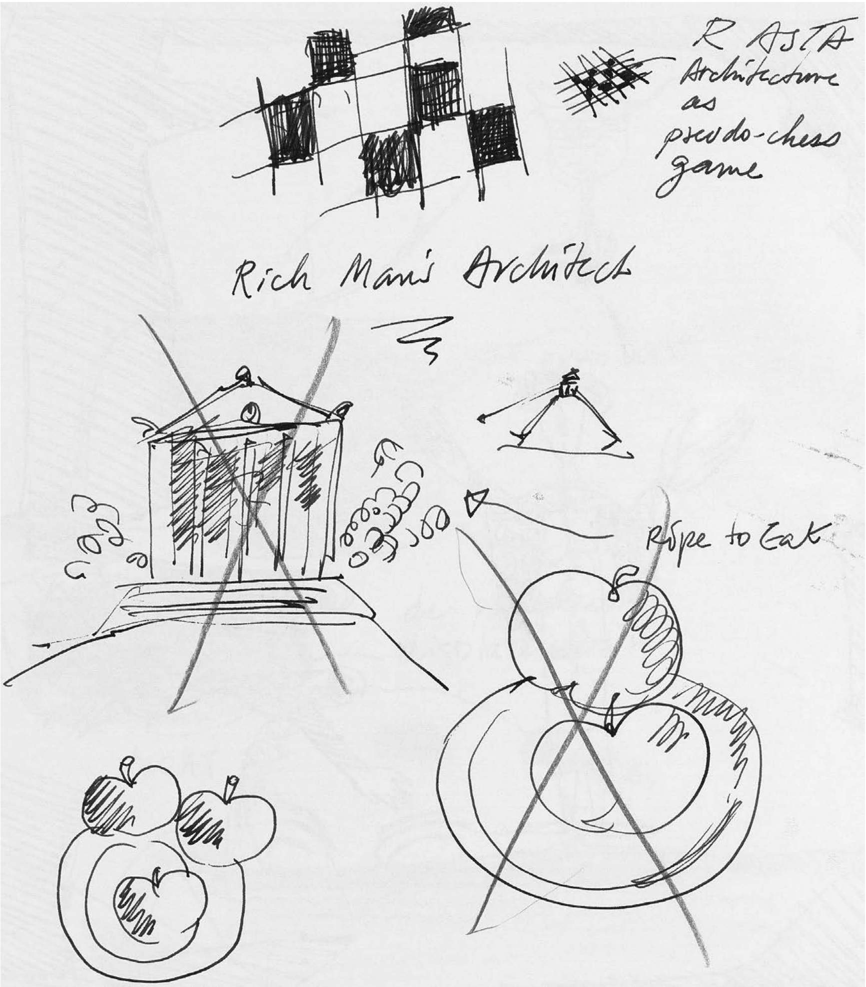


Figure 2.1 Daniel Libeskind's depiction of architecture as a pseudo chess game
Source: Getty Research Institute, Los Angeles, 920061

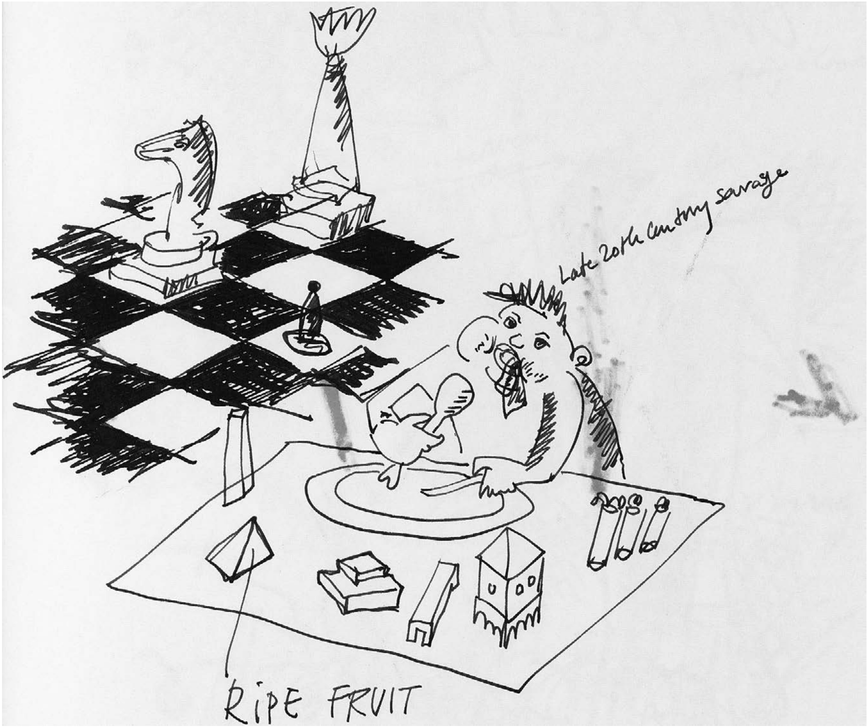


Figure 2.1 Continued

The notion of design as a problem-solving activity gained currency with the "design methods movement" of the 1960s. Largely influenced by philosophers in science such as Popper, Kuhn, and Lakatos, the movement brought an emphasis to both deductive and inductive logic in approaches to solving design problems.[58] "Deductive logic" is the process of reasoning from the general to the specific, while "inductive logic" occurs from a set of specific observations to a general theory.

This problem-based approach sought to break down the complexity of design into quantifiable logic and to exercise greater control in the design process. In contrast, subjective design practices, such as the lone architect working in his or her office without any objective framework, were increasingly viewed as obstacles to rational thinking. The design methods movement ushered in the idea that, no matter how complex, design should be partitioned into rational sub-processes and solved using explicit logical techniques. As design was cast as a problem-solving endeavor, numerous researchers proposed different types of design method models primarily in the form of staged phases.

The prevalent model in the 1960s was the three-phase analysis-synthesis-evaluation model.[59] In the analysis phase, design objectives are identified and rationally ordered, followed by a *synthesis phase* in which solutions are solved and combined, concluding with the critical *evaluation phase* of the resultant solutions. This model presupposed the existence of specific or ideal starting points in every design inquiry with "closed" options for their development. For example, synthesis can proceed only after the analysis has been completed with no chance for backtracking. Archer suggested an alternative three-phase analytical-creative-executive model in which the design process becomes rather iterative and cyclic.[60] In this respect, the cycle advances the design solution from an abstract to a concrete form.

Other researchers have considered an inverse model that works in opposition to the previous model. March, for example, rejected the analysis-synthesis-evaluation model in favor of a synthesis-analysis-evaluation model.[61] He proposed a model of the design process that starts with a *synthesis* of the preliminary statement of performance requirements and previous knowledge. It is here that architect proposes a candidate solution called the "protomodel." Working from scientific theory and design suppositions, the expected performance characteristics of this protomodel are predicted in the *analysis* phase and finally organized in the *evaluation phase*. Darke proposes a similar generator-conjecture-analysis model.[62] In this model, the *generator phase* consists of a simple idea to which the designer latches on very early in the process, which provides focus for the ensuing phases of design development. The conjecture phase entails the conceptualization of a possible solution, while the *analysis phase* leads to further understanding of the problem due to testing the conjectured solution.

However, the phase models propagated by the design methods movement have been sometimes resisted by the design community because of the difficulty of typing design problems prior to encountering them, in contrast to scientific problems. Hence, some design researchers proposed that "abductive reasoning," which involves educated guessing or sense making, is more in line with design thinking and provides a basis for hypothesis of what may be.[63]

For Bijl, a design idea cannot be fully realized within the initial stages of the design process because the client may need something later on or the context may pose challenges that force a change in strategy midway.[64] In their book on problem seeking, Pena and Parshall refer to these unanticipated challenges as "late-blooming goals."[65] Moreover, the "wicked" nature of design problems (i.e., vicious, tricky, and aggressive) may serve to compound these issues further, as opposed to "tame" problems with more straightforward solutions.[66] Because of this wickedness, design problems tend to be ill-structured and possess a mystical quality to them, and unlike tame problems, they cannot be solved; they can only be re-solved. Ultimately, there is no test for design problems, nor is there a way to know if all the possible solutions have been identified, which solutions are adequate, or what their consequences might be. Consequently, given the wicked nature of design problems, some researchers suggest that designers should strive for sufficient solutions (i.e., good enough), rather than ideal ones.

Rittel and Webber elaborate on several factors that exacerbate this wicked quality of design, including indefinite formulation of the problem, absence of a stopping rule, and lack of true or false solutions (but only good or bad).[67] The wicked nature of design problems may contribute to a notion of "stuckness" in design, which includes: not knowing how to begin, where to focus, or how to proceed; fixating and repeating; an inability to move forward; and too much time spent on a task. Moreover, the co-evolution of the design problem and solution in design activity may also factor in, making the problem and solution interdependent.[68] Lastly, design solutions are often characteristically holistic responses to the design problem. Thus, skilled designers must bring some extra knowledge to bear on the problem in order to transform it into an integrated solution.[69]

In my prior work, I have addressed the idea of wholeness through an example from quantum physics in which I considered design problem evolving like the integration of fragmented hologram pieces.[70] A hologram does not record an image of the object but provides an optical reconstruction of it in seemingly multidimensional form. For instance, the hologram plate is broken into fragments, where each individual fragment shows the same three-dimensional optical reconstruction of the original object. The whole exists in its parts. Design is the reversal of the process of hologram construction, fused together to form a complete picture.

Now the question is, if a designer's goal is to maintain wholeness, how can the designer solve problems without reducing them to sub-problems? In my study, I invoke science educator Henry Bortoft's analogy to make a distinction between the whole and the totality.[71] The "whole" is a coherent conjecture, in contrast to the "totality," which is a complete solution. Often designers have a whole solution (by the way of conjectures, concepts and so on) at the conceptual design stage, but the totality is still lacking. The totality can only emerge from the progressive resolution of these wholes. This is not to say that designers do not put parts together; they do. However, in putting parts together, they do not necessarily create a *whole*; neither do they put the whole together in the manner that the parts are laid. Thus, the holographic thinking tool allows one to move in both directions conceptually to reach an emergent whole, which comes forth into its parts. If the whole is present within each of its parts, then each part is representative of the whole.

Another lurking debate within the design community is the dichotomy of intuitive and rational approaches to solving problems.[72] The famed architect Frank Gehry clearly demarcated the two:

> Solving all the functional problems is an intellectual process. It is not less important. It is just different. That is a different part of my brain. If you look at our process, the firm's process, you see models that show the

> pragmatic solution to the building without architecture. We start with shapes, sculptural forms. Then we work into the technical stuff.[73]

But this dichotomy might be more a result of a division of labor rather than a truly *cognitive* demarcation. In his paper on the dual knowledge thesis, Coyne and Snodgrass eloquently argue that it is misguided to believe that designing involves a special kind of knowledge that is subjective, fundamentally difficult to grasp, and therefore mysterious.[74] This idea relies upon the assumption that there are two ways of thinking: on the one hand, logical, analytical, and rational thinking, with subjective, idiosyncratic, and irrational thinking on the other hand. Coyne and Snodgrass suggests positioning design thinking among the latter removes design from effective dialogue, as design ideas are viewed as too subjective or personal to be subjected to general scrutiny. In this respect, the problem here is that the designer becomes associated with the great themes of the Romantic Movement, the oppressed and misunderstood hero, rather than the problem-solver that resides at the other end of the dichotomy.

Whither design creativity?

Yet, the idea of design as a mysterious, intuitive, and creative form of thinking cannot be discounted. As has been described, the goal of design process is not simply to produce but to produce "creatively."[75] Creativity has been described in the literature in various ways, ranging from solutions that are unconventional or unique, novel (i.e., original or unexpected, new or new ways of seeing) and appropriate (i.e., useful, adaptive, goodness of fit). Some have considered creativity from the point of view of four P's (person, product, process, and press):[76] the *person* use their skills, motivations, and abilities to create; *products* demonstrate the manifestation of creative thought and can be evaluated based on their creative merit; *press* represents the inspirational environment in which the person operates to create the product; and *process* refers to the procedure in which creative products are made.

Others have outlined the systems perspective on creativity that includes the domain, individual, and field interaction (DIFI model).[77] The *domain* is the specific organized body of knowledge in which designers work. The designer's *field* socializes them with respect to their domain and profession. Lastly, the *individual* brings specific personality characteristics. These three aspects work together to produce creativity.

In the 1960s, psychologist Richard Mackinnon, on behalf of UC Berkeley's Institute of Personality Assessment and Research, conducted a landmark study on creative architects, which included administration of psychometric experiments, tests of personality and attitude, and interviews of life history and behaviors.[78] He invited reputed "creative" architects, such as Louis Kahn, Philip Johnson, Eero Saarinen, I.M. Pei, and Richard Neutra, to participate. Mackinnon found that most creative architects scored highly on originality, aesthetic sensitivity, and sense of destiny. They were also ingenious, imaginative, courageous, and insightful. He concluded that the "creative "architect is discerning (observant in a different fashion), alert (can concentrate attention readily and shift it appropriately), and fluent (in scanning thoughts and producing those which meet some problem-solving criteria). They give marked consideration for the aesthetic and embrace their work as a vocation rather than as a chore.

While finding common traits across creative architects, MacKinnon found that they used a diversity of approaches. In one instance, he used the popular Mosaic Construction Test to compare creative characteristics of these architects with interesting results. The test assessed creativity, specifically aesthetic sensitivity and originality, by asking subjects to place different mosaic tiles to create any pattern of their choice. The mosaic tiles highlight the strong individual bias of various architects. Architect Philip Johnson only used minimalist colors. Saarinen went fully minimalist in white, later went on to say that his design carried no meaning other than the pleasure of texture itself. Others such as I.M. Pei, Richard Neutra, and Louis Kahn focused on tonal arrangements, particularly relationships between primary colors and the search for accent and balance. The results speak to the challenges in creating universal measures of creativity, given the diversity approaches that architects may implement.

While studies on creative personalities are popular in the psychometric literature, studies on the creative process of designers are seldom conducted. However, researchers have alluded to some possible process models from creativity research. Wallas outlined four primary stages in the creative process: preparation, incubation, illumination, and verification.[79] In the *preparation stage*, the creative person familiarizes with the problem by engaging in conscious, strenuous, and systematic but usually fruitless work. Although this preparatory work may not lead to any solution, many attest that it is necessary in order for inspiration to be forthcoming. In the *incubation stage*, the designer takes a break from the problem, and no conscious work is carried out, which enables later conscious work to proceed more effectively than it would have otherwise. The *Illumination phase* is one in which the "creative leap" or the "aha moment" occurs, perhaps very suddenly and without warning, although often preceded by a vague feeling that the solution is near. This inspiration is not usually a complete solution to the problem but points in the direction in which eventual solution may be found. Lastly, the *verification stage* is somewhat similar to the preparation stage in that the conscious work must be done in order to develop, test, and evaluate the inspired solution.

In their description of S-creativity, Tang and Gero suggest that creativity necessitates that novelty be provoked by the design situation.[80] Creativity does not happen solely inside people's minds but in a social context. In the context of team creativity, my own research challenges the notion of creativity as one big creative leap (big-C(p)) orchestrated by an individual designer, rather the product of a contribution of smaller creative events (little-c(p)).[81] The little-c(p) might not lead to the big-C(p), but there are points of alignment. For example, the events consisted of high intensity of little-c(p) and big-C(p) in the beginning of the design process, a period of reasonable calm with most little-c(p)'s following it, a high intensity session midway with higher occurrences of more big-C(p), and an intense finish with little-c(p) and big-C (p) at the end. In summary, the process consisted of set patterns of linear periods of incubation and giant creative leaps, and the events of the creative process tend to ebb and flow.[82]

While research on the creative process was still in its nascent stages, the psychologist J. P. Guilford gave an influential address to the American Psychological Association on *divergent thinking*, a key component of creativity that involves the ability to produce multiple, equally valid responses to a given problem.[83] Guilford found that creative people routinely underperform on standardized intelligence tests, such as IQ tests, which reward "convergent thinking" that arrive at one identifiably correct answer.

However, the construct of convergence is gaining more traction in more recent studies, as evident in the terminologies of blends, conceptual blending, synthesis, and integration, among others.[84] *Conceptual blending* is further elaborated in terms of the "analogy," which recalls familiar past situations to deal with novel ones and lead to creative insights.[85] Nagai and Taura have explored concept-synthesizing in creative process through *concept abstraction* (identification of similarity), *concept blending* (identification of similarity and dissimilarity), and *concept integration* (identification of thematic relations).[86] Of the three, concept integration goes beyond the literal level of objects to the thematic level and is shown to have the highest effect on creativity.

Some have even proposed a multiple divergence-convergence process at different stages of the design process. Lawson insists that creativity not be seen as simply as the ability of divergent thought but rather as a balance of convergent and divergent thinking abilities appropriate to the situation.[87] In this respect, Jones suggests that design inquiry is much more dynamic with activities, such as divergence, transformation, and convergence.[88] *Divergence* is the act of extending the boundary of a design situation so as to have a large enough, and fruitful enough, search space in which to find a solution. *Transformation* is to narrow down results of a divergent search to find a pattern that will permit convergence. Finally, *convergence* is the final stage in which the designer aims to rule out secondary concerns until one of many possible alternatives is left.

Nature of design representations

Another unique feature of design is its use of a variety and modes of representations. The process of making representations involves some level of abstraction in which the reduction of some aspect of an artifact allows for concentration on others, for conception, description, and construction of a built work.[89] Reyner Banham argues that the secret profession of architecture is defined not by *what* is produced but by *how* it is done.[90] Leatherbarrow goes further to contend that the chief skill of designers is to create unique design representations.[91] As architects deal in drawings and models, rather than brick and mortar, a design idea does not come to fruition until it is captured in drawing. Furthermore, understanding does not precede articulation but progresses through it.

Leatherbarrow distinguishes between design representations of the architect from the artistic representations of the self-expressive painter. First, the design representation is less a mimetic achievement than it is a prospective one. They are fictive in character in that they depict something that does not exist. Second, while architectural drawings can be looked at physically, much in the same way that one looks at a painting, the primary purpose of the architectural drawing is not in act of viewing. The plans, sections, and details of a building are often pictorially insignificant because they are rarely intelligible in isolation. For instance, graphic sheets typically come in sets, with each drawing cross-referenced to many others. Architectural understanding is therefore realized through grasping a network, weave, or matrix of figures, each partial but mutually dependent. Finally, another peculiarity of architectural representations, as noted by Leatherbarrow, is that architects literally see the world in a unique way, as though they have x-ray vision. In this respect, architects see *through* rooms, buildings, and streets, even entire neighborhoods and landscapes.[92]

The ways by which designers create architectural representations has also changed over time. Architectural historian Alberto Pérez-Gómez explains that the linear perspective was conceived and used extensively during the Renaissance in expressive ways through the works of Brunelleschi and Alberti.[93] It extended further through the theoretical works of Baroque Jesuit architect and painter Andrea Pozzo during the 17th century. However, these systems of architectural representations became increasingly more precise and reductive after the Renaissance. For instance, at the time of Piranesi (ca 1750s), Jean-Laurent Le Geay taught Parisian students that the architect must provide a fully comprehensive picture of the future building, including an aerial perspective and a full set of drawings and specifications. Pérez-Gómez also observes that Durand, who taught at Ecole Polytechnique (1794), spoke to the futility of rendering and color while at the same time asserting instrumentality in the form of precise ink lines as the only scientifically unquestionable value in architecture and architectural drawing.[94]

While Ecole Polytechnique was conceived from the larger philosophy of architecture as engineering, the emergence of rival school of Ecole des Beaus-Arts (1863) was conceived out of a notion of architecture as a fine art. The Ecole des Beaus-Arts promoted a conception of design as fundamentally dependent on the geometry, reliant on Cartesian spaces, which led to the obsessively sophisticated presentation renderings characteristics of the school. The beginning of a modern paradigm brought yet another transformation, during which architects drew and built models. In the process of construction, architects presented mostly plans, elevations, and sections, sometimes revealing the poche techniques that conveyed the "shadowy depths" of the buildings to be built.[95]

Today, designers use representations for a variety of purposes. There are 20th-century architects, like Walter Gropius for example, who were unable to draw.[96] Other designers, like Louis Kahn, show numerous sketches in development, the traces of which are visible in subsequent developments. The trace is much harder to decipher, however, in the works of designers who work in computational media, such as Greg Lynn or Bjarke Ingels.

For architect Frank Gehry, the use of drawing is not a question of ability or even a conscious decision. Rather, drawing is the creative foment of his goals in the interplay of thinking and hand movements. Gehry uses representations to achieve compositional equilibrium. As he and his team start a project, they play and work with neutral blocks of wood until they find the proper scale and organization for the buildings on site.[97] Once Gehry establishes the scale of the building and the relationship to the site and the client, he begins drawing. These drawings then give a sense of direction to his associates to create the study models. In this respect, Gehry suggests that he uses models as a crutch and works more like a sculptor, molding, pushing, changing, and sketching back to the plan.[98]

In Gehry's world, ambiguity in representations provide the impetus to design more than precise drawings.[99] Drawings are not only ambiguous but can be contradictory. For example, he uses lines that suggest a certain form in one moment, only to use lines that negate that initial form in the next. For Gehry, drawings are both a verbal description and a gesture. As his associates observe, their task is to discern the energy of the gesture in Gehry's drawings, which can be difficult.[100] Sometimes the drawing has more movement than Gehry would prefer and sometimes less. Sometimes the drawings are quite literally a specific shape and gesture, and sometimes they are more about the energy of a design. Other times, Gehry will direct them to build exactly what has been drawn, taking a flat thing and expanding it into three dimensions.[101]

Emmons and Dayer describe drawing as a "gestural art," a performance that traces the movements of its creation by recording its unique temporal construction.[102] They quote artist Philip Rawson that the word "drawing" is a verbal noun, which is to make a thing out of what is fundamentally an action. Emmons and Dayer argue that architectural drawing is misconstrued as the transparent translation of a pre-formed idea of the mind into lines on paper, as opposed to being a pre-formed bodily, material construction. However, the medium of drawing, whether by ink, pencil, or paint, must be recognized as an intrinsic companion to creative thought, so the act of drawing resists the reductive Cartesian split between mind and body.[103]

Herbert suggests that graphical ambiguity in drawing does not necessarily imply unskilled drawing.[104] Accordingly, a designer must be skilled enough to produce graphics with the right level of ambiguity to attract, admit, and hold new information from the designer's cognitive experience as it enters the schematic process. Herbert goes on to argue that study drawings are not simply a handy tool for working out a design problem. Indeed, the origin, nature, and methods of obtaining knowledge in architectural design can be associated with such ambiguous study drawings. The ambiguity of architectural sketches therefore serves as a tool for a trial-and-error process of learning where a designer puts forth alternative conjectures in graphical form before testing them as tangible solutions.[105]

Goldschmidt, who has written extensively about the value of sketching in design cognition, suggests that sketching serves as an extension of imagery for the designer and can be thought of as "interactive imagery."[106] This characterization implies a circular feedback loop between two kinds of pictorial representation: the internal representation in imagery and the external representation on paper or some other sketching surface. For Goldschmidt, sketching has the potential to enhance design reasoning particularly in the "front edge" conceptual phase, when the designer is actively searching for ideas and information that may help generate or fortify a design rationale and design story.[107]

Goldschmidt concludes that the role of sketches in the design process can be distinguished from the role of other images and visual displays used to support the design process. Designers make sketches because the sketch is an extension of mental imagery, which allows them the freedom of imagery to retrieve previously stored images and manipulate them rapidly. At the same time, sketching leaves a hard trace of these images on a visible surface, and because this is an additive process, the sketching surface soon contains unforeseen configurations and relationships among its graphical components. The resultant displays are then open to new interpretations, and if one consciously looks for them, they can be generated with relative ease using additional input from the designer's memory structures.[108]

Goldschmidt and Klevitsky elaborate upon the role of sketching found in James Stirling's work.[109] Stirling's first phase of design consists of tiny sketches made on every available piece of paper, some quite literally "back of the envelope" and "cocktail napkin" sketches made in transit and others on full sheets of paper sketched in his office. These small, diagrammatic sketches are subsequently developed into small axonometric drawings showing the relationships between volumes and heights. Stirling then involves his associates in a process of elaboration through doodles to reach an agreed upon set of ideas, rather than alternatives. Goldschmidt and Porter describe these series of sketches as a sort of "cinematic association," one of the sources for serial representation pioneered by Stirling and later practiced by other postmodern architects, such as Aldo Rossi, Bernard Tschumi, and Daniel Libeskind, among others.[110] As an example, some of Bernard Tschumi's representations of Le Fresnoy National Studio for Contemporary Arts (1991) went even further, made up a superimposition of hand-drawn sketches and newspaper cut-outs (Figure 2.2), which he claims were rapidly done in one evening using a 11″×17″ format just prior to the client meeting.[111]

While much attention has been given to sketching, which will be subjected to detailed examination as cognitive evidence in this book, other less ambiguous forms of drawings have been used in various periods through history. The classic perspectival drawings were surpassed by the axonometric views free of architectural distortions demonstrated in the works of Theo van Doesberg,[112] and the more recent "worm's-eye view" drawings of Stirling

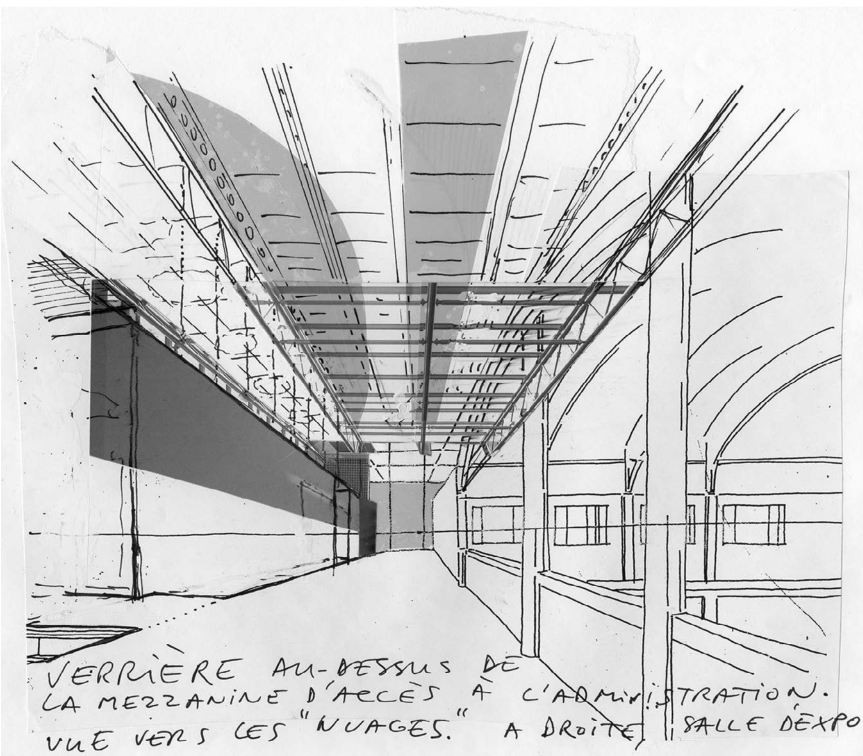
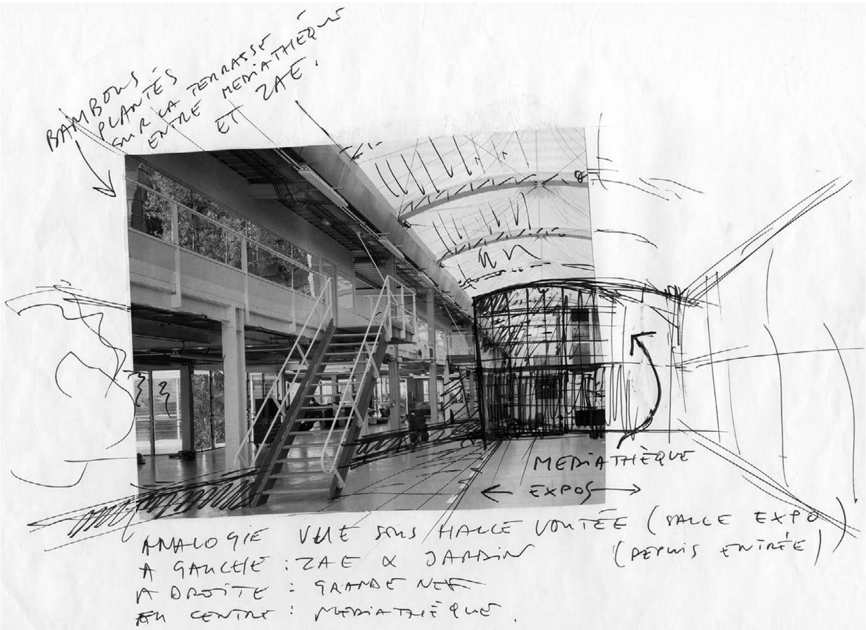


Figure 2.2 Bernard Tschumi's quick sketches for Le Fresnoy National Studio for Contemporary Arts (1991) indicate the cinematic nature of design representations

Source: Bernard Tschumi Architects



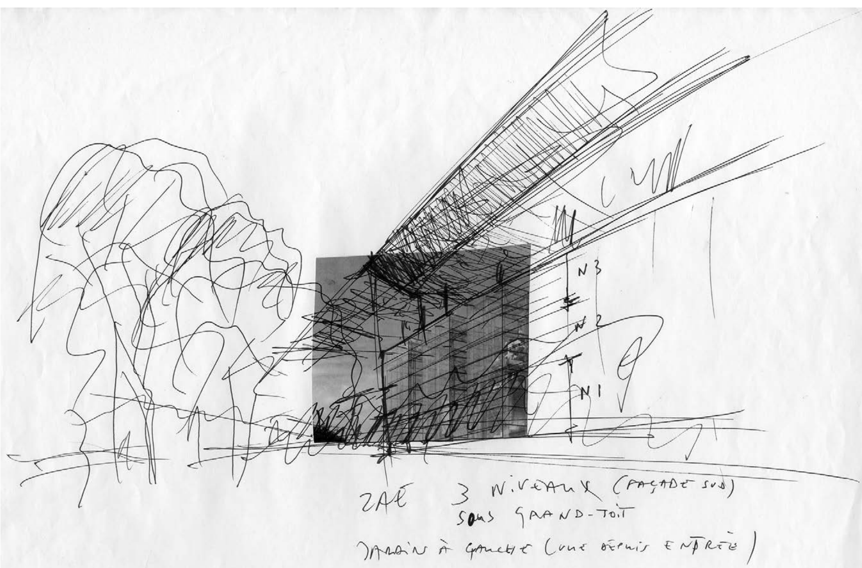


Figure 2.2 Continued

and Wilford in which selected elements of the designed buildings were shown just enough to document an overriding idea, a central concept.[113]

Referring to design representations (e.g., Louis Kahn's perspective sketches), Yates observes that it is surprising to see how frequently representational drawings and photographs do not admit a corporeal viewer.[114] The starting point of the perspective views, for instance, is one that is impossible or irrelevant with respect to the experience of an actual body coming into contact with the architectural artefact. She further observes that the eye and the mind are thus embodied. If depth is visible in such representations, then the question is, for whom? The point of view in these images is devised for the observer of the simulacrum.[115]

With reference to cognitive aspects of design representations, Goldschmidt and Porter pose some important questions that might be useful to reflect on here.[116] Are representations simply stand-ins for some other reality? Or do they comprise a reality in and of themselves? Can a sharp distinction be made? Furthermore, are representations implicit or explicit? And, why are some representations so idiosyncratic? While there are no easy answers here, Rappolt and Violette argue that, at the very least, drawings can be viewed as clues into the inner workings of a designer's mind. To the architectural detective, drawings exist as an architectural "whodunit," such as how they *dunnit* and, with a little luck and imagination, where they *dunnit*. Architectural drawings might also be thought of as the building's DNA, codifying the rules of architectural design.[117]

Where goes the digital turn?

Although the dawning of the digital age threatens to make more traditional design representations obsolete, sketching is still often touted as the most important design representation. In a recent conference at Yale, provocatively entitled *Is drawing dead?* the role of sketching was still being seen as vital to the cognitive process of designers. For instance, Julie Dorsey lectured on the interaction between seeing, imagining, and drawing. She argued that seeing facilitates drawing, while drawing invigorates seeing. Furthermore, drawing stimulates expressive imagining, while imagining provides the impetus and material for drawing. And finally, imagining both directs and filters seeing, while seeing in turn provides raw material for imagining.[118]

Designers and researchers have acknowledged a fundamental difference in design representations using handmade and digital tools. Nancy Cheng observes that manual models appeal to human emotion through the tactility of the materials used and the mark of human hand.[119] In this respect, physical models communicate better than flat screen simulations because sculptural objects inhabit the real space of the viewer, while computer frames isolate imaginary spaces. The sheer presence of the physical model elicits a confrontation from the viewer, interacting with the viewer by providing different appearances from different angles and reflecting lighting and images from the enclosing room.[120] Chen observes that modeling with materials, which are subject to some of the same physical forces, provides an intuitive connection to our sensory experience of the environment. For instance, the imagination is charmed by quirks and asymmetries reflect the human touch. The gestural sketch or the plot enlivened by a shaky pen provides fodder for the imagination. Models appeal to the emotions through the tactility of materials, miniaturization of scale, and the mark of human hand.[121]

While digital tools have changed dramatically in the past 20 years, some of my own studies explore the role of digital media in design and how digital tools force designers to think sequentially (starting from parts to whole) while manual models are holographic (where wholes and parts are reciprocally determined).[122] I explain how digital tools have facilitated incremental growth of ideas, focus on linear ways of problem-solving, and present difficulties for spatial memory and hand-brain coordination. Manual models, in contrast, have led to rapid re-configuration of ideas, reciprocal forms of problem-solving, and the facile use of spatial memory and hand-brain coordination. Some researchers suggest that the difference between manual and digital model ultimately boils down to the issue of how the different mediums allow one to frame the problem.[123]

Adopting a rather skeptical view of how digital media is used in design, Lawson argues that not only are digital tools non-neutral, but they also lead to poor design. His primary grievance is not so much in the nature of digital tools but in how they are used.[124] For example, Lawson points out that, while digital tools enable the design student to produce three-dimensional forms, they may do so by bypassing the visual editing so essential to the training received in design school. Because digital media makes it easier to manipulate complex shapes based on ellipsoidal sections, rotations of curved parabolic forms, and so on, the design student mistakes this ease as creativity.[125] Others have pointed out how the computer can act as a double-edged sword. For instance, John Fraser observes the irony in trading drawing boards in for computers in order to capture fixed ways of representing and abstracting building form. Geometrical forms, he says, could have remained so plastic and fluid in the computer, but instead they have become rigid.[126]

Yet, the advancement of digital media in design is challenging our very notion of the role of sketching and drawing in design practice today. Instead of points, lines, and planes, today we work with control points, splines (Smooth Polynomial Lines Interpolating Numerical Estimates), NURBS (Non-Uniform Rational B-Splines), and force fields. Hence, it would be valuable to question what impact the new digital technology has not only on design representations but on the idea of design itself.

In a series of essays compiled from 1992 to 2012, Mario Carpo presents an overview of emerging media and its impact on the design process.[127] In one of these essays, Peter Eisenman suggests that the electronic paradigm poses a powerful challenge to architecture because it defines reality in terms of media and simulation, where appearance is valued over existence and what can be seen is valued over what is.[128] He observes that digital media has changed the way we see – not seeing as we formerly knew it but rather a seeing that we can no longer interpret. The rise of electronics is understood here as a general techno-cultural shift that influences architects to engage with an unprecedented cultural environment and a new view of the world.[129] In Eisenmann's reading, the new paradigm of electronic mediation destabilizes and "dislocates" centuries-old habits of anthropocentric vision, rooted in monocular, perspectival tradition and the modern technologies of mechanical reproduction.[130] According to Eisenman, architecture will continue to stand up, to deal with gravity, to have "four walls." However, these four walls need no longer to be expressive of the mechanical paradigm but encompass the potential for other discourses, such as the affective senses of sound, touch, and light within darkness. So, what does this mean to the practice of design today, particularly in terms of design skills?

Proponents of digital tools argue that the digital models are helpful precisely because they structure the imagination better than working models, providing a legible structure to the otherwise ambiguous nature of manual tools.[131] Moreover, new forms of visualizations are being invented through digital tools. According to Schumacher, the virtual three-dimensionality afforded by 3D modeling software offers a new way of working that combines the intuitive possibilities of physical model making with the precision and immateriality of drawing. Furthermore, 3D modeling introduces a whole new series of "primitives" and manipulative operations, which suggest and give possibilities for new architectural morphologies.[132]

Digital modeling and fabrication has not only allowed designers to produce material digitally but take that precision to the factory through computer milling and fabrication. For instance, Morel uses his own Bolivar chair to elaborate upon the impact of digital tools. The chair encompasses a genetic notation supported by distributed computing, which includes expert structural feedback and file-to-factory fabrication technologies.[133] Use of CNC routers, 3D printers, and robotics also allow one to produce geometries, which are not easily created otherwise.

In furthering the affordances of digital technology in design, Barcelonian architect Enric Miralle has developed various notation systems for dealing with the landform building, primarily the cinematic sectioning and analysis of a large land-mass by making many cuts through it (Eurhythmics Centre in Alicante, Spain).[134] Through the notations, one follows the rise and fall of land waves as they move under the ramps. The method also choreographs the movement of people on the ramps. Sectioning techniques have also been used by several other digital designers, such as Greg Lynn.

Lynn observes that in the digital design term virtual has recently been so debased that it often simply refers to the digital space of CAD. It is often used interchangeably with the term simulation. Simulation, unlike virtuality, is not intended as a diagram for a future possible concrete assemblage but is instead a visual substitute.[135]

It is also interesting to note the generational divide in ideas concerning the role of digital media and its ease of use. In one of my papers on understanding design skills of the contemporary generation at the time, popularly known as "Generation Y," my colleagues and I suggested that the traditional ways of design academicians was significantly at odds with technologies influencing the next generations of designers.[136] According to Nimon, perhaps the most predictable effect of the newer generations has been their attitudes toward technology itself.[137] For the Baby Boom Generation, technology, while useful, is not viewed as essential. For younger generations, however, technology is now inseparable from daily existence, just as clothing or food. Consequently, technologies have been transformed from the simple tools of the Baby Boom Generation into mediums through which younger generations experience and interact with their world.

This changing perspective can be gleaned from one of the most prolific users of digital media in design, Greg Lynn. According to Lynn, architects have been reluctant to use the computer as a schematic, organizing, and generative medium for design for fear of stigma and relinquishing control of the design process to software. For instance, architects such as Frank Gehry and Zaha Hadid have only used computers during the latter stages of their conceptual process.[138] Furthermore, Lynn distinguishes the "analog" person from the "digital" person. When the analog person boots up his computer in the morning, he knows exactly what he wants the computer to do that day. In contrast, the digital person turns on her computer with the expectation that the computer will generate ideas. Lynn observes that while the computer is not a brain, machine intelligence demands one to develop a systematic human intuition about the connective medium and to engage with the computer as an intelligent tool in its own right.[139]

Loukissas, for example, describes how the architectural firm of Ralph Jerome skillfully uses digital platforms in a way that the computer becomes the unifying collaborative space for designers – almost as though there is a master techie-enabled architect sitting in the middle of everything. The techie-enabled architect has the potential to crystallize a new kind of integration among members of the firm and external contractors.[140] Using another example, Marcos Novak describes himself as a "trans-architect" due to his work with computer-generated architectural designs, conceived specifically for the virtual domain, that do not exist in the physical world.[141] Novak suggests that architects will eventually have to learn to design by algorithms, then learn to design the algorithms themselves, and finally learn how to let algorithms design themselves.

In a paper we presented at the Association of Collegiate Schools of Architecture (ACSA), my colleagues and I proposed a modest reframing of "digital tools" that moves away from their current usage as "tools for design" to "tools of design."[142] In this reframing, digital tools are viewed as "design tools that happen to be digital", rather than as aids to carry out the design task. The traditional role of digital tools, such as efficiency, precision, and form making, while valuable, must be balanced with intellectual core of architectural design discourse. We have demonstrated how this reframing might be possible, as well as how one might take advantage of the affordances of digital tools, such as section planes, multiple viewpoints, void modeling, and Boolean operations.

Even a supposedly technophobic designer such as Gehry acknowledges that computers have allowed him to remain a few steps ahead of the developers, with advance knowledge of what it will take to deliver buildings on time and on budget.[143] A reciprocal relationship of this kind is has already been extensively documented in the design processes of Zaha Hadid and Patrik Schumacher.[144] As Hadid observes, one focuses more on certain critical issues in the manual drawing. Yet, as she sits with 15 or 20 computer screens in front of her, able to view them all at the same time, she is given another repertoire. Because she can see and work on multiple drawings simultaneously, she is able to see them in yet another way. While Hadid still works with physical models and sketches, she also uses computers as simply another way to do design.[145]

Design as co-inquiry

In recent times, changes in the advancement of technology, distribution of labor, and the complexity of design projects have pushed design into a collaborative endeavor. Unlike a couple of decades ago when the "starchitect" was considered the sole creator of design, the design profession today has become a practice of co-inquiry. In the past, an aversion to collaboration in design can be seen in Donald Mackinnon's study of creative architects in the 1960s, which revealed that architects resisted efforts to integrate into groups and usually desired to be left alone.[146] The creative architect, infused with high energy, channeled this vigor into autonomous, non-group coordinated work. Mackinnon inferred from his study that that architectural practice through collaboration could not reach the same level of creativity, whether through teams of narrow specialists or broadly trained generalists or even specialists and generalists working in concert. In order to reach the same level of creativity, collaborative work would require that all people be creative and, in this respect, challenges existing power structures by requiring some control to be relinquished on the part of the architect.

Given the advances in technology and distributed nature of the profession, the aversion to collaboration seems to be lessening. In recent years, concepts such as co-creation and co-design have become prevalent. "Co-creation" refers to any act of collective creativity (i.e., creativity that is shared by two or more people) and has broad application, ranging from the physical to the metaphysical and from the material to the spiritual.[147] "Co-design" is a sub-category of co-creation referring to the design process, whether through designers collaborating with each other or with people not trained in design. Opinions vary widely about who should be involved in these collective acts of creativity, when they should become involved, and to what capacity. However, Kvan notes that collaboration does not imply capitulation by individual members nor does it imply decisions by consensus but by compromise.[148]

Collaborative design has also been referred to as "participatory design," which builds on the workers' own experiences and provides them with the resources to act in their current situation.[149] Henry Sanoff has demonstrated community design techniques through a technique known as "design games" extensively using visual imagery, such as diagramming, photo-sorting, mapping, and notation, among others.[150] Here, the idea is to integrate research and design to produce user-sensitive design strategies. This idea is predicated on the belief that people who use the design space become active participants in the shaping of their environment. Similarly, Randolph Hester has worked on spaces that grow out of a true understanding of the needs of local communities and the potential of its resources to develop, what he calls "ecological democracies."[151]

The classical roles of users, researchers, and designers in the design process merge with one another in the co-design process. The user is given the authority of "expert of his/her experience" and plays a large role in knowledge development, idea generation, and concept development. While the designer still plays a critical role in giving form to the ideas, they also take on the role of a facilitator. The designer is active in leading, guiding, and providing scaffolds, as well as clean slates to encourage people at all levels of creativity.

In a recent Design Thinking Research Symposium hosted by the Copenhagen Business School, a cross-cultural co-creation dataset was created by recording material from co-creation workshops between two distinct cultural groups, Asian and Scandinavian teams.[152] The Scandinavian team included product design specialists and experts in accessory design, whereas the Asian team included external consultants and lead users. Designing through co-creation, along with user understanding and user experiences, was a central element in these design processes. Such cross-collaborative approaches are quickly becoming the norm, rather than the exception.

Processes of co-creation/collaboration between architects and other fields are also becoming commonplace. For instance, physicians, nurses, and other healthcare professionals are working with designers to develop efficiency benchmarks and optimization of clinic design. Diana Anderson and Eve Edelstein for example have started an interdisciplinary group called "Clinicians for Design" to inspire and accelerate the design of environments and systems, enriching how healthcare interfaces with its patients.[153] According to them, clinicians are asking not only for the architect's perspective but to develop a skillset and knowledge-base that will allow them to help shape the future of hospitals, medicine, and healthcare. Ultimately, the design team and the healthcare team may together serve each other and our patients.

These participatory processes have taken hold in several university-based community design programs as well. The Detroit Collaborative Design Center (DCDC), for example, is a multidisciplinary, non-profit architecture and urban design firm at the University of Detroit Mercy School of Architecture dedicated to creating sustainable spaces and communities through quality design and the collaborative processes. The DCDC works with community-based development organizations, local governments, residents and stakeholders, private developers, students, and local design professionals to enhance local leadership capacity and promote quality design. Utilizing broad-based community participation in conjunction with design technologies, these projects respond to locally defined concerns while empowering residents and stakeholders to facilitate their own process of community planning, development, and building design.

In their discussion on the future of codesigning, Sanders and Stappers predict that design will become synonymous with design research, which will create new landscapes of opportunity for both designers and researchers.[154] The blurring of research and design has the potential to create new types of designers and researchers with specialties based more on the purpose of designing, as opposed to the products of designing. There is also potential to create professionals who have special expertise in certain stages of the process, such as in the fuzzy front end. Either way, co-designing teams will be far more diverse than they are today. Future co-designing will be a close collaboration between all the stakeholders in the design development process together, with a variety of professionals possessing a hybrid of design and research skills.[155]

Such collaborative practices are quickly replacing the traditional consultative model, where an individual designer would complete most of his work by himself and then consult with an expert after the majority of design work has been completed. Loukissas provides an example of how different disciplines such as acousticians and structural engineers are positioning themselves professionally using simulations as a bridge to work between themselves and as bridge to designers.[156] Similarly, using the example of the Fire Group at Arup, he illustrates how new identities can arise around technologies, such as simulation, which bring together experimental, observational, and mathematical evidence to create believable predictions.

In the design cognition literature, there has already been some discussion on collaborative design through shared or team mental models. Team mental models, in particular, are characterized by knowledge or belief structures shared by members of a team, which allow them to form accurate explanations and expectations about the task and to coordinate their actions and adapt their behaviors to the demands of the task and other team members.[157] The term "team mental model" not only refers to multiple sets of shared knowledge or an aggregate of individual mental models but also to a synergistic aggregation of the entire teams mental functioning.[158]

In an early attempt to understand an interdisciplinary design teams (as opposed to homogenous teams) involving industrial, mechanical, and electro-technical engineering, it was concluded that aggregate "frame" transitions were critical in the team design process.[159] In one of our own studies, we examined multidisciplinary design teams that had incorporated diverse expertise (e.g., graphic design, web design etc.), disciplinary affiliations (e.g., journalism, art, psychology etc.), and knowledge levels (e.g., freshman, juniors, and graduates). We found that the team members' background and knowledge level was critical to the manifestation of creative vents, while disciplinary affiliations and expertise of team members were less critical. However, the success of the multidisciplinary team relies on a good balance between individual performance and team dynamics.[160]

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3 Mapping design skills

Psychometric measurements

While the previous sections provided a broad background on design cognition in conceptual design, specifically what skills are required to conduct conceptual design leads to the following questions. Are design skills merely mental constructions or external depictions? To what extent are they embodied? What skills should a designer possess in order to conduct good design? Are these skills innate or can they be learned?

Although the literature on design skills is limited, measurement of general and specific mental capacities have a long tradition in psychometric measurements. However, there is some debate regarding what G captures. Some suggest that G is more the measure of the brain's hardware, while others believe it reflects efficient nerve signal pathways between the brain centers, and still others contend that it is a special command center in the brain. Most researchers believe, however, that G is innate and cannot be altered. The most popular measure of mental capacity is the intelligence quotient (IQ).[1] Some IQ measures use Wechsler's Intelligence Scale, while other known scales include the Stanford-Binet Scale or Raven's Progressive Matrices.[2] Spearman was among the first to propose that mental capacities are a form of an overarching executive skill in the form of "general intelligence" (G).[3]

This concept of intelligence is central to the nature versus nurture debate regarding how mental capacities are derived. The "nature" view side theorizes that intelligences are hardwired and genetic and therefore cannot be learned. For instance, studies among twins find that genes explain approximately 40% of intelligence, and this number grows larger into adulthood, reaching upward of 80%. It has been suggested that genes become a more significant determinant of intelligence as a result of the brain not being challenged enough in youth, therefore not reaching its genetic potential.[4] In contrast, the "nurture" view is that skills are acquired through our experience in our environments and practice. Fred Gage and colleagues, for example, have shown that the human brain can and does produce new nerve cells into adulthood.[5] The discovery of neurogenesis and neuroplasticity – the ability of the brain to shape, form, eliminate, and strengthen new connections throughout life – has the potential to sway the debate in favor of nurture.

While good genes are considered essential to a high IQ, a study conducted at Oxford University suggests that, instead of being predisposed to excelling in a single ability, individuals are equally likely to thrive in all abilities. Individuals therefore have the same potential to be good at construction as they do at practicing law or playing music. One's intelligence depends on how one's genes have shaped brain functions.[6]

Thomson critiqued the general intelligence model by proposing that there were no pure factors, but rather there is a combination of underlying factors.[7] Accordingly, two schools of thought have emerged: a non-hierarchical school, where several factors are of equal importance, and a hierarchical school. A good example of the non-hierarchial is the *structure of intellect model*, which considers a whole series of factors: *content* categories (made up of contents such as figures, symbols, and so on), *operational* categories (made up of operations such as evaluation, cognition, and so on), and *product* categories (made up of relations, systems, and so on).[8] Vernon's model of intelligence provides a good example of the hierarchical model, consisting of three levels: *general* factors (example G), *group* factors (such as verbal and numerical), and *specific* factors (conducted through specific testing).[9]

Other researchers have tried to move beyond the general intelligence model. For example, the Cattell-Hom-Carroll theory accepts G as the foundation of intelligence but layers nine additional abilities on top of it.[10] The theory suggests that the most important of these are crystallized intelligence and fluid intelligence. *Crystallized intelligence* includes the ability to exploit existing knowledge and experience in order to solve a problem and is concerned with skills and knowledge acquired through culture, such as vocabulary and numerical ability. *Fluid intelligence* includes the ability to reason and solve problems in a creative way without calling on experience. Fluid ability therefore consists of tests of classification and analogies of familiar pictorial figures.

Psychometric models have also been criticized because they treat intelligence as a universal phenomenon. Given that architectural design relies so much on context and specificity of tasks, some argue that such tests fail to address the variability of skills in design. While quite a few schools use design aptitude tests, unfortunately our understanding of them is limited, as many are not explicitly documented in design research journals. However, we know that these tests emphasize graphical ability (sketching, poster design, and anthropometry), formal/visual ability (visual memory task, Torrance test), spatial ability (conversion of three-dimensional photographs into plans/sections), and logical-mathematical ability (numerical ability, reasoning power). According to an international survey of 60 schools, 55% of schools rely on scholastic aptitude tests, and 26% rely on special architectural aptitude tests. Their primary use is for admission screening.[11]

Aside from design skills in the form of mental capacities, related studies have examined personality traits of architects in terms of thinking styles. Using Kolb's learning styles, Newland and colleagues studied designers' selective information handling and categorized them into four types of personalities: common-sense designers, dynamic designers, contemplative designers, and zealous designers.[12] *Common-sense designers* are abstract thinkers but survive as designers by combining the abstract with active experimentation and concrete experience. These designers are efficient planners. *Dynamic designers* continually sense the world, receive feedback quickly, and work opportunistically, which allows them to switch rapidly from being entrepreneurs to rapidly producing designs. These designers are accommodators. *Contemplative designers* possess a learning style that is a combination of reflective observation and abstract conceptualization. Their preferred mode of information transfer is transcendence, that is, they learn best by synthesizing apparent information into a unifying altruistic theory, which they use to create metaphors and make sense of seemingly unrelated sets of information. *Zealous designers* are cooperative, draw in others, and tend to coalesce or form groups. Such designers are down-to-earth and practical and are generous with their advice for colleagues, expecting the same in return.

Cross and Nathenson have described design thinking through a series of dialectical personality traits, such as field-dependent/field-independent thinkers or serialistic/holistic thinkers.[13] The *field-dependent thinker's* conception of the whole is an extension to the context as a total organization (i.e., objects in a given context are fused with their background). In contrast, the *field-independent thinker* may be able to think independent of the context. Moreover, the *serialistic thinker* moves linearly, with decisions made at each point before moving on to the next. In contrast, the *holistic thinker* proceeds more broadly, addressing issues that are not necessarily sequential, as long as they can maintain some conceptual order. Other dialectical personality traits, not described here, include divergent/convergent and focused/flexible ways of thinking.

What does the brain tell us?

If mental capacities are a function of the brain and its capacity to process, then are there particular correlates of skills in our brains? The field of neuroscience offers some insight.[14] While neuroscientists agree that specific areas of the brain are involved in complex functions, they do not yet understand how the brain works specifically. For example, when something is stored in memory, where does it go and in what form is it stored? And when a designer conceptualizes, how do thoughts come about and from where do they emerge?

For the most part, two schools of thought have dominated our theories of how the brain works: holonomic brain theory and localized brain theory. The *holonomic brain theory*, developed by neuroscientist Karl Pribram in collaboration with physicist David Bohm, suggests that the brain works as a whole. The brain is a holographic storage network in which each part of the hologram contains the whole of all stored information. This model encompasses important aspects of human consciousness, such as fast associative memory, which allows for connections between different pieces of stored information and the non-locality of memory storage.

On the other hand, *localized brain theory* suggests that the brain has separate faculties; therefore, specific parts of the brain are associated with specific functions. For example, Paul Broca discovered that damage to the left frontal lobe results in speech impairment,[15] and Carl Wernicke discovered that the upper rear part of the left temporal lobe is responsible for receptive speech.[16] When the nerve connection between two areas is destroyed, a patient may speak fluently and understand speech because the language centers themselves are undamaged, but they will have difficulty reading aloud or repeating a word as these centers do not communicate with one another.

On the continuum between the holonomic and localized brain theories, *equipotential theory* asserts that all areas of the brain are equally active in overall mental functioning. Early proponents of this theory suggested that basic motor and sensory functions are localized, while higher mental functions are not.[17] The effects of damage to the brain are therefore determined by extent, rather than the location, of the damage. In any case, new theories of brain suggest that the brain functions as a system of multiple neural operations, working either in parallel or in succession in different locations.[18]

There is also the view that consciousness and brain cannot be studied in isolation from one another. In his book *Consciousness and the Brain*, Stanislas Dehaene argues that consciousness is how we become aware of a specific piece of information. This is different from other related concepts, such as *selective attention* (how brain systems unconsciously apply a selective filter), *wakefulness* (referring to the sleep-wake cycle), and *vigilance* (excitement in the cortical and thalamic networks).[19] Instead, attention, wakefulness, and vigilance are all just enabling conditions for conscious access, and, while they are necessary, they are not always sufficient. For example, some stroke patients can be awake, attentive, and vigilant but still become color blind due to the loss of a small circuit specialized in color perception that prevents them from gaining full conscious access.

Interestingly, 80% of the human brain's total energy is spent in a default mode network, which keeps the brain engaged in a myriad of free thoughts and daydreams that never quite reach consciousness.[20] This is why we struggle to say what we are thinking when asked. Recent brain imaging techniques on spatial neglect patients show that unseen stimulus and subliminal suggestions can activate the regions of the visual cortex through an unconscious processing.[21]

Given such complex functioning of the brain, we might not be able to fully understand or grasp all the possible theories of the brain in the scope of this book, but the goal here is to derive some insights into brain faculties and their function. In the following paragraphs, I outline some basic brain faculties and their specific functions to essentially demonstrate that the existence of multiple skills are plausible because of multiple brain faculties. These faculties, however, are not clearly defined nor neatly packaged to correlate with specific skills, as is proposed in the multiple skills framework.

As seen in Figure 3.1, one could divide brain space into three major parts at the basic level: the cerebral cortex, cerebellum, and stem. The c*erebral cortex* is the outer layer of the brain and is composed of folded gray matter. The thicker the cerebral cortex, the more information the brain can process and the faster it can analyze it.[22]

The *cerebellum* is attached to the bottom of the brain and sometimes referred to as "the older brain." Its function is to coordinate and regulate muscular activity. Damage to the cerebellum can result in the loss of the ability to learn new movements, disruption of posture, jerkiness of movement, and an inability to make rhythmic movement. The cerebellum also gives us the ability to maintain sbalance and is responsible for procedural memory and the ability to remember how to do things. The *brain stem* is the central trunk of the brain, continuing downward to form the spinal cord. It is considered the most primitive area of the brain because it handles vital functions such as heart rate, blood pressure, breathing, awareness, digestion, body temperature, and sleep.

Besides these basic categorizations of the major brain parts, there are also the left and right hemispheres of the brain. The *left hemisphere* of the brain is associated with analytical and logical thought, language, math, abstraction, and reason and controls the right side of the body. Here, memory is stored as words. In contrast, the *right hemisphere* of the brain is largely associated with creativity and controls the left side of the body. Information about ourselves and our environment is coordinated into an overall picture, as memory here is stored as images. While the right hemisphere specializes in discerning spatial relations or the distance between objects, the left hemisphere specializes in delineating regions or boundaries in a categorical way, such as the topological relationship between inside and outside. Moreover, the two halves fundamentally work differently: the left half has more grey matter, which processes information, while the right has more white matter, which forwards information.

This strict demarcation of the two hemispheres, however, also raises some questions. We already know that the corpus callosum connects the two hemispheres of the brain and allows them to communicate with one another.[23] For example, even as the left hemisphere directly specializes in

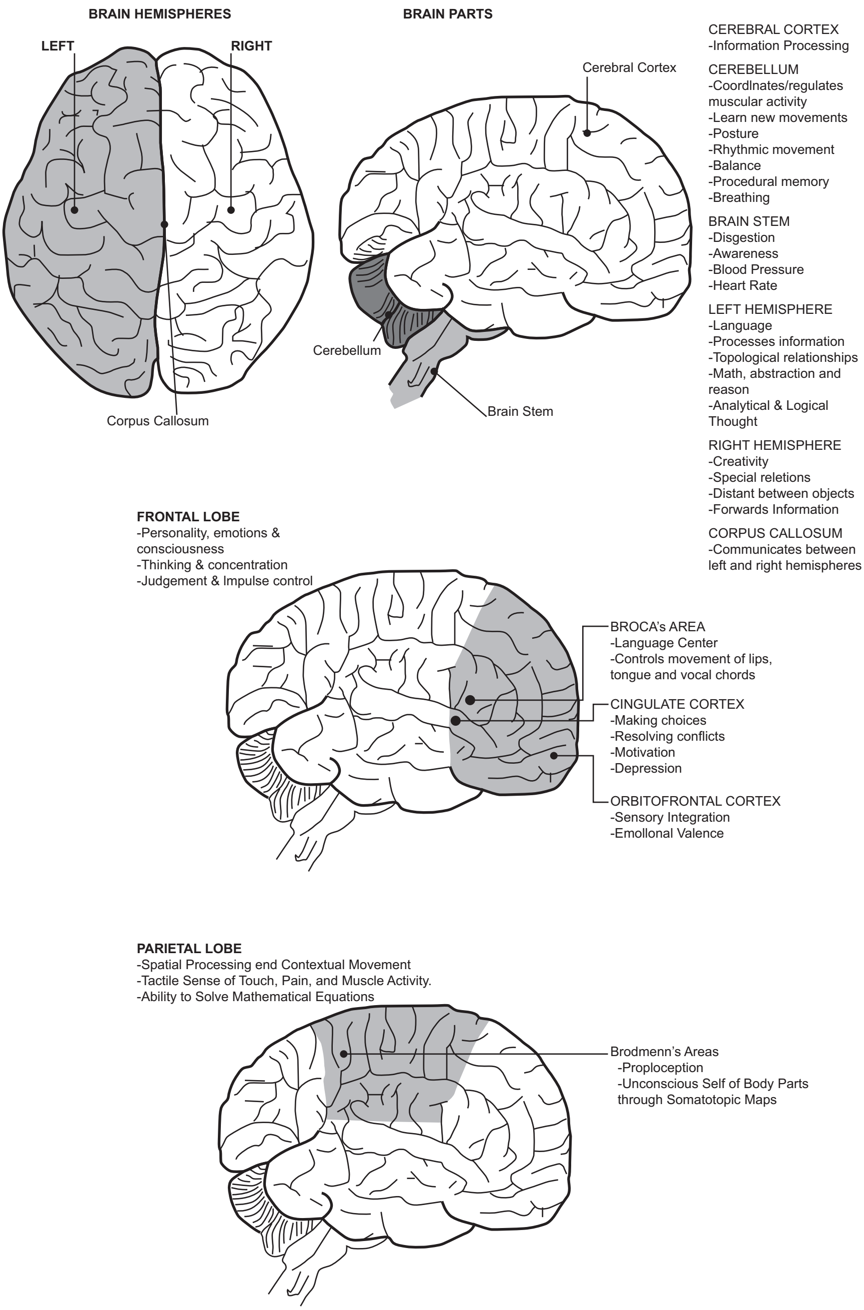

Figure 3.1 Brain faculties associated with mental capacities

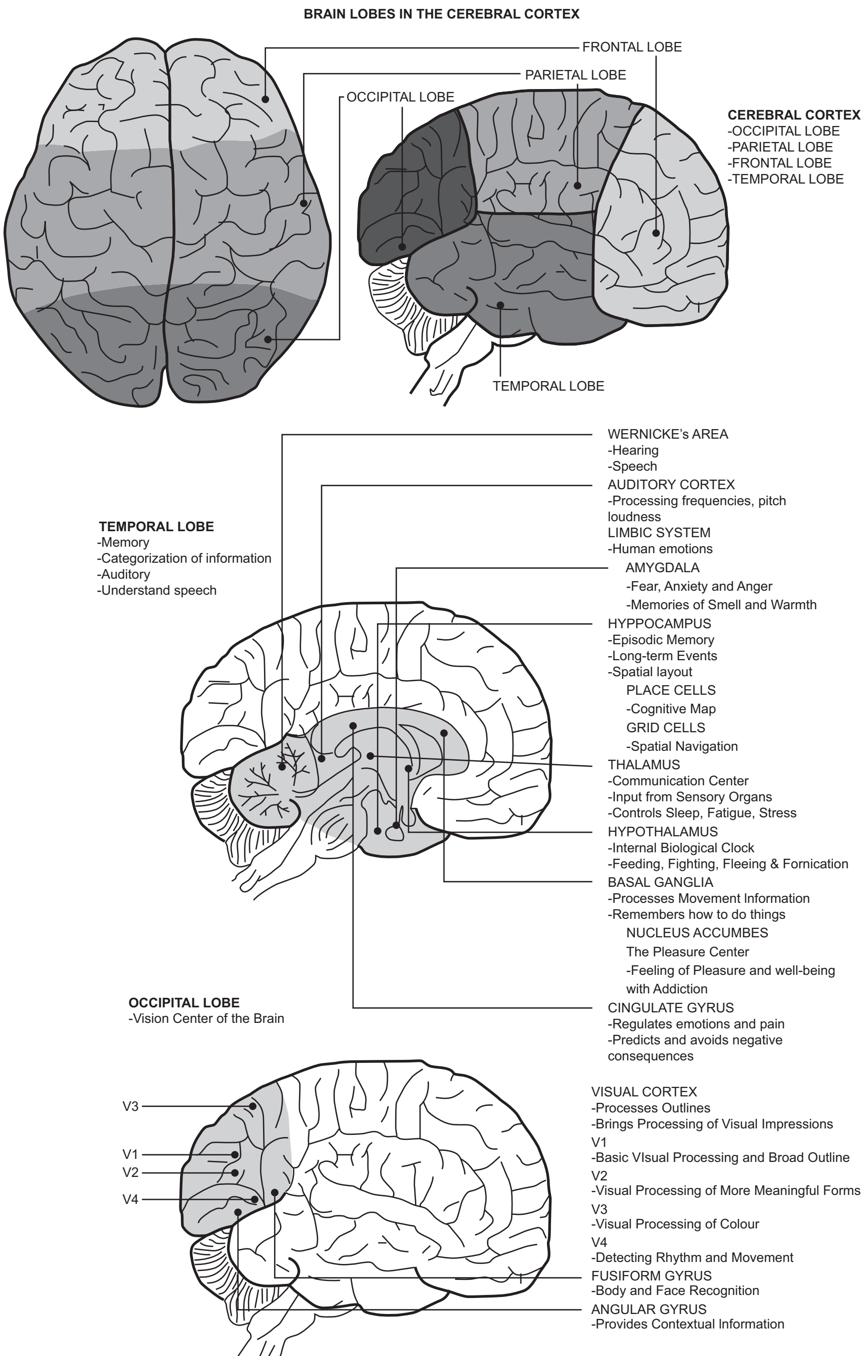

Figure 3.1 Continued

grammar, vocabulary, and words, the right hemisphere is responsible for pronunciation and grasping the underlying meaning of words.[24] Recent studies also suggest that we possess two functionally distinct visual systems, the ventral visual system and the dorsal visual system, which are responsible for perceptual processing of object properties and spatial relations.[25] Spatial and object imagery tasks led to very different patterns of brain activity.[26] Therefore, the ventral visual system functions mainly processes shapes and other properties of objects such as color and texture, and the dorsal visual system processes spatial relations.

While the previous paragraphs outlined the basic understanding of brain space into cerebral cortex, the cerebellum and stem, the next few paragraphs will describe the cerebral cortex in more detail. The cerebral cortex, is the largest area of the brain and can be functionally divided into four main lobes: frontal lobe and three posterior lobes (temporal, parietal, and occipital).[27] The *frontal* lobe is located in the front part of cerebral cortex and is the center for personality, emotions, the perception of consciousness, and the ability to think and concentrate. Judgement and impulse control are said to originate here.[28] Within the frontal lobe is the cingulate cortex and the orbitofrontal cortex. The cingulate cortex is involved in making choices and resolving conflicts, has the ability to empathize, is crucial in motivation, and plays a role in depression. The orbitofrontal cortex is involved with sensory integration and is an important component of the hedonic pleasure circuit. It is activated by sensory stimuli from the auditory, gustatory, olfactory, and somatosensory cortices; visual processing areas of the temporal lobes; and visceral and sensory systems.[29] It is also one of the principal mediators of emotional valence. Broca's area, which of the language centers of the brain (the other being the Wernicke area), is located in the left frontal lobe, right next to the motor cortex of the frontal lobe that controls movements of lips, tongues, and vocal cords.[30] In the case that this language center is damaged, the person will understand what is being said but themselves can only speak with great difficulty, if at all. This condition is known as Broca's aphasia.

The second lobe of the cerebral cortex, the *temporal* lobe, is located in the bottom-middle part of cerebral cortex and relates to memory, ability to understand speech, auditory capacity, and categorization of information. The auditory cortex is located in the temporal lobe and specializes in processing of frequencies; pitch; loudness; and harmonic, melodic, and rhythmic patterns. In brief, it consists of a precise tonotopic map. The other language center, the Wernicke area, is located in the temporal lobe, which is close to tissue involving hearing (auditory cortex). Any damage to this area may result in another type of language disorder in which one can speak fluently but what they say has no meaning. This condition is called Wernicke's aphasia.

Deep within the temporal lobe is the *limbic* system, sometimes known as "the emotional brain" because it consists of several parts that relate to human emotions. The limbic system includes the amygdala, hippocampus, thalamus, hypothalamus, basal ganglia, and cingulate gyrus.[31] The *amygdala* handles emotions such as fear, anxiety, and anger and is responsible for linking emotions to stored memories such as smell of a rose, warmth of a holiday, etc. The *hippocampus* controls episodic memory and long-term events and is essential for knowledge about the spatial layout of the environment. The hippocampus is home to place cells, first discovered by John O'Keefe and Lynn Nadel, which collectively act to produce a cognitive representation of a specific location in space, otherwise known as a "cognitive map."[32] These cognitive maps consist of localizing firing patterns called "place fields." The grid cells, which are another type of neuron and were discovered by Moser and Moser, are located in an adjacent area in the temporal lobe and allow a person to dynamically compute one's position in space for navigation.[33] Until recently, researchers believed that the entire human memory was stored in the hippocampus; however, new research suggests many memories are stored in the cerebral cortex.

The thalamus acts as a communications center that receives input from eyes, ears, skin, and other sensory organs, whereas the *hypothalamus* controls the four F's (feeding, fighting, fleeing, fornication), as well temperature regulation, sleep, fatigue, stress, hunger, and thirst. The hypothalamus also produces orexin, a small protein molecule, which activates neurons in the brain, awakening it and keeping us aware. Another protein, adenosine, actually lulls us to sleep.[34] It is thus here in the hypothalamus that our internal biological clock is maintained, regulating physiological, biochemical, and behavioral processes.

The *basal ganglia* is a cluster of neurons located deep beneath the cerebral cortex and specialize in processing movement information and brain circuits that determine the best possible response in a given situation.[35] Along with the cerebellum, the basal ganglia is responsible for procedural memory and the ability to remember how to do things. It also contains the nucleus accumbes, which, as part of brain's reward center, triggers intense feelings of pleasure and well-being and is even associated with addiction.[36] Some researchers have referred to this as "the pleasure center" of the brain. Lastly, the *cingulate gyrus* helps regulate emotions and pain. It is also involved in predicting and avoiding negative consequences.

The third lobe of the cerebral cortex, the *parietal lobe*, is located in the top-middle part of the cerebral cortex and is involved with senses relating to the physical body, spatial processing, and contextual movements. It processes tactile senses such as touch, temperature, pain, proprioception, and muscle activity but also involves numeracy and the ability to solve mathematical equations. Proprioception is the unconscious sense of where our body parts are in space, and the brain has created its own model of its understanding of our body parts through somatotopic maps. A specific region called the "Brodmann areas" contain the somatotopic maps where our body parts such as the foot, leg, trunk, forelimbs, and face are represented.

A feature of a somatotopic map is that our body parts are not mapped based on the real human proportions but with grossly enlarged face and hands compared to the torso and proximal limbs. This representation is also called the homunculus (i.e., "little man")[37] Damage to the parietal lobes, especially the right one, impairs performance on several tests of spatial ability. The frontal and the parietal lobe is also related to working memory. A large working memory helps in handling multiple tasks at once.

The final and fourth lobe of the cerebral cortex, the *occipital lobe*, is located in the rear part of the cerebral cortex and consists of the visual cortex or the vision center of the brain. It is fully occupied with brain processing of visual impressions so that the brain can form pictures.[38] Different areas in the visual cortex, as well as those adjacent to it, are highly specialized in processing shapes, objects, human faces, and body parts.[39] However, visual processing is a complex process involving several areas of the brain. Interestingly, the primary visual center, V1, actually does not do much in the grand scheme of things.[40] If we take the example of visually processing an image of a jogger in a park, the V1 will record only a broad outline of the jogger's body. This outline is then converted into simple line drawing that merges with the outlines of trees and buildings in the background. New nerve signals transmit the rough sketch to another brain center, the V2, where lines take on meaningful forms that differentiate the runner's physical outline from the background, but the image remains pale and flat. The V3 and V4 areas then insert the color of the track suit and detect the rhythmic jogging movements, respectively. However, there is still a long way to go before the visual impression makes any real sense. The image must be passed where the temporal, parietal, and occipital (TPO) lobes meet. Here, the color is tweaked according to light conditions. The signal then travels to the fusiform gyrus, which is an elongated area at the bottom of the brain specializing in body and face recognition. The angular gyrus is the brain's upper part that directs the viewer's attention to the fact that the jogger is out of breath and provides additional context in terms of the residential surroundings and the weather. In summary, although the visual cortex starts the first impression of the visual stimulus, over 50% occurs in frontal cortex where visual information is processed and given meaning.

The multiple intelligences framework

Just as we saw how the complexity of information processing requires multiple areas of the brain, the same can be said for functions. In other words, designating specific areas to specific functions is misleading.[41] Instead of a collection of specialized centers, researchers now believe the brain consists of a closely linked network of entities where these entities contribute in some part to the function, as though working together on a major collaborative project. The collaborative aspect of the brain is further elaborated in the book The Society of Mind by Marvin Minsky, who portrays the mind as a "society" of tiny components that are themselves mindless.[42] Minsky casts the brain as an intellectual puzzle with pieces that are assembled along the way. He believes that inside our brains exists a society of different minds. Like members of a family, these different minds work together and help one another, with each possessing its own mental experiences that the others never know about. Thus, the power of intelligence stems from our vast diversity. Aside from being highly collaborative, the brain simulates an action-oriented response.[43] For example, Lakoff and Gallese point out that the various sensory modalities (vision, tactility, hearing, olfaction) are fully integrated with each other to respond to a specific environmental event.[44] This multisensorial view is critical to understanding the experience of design and its making. Because of the context-specific nature of design discipline, the understanding that the brain functions through the perceptual act of how objects are to be responded to, handled or manipulated is critical.[45]

According to Pallasmaa, every experience of architecture is multisensory – the qualities of space, matter, and scale are taken in by the eye, ear, nose, skin, tongue, skeleton, and muscle.[46] Architecture strengthens the existential experience, one's sense of being in the world, and this strengthens one's experience of self. Beyond any one of the five classical senses, architecture taps into several realms of sensory experience, which interact and fuse with one other.[47]

Mallgrave highlights this connection to action is his book *Architecture and Embodiment*, where he describes how functional magnetic resonance imaging (fMRI) studies on action words such as "lick," "pick," and "kick" differentially activated areas along the motor strip directly adjacent to or overlapping with areas activated by tongue, fingers, or feet. He argues that, as intentional beings, our very consciousness is corporeally defined by our spatial or situational responses to understanding of the built environment.[48] It may seem obvious that we perceive, and therefore conceive, the built environment through our whole bodies, rather than simply through our senses or our brains. However, architects are generally trained to think of buildings as abstract objects of formal compositions existing in free geometric space, not as the existential fields of our tactile consciousness.

Given the above studies, one might conclude that while researchers have explored different parts of the brain and have a fair idea of its abilities, there is still a knowledge gap in correlating these parts to specific skills. There is hence legitimate criticism of directly correlating design work to brain parts and individual skills. Howard Gardner's Multiple Intelligences (MI) framework, first published in his book *Frames Of Mind*, is a good example of one such criticism.[49] His framework was mainly influenced by his observation of studies conducted among people suffering brain damage who had lost one ability, such as spatial thinking, but retained another, such as language. That two abilities can operate independently of one another suggests that separate intelligences exist and that skills, such as geometric reasoning, three-dimensional problem-solving, and visuospatial thinking, are indeed located in specific brain-centers. Gardner therefore argues that intelligences can be analyzed as separate faculties and that the function for true intelligence can be identified in a specific location in the human brain.

While some criticize the MI framework for lacking an empirical basis, Gardner strengthens his argument by triangulating his points with other sources of evidence, such as the existence of idiot savants, prodigies, and other exceptional individuals. He also derives some of his views from evolutionary history, suggesting that different forms of intelligence must have arisen through evolutionary antecedents, including capacities that humans share in common with other organisms. Gardner went on to conceive of eight forms of intelligence: verbal, logical-mathematical, spatial, bodily/kinesthetic, musical, interpersonal, intrapersonal, and naturalistic intelligences (Table 3.1). The MI framework is still under development as Gardner continues to explore the possible existence of other intelligences, such as spiritual/existential and moral intelligences[50]

Irrespective of the critiques of the MI framework, many researchers share Gardner's desire to broaden the classical definition of intelligence – whether general intelligence or G as proposed by Spearman. As he explains that in most countries throughout history, school has focused almost exclusively on language and logic. Formal education has virtually ignored other forms of mental representation – artistic forms (musical), athletic (bodily), personal (knowledge of others and self), knowledge of natural world, and knowledge of big questions. According to Gardner, all of these "Frames of Mind" are there to be mobilized.[51] He explains that the current education system, one that focuses on logical and verbal intelligences, fails to serve the academic and career needs of many students whose strengths lay outside of these two intelligences.

Gardner proposes a more vertical conceptualization of intelligences, as opposed to conventional horizontal theories. It has been argued that IQ and other psychometric tests of intelligences are *horizontal* assessments because general attributes, such as memory and cognition, are believed to be common to specific abilities, like verbal and mathematical abilities.[52] These models view intelligence as dependent on both *general abilities* (used in all intellectual works to some extent) and specific abilities (unique to carrying out a given task). In contrast, Gardner suggests that each intelligence category has its own attributes of memory and cognition rather than a central executive that applies across all intelligence categories. Hence, instead of a horizontal conceptualization of intelligences, Gardner proposes a vertical conceptualization of intelligences that are relatively independent of each other.[53]

Gardner's MI framework seems to follow a non-hierarchical model of intelligence as he claims that the strength and weaknesses in one category

Table 3.1 Descriptors of multiple intelligences[54]

Intelligence type	*Features*
(i) Verbal/Linguistic	A person with verbal intelligence is sensitive to meaning and order of words. Verbal intelligence involve excellence in activities such as hearing, listening, impromptu or formal speaking, tongue twisters, humor, oral or silent reading, documentation, creative writing, spelling, journal and poetry. Personalities associated with verbal intelligence are poets and journalists.
(ii) Logical-mathematical	A person with logical-mathematical intelligence is able to handle chains of reasoning and recognize patterns, numbering and order. Logical-mathematical intelligence involves excellence in activities such as understanding abstract symbols/formulae, deciphering codes, numerical calculations and problem solving. Personalities associated with logical intelligence are mathematicians and computer programmers.
(iii) Musical	A person with musical intelligence is sensitive to pitch, melody, rhythm, and tone. Musical intelligence involves excellence in activities such as musical recitals, singing on key and musical compositions. Personalities associated with musical intelligences are composers and conductors.
(iv) Spatial	A person with spatial intelligence can perceive, transform and modify spatial information easily. Spatial intelligence involves excellence in activities such as recreation of images, drawings, sculptures, forms, color schemes and so on. Personalities associated with spatial intelligences are artists, painters and sailors.
(v) Bodily-kinesthetic	A person with bodily-kinesthetic intelligence is able to use the body, has control over motor actions and the ability to manipulate external objects. Bodily-kinesthetic intelligence involves excellence in activities such as drama, role playing, sports and dancing. Personalities associated with bodily-kinesthetic intelligences are dancers, gymnasts and rock-climbers.
(vi) Intrapersonal	A person with intrapersonal intelligence has the ability to recognize personal feelings and emotions. Interpersonal intelligence involves excellence in activities such as silent reflection, concentration skills and higher order reasoning. Personalities associated with intrapersonal intelligences are writers and thinkers.
(vii) Interpersonal	A person with interpersonal intelligence has the ability to recognize others feelings, beliefs and intentions and understand people and relationships. Interpersonal intelligence involves excellence in activities such as group projects, counseling and feedback. Personalities associated with interpersonal intelligences are counselors, human resource personnel and teachers.
(viii) Naturalistic	A person with natural intelligence is able to connect with the intricacies and subtleties of nature. Naturalistic intelligence involves excellence in activities such as archeology, paleontology and wildlife watching. Personalities associated with naturalistic intelligences are botanists and archeologists.

of intelligence do not necessarily predict strength and weakness in the others, although relations between intelligences cannot be ruled out. Gardner's model is hence unique to other models because it is both a *vertical* and *non-hierarchical* model of intelligence. Whether intelligences can be said to be independent is one aspect of the MI framework that has received greater scrutiny. Klein contests the autonomy of intelligences using the example of parking a car to critique the MI framework.[55] He suggests that one uses logic to maneuver the car to fit exactly in the parking lot so one must use *logical* intelligence, but parking also requires a content area such as *space* to be acted upon. Therefore, Klein claims that logic is an *intended act*, while space is the *intended object*. In the MI framework, however, logic and space comprise the autonomous categories of logical intelligence and spatial intelligence, respectively. Klein raises the question of how these two intelligences could exchange information if they are so independent. This argument seems to be valid, especially in the context of design that thrives on skill convergences, where different intended acts of logic, visualization, and drawing are integrated with objects such as form, space, and graphics.

Gardner's MI framework assumes that intelligences and mastery of specific domains (e.g., musical, arts) can be attributed to mastery over specific forms of intelligences (e.g., music, sculpting). Empirical studies of MI framework conducted among college students have identified and validated this claim. According to one study with a sample of 224 college graduates, dance majors scored 65% on kinesthetic intelligence compared to students in math (43%), music (46%), and writing (48%).[56] The same patterns held for students in other domains, as interior designers/sculptors scored 66% on spatial, musicians scored 73% on musical, engineers scored 68% for logical, writers scored 72% for linguistic, psychologists scored 68% for interpersonal, and pilots scored 68% for intrapersonal intelligences. Overall, the magnitude of these results were found to be logically consistent with well-defined ability groups, validating the claim that the MI framework can help identify diverse sets of intellectual abilities.

Design skills: cognitive constructs or external depictions?

While much of the psychometric literature describes mental capacities in terms of "intelligence," I use the term "skill" as a more inclusive terminology in reference to design. In the context of design, the terms "design" and "intelligence" are traditionally viewed as antithetical because of connotations of architectural design with art and of intelligence with mental and physical capacities. Consequently, architectural design researchers use the term "creativity" more frequently to describe inherent abilities of designers.[57] However, our understanding of mental capacities in reference to design is complicated when one considers the wide array of activities involved in architectural design. First, design problems vary in content, scale, and complexity, and a designer must apply a repertoire of mental capacities and representations to solving design problems. This repertoire may include activities such as visualization, drawing, formal logic, and emotional reflection, among others. Additionally, design involves the ability to think in terms of various scales (macro to micro) and degrees of abstractions (abstract to concrete, symbolic to literal). Designers must also contend with conflicting architectural issues, such as aesthetic judgments (heavy versus light, dark versus bright), functional conflicts (work versus life, movement versus static) and psychosocial issues (community versus privacy, safety versus freedom, etc.). Thus, given the complexity of activities involved in the design process, the term "skills" is often invoked to describe both mental constructions and external depictions, as architectural representations lie somewhere on a continuum between the mental conception and where its material expression has taken place.

Some have suggested that design should be regarded as a unique form of intelligence, which is different from the scientific or scholarly thinking styles but just as powerful.[58] Cross suggests that even if we have yet to develop a conclusive model for studying design itself as a separate form of intelligence, there exists a nascent framework for further developing the case for "designerly ways of knowing, thinking, and acting."[59] However, while Cross's brings much needed recognition and appeal to the study of design intelligence, the idea of design as a unique form of intelligence might also serve to render design as an esoteric skill that precludes multiple forms of thinking. Design then becomes an ability restricted to autonomous self-referential logic.

While Gardner relies heavily on "intelligences" to describe mental capacities, he qualifies his prevailing terminology by suggesting that, as long as one can find a culture that values the ability to *solve* a problem or *create* a product in a particular way, then we can describe this in terms of intelligences. My use of "skills" in this book supports this definition. The MI framework is relevant inasmuch as it affords a way to think of architectural designing as a diverse set of skills. As the concept of "skills" is somewhat ambiguous, it can be associated with various commonly used terminologies such as ability (skill to do something), aptitude (natural skill), competency (the skill to do something well), intelligence (skill to learn and understand), and creativity (the skill to make new things). To the extent that the MI framework can be used to explain variation in design approaches, it not only refers to the diverse abilities of the designer but also the intentional use of such abilities for specific design tasks.

In a series of past studies, I have used the MI framework as a broad framework to empirically examine utilization of design skills among architectural designers by studying their tendency to possess multiple intelligences, the relationship between possessing intelligences and applying them to specific design tasks, and the relationship between these intelligences and academic standing.[60] Other studies have recently furthered this framework in disciplines such as Landscape Architecture.[61] I operationalized the MI framework through the Multiple Intelligences Development Assessment Scale (MIDAS) developed by Shearer for the educational settings.[62] The MIDAS is designed to give a reasonable estimate of a person's intellectual disposition in each of the eight main skill areas of the MI framework. In one study, I utilized this scale to measure the design skills of architecture design students throughout their design process.[63] When I compared with the MIDAS scores of these students to others (such as dancers, artists, psychologists, etc.), their scores were relatively well-balanced (i.e., neither too high nor too low). I concluded that, when compared to other disciplines, designers are more likely to use all skills in some threshold capacity, although they excel in specific disciplinary skills (such as spatial skill in architecture). Using these results, while extrapolating on the design literature as well as protocol analysis of design student activities, I have developed a framework to measure architectural design skills called ADIAS (Architecture Design Intelligence Assessment Scales) (D'souza, 2007). While I will not go into a detailed description of these scales, I have used the ADIAS as a broad framework to map design skills in this book. These include:

- Intrapersonal skills (sensitivity to examining and applying one's own feelings in design)
- Interpersonal skills (sensitivity to incorporate another's feelings in design)
- Suprapersonal skills (ability to conduct deep existential thinking in design)
- Bodily-kinesthetic skills (ability to choreograph about body movement in design)
- Naturalistic skills (sensitivity to natural environment of design)
- Spatial skills (ability to manipulate and transform spatial information in design)
- Linguistic skills (ability to use language as a design generator)
- Logical-mathematical skills (ability to logically reason and use rational thought in design)

As you will note in the chapter on implications, some of these skills tend to cluster with each other, and therefore will be grouped under a more streamlined taxonomy. Also while this study relies on the original intelligences presented by Gardner, one skill has been omitted, and one has been added. Omitted skills include musical intelligence. While some designers, such as Le Corbusier, have used musical scales as a background to their design compositions, and others such as Daniel Libeskind have expressed their affinity to it, there was insufficient evidence as a consistent design generator. However, the skill added to Gardner's original intelligence scale is suprapersonal skills. Although not originally present in Gardner's multiple intelligences framework, he has alluded to the existence of a similar skill called "existential intelligence" in the past but did not pursue it vigorously. This skill, might be relevant to designers who generate their design projects through spiritual meaning.

In some instances I have modified Gardner's minimal definitions of skills to bring about a more design-based interpretation. For example, Gardner's conception of "bodily-kinesthetic skills" is limited to the use of the body in doing skilled tasks, whereas my framework encompasses how designers conceptualize about body movements and human scale. This latter definition aligns more with recent neuroscience studies that have challenged the body-mind separation and rather that all mental operations are in fact embodied. Modifications such as these to Gardener's essential framework not only allow for more speculative discussion about design skills but contribute to a larger discourse and translational knowledge between the designer, the psychologist and even the neuroscientist – disciplinary specialists that rarely have an opportunity to converse with one another and examine each other's domains of knowledge critically.

Examining the design domain from a multiple skills standpoint can also bring some much-needed critical self-reflexivity upon our own domain. For example, in expanding the notion of design thinking to include the role of the body in design, Aguiar observes how we view spaces in terms of mere appearance and surface neglecting the role of that is both physically and mentally experienced and lived.[64] Aguiar further argues that that spatiality – so incredibly rich from the experiential standpoint – is impossible to capture through representation. Therefore, research concerned with spatiality is often rendered to the traditional set of architectural representations, which is naturally insufficient to describe the magnitude of actual spatial experience.[65]

One of the challenges of mapping design skills is that not all skills can be derived through conceptual diagrams or verbal descriptions alone. For instance, Perez-Gomez observes that "spatiality," although incredibly rich from the experiential standpoint, is difficult – if not impossible – to be adequately represented with traditional set of architectural representations.[66] Similarly, Bloomer and Moore observe that perspective drawings, which are typically drawn from a single station-point, might describe the visual intentions of the designer but fail to capture being in a place relative to time and the imageability of the space in one's memory.[67] Thus, the limitations of representations should be considered in the context of this book especially in the representation of skills such as kinesthetic and intrapersonal skills.

Indeed, the limitations of design representations makes it difficult to capture all the design skills equally. While distinctions can be made, for example, between skill as a cognitive construct (spatiality and lived spatial experiences) and the external depictions to convey the skill (sectional sketch drawing), this is still challenging since in many cases the cognitive construct and its external depiction tend to be interrelated and sometime work congruently. In the final analysis, a design intention was considered a skill only if the particular intention was purposive and deliberate and had multiple means of corroboration for example in written form, drawing, interviews, and expert reviews among others.

Mapping design skills in architectural works

The classical mode of conducting design cognition research is through experiments in which designers are given a design problem in a limited time and asked to "think aloud." The idea is that one can capture design thinking as a sequence of event in time through the designer's explicit verbalization of his or her thought process. Popularly known as *protocol analysis*, in such studies one can observe a designer in action and get a first-person understanding of their process. The current study, however, relies on a *cognitive-historical method of analysis* through the use of original drawings, sketches, doodles, and writings by architects already conducted.[68] The cognitive-historical analysis borrows documentation from various sources and allows an analysis of a large corpus of a designer's work. This method is valuable for this book because it allows one to make deductions of skill affiliation from a designer's lifetime work in which a consistent pattern can be elicited. One way to conduct a cognitive-historical method of analysis is to focus on minimal number of designers and delve deeper into their individual body of work. Researchers such Bryan Lawson have used minimal cases, arguing that it is more useful to better understand how a few outstanding designers work and think than to conduct experiments a larger number of less able designers. While this book adopts a similar strategy the book further attempts a deep dive of only one significant project of a given designer that illustrates the ideal example of a specific skill.

Since the design works have already been conducted in the past, historical interpretation comes with its set of challenges as far as gathering cognitive evidence. In profiling the works of architect F.L. Wright, the architect and historian McCarter observes that the single building study, while at first appearing to be of limited in scope in terms of the grand sweeping theories of architecture, can actually broaden our understanding of how Wright engaged in the act of design and construction. McCarter suggests that buildings are inevitably more complex, subtle, and deeply layered than any historical study of formal analysis can capture or convey.[69]

Additionally, cognition is not located within the individual "thinker" but as a process that is distributed across the "knower," the environment in which the "knowing" occurs, and the "activity" in which the learner participates. Thus, learning, cognition, knowing, and context are intrinsically combined.[70] Making a distinction from a traditional historian's point of analysis, in which buildings are seen as results of biographical events, historical influences, and preconceived theories resulting in a "read into" or "read onto" of design works, he suggests that in order to understand the architecture and the process more deeply, one should analyze through the mind of the designer – who may "draw out of" or "draw from" the design works themselves, searching for the ordering ideas and principles generated them.[71]

Cognitive-historical method of analysis assumes that cognitive processes or creativity are an extension of everyday cognitive capacities.[72] The principal claim is that design representations in the form of conceptual diagrams are not simply a transfer of completed thoughts onto external media but emerge from an interaction between partially formed and evolving ideas through dynamic thinking processes. For instance, in their analysis of Libeskind's Jewish Museum Berlin, Dogan and Nersessian examine the archival records of creative processes in order to better understand how Libeskind represented, formulated, and modified his design ideas through constructing a voluminous set of design sketches and diagrams. They argue that conceptual diagrams have significant correspondences with mental models that indicate an early commitment to a design situation and the interactions with such conceptual diagrams constrain and facilitate design exploration.[73]

However, one needs to be speculative when interpreting the conceptual diagrams. Emmons and Dayer observe that some architects sketch in front of clients, builders, or other architects, literally performing certain key drawings (usually carefully rehearsed) to make them appear as if by magic, in a rhetorically persuasive demonstration their conception.[74] They suggest that one also has to carefully consider differences between a designer's explanation, justification, and post-rationalization. In expressing such challenges, Kendra Schank Smith, in her book on architectural sketches, observes that all reading is a matter of interpretation, but associating a specific mark on paper with a constant and universal meaning is problematic.[75]

In outlining the challenges of interpretation, Michael Abrahamson observes that there is a fine line between "explanation" and "justification."[76] According to Abrahamson, an explanation reveals what is unseen or not understood while a justification offers proof that something is correct. However, he also questions whether some architect's works can indeed be subjected to this distinction because of the nature of their work. For instance, in referring to the architect Bjarke Ingels Group (BIG), he describes that their representation in the form of iterative diagrams and exquisite PowerPoint presentations tow a fine line between explanation and justification. Abrahamson wonders whether one is convinced by the lucidity of narration on how design ideas originated or the retroactive sense making that occurs after a design project is completed. Goldschmidt and Klevitsky have used the term "reconstructive memory" to describe representations that blend standard conceptual drawings at the beginning of the process and abstractions made post factum in order to tell the design story. In this context, Abrahamson observes that instead of providing a window into

BIG's design process, the representations actually detract the complexity of how design projects are made. In this new design paradigm, Abrahamson suggests, researchers need a new way of documenting design works. The traditional format of a "monograph" (an expert or a specialist writing about a single architect) would do a talented firm such as BIG no justice.

Another issue to be considered is the use of secondary data from archival sources since most of the architectural works evaluated in this book does not come from firsthand interviews. This limits the sources for verification especially in interpreting whether or not a design is based on specific skill. Chan points out that while it is debatable that secondary sources generates a perfect picture of design process, it can still be effective to describe cognitive phenomenon of style. Chan argues that as long as the collected information is verified by specialized experts, then it is justifiable and legitimate to say that the stories are reliable to certain degree in representing a cognitive phenomenon.[77]

Identifying design skills among archival design works poses several challenges. The *black box* model of design cognition suggests that it might be difficult or impossible to capture design cognition explicitly because the process of design itself may not be always visible to anyone but the designer.[78] In some instances, one would not really know how one discovers a design solution. Nor could a designer always provide a rationale behind every choice made in the design process. As Schon points out, designers know more they can say and sometimes give inaccurate descriptions of what they know. They have access to their knowledge only by doing.[79] Hence, any cognitive interpretation can be challenging because it provides only a narrow slice of the complexity and totality of design thinking.

Keeping these challenges in mind, the first task of this book project was to identify a corpus of archival design works affiliated with specific skills. For example, preliminary reading of Steven Holl's works relates to kinesthetic skills (representations of parallax), while Le Corbusier's works can allude to logical skills (use of rationalistic grid system). However, the difficulty of attributing specific skills to specific architects, who might be prolific in a variety of skillsets, can also be simplistic given that great architects such as F.L. Wright could fit in several skill categories such as spatial, naturalistic, bodily-kinesthetic, and so on. In such instances, I decided to focus on skillsets for which the designer expressed their greatest affinity. To overcome the challenge of categorizing competing design skills in a specific design work, design intentions were coded in multiple design skills categories, and the strongest affiliation toward a specific design skill was more weighted for the purpose of this book.

In some instances, I worked backward to understand the skillsets of the designers. For example, while the design products of Tadao Ando express nuanced spatial articulations, this curiosity evoked me to examine the process more closely to investigate whether spatial skills are in play.

Hence, while the book is focused on the conceptual process, I had to maneuver between the product and the process to select the appropriate design work. In this sense, one could say I used a deductive/inductive technique.

Going with these initial hunches, the next task was to conduct a more formal search for cognitive evidence in archival collections across libraries in the US.[80] Archival literature on architectural works are fragmented and dispersed in architectural libraries and professional bodies around the world. Moreover, not all materials are relevant. Indeed, more is written and documented on star architects than designers with alternative practices, thus creating a paradox. The goal of this book is to ultimately represent a diversity of approaches including alternative forms of practice, even if such practices do not use a uniform medium of expressions. As described before, the different skills deal with differing content area, and their documentation through a verbal or visual sometimes might be limited. To reduce such biases, the final selection of design works were based on those works that express maximum skill diversity irrespective of their chronological or paradigmatic considerations.

Additionally, while the focus was on individual design work, one needs to read it in the context of the teamwork that has made some great design works possible. David Robson, one of the historians who has profiled the great architect Geoffery Bawa, claims that today's historians and critics conspire to perpetuate the myth of the architect by writing almost exclusively about the work of individual architects, elevating the more successful of them to star status. He observes that such works ignore the realities of architectural production. Providing an example of how architect Norman Foster's work is indeed a team product, he observes that Foster's vision and judgement inform and direct the whole process and one should think of Foster not as an individual architect but as a phenomenon.[81]

Once suitable designers were identified, the next task was to map design skills based on design intentions and representations of the given designers. In the scope of this book, *design intentions* is characterized as the smallest meaningful unit in a conceptual design process.[82] This unit of analysis is analogous to a *design move*, which is defined as an act of reasoning that presents a coherent proposition pertaining to an entity that is being designed.[83] To make this determination, Architecture Design Intelligence Assessment Scales (ADIAS) scales were used as a broad framework, with relevant contextual information including writings by specific designers, historical contextual information, and the views of other authors. If design intentions were not coherent enough to be placed in any of these skill categories, they were omitted.[84]

While care was taken to record design intention sequentially, the exact sequence was less important than organizing the data to reveal multiple ways of thinking. In some cases, a single design intention might involve several design representations, but not all representations could be covered in the scope of the book. Moreover, preference was given to those intentions that could be sufficiently backed up with multiple media (drawing, writing, and other means), and cognitive evidence was primarily focused on the conceptual design process rather than the final refined product.

In the final list of archival works I selected for the book, one aspect that becomes abundantly clear is the diversity of each design personality. Louis Kahn, for example, expressed his design process through multiple trace drawings, while Wright seldom showed how these traces evolved. Zaha Hadid's works were conceived like abstract painting projects where the design traces were not easily discernible, although one could observe a series of developments with some imprint of the prior one. In contrast, Alejandro Aravena's projects are political and procedural in nature, rather than represented through a conventional sketching process. Bernard Tschumi incorporates a high level of personal reflection in his design thinking, while Daniel Libeskind's diaries shows intellectual rigor in the conceptual process. One cannot help but marvel at not only the quality of work but also the quantity of work produced by these designers that is not readily apparent from the popular literature. For example, Getty Research Institute houses at least 19 sketchbooks of Libeskind's sketches for the Jewish Museum Extension to the Berlin Museum alone, while the Garland Architectural Archives at the University of Pennsylvania Historical and Museum Commission holds at least 600 trace diagrams of concept sketches by Louis Kahn. The following chapters will elaborate on these specific design personalities associated with relevant skills.

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4 Intrapersonal skills

Daniel Libeskind's multivalent explorations and Peter Zumthor's atmospheric poetics

Individuals with strong intrapersonal intelligence are aware of their own emotional states, feelings, and motivations. Intrapersonal skills consist of one's introspective and self-reflective capacities, one's strengths or weaknesses, one's uniqueness, and the ability to predict one's own reactions or emotions. Intrapersonal skill involves the sensitivity to one's own feelings, one's own wants and fears, and one's own personal histories.[1] They tend to enjoy self-reflection and analysis, including daydreaming, exploring relationships with others, and assessing their personal strengths.[2] In the book *Emotional Intelligence*, Goleman found that people with high emotional intelligence were more adept at identifying their own feelings and solving problems.[3] For Goleman, emotional intelligence consisted of self-awareness, self-regulation, social skill, empathy, and motivation.

In any design process, pure logic doesn't always suffice. When a designer does not have enough information, he or she may rely on emotions, instincts, implicit experiences, and reflection to solve design problems.[4] In design, intrapersonal skills may be categorized into three subskills: ability to pursue emotions and meaning and draw inspiration from personal memories in design; the ability to explore metaphors and analogies in design; and sensitivity to personal knowledge.

Ability to pursue emotions and meaning, and draw inspiration from personal memories in design

Personal feelings and emotions comprise a large part of a design process, and many radical solutions and visionary forms of architecture have had roots in them. Several phenomenological studies have addressed the value of personal and subjective experiences in design.[5] Downing contends that architectural designers imbue the design process with meanings through utilizing *emotive* frameworks, which are personal constructs of internal, sympathetic, sentimental, or passionate reference.[6] She observes that emotions allow for body-memory constructions and event experience and attach a significance to sensate memory that is important to the design process. Similarly, Schon observes that non-logical internal conversation and reflection occur more frequently than thought in the design process.[7] Hence, a designer's emotional responses such as internal moods, feelings, or sense of comfort largely influences the design process.

While reconstructing the San Giovanni Battista Church, designer Mario Botta writes about how he was emotionally moved by the devastation of the small community destroyed by an avalanche.[8] He channeled his emotional experiences into several goals for the project, including the need to bear witness beyond one's lifetime, the need to overcome the feeling of loneliness, and the need to bear witness to hope. In this sense, the architectural space embodied the senses and concretized environmental schemata/ images.[9] Lyndon and Moore have also written about the use of memory palaces in his design thinking.[10] They constructed memory palaces based on visits to several countries, usually in the form of a miniature model or drawings that abstract the components of places, which invoke emotion, recollection, people, and ideas. Others, such as Peter Zumthor, have been inspired by an emotional response to atmosphere (e.g., water, mountains, light, and so on),[11] while the extensive use of analogy and metaphors that evoke emotions has been well documented in Daniel Libeskind's works.[12]

Ability to explore metaphors and analogies in design

Metaphors and analogies are useful in design as an important device in generating and conveying design ideas. Metaphors imply that the architectural object symbolizes another object with similar characteristics (e.g., Daniel Libeskind's Jewish museum as concretizing Jewish culture, specifically a Jewish star). Analogies imply an architectural object to be structurally or functionally acting like some other object (e.g., Le Corbusier's Notre Dame Du Haut, like a nurse's cap). According to Casakin, metaphors affect the way we perceive the world, categorize experiences, and organize our thoughts.[13] They allow the designer to think unconventionally and encourage the application of novel ideas to a design problem. According to Lakoff and Johnson, metaphors constitute an uncommon juxtaposition of the familiar and the unusual.[14] Downing has also discussed how experienced designers create and use "image banks" based on analogy and metaphor as an effective device in the design process.[15] Similarly, Pallasmaa observes that metaphors structure our perceptions, thoughts, and feelings, and they are capable of communicating deeply messages of time, as well as epic narratives of human life and destiny.[16]

The use of analogy is the process of finding correspondences between apparently unrelated sets of information and "thinking outside the box" in order to arrive at creative and novel solutions. According to Holyoak and Thagard, analogical thinking entails three cognitive constraints: similarity, structure, and purpose.[17] Constraints provide a tool to narrow down infinite possibilities of finding correspondences. *Similarity* is the correspondence between objects that have properties that are perceptually similar. *Structure* refers to the basic typology and the value of an analogy. The value of an analogy depends ultimately upon its *purpose*, which may include problem-solving, explanation, or communication. Others such as Fauconnier and Turner observe that the mind works in terms of c*onceptual blending*, which is the capacity to take two mental spaces and connect them in such a way that blended mental space emerges.[18]

Sensitivity to personal knowledge

Understanding one's own personal strengths and weaknesses helps the designer stay motivated in pursuit of their personal goals. A designer with high personal efficacy not only brings focus to their design process but also knows which design issues to explore further and through which medium to explore them. In Mackinnon's study of creative architects, he found that architects tended to value personal identity as one of their important traits.[19] He also found that the more creative the person, the more s/he exhibited openness regarding personal feelings and emotions, sensitive intellect, and self-awareness. Nearly two-thirds of the creative architects also considered themselves as introverts, with personal judgment and motivation seen as important aspects of self.

Understanding one's own design process, what works best for a designer, and an awareness of the context in which one is operating are also important aspects of intrapersonal skills. Designers bring a unique set of values and mode of operation to their design, some influenced by paradigms and styles, while others are willing to flout convention. Goldschmidt points out that designers such as Tschumi, Libeskind, and Hadid have used idiosyncratic design notations completely divorced from habitual drawing conventions to communicate ideas of pluralism, ambiguity, and lack of conventional order.[20] Others, such as Eisenman, use drawings that are objective and clear in structure, including axonometric drawings that rely on accurate measurement and drawings.[21] For others, such as Aravena, the contact and interaction with the users are critical to the design process, and representational drawing is only a minimal part of the design process.[22] Therefore, sensitivity to one's personal knowledge and an awareness of one's personal strengths and weaknesses can be an important assets to a designer's creative expression.

Intrapersonal skills of Libeskind and Zumthor

To highlight the use of intrapersonal skills in design, I have selected two designers who have extensively discussed the role of emotions in their design process: Daniel Libeskind and Peter Zumthor. In Libeskind's work, there is no such thing as neutral space. All space – even space thought to be neutral – is full of emotion. For Libeskind, architecture carries higher-level meaning, to the level of social, political, and cultural abstraction. In contrast, Zumthor's work can be characterized by architectural meanings that are more intimate and sensory. Instead of finding meaning in complex cultural tensions brought on by symbols and history that inspire Libeskind, Zumthor finds solace in the purity of poetics.

For Libeskind, emotion is complex and involves self-reflection, rather than an eternal order given by God.[23] Libeskind suggests that stories cannot exist without emotion. Stories told with emotion are what makes us human. Symbols are never without emotion. Furthermore, since architectural design is a storytelling profession, emotions are critical to the design process. Throughout his writings, Libeskind links architecture to humanity's complex currents of thought, memory, and imagination, where architecture explores the deeper order rooted in culture. History and tradition can be thought of as a body whose memories and dreams cannot be simply reconstructed in a straightforward way; therefore, Libeskind's designs often involve lines that slice and intersect.[24]

Libeskind's use of intrapersonal skills can be observed in one of his most famous works, the Jewish Museum in Berlin. His use of symbolism in this project is elegantly captured in several sketchbooks that he donated to the Getty Research Institute at Los Angeles. The Jewish Museum Berlin, which opened to the public in 2001, exhibits the social, political, and cultural history of the Jews in Germany from the 4th century to the present. The new building is housed next to the site of the original Prussian Court of Justice building, which was completed in 1735 now serves as the entrance to the new building. Libeskind's design, created a year before the Berlin Wall came down, was based on three insights: that it is impossible to understand the history of Berlin without understanding the enormous contributions made by its Jewish citizens; that the meaning of the Holocaust must be integrated into the consciousness and memory of the city of Berlin; and, finally, that the City of Berlin and the country of Germany must acknowledge the erasure of Jewish life in its history in order to ensure its future.[25]

For Libeskind, the holocaust museum form has several meanings and emotions. What is remarkable about these sketches is his intense engagement with social and cultural constructs, and how he makes meaning by relating them to his own personal experiences as Jewish. Through his sketches, Libeskind utilizes a variety of analogies and metaphors: fragmented walls, transformed Jewish star, voids that represent an absence of Jewish past,[26] Jewish baggage, book burning, and unrolling the Torah, among others (Figure 4.1). The intensity of the symbolism can even be found in the details of structure, open spaces, and parking. For Libeskind, every element is rich with symbolism and meaning.

Libeskind's intrapersonal skills are facilitated by his elaborate design sketches, as well as improvisational drawings, such as Micromegas and Chamber works. Micromegas consists of elaborate geometric patterns,

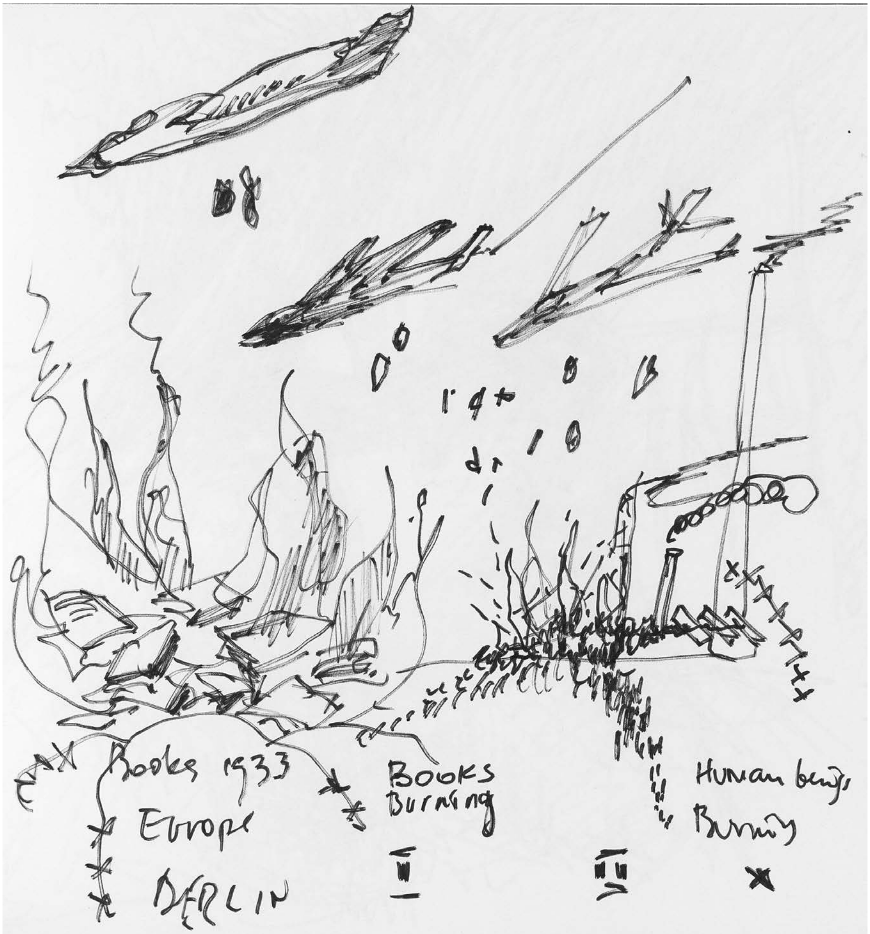

Figure 4.1a Daniel Libeskind's concept sketches for Jewish Holocaust Museum demonstrating the use of intrapersonal skills (a: book burning; b: unrolling the Torah; c: Jewish baggage)

Source: Getty Research Institute, 920061

while Chamber works demonstrates his affinity for architecture-music fusion.[27] Micromegas, named after satirical stories of science fiction by philosopher Voltaire, consists of pencil drawings. The drawings are experimental studies of space based on intuition, blind chance, and gestures and use multi-directional, crossed lines, curves, and circles. They create an impression through the penetrating, searching, tracking, or marking of traces.[28] Chamber works derive from Libeskind's attempts to connect music and architecture, given that he was a virtuoso accordion player. Similar to a

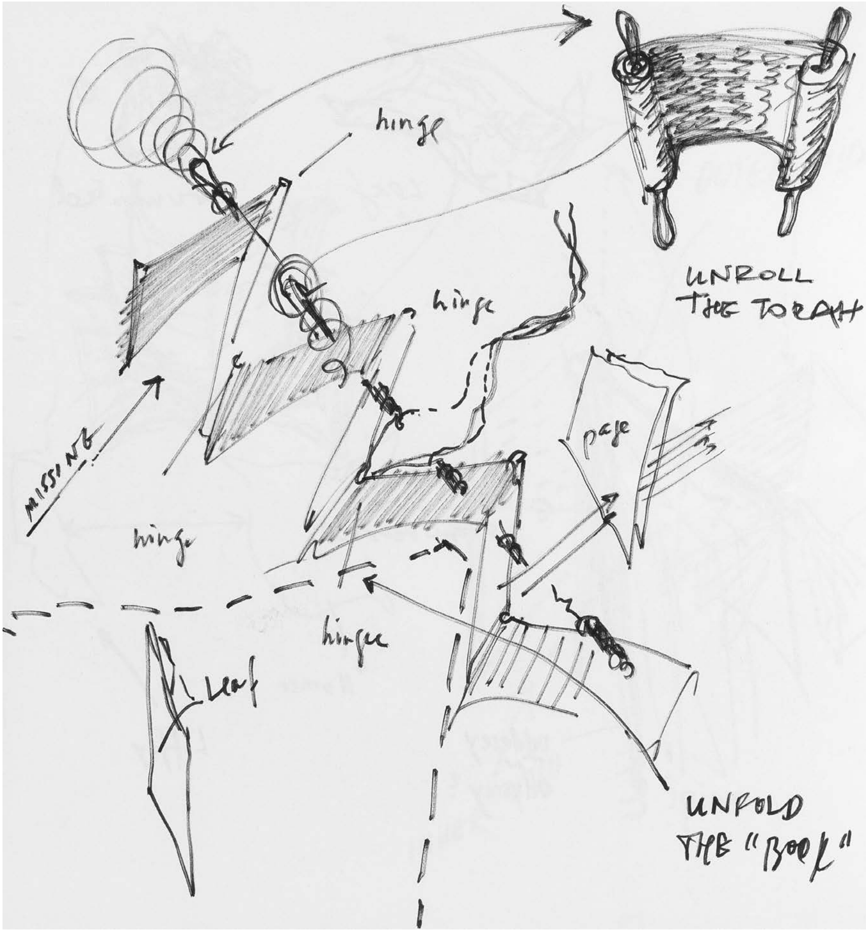

Figure 4.1b

musical score, the drawings consist of double axial structure of sounds, melody and/or chords, horizontal and/or vertical structure, regulated by the common principle of liberal variation.[29]

For Libeskind, an architectural drawing functions to unfold future possibilities, especially as much as it allows him to recover history. In the Jewish museum projects, he observes how lines hold special meaning, indicating varied meanings such as torturous history, absence, and paradoxical relationships. For Libeskind, the drawings must function as the embodied connection of eye, hand, and mind; otherwise, it is reduced to a soulless and abstract exercise.[30] This shows his personal knowledge and efficacy of using drawings in a deliberative way.

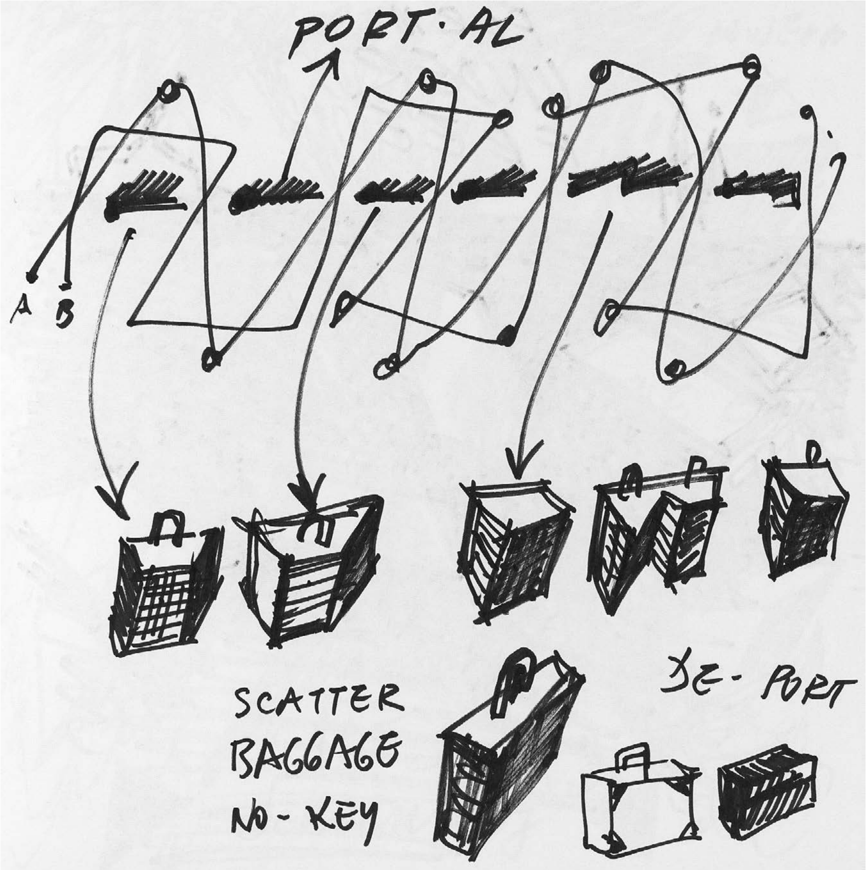

Figure 4.1c

Contrary to the orthogonal grid of the older museum, the new Jewish museum takes on the zigzag form of an invisible matrix. The form consists of a dialogue with the older museum, highlighting the paradoxical relationship between the material history of Berlin and its invisible Jewish past.[31] The project represents a dialectic between these two lines: one straight but broken into fragments, the other tortuous but continuing into infinity. As the lines themselves are constituted by this dialectic, they also fall apart and reveal separation so that the void runs centrally throughout. What is continuous materializes itself outside as ruined. According to his concept statement, like Berlin and the Jewish people, the immeasurable and unshareable burden is outlined in the exchanges between two architectures. For Libeskind, the forms are not reciprocal because they cannot be substituted for one another.[32] The past fatality of the German-Jewish cultural relation in Berlin is enacted in the realm of the invisible, and it must be made visible to give rise to a new hope and to a shared inner vision.

The resulting form is the result of intense personal reflection, borne out of, for example, questions about how to give voice to an absent Jewish culture without presuming to speak for it.[33] The design is a museum built around a void that runs through – one in which the form appears not so much from its presence but what Libeskind describes as the "voided void" reflective of the absence of meaning.[34]

While Libeskind's use of intrapersonal skills is inspired by history and tradition, Peter Zumthor's work reflects a more poetic approach to design. Zumthor contends that since materials are not meaningful or poetic in and of themselves, architects must create meaningful situations for them. For Zumthor, the unconscious absorption of landscapes become conscious experiences through memory, and this sensuous quality enables designer to impart the quality of spaces.[35] His aim is to create sensual, emotive, and responsive images that can receive and reflect personal feelings or emotional tendencies regardless of the audience.[36] Zumthor's primary use of emotion is through atmospherics – which involve the conscious perception of the environmental elements and is demonstrated by one of his well-known buildings, the Therme Vals. For Zumthor, the Therme Vals are a meditation of three sensory elements: mountain, stone, and water. Zumthor stays true to these elements, starting from the first phase of translating ideas into initial sketches and throughout the design process. Poetically describing his thoughts, Zumthor observes that in architecture, stone and water can enter a natural and even charmed relationship. He describes this reciprocal relationship by observing that while stone loves water, water loves stone more than any other material.[37]

These sensory qualities are evoked in his drawing and study models. For Zumthor, sketching is a playful form of research without architectural models.[38] He recalls feeling great freedom in pursuing issues of composition, working them out through block studies, giving them shape in spontaneous drawings, and trying to understand them by talking about them. In his first series for the final design, he uses monochrome in black and grey, thick mark at right angles made by shorter and longer sections of broken pastel crayons on paper. Later, he uses a series of block studies in blue and black. In most cases, the blue symbolizes the water surfaces; the blocks as load-bearing piers. According to Zumthor, the building grows out of the mountain and into the light. His strategy of using block diagram and rough-cut models reflects his personal knowledge of using specific forms of tools and inspiration to advance his design thinking. The abstract nature of it captures his personal experiences with the mark of his hand.[39]

Zumthor reveals his many sources of inspiration for the Therme Vals.[40] One vivid inspiration for him is the pictorial Rudes Baths in Budapest dating to the days of Turks, which he had copied from a book and stuck on the wall. He describes aspects of the picture, which include rays of light falling through the openings in the starry sky of the cupola that illuminates a room fit for bathing; the ambience of water in stone basins, rising steam, luminous rays of light in the semidarkness; and a quiet, relaxed atmosphere. Recalling his experience of the Baths, he describes rooms that fade into the shadow, the sounds of water, and how the rooms echo. For Zumthor, there was something serene, primeval, and meditative about it and one which was utterly enthralling. Another inspiration for the Therme Vals is the interior of the Albigna dam, which for him is analogous to the cathedrals. Zumthor also uses other analogies, such as boulders standing in the water and rock quarries.[41]

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5 Interpersonal skills

Alejandro Aravena's social persuasion and university-based design center's community engagement

While intrapersonal skills involve an intense exploration of a designer's self-motivations and emotions, interpersonal skills demand an understanding emotions of others. Since designers are concerned with how people experience their designed works, a deep understanding of people's needs, socio-cultural norms, and behavioral patterns are critical. Interpersonal skills involve empathy and recognition of user needs, as well as an appreciation for diverse perspectives among people and groups, with sensitivity to their motives, moods, and intentions. Goleman (1997) describes *empathy* as an important trait of emotional intelligence.[1] Empathy is the ability to free oneself from one's own view and recognize the thoughts, feelings, and motives of the self and others (Davis, 1996).[2]

Interpersonal skills in design demands that designers need a keen sensitivity to human behavior. Environmental psychologists and designers have conducted several studies on the interaction between environment and people's behavior in the hopes that designers could use it in their design process. For example, studies have correlated aspects of biophilic design to impact on health and well-being, stress reduction, cognitive performance, emotion, mood, and preference (The Drive Toward Healthier Buildings, 2016).[3] Commonly known as environment-behavior studies, such research includes place attributes,[4] sociocultural factors and cultural change,[5] universal design/ accessibility,[6] privacy,[7] personal space,[8] territoriality,[9] environmental stress,[10] environmental press,[11] aesthetics,[12] preference,[13] meaning,[14] spatial behavior,[15] legibility/imageability,[16] spatial nostalgia,[17] and way finding,[18] among others.[19] Interpersonal skills also involve working collaboratively with fellow designers and the community of stakeholders as demonstrated in large corporate firms, such as Gensler, HOK, and Perkins + Will, for example. These firms are all known for conducting design through cross-departmental project-based teams. In summary, interpersonal skills in design can be categorized into three subscales: empathy toward human needs; the ability to be socially persuasive; and the ability to engage in design collaborations.

Empathy toward human needs

Addressing human behavior and user needs has a mixed legacy in the design field. While some designers consider responding to human behavior as part of their role, others consider it to be outside of their purview. For example, celebrated architect Frank Gehry thought that architects should not concern themselves with social problems but should stick to what they are best at.[20] According to Gehry, architecture is not social science but rather an art. Hence, designers should not focus so much on people but on the tasks for which they have been trained. In contrast, Dana Cuff's famous study of NY architects demonstrates a range of perspectives in architects' conceptualization of people.[21] In her study, she creates a typology of designers: for the first group of designers, people cannot be known except through self (Eisenman, Williams); for the second group, people are hard to generalize so the audience is largely unknown (Meier); for the third group, people's memories are important (Polshek); for the fourth group, people's behavior can only be measured through cultural regularity (Holl); and for the fifth group, people are not abstract but real, so architecture should be a collective endeavor (Hardy).

The use of empathy is evident in the humanitarian works practiced by non-profit groups, such as Habitat for Humanity, Detroit Collaborative Design Center, and others. Habitat for Humanity helps families build and renovate homes with affordable housing strategies, while the Detroit Collaborative Design Center is dedicated to creating sustainable communities through a multidisciplinary collaborative process. Designers such as Lauri Baker and Samuel Mockbee have committed their lives creating affordable housing for the underserved in rural areas. While Baker absorbed local wisdom to construct suitable buildings at a low cost to address the growing needs of the poor in rural India, Mockbee established the Auburn University Rural Studio within the University's School of Architecture as to improve the living conditions in rural Alabama. B. V. Doshi, Charles Correa, and Christopher Alexander have also sought socially transformative work through voices to the underserved and underprivileged.

Designers such as John Zeisel have focused their efforts on vulnerable populations such as the elderly. As co-founder of the Hearthstone Alzheimer Care, Zeisel applies environment-behavior principles in his designs of nursing homes. For instance, the hallways within Hearthstone's facilities are each designed with a destination at the end for people to walk to – so they don't wander. Instead of the bland, empty walls characteristic of most nursing homes, the walls are adorned with visually distinctive photographs, painting reproductions, and individualized "reminiscence boxes" so that people can determine where they are.[22]

The concept of "universal design," which is the design of all products and environments to be usable by people of all ages and abilities to the greatest extent possible, also incorporates empathy and inclusiveness.[23] The concept of universal design has also been used in architecture[24] among those striving for emancipation and inclusion. The celebrated architect Michael Graves, who became paralyzed in his later life, dedicated to designing universally accessible solutions. Graves' hospital bed-hopping experiences during his two-year recovery process greatly influenced his mission to bring colorful, uplifting design to otherwise drab, morale-deflating healthcare facilities.[25] Graves also teamed with Kimberly-Clark for Better Life By Design, a "human-centered" product collection intended to celebrate aging as full of spirit, possibilities, and growth.

Other designers have taken a humanist approach to address vulnerable populations, such as those living in poverty. Inspired by homes made by ordinary villagers, British Indian architect Lauri Baker absorbed local wisdom to construct suitable buildings at low cost to address the growing needs of the poor.[26] Baker did not approach his design with any predetermined visions of a grand scheme. Most of his thinking and process occurred on site, with improvisations made to suit the life pattern of each client. In Baker's view, the specific task of an architect includes not only providing basic shelter to their clients but also accounting for their accumulations, peculiarities, and specific requirements.

Human needs have also been studied under the broader umbrella of cultural variation. Culture has been studied as an explanatory concept to understand built environment,[27] as well as to understand social systems and resilience.[28] In his pioneering book *House, Form and Culture*, Amos Rapoport suggests that environment is shaped by cultural templates and that cultural codes need to be decoded in order to understand the built environment.[29] Rapoport proposes a series of layers of examination starting from ideals, to values, worldview, lifestyle, activity systems, and ultimately the environment. Similarly, Walker addresses culture in heterogeneous contexts that consist of growing urban forms, such as the case of informal housing production in Mexico City. Instead of viewing culture as the determining factor to explain house form, Walker suggests social change should be thought of as the determining factor while considering design.[30]

Research on human behavior has also examined the characteristics of homogenous and heterogeneous communities. Isaacs proposes that urban places are not composed of a single stable community defined by a delimited space but of dynamic, multiple-layered communities, transformed by the interaction of confronting difference and changing.[31] Isaacs also invokes Anne Vernez Moudon's term "resilience" to describe the ability of a place to adapt to changing social structures without major disruption to the principles of structure of that space, thereby balancing continuity and change. The idea of resilience has been adapted by more recent architects such as Alejandro Aravena and others in their designs of social housing.[32]

Walter Hood witnessed and documented scenarios of everyday experience and ordinary happenings, constructing new narratives to reflect the soul of the self and the community.[33] In a series of illustrative water color and sketches, Hood studied behavior patterns of urban mini-parks and described users that are traditionally excluded in design: the inventor, thief, musician, anarchist, workaholic, apathetic, loner, lover dreamer, cook, optimist, doubter, single parent, revolutionary, and bureaucrat. Like stanzas in music, Hood observes that a designer starts with a set of spatial principles and that social injustices arise when certain societal and user needs are ignored and unaccommodated in the initial planning and design, and conflicts arise when unprogrammed uses occur.

Evidence-based design (EBD) has gained traction among the design research community with increasing research to establish measurable, positive impacts of design on human behavior. Popularized by Roger Ulrich, EBD is a process of basing decisions about the built environment on credible research to achieve the best possible outcomes[34] and includes a wide range of sources of knowledge, from systematic literature reviews to practice guidelines and expert opinions. Currently, the primary metric for measuring the impacts of buildings is through occupant feedback and complaints. Therefore, one of the goals of EBD is to establish systematic post-occupancy evaluations of buildings that feed back into the design creation cycle.

Ability to be socially persuasive

The ability to be socially persuasive in design relies on the extent to which a designer can elicit user participation and remain open to criticism, advice, or ideas from others such as clients and peers. In their study of personality traits of designers and their design thinking styles, Newland and colleagues identified several types of personalities. Among them, one type of designer, the "zealous designer," is of a co-operative nature, draws others, and tends to coalesce or form groups.[35] Such designers are down-to-earth and practical, give generous transfusions to their colleagues, and expect the same in return to keep them going. They continually sense the world and get quick feedback and work in an opportunistic fashion.

One way to be socially persuasive is to involve the user early in the design process. For instance, action research emphasizes user participation in examining and testing change by active design intervention and application in real world contexts.[36] Action research strives for community participation and collaborative approaches to design inquiry. Another strategy for encouraging user participation includes the use of charrette process. A "charrette" is an intensive multidisciplinary workshop with the aim of developing a design or vision for a project or planning activity. A team of design experts meet with community groups, developers, and neighbors over a period lasting from one day to a couple of weeks, gathering information on the issues that face a community.[37] Others techniques for inclusive participation include the use of design games in the hope of making it more democratic[38] or evaluating social layers by uncovering hidden architectural programs.[39]

To engage clients more fully in the design process, Zeisel advocates an iterative model that consists of "design spiral" that involves imaging, presenting, and testing.[40] *Imaging* is the process of creating a "picture in the mind" of users and their environment; *presenting* is accomplished through sketches, words, plans, section, and vignette; and *testing* involves evaluation of design responses. The design spiral starts with an initial image based on acceptable and optimum design responses, passing through consecutive imaging, presenting, and testing cycles, and culminates in a decision to build.

Randolph Hester suggests that observation is the single best technique for discovering what people do and how people interact with other people in neighborhood space. His work for the mid-block urban mini-park in West Oakland reveals the ways in which improvisational design can open up new levels of community awareness and empowerment and offers a pragmatic illustration of how disenfranchised communities can participate in reconstructing their public environment. His work in the town of Manteo provides a prime example of how to incorporate user participation systematically.[41] Hester's team investigated aspects of community life cherished by residents of the town of Manteo through a series of interviews and behavior mapping. From the resulting information, they determined the places that were most important to the social fabric of the town. Newspaper questionnaires were subsequently developed for the townspeople to rank places in order of significance. Their responses were used by the designers to measure the intensity of attachment to places in contrast to the benefits of tourism. A ranked and weighted list of significant places resulted. One resident, upon seeing how many places ranked higher than local churches and cemetery, described them as "sacred structures." These places included buildings, outdoor spaces, and landscapes that exemplify, typify, reinforce, and even extol the everyday life patterns and rituals of community life. While the sacred structures were almost universally unappealing to the trained professional eye of the architects, historians, real estate developers, or upper middle-class tourists, for the townspeople, they inspired economic recovery, preserved cherished landscapes and concretized the virtues in Manteo's identity.

Ability to engage in design collaborations

Designers must be increasingly collaborative as the field has shifted from an insular, solitary, and private activity into a more distributed, cooperative, and community-based one.[42] These collaborative practices are upending the existing power structures by requiring the sole designer to relinquish control of the design project to design teams and to the lay public. Sanders and Stappers predict that design practice will eventually become synonymous with design research, creating new landscapes of opportunity.[43] This will render obsolete the traditional consultative model in which a designer completes most of his or her work in isolation and then outsources it to specialized consultants. Similarly, advances in technology facilitate previously untested collaborations. Loukissas, for example, illustrates how new identities can arise around technologies such as design simulations that bring together experimental, observational, and mathematical evidence to create believable predictions.[44]

Design involves action and leadership, engaging people, and involving a component of diagnosis to solve real-world problems. In this regard, the ability to interact with other designers, clients, and end-users or to take up leadership are invaluable skills. In the collaborative design (co-design) process, the user is given the position of "expert" of his or her experience and plays a large role in knowledge development, idea generation, and concept development. In contrast, the designer assumes the role of facilitator, active in leading, guiding, and providing a scaffolding that requires empathy and leadership. The co-designing process is critical in an increasingly globalized design world where collaboration involves both local and global designers.

Large corporate architectural firms in North America such as Gensler and HOK rely not on one individual designer but a team of principals who manage large-scale collaborative design strategies, both regionally and globally. For example, Gensler's projects span scales, communities, and practice areas, consisting of 2,569 architects out of more than 5,000 employees, 31 practice areas, and 48 offices across 16 countries.[45] According to Julia Simet, Gensler's Managing Director and Principal, the company facilitates cohesion across thousands of employees by promoting enthusiasm for entrepreneurship.[46] In order to keep all employees on the same design spectrum, the company implements a multiday orientation program for new employees, the Gensler Orientation Program, which pairs new employees with experienced employees to make connections and foster a sense of community.[47] Similarly, HOK creates design solutions through collaborative and an integrated process that encourages multidisciplinary professional teams to research alternatives, share knowledge, and imagine new ways to solve the challenges of the built environment.[48] Their firm involves the collaboration of approximately 1,700 people across a network of 24 offices on 3 continents.[49] These large firms are providing new models of collaboration both locally and across geographic boundaries.

Interpersonal skills of Aravena, Detroit Collaborative Design Center, and Clemson University Architecture + Health Program

To demonstrate the use of interpersonal skills within design, I present the work of one activist designer and two university-based design organizations. architect Alejandro Aravena, a champion of Chile's low-cost social housing, relies on intense user participation in design. Similarly, the two university-based design organizations, the Detroit Collaborative Design Center (DCDC) and Clemson University's Architecture + Health Program, demonstrate best practices for inclusive design and community engagement.

Aravena founded the design firm Elemental in 2000 while at Harvard with Andres Iacobelli, a transport engineer, and Pablo Allard, a doctoral student at the time.[50] Given the instrumental philosophy of the firm, he describes it is more of a "Do Tank" rather than a "Think Tank." Elemental pursues projects of public interest that are bound to have a social impact, such as housing, public space, infrastructure, and transportation. Despite this focus, Aravena insists that the firm should not be thought of as working on behalf of the urban poor or as a humanitarian project – instead, Elemental is a profitable organization that rigorously pursues better solutions to complex challenges in the built environment.[51]

Elemental began their reformulation of housing delivery with a few basic precepts: quality and quantity should both possible with social housing; social housing should be viewed by occupants and the government as an investment in a tradable asset, rather than simply an expense; and social housing should increase in value over time. These precepts were intended to strategically move social housing out of the realm of humanitarian territory within social discourse to the administrative realm of political discourse, involving economists, public administrators, lawyers, engineers, and architects, as well as community organizers and charities.[52] Aravena believes that design can act as a synthesizing force across various disciplines-/approaches typically associated with solving social problems.[53] He observes that a designer need not be a policymaker or an economist in order to make a social impact but can do so through the act of design.[54] Accordingly, he considers participatory design as not about consulting by committee but to have every stakeholder involved so one is not missing any dimension of the problem. Aravena observes that a common problem in participatory design is that inviting people to complain sometimes makes it difficult to channel problems in one specific direction. Moreover, he suggests there is no room for guilt or arrogance at the table within the participatory processes; instead, honest, horizontal relationships allow for the shared transmission of ideas back and forth.[55]

Rather than initiating a project with design questions already formed as is often the mindset, Aravena takes his starting point as far away from architecture as possible. He suggests that it does not matter if questions have good answers if they are the *wrong* questions to begin with; the power of architecture lies in its ability to synthesize the complex entry to the problem.[56] Aravena also acknowledges that setting priorities is a critical part of effective participatory processes. It does not matter if a specific goal has a 95% consensus if the goal is not within the priorities, does not make sense, or is professionally irresponsible. The uniqueness of Aravena's approach is further highlighted when juxtaposed with other prevailing methods in architectural thinking, specifically from the charge to the "first sketch." During the design process, Aravena's team moves away from a prescribed program to explore other possibilities of inhabitation rather than the initial solution from which they started.[57]

Aravena's interpersonal skills are clearly evident in one of his most well-known projects, the Quinta Monroy housing project in Iquique, Chile. When Elemental first started the project around 2002, as is common in urban sprawl, nearly 100 families were illegally squatting on a half hectare of private valuable land located near the center of the city. The families had long-established community networks and other linkages to employment and education that would be irreversibly upended by re-locating them to the edge of the city, where land was more affordable. Using his interpersonal skills, Aravena relied on an incremental housing scheme, consisting of a series of partial structures that residents were able customize to their own needs and financial situations over time.[58] The firm used state resources to perform the heavy lifting, building the infrastructure and providing basics such as plumbing, while the residents were responsible for completing the rest. In this respect, Elemental focused its time and resources on constructing half of a "good" house instead of a fully finished "bad" house. Once residents were given the building blocks of a house, they could then expand upon their houses using their own labor and skills.[59] The empty halves of these houses allowed space for individual residents' imagination to thrive within a collective framework.[60] In this respect, Aravena put into practice his belief that architects design in nouns (windows, ceilings, floors) but these nouns derive from verbs (cooking, eating, and meeting); hence, designers should always consider both the nouns *and* the verbs.

According to Aravena, incremental housing, such as the Quinta Monroy housing project, where nearly 50% of the façade remains uncertain, requires special attention to maintain a homogenous and collective feel. For instance, photomontages, a process of creating a composite photograph by cutting, overlapping, and rearranging photographs into a new image, were used for visualizing the practical and aesthetic interventions. Aravena also conducted a participatory Minga workshops – a collective activity developed by a community in favor of an individual (Figure 5.1). Initially, Aravena invited residents to the two vacant sites of the camp, equipping them with shovels, wheelbarrows, spikes, and measuring tape. Residents constructed three-by-six modules of the houses of stones, and a plastic net was stretched along the available space to form the basis for the public space workshop.[61]

Later workshops provided tips to residents about harmonious growth and structural safety. In these workshops, to promote harmonious growth, residents were asked to express on paper what they thought represented Quinta Monroy and then make a proposal for the collective spaces (the courtyards). Many of the residents viewed the project as a result of a long struggle. Some residents viewed the housing as an opportunity for a

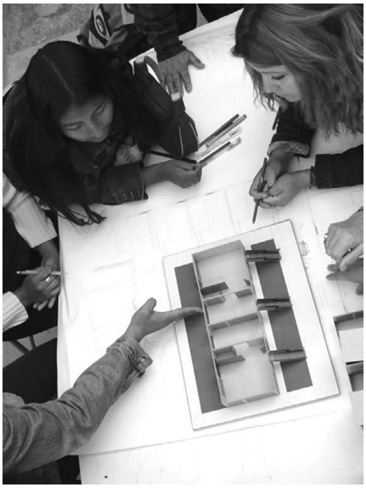

Figure 5.1a–b Alejandro Aravena's demonstration of interpersonal skills (a (top): Minga workshops with the community conducted on site; b (bottom): discussions with community on drawing board; c: one community member's personal expression of the future homes)

Source: Elemental

(*Continued*)

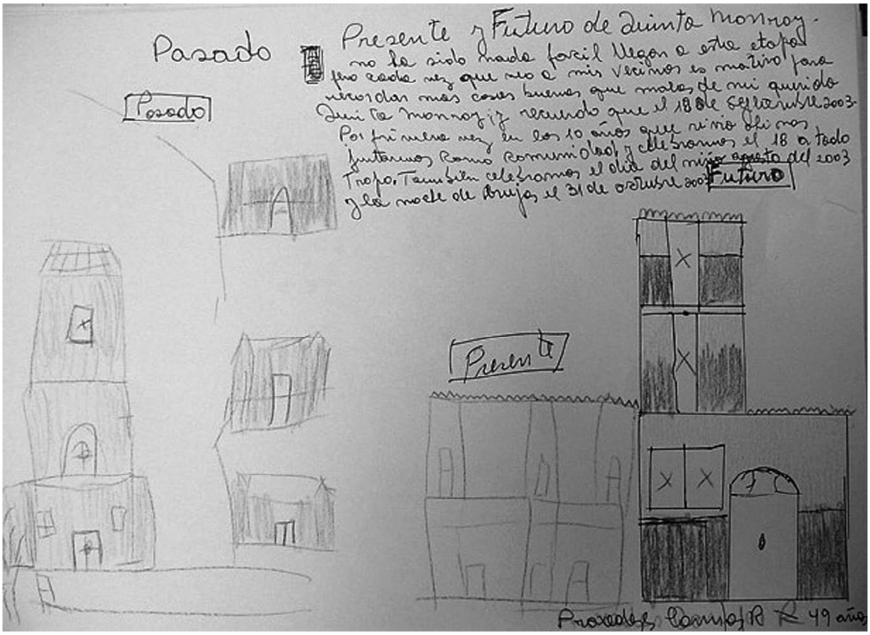

Figure 5.1c

new start on a better foot, while others viewed it as an intrusion into their familiar lives. Ultimately, the workshops revealed the diversity of the residents' visions and expectations. However, the workshops also allowed Aravena's team to use the organized action of the residents to transform what might be considered "nobody's space" into a "collective space." Moreover, through participatory processes, they sought to instill a sense of responsibility and an appreciation of the project in the future owners of the project.[62]

When it came to individual spaces, in order to discern preferences while simultaneously being mindful of costs, Elemental asked families to choose between pairs of comparable alternatives, rather than asking them to describe their dream homes. For instance, each family was asked whether they would prefer a bathtub or water heater (with a shower stall), two items of approximately equal cost. For the most part, families preferred the bathtub over the water heater, explaining that it was nearly impossible retrofit units for bathtubs later on, not to mention that bathtubs provide enough space to bathe infants while shower stalls do not. Ultimately, Elemental included bathtubs and not water heaters. While this decision may at first blush seem inhumane, it was made within the context of a poor family's economic reality, as well as Chile's culture of self-construction. It made sense water heaters could always be added later, and that would likely be the case. The design process not only made this blind spot visible but allowed Elemental to make an evidence-based decision. In the case that they were met with political opposition, the team could always point to their thorough needs-finding assessments, which the families themselves could also defend. In this respect, Elemental rejected more conventional solutions found in the market, instead acknowledging the challenges faced specifically by poor families. This was made possible by asking themselves a series of basic questions, such as: *Who are the players? What are their motivations? What are the constraints? Where are the opportunities?*

Two months after construction began on the Quinta Monroy housing project, almost 60% of the residents initiated expansions, the majority of them following the recommendations discussed in the workshops.[63] Eight months after the program's initiation, and in the process of occupation, Elemental conducted another workshop to facilitate the population's transition from squatter to citizen, emphasizing the beneficial networks intrinsic to a formal city so as to offer a collective mindset for their individual actions.[64]

Elemental also strived to produce public housing that would appreciate in value over time. Rather than build 100 homes for $750,000US, they would build an entire building for the equivalent amount. By providing upper and lower floors, the building could be expanded in a harmonious fashion. Interior finishes, paint, and plaster would be omitted initially to reduce upfront costs, with the understanding that families could install these later on. As construction commenced, Elemental conducted workshops with the families to familiarize them with their new homes and provide instructions for safely expanding individual units. As intended, self-construction made expansion possible for the families at a pace set by their own finances. Within two years, additions had been made at an average cost of $750US per family, providing evidence of the community's growing wealth. Not only did this provide families with more space; it also increased the size and value of their homes.[65]

While Elemental's affiliation to interpersonal skills is evident in its inclusive design process, albeit from a profit-oriented business standpoint, several university-based non-profit organizations have taken a more activist and research-based approach. Two of these organizations highlighted here are the Detroit Collaborative Design Center (DCDC) at the University of Detroit Mercy School of Architecture and Clemson University's Architecture + Health Program.

Stephen Vogel and Terrence Curry established the DCDC in 1993 to create a neighborhood design studio that would enhance the abilities of local leaders to produce quality design through broad-based community participation.[66] Nearly a decade later under the leadership of Dan Pitera, DCDC diversified its projects and was working with over 80 Detroit non-profit organizations, community groups, and philanthropic foundations. Pitera's motivation for focusing on community design was in response to what he has described as an obvious anomaly in the design profession: an underservice of people of lower socioeconomic status; reduced opportunities to reach a wider range of people; and too few architects willing to be involved in the critical issues faced by everyday citizens.[67] DCDC works to bring these diminished voices into an equitable dialogue that encompasses more people, more programs, and more geographies.

DCDC refuses to label itself as an "alternative practice," instead viewing its work as *altering* how to practice. According to Pitera, DCDC emphasizes learning by doing, and models itself after a teaching hospital. Rather than prescribing solutions to any given community, DCDC accommodates the communities that come to them for assistance. Students and professionals conduct diagnostic tests and applied research in order to better understand the issues communities face. Not unlike holistic medical practitioners, the members of DCDC must be open to all perspectives, rather than adhering to a regimented typology-based design in which a particular formula is applied and repeated.[68] This leads to projects that are borne out of the community, with a participatory design that engages already existing systems – much like a block club model that exists irrespective whether a project exists or not. A block club is a group of self-initiating citizens who live on specific blocks or within a specific geographic area who come together to improve their communities.

Pitera credits this approach for sustaining long-term community relationships.[69] He makes a distinction between *community participation* and *community engagement* in that he sees the role of the DCDC in promoting the latter. According to Pitera, it is important to start with a defined methodology of community engagement with an ethic of mutual knowledge sharing at its core, as opposed to a methodology of community participation based on hierarchical working relationships with the design center at the top[70] Unlike a typical project-based studio model where interaction with communities is episodic, often leading to short-term, quick interactions, DCDC strives for meaningful long-term day-to-day engagement.[71] For example, one of their projects, the Detroit Hispanic Development Corporation (DHDC), continued for nine months with three groups of students rotating in and out of the project, unconstrained by the length of a university design studio.

Pitera suggests that failure is always a possibility when working with communities and that a community has to be prepared to make mistakes and fail as a community. Innovative ways of problem-solving are rarely successful on the first try. The path to success is found after many failed turn-offs, perhaps a missed exit or two, but these mistakes provide or reveal unexpected opportunities. With this in mind, the people working together through these intense and dynamic issues must be willing to admit mistakes, be adaptive to change, and embrace new potential and unexpected opportunities.[72] Pitera believes that to be engaged, one has to relate to people who might not know the trade talk of designers. Designers who can bridge discipline expertise with stakeholder expertise will be the most successful. In particular, non-judgmental body language that demonstrates respect for everyone's expertise in the field is of critical importance.[73]

DCDC adopts a philosophy of "creative amnesia," which is to say that designers enter into project with their partners with as little preconception as possible. The designer's role is to stimulate engagement and use locally driven responses as a starting point, upon which creative solutions can be developed.[74] Pitera's approach does not mean that designers must relinquish the expertise as designers but that great designs are realized through the synthesis of two bodies of knowledge: the body of knowledge of the design discipline and the body of knowledge brought in by the stakeholders. While the tendency of most design firms is to give primacy to the former, creative amnesia helps to suspend it until the stakeholder expertise is given its due attention. For example, "street knowledge" is less accessible to designers but rather resides in the knowledge base of the community.[75] Since many are not able to attend or do not want to attend traditional community planning meetings or town hall events, Pitera suggests using a mosaic of engagement tactics. Some engagement tactics allow designers to enter into a dialogue with the community using small participatory methods and others celebrate the dialogue using more intensive workshops.[76]

The "Roaming Table" from the Detroit Future City project is a prime example of a tactic used to enter into a dialogue with a community and broaden engagement (Figure 5.2). The DCDC team constructed a mobile wooden table to take around to public places or meetings throughout the city several times a week for three to four hours, placing it in front of schools, libraries, businesses, bus stops, and other public sites to increase participation. The table alone facilitated one-on-one conversations with approximately 6,000 individuals. Overall, the Detroit Future City project connected with people over 163,000 times, including 30,700 one-on-one conversations, using a variety of tactics, such as: the DetroitStoriesProject, Detroit 24/7, Roaming iPad Station, Community Conversations, Process Leaders, Open Houses, HomeBase, Traveling Road Show, and Street Team Deployment. A brief detail of these tactics are as follows:

- DetroitStoriesProject, asks citizens to share their versions of the story of city. Each week one person's oral history is selected to be released and celebrated;
- Detroit 24/7 is an online social media gaming tactic, executed using the Community Plan and in partnership with the Engagement Game Lab at Emerson College;
- Roaming iPad Station attempts to bridge the digital divide in Detroit by using iPads to help ensure that the citizens have access to play the Detroit 24/7 gaming opportunity;
- Community Conversations involves participants discussing an issue in groups of 8 to 10 and involving about 10 to 20 issue-based conversations simultaneously;

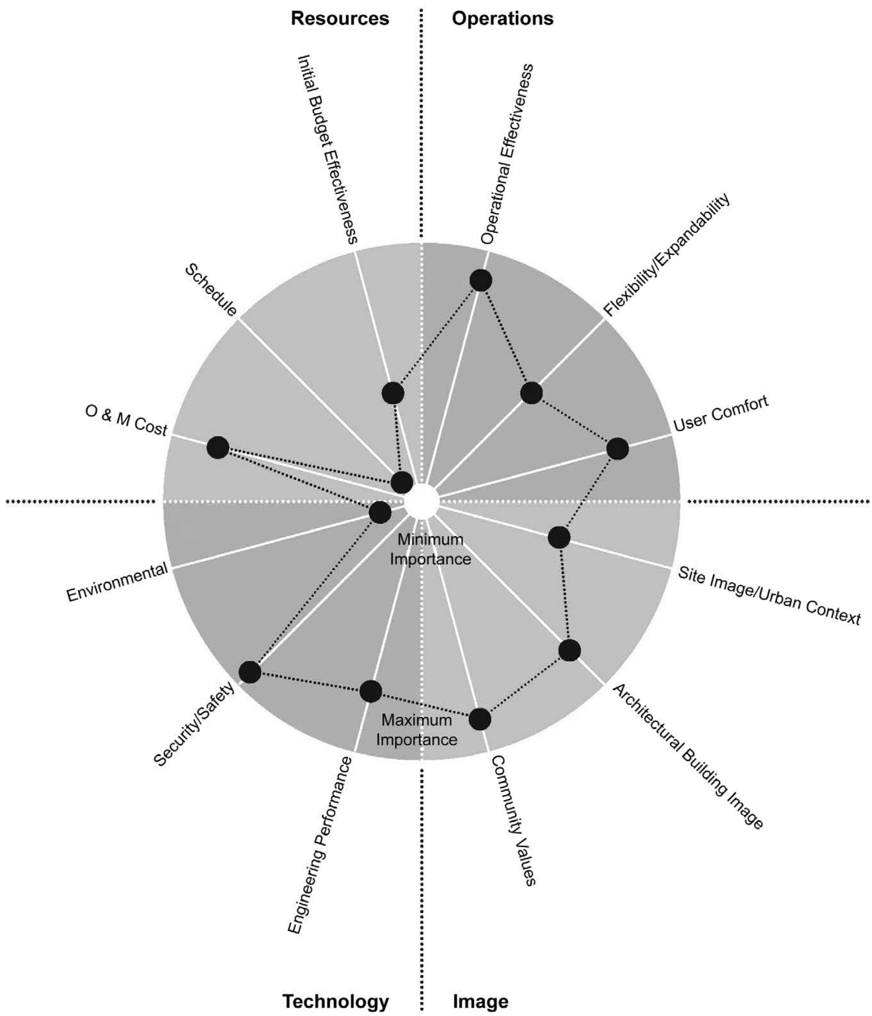

Figure 5.2a Detroit Collaborative Design Center's community engagement strategies demonstrating interpersonal skills (a: Shopping Trip Categories; b: "thought" diagrams; c (top): Play-doh exercise; d (bottom): Roaming Table)

Source: Detroit Collaborative Design Center

- Process Leaders are essentially multiple citywide engagement leaders whose role was not to determine the future of Detroit but instead to lead, advise, and direct the process of engagement toward a blended community and expertise. Process leaders are recruited and selected for their expertise in civic engagement among different constituencies and geographic areas in Detroit;

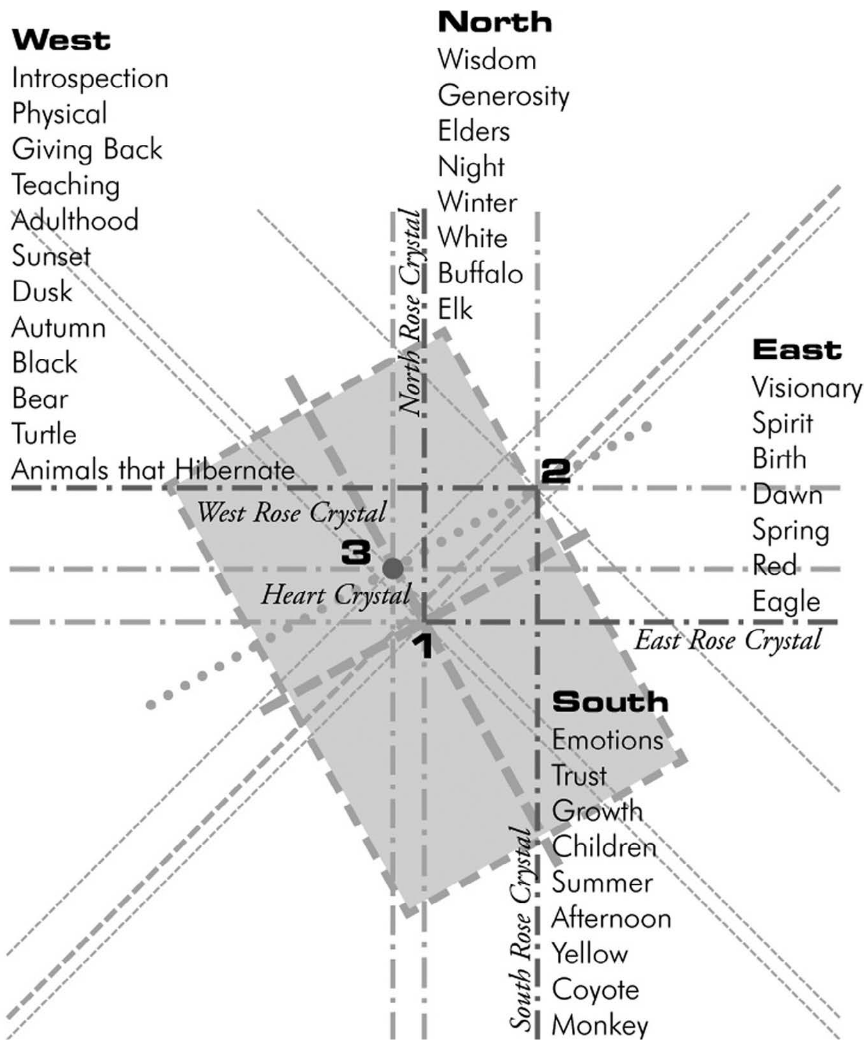

Figure 5.2b

(*Continued*)

- Open Houses are designed to be community celebrations of the work and garner one-on-one feedback focused on issues such as economic growth, land use, and city systems;
- HomeBase is an "open door" public office and meeting space in order to have an "open door" where DCDC hosted walk-in visitors and community events;
- Traveling Road Show exhibits community projects in schools, businesses, non-profits, and institutions;

Figure 5.2c–d Detroit Collaborative Design Center's community engagement strategies demonstrating interpersonal skills c (top): Play-doh exercise; d (bottom): Roaming Table)

- Street Team Deployment involves Detroit residents from a variety of city geographies who engaged in community conversations and distributed information about the process throughout the city, targeting residences, businesses, organizations, and institutions.

Besides these short-term tactics that allow DCDC to enter into a dialogue with the community, celebrations of these dialogues also require intensive workshops and other long-term tactics. These workshops are not determined a priori but arise out of specific demands of the project, such as budgeting, programming, siting, visioning, etc. The Neighborhood Engagement Workshops (NEW) are based on the idea that creative making comes from the synthesis of creative listening and creative thinking. Workshops are not designed to achieve specific and particular responses but involve a series of designed activities that are active and meaningful to encourage dialogue and potentially reveal hidden intentions, agendas, desires, and needs. Initially modeled after other design centers across the country that have traditionally conducted workshops, NEW empowers stakeholders to renew their communities through collaboration and coalition building,[77] developed through trial and error over a long period of time. However, the DCDC was able to formalize this process much more systematically.[78]

In the Detroit Hispanic Design Corporation project (DHDC), the NEW process brought together about 25 participants, including community leaders, youth, and staff to plan their own projects, discussing neighborhood needs and harmonizing diverse perspectives. Design issues were classified into 12 categories, which were then grouped into 4 broader categories – resources, operations, technology, and image – that could be ranked and prioritized (Figure 5.2). Participants were given an exercise in which they were to envision these 12 categories in terms of a "shopping trip," allowing each stakeholder to make design decisions by placing their priorities using pretend currencies in a closed envelope, without seeing how others have done. This reduces bias introduced by the dot exercise where the visibility of the dots drives the process.[79]

DCDC also uses other exercises to help the community visualize three-dimensional spaces. The "scavenger hunt" exercise is used to create spatial literacy among the community members and educate them on how to read a plan. In this exercise, participants are given a list of specific features in a plan drawing, which they must identify and mark by physically moving through an existing building. Similarly, to create meaningful conceptual development of spaces, a Play-doh exercise was used (Figure 5.2), which is a clay-like colorful material generally used by children for arts and craft projects. Since Play-doh is pliable and comes in different colors, the community can use it represent building spaces and move it around based on the functionality of spaces. This interactive exercise provides the community a means to think along with the designers and other community members about programs, functions, and adjacencies, among others.[80]

Much like Aravena, DCDC emphasizes verbs over nouns, as evident through the DHDC project's "Nouns and Verbs" workshop, which encourages the community to do the same. For example, a design element such as a stairs (noun) can also be thought of in terms of ascending or descending (verb). As Pitera observes, if individuals are asked to think about stairs as a noun, everyone will envision different sets of stairs, but they will all imagine stairs. However, if one were to ask the same individuals to envision verbs such as ascending and descending, one person might think of mountain climbing, another will imagine an elevator, and yet another will think of a ramp. Thus, the framing of program and design in terms of verbs instead of nouns not only provides more varied options but also expands opportunities for creativity.[81] It encourages individuals to suspend the visual preconceptions they make when asked to think about nouns.

After these engagement workshops, the DCDC design team synthesizes the information in order to distill the complexity. One synthesis approach is to visualize the information through the use of "thought diagrams." In the DHDC project, for example, the DCDC team created a thought diagram by capturing abstract concepts pertaining to medicine wheel crystals proposed by the community which involves a traditional ritual of holding appropriate crystals in meditation to find balance in life. These concepts were subsequently translated into functional and orientation decisions by the design team (Figure 5.2). The team follows up the diagrams with sketches and small chipboard models. To be more inclusive in the process, sketches are made while standing up so that no one designer can dominate design process. The initial focus is on the sectional drawing before the plan drawing is made.[82]

Another example of University-based community engagement is Clemson University's Architecture + Health Program – a collaboration between the School of Architecture's research center and the Center for Health Facilities Design and Testing – which uses a multidisciplinary, evidence-based approach to design healthcare space. In this process, researchers and design students work closely with clinicians and architects using simulations to iteratively test design solutions. For example, the program's Realizing Improved Patient Care through Human-Centered Design in the Operating Room (RIPCHD.OR) project – a four-year multidisciplinary patient safety-learning lab funded by the Agency for Healthcare Research and Quality spearheaded by architect and researcher Anjali Joseph, an expert in healthcare design research – focuses on designing safer and more ergonomic Operating Rooms (ORs) using an integrated design philosophy.

In the RIPCHD.OR project, the learning lab is organized around a systems framework where the built environment of the operating room along with people, tasks, technology, and the organization interact to impact safety outcomes. The semester-long design process was built upon a foundation of a yearlong research study on the operating room, which included literature reviews, in-depth observations of 35 surgeries, case studies of best practice facilities, and focus groups with clinicians. The process began with a multidisciplinary design workshop, which included students, the multidisciplinary learning lab team, and national experts in architecture and healthcare (Figure 5.3). The purpose of the workshop was to facilitate exploration of ideas between architects and clinicians through structured questions and to develop clear guidelines to support the design process.[83] The theoretical framework of the project resulted in assembling a multidisciplinary team that could focus on all the different OR components in an integrated manner.

Once the team began to establish a common set of values, they were able to translate ideas into design guidelines. Design students then worked with the cross-disciplinary team to develop design solutions for an innovative, safe, operationally efficient, and flexible OR that could fit any OR suite configuration. The idea was to iteratively test design ideas using mock-ups of different levels of fidelity. The team of researchers and educators determined the scope of the mock-up construction (tape on the floor, cardboard mock-up) to support the key decisions that needed to be made during that phase in the design process. Concurrent to the mock-ups, the research

Figure 5.3a University-based community engagement conducted by Clemson University's Architecture + Health Program demonstrates use of interpersonal skills (a: collaborative workshop; b: collaborative workshop; c: cardboard mock-ups)

Source: Center for Health Facilities Design and Testing, Clemson University

(*Continued*)

Figure 5.3b–c University-based community engagement conducted by Clemson University's Architecture + Health Program demonstrates use of interpersonal skills (b (top): collaborative workshop; c (bottom): cardboard mock-ups)

team developed a systematic evaluation protocol to facilitate the next round of design refinements.[84]

For the first phase of mock-ups, students developed four design options, two of which were selected for testing in the tape on the floor mock-up. For the second design iteration, four primary design options using the same footprint were selected for testing. Students pre-fabricated cardboard modules to be assembled on site (Figure 5.3). The cardboard modules could be moved around to test different door locations. The third mock-up phase evolved with more detailed design refinements to the OR design and physical construction.[85]

RIPCHD.OR was inspired by the integrated design philosophy of team members David Alison and Byron Edwards while working for a firm Kaplan, McLaughlin, Diaz in the 1980s.[86] This model seems to typify the modern design thinking models of collaborative design (co-design), where the fuzzy front end of the design process becomes populated with hybrid design researchers and research designers.[87] As Sanders and Stappers have observed, in the co-design process, the design/research blur will be disruptive at first, with arguments going back and forth about who is best suited to do what, which tools and methods belong to whom, and how to analyze the data.[88]

According to Allison, two types of collaboration are possible as far as designers are concerned: interdisciplinary (*within* designers, such as architects, design researchers, design students) and cross-disciplinary (between designers, such as nurses, clinicians, and other stakeholders). In both cases, Allison suggests that developing a common language and knowledge base is critical. The work conducted in the first year of the grant was crucial in developing this knowledge base. This exercise allowed discussion within the Clemson team to clarify disciplinary jargons and build a common vocabulary to supplement shared experiences.[89]

The Clemson team believes that the use of simulation-based mock-up evaluation was one of the most powerful tools in their collaborative design process. A simulation director as assigned to provide overall management of the mock-up evaluation. The first and most critical step in developing the evaluation tool was to identify the key outcomes to evaluate based on the previously established design guidelines for the OR prototype design, then a master document was developed to help formalize the execution of the simulation scenarios. Additionally, note takers were trained to annotate the plans to indicate any adjustments made during the scenario enactments.[90] Given that non-designers often misunderstand drawings, the Clemson team believes that even crude cardboard mock-ups allow them to communicate in haptic and visceral ways to build common knowledge and perspectives. Mock-ups also allow the team members to critique and manipulate ideas in real time, fulfilling the role of rapid sketches of a traditional design process.[91] These mock-ups are then rigorously evaluated using a simulation-based approach in which clinicians simulate a range of typical tasks that require them to interact with the built environment.

Based on her experience with this collaborative process, Joseph believes that designers have an important role to play in translating ideas to non-architectural team members. For example, in one of the task-analysis studies that the team conducted in order to better understand anesthesia workflow, although the clinicians and engineers had an in-depth understanding of the process, they did not understand how to effectively translate it into the design process. In another example, industrial engineering colleagues collaborated with architects on the team to develop simulations based on observed clinician behaviors that could be used to test new or proposed designs. While the engineers had used discrete event simulation modeling in past projects, this application proved novel for both teams.[92] Joseph believes that after discussions and regularly scheduled meetings over the course of two to three years, the team was able to realize its full potential, and collaboration became more seamless.[93]

The Clemson team has identified several challenges to the collaborative process given the diversity of its team members, including their unique experiences, expertise, and knowledge. First, the presence of collaborates from different disciplinary areas with their own cultures creates disciplinary conflicts. Specifically, in a healthcare design setting, clients and clinicians have very deep knowledge about their work and the environment in which they work but had less knowledge about all the range of factors that go into designing and operating a healthcare setting, including industry design best practices from other health systems. While all disciplines involved in the project had deep knowledge about their specific areas, they do not clearly understand the needs and priorities of those from the other disciplines. Alison argues that working in a team means that one must be constantly aware and ready to openly discuss what people know and what they do not know, as each team member is so embedded in his/her own culture. The key is for team members to go beyond what they know very intimately and expose them to many experiences.[94]

Second, the gap between the cultures of design and research also proved a challenge to collaborative processes. Team members found themselves in a continuum of research roles from more applied to generalizable research. Design practitioners and clinical cultures tend to focus on application by making designs tangible, while researchers are geared toward producing research that is generalizable within the broader academic community.[95] For example, designers often prefer explicit visual formats to published research that must be read and consumed. It is thought that designers do not have the temperament or patience for research or deliberating findings from research material. Instead, designers are more inclined to rely on intuition as a mode of thinking. In light of these tendencies, Allison suggests that preconceptions that serve to form initial insights are still valuable provided they are not biased as long as they do not become rigid in light of emerging information. Thus, one of the challenges to collaborative design, he observes, is participants' willingness to suspend allegiance to any kind of preconception but not abandon them entirely.[96]

Allison also observes that the gap between design and research is also partly due to the varied speeds at which design and research are produced. While research is time consuming, designers must work more quickly in order to get timely information. Given this challenge, he feels that the Clemson team continues to implement and search best strategies to integrate research in design following an open informed design process, which is rigorous and includes as much knowledge, experience, perspectives, sources, and dimensions as possible.[97] One strategy that the Clemson team has used to bridge the design and research gap is to embed researchers in the design team to increase their awareness of how to conduct research that specifically addresses the questions posed by designers. By the same token, efforts are made to educate designers on the value and process of research but with an understanding that designers will never fully assume the role of researchers in future. Clemson team member Byron Edwards therefore prefers to describe the work as "research-informed design" rather than "evidence-based design," with the latter having connotations with left-brain quantitative thinking.[98]

Joseph believes that effective design collaboration requires interpersonal skills such as empathy, listening capacity, understanding relationships, and an appreciation of the time and schedules of other team members. Similarly, Alison observes that healthcare designers are problem-solvers whose role is to deal address complex problems. He observes that many of the design issues encountered often have many competing forces and different dimensions of complexity and require the ability to work in a fuzzy world with complex problems. Most importantly, the team borrows William Pena's philosophy that being a good problem seeker is as important as being a problem-solver and that there is no sharp distinction between programming and design, that that they are evolving and iterative processes.[99] Lastly, Allison suggests that good leadership is critical to collaborative design, and he likens effective collaborative designers to conductors who must bring all instruments together in harmony. To achieve a certain level of facilitation requires the ability to listen, to ask questions and challenge assumptions, as well be sensitive to the contributions of the various members of the team. Effective leadership is thus a balancing act, rather than an explicit directing, which he observes as a kind of art form in and of itself.[100]

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6 Suprapersonal skills

Louis Kahn's Treasure of Shadows and Zaha Hadid's force fields

While intrapersonal and interpersonal skills involve the ability to pursue emotions to shape design, *suprapersonal skills* transcend the emotions[1] and delve into deep existential thinking of a higher order. I use the term "suprapersonal skills" to distinguish them from intrapersonal skills: the former refers to the ability to manipulate ones' own emotions, while the latter refers to the ability to manage the emotions of others. Suprapersonal skills go beyond worldly emotions and transcend into spiritual and existential realms. The reputed psychologist Carl Jung believed that the suprapersonal was an unconscious force that reveals itself in the vision of the artist, in the inspiration of the thinker, and in the inner experience of the mystic.[2]

Suprapersonal skills might also capture what Gardner has recently termed as "existential intelligence," which is the capacity to locate oneself with respect to existential features of the human condition, such as the significance of life, the meaning of death, the ultimate fate of the physical and the psychological worlds, and such profound experiences as the love of another person or total immersion in a work of art.[3] In design, one can interpret suprapersonal skills as the ability to transcend the physical formalism of architecture into higher-order thinking and abstraction. Hence, in design, one can consider suprapersonal skills under two subskills: the ability to conceptualize wholeness beyond the material world and the ability to engage in vivid cognitive imagery.

Ability to conceptualize "wholeness" beyond the material world

One characteristic that sets suprapersonal designers apart is their ability to conceptualize wholeness beyond the material world. Designers like Alexander have alluded to the ability of designers to strive toward "quality without a name," a way of expressing oneness that goes beyond physical senses, emotion, and language.[4] According to Alexander, this is the central quality that comprises the root criteria of the life and spirit of a man, a quality that, while objective and precise, cannot be named.

Suprapersonal skills are also characteristic of what Newland and colleagues have termed as "the contemplative designer," one who strives to find the meaning of existence and the unique wholeness in life.[5] For the contemplative designer, the preferred mode of information transfer is *transcendence*, whereby he or she learns best by rising above apparent information into a unifying altruistic theory.[6]

Designers like Louis Kahn have exemplified the use of suprapersonal skills by considering the architectural design process as a high test of "tremendous transcendence" and one of the highest spiritual acts. Kahn observes that instead of taking nostalgic memories of what you already know and reusing them, it is better to erase them from your mind and start over at the beginning. Kahn is interested in a state of optimal experience where emotional conflicts are erased and higher-order feelings are generated. Designer Tadao Ando contends that contemporary architects are trained for practicality – in other words, to set achievable goals and compete them. For Ando, this role denies further spatial possibilities, so instead he advocates a sense of incompleteness and room for more in each project allowing for what he calls as spaces of "nothingness," a state where a designer goes beyond mere completion but yearns for self-actualization and discovery of self.[7] He views design based on sign and material meanings as restrictive because of the focus on the physical and cultural. Instead, architectural needs to go beyond the physical to an existential dimension of embracing states of being and non-being.[8]

Ability to engage in vivid cognitive imagery

Suprapersonal skills also involve vivid cognitive imagery of the world at an abstracted and transcended level leading to a superior kind of awareness.[9] According to Lobell, the powers of creative process have been the traditionally described as emanating from intuition, which implies that these powers are vague, undefined, subjective, and of unreliable accuracy. However, those who hold this view are usually themselves operating out of the systems that reject the complexities of deeper logics of mind. These designers might rely on the imaginative faculty of "lucid dreaming," which is a conscious effort to dream vividly within an imaginary space and participate fully in the events of that place as if it were real.[10] When the mind is sufficiently purified, rationality takes a backstage to a superior kind of awareness that arises and leads to a super sensuous perception.[11]

Suprapersonal skills help to attain what Csikszentmihalyi refers to as the "psychology of optimal experience," which involves those moments that people call their most intensely concentrated and enjoyable.[12] Flow is a state of concentration so focused that it amounts to absolute absorption in an activity when consciousness is harmoniously ordered. Similarly, Pallasmaa observes that all artistic and architectural effects are evoked, mediated, and experienced through poeticized images.[13] These images are embodied in the lived experiences that take place in the world, and at the same time we unconsciously project aspects of ourselves onto a conceived space, object, or event. Therefore, the material reality is fused with our mental and imaginative realm.[14]

Suprapersonal skills of Kahn and Hadid

For demonstrating suprapersonal skills, I have selected the works of two well-known designers of different eras: Louis Kahn and Zaha Hadid. On the surface, these two examples might seem like anomalies given their completely different formal vocabulary: the former focused on platonic solids and the latter on curvilinear forms. However, at the deeper level of cognition, these two share a common set of skills. For Kahn, the transcendence of his architectural thought is demonstrated in his exploration of light and shadows,[15] while for Hadid the transcendence is achieved in rigorous abstracts and striated lines.[16] For Kahn, design drawings embody the manifestation of lines and poche, the play of where light is and where light is not, while lines are collectors of force fields that activate her design projects for Hadid.

Louis Kahn was one those rare designers who could synthesize deep existential philosophy on one hand and engage in intense architectural detailing on the other. According to Kahn, there is no such thing as architecture *per se*, only its spirit, and this spirit has no presence.[17] The product or work of architecture is what is given presence in the form of a "treasury of shadows" made possible through light.[18]

According to Buttiker, Kahn's design process consists of drawing a line with a soft charcoal on sketch paper then erasing it in the next moment in the hopes that the next line would be "the more appropriate."[19] Kahn's complicated and time-consuming method of design, in conjunction with his intensive degree of involvement with details, sometimes resulted in not being able to finish a project by the agreed time. For instance, Alexander Tzonis documents Kahn's voluminous work in one of the Garland collection archives, which consisted of almost 600 trace diagrams of concept sketches.[20] Part of the reason that Kahn engaged in such a laborious process is his propensity to use light as a predominant element to shape his design.

This philosophy is reflected in his architectural drawings of almost all buildings, including the Indian Institute of Management building at Ahmedabad, India, where he creates spaces of shadows based on the gradients of illumination, heights of ceiling, and the heaviness of masses[21] (Figure 6.1). Given the commission to build this project in 1962, Kahn's goal was to create a monumental building with a universal quality. His several concept sketches explore the idea of light and shadows through repeated pencil smudging. The emphasis is not only on the material surface but the shadows casted by the material surface and their visual depth. According to Kahn, the entirety of the material world is light that is spent, and a building begins

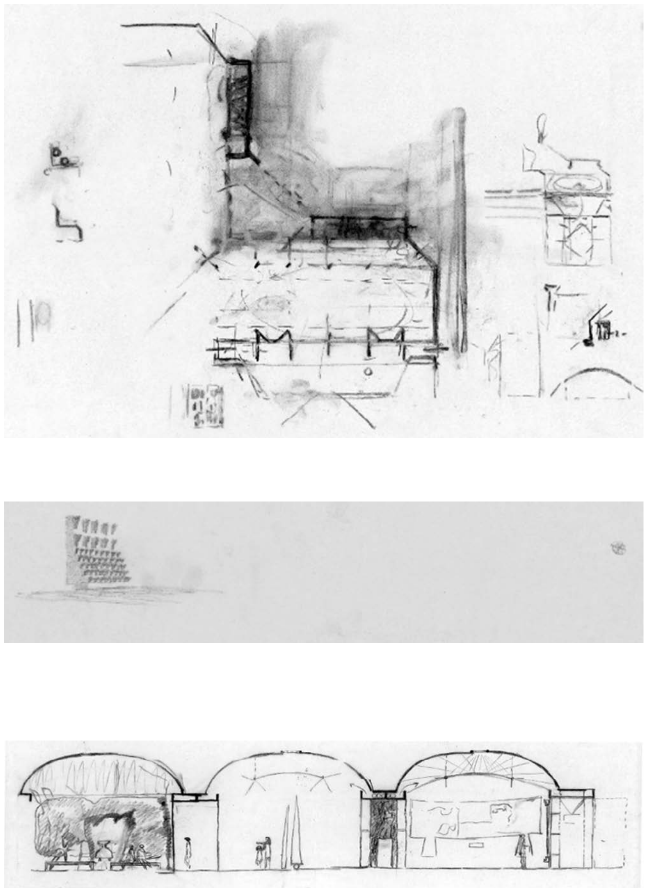

Figure 6.1 Louis Kahn's concept sketches demonstrating the use of suprapersonal skills (top: erasing and smudging the poche for Indian Institute of Management, Ahmedabad; middle: exploration of light and shade at Indian Institute of Management, Ahmedabad; bottom: modulation of light through sectional thinking for Kimbell Art Museum)

Source: Louis I. Kahn Collection, University of Pennsylvania, and Pennsylvania Historical and Museum Commission.

with light and ends with shadows. Therefore, the plan of a building should read like a harmony of spaces of light. Even a space intended to be dark should have just enough light from some mysterious opening that conveys to us how it really is. Each space must be defined by its structure and the character of its natural light.[22] Kahn is conscious not only in how light penetrates in plan but also in section as demonstrated in his detailed notes about illumination in the concept sketches of Kimbell Art Museum (Figure 6.1).

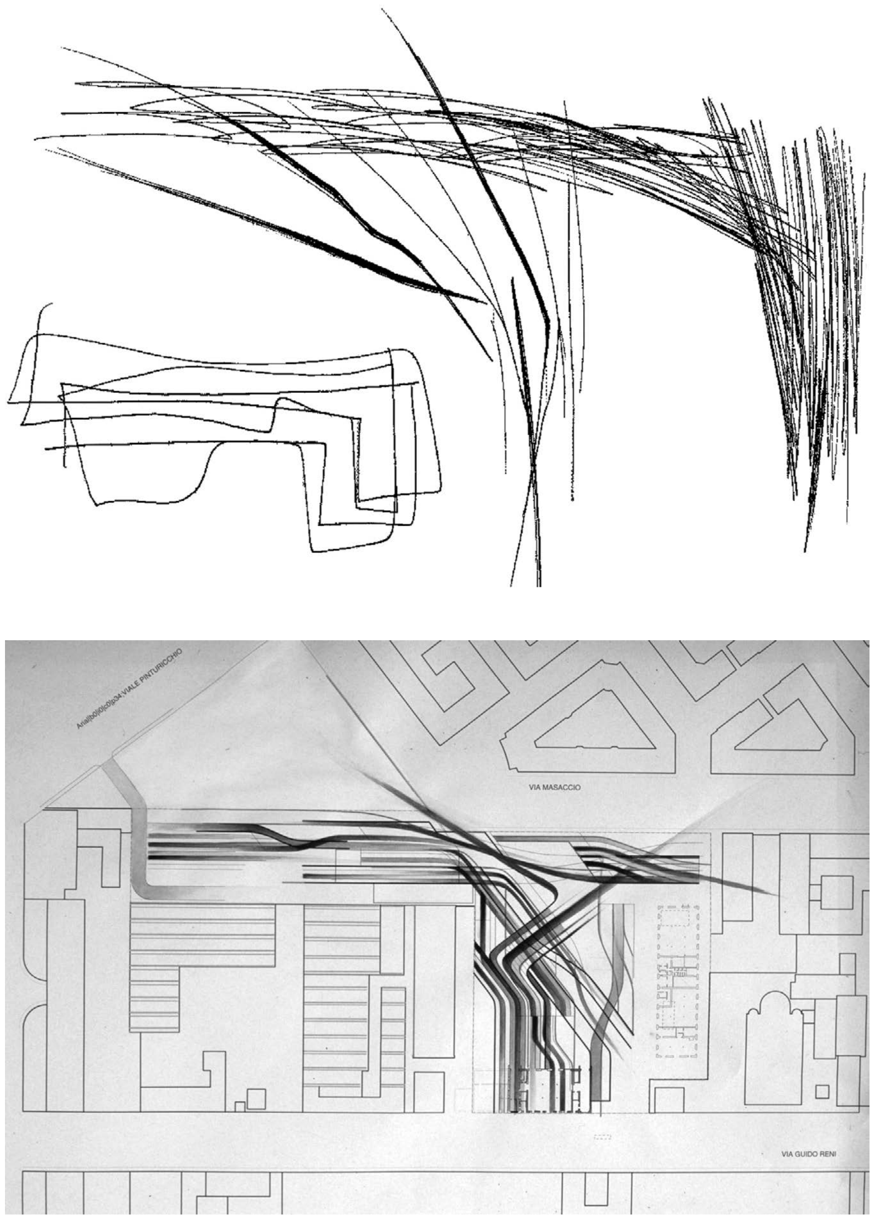

Figure 6.2a–b Zaha Hadid's concept sketches for the MAXXI demonstrate the use of suprapersonal skills (a (top): early concept sketch; b (bottom): more advanced sketch using acrylic on black cartridge paper; c: paper relief model)

Source: Zaha Hadid Architects

Figure 6.2c

For Kahn, material begins where the light stops. Kahn recalls a self-experiment where he challenged himself to draw a picture that demonstrates light.[23] Although he considered this to be an impossible task, Kahn recalls that when he put a stroke of ink on the paper, he realized that the black marks represented where the light was not. By using this technique of negation, the picture for him became absolutely luminous.[24] One can see this in the sensitivity to light and shade through his use of experimental studies for the solar shades in the project at IIM Ahmedabad, where the building is drawn to a small scale on a large sheet of paper. The large white space around the drawing almost miniaturizes the drawing but captures the power of light and shade (Figure 6.1).

Kahn believed that form has no shape or dimension.[25] It is completely inaudible, unseeable, and has no presence; it exists only in the mind. Design gives the elements their shape, transferring them from their existence in the mind to their tangible presence. This philosophy permeates Kahn's conception of space, structure, or material. According to Kahn, the tonality of space is differently reflected in a lofty vault than in a dome or a narrow and high space. Similarly, when choosing a structure, he imagines its rhythmic variations of light and darkness. He observes that all material in nature – the mountains, the streams, the air, even us – are constituted by light that has been spent, and this crumpled mass that we refer to as "material" casts a shadow, and the shadow belongs to light.[26]

This duality between materiality reflected as lines and immateriality reflected in light is a constant theme that guides Kahn's design philosophy. He contends that a great building begins with a realization in the unmeasurable. Measurable means are then used to construct the building, and when it is complete, we are given access to the original realization in the unmeasurable.[27] This transcendental movement reflects Kahn's fluid ability to move between physical and spiritual realms.

Similar to Kahn, Zaha Hadid radically experimented with architectural abstractions in her formal design. Because of her expressive curvelinear design elements, one would conventionally believe that Hadid was heavily influenced by the computer generated parametric paradigm. However, her intense cognitive visual imagery of force fields and striations are well documented in both her academic and practice work prior to any influence by compuers. In fact, her imagery excercises were considered so abstract and impractical during the 1980s that she did not complete a single building in the first decade of her career.[28]

To understand Hadid's work in the context of suprapersonal skills, one needs to revert to her early design philosophy influenced in particular by Kazmir Malevich, a pioneer of the 1920s Russian avant-garde. At the time, the Suprematism movement was well known for its radical experimentalism that attempted to transcend material reality.[29] The basic units of this visual vocabulary (lines, planes, and shapes) were stretched and rotated on white backgrounds to represent boundless space that is liberated from all the rules of the world. Malevich wrote that he transformed himself in the "zero of form" by destroying the ring of the horizon and escaping from the circle of things that confines the artist and forms of nature.[30] According to Malevich, the Russian Revolution paved the way for a new society in which materialism eventually lead to spiritual freedom, and hence Suprematism was borne out of "pure feeling or perception in the pictorial arts." The imprecise outlines characteristic of this work is meant to evoke a feeling of infinite space, rather than definite borders.[31]

Zaha Hadid's work similarly translated the warped and anti-gravitational space of such Russian avant-garde painting and sculpture into her own unique architectural language. The inspiration came not only from the paintings of Malevich but also through Laszlo Moholy-Nagy and El Lissitzky's paintings, Naum Gabo's sculpture, and Alexander Rodchenko's photography. Space, or even better the world itself, soon became the site of pure, unprejudiced invention. Malevich has been a pioneer of abstraction, as well as in directly linking abstract art with architecture via his seminal Tektoniks. It is interesting, however, to observe that these Tektonik sculptures, which were conceived as a kind of proto-architecture, were geometrically far more constrained than his compositions on canvas.[32] One could say that Hadid's projects encounter similar issues, especially in translating abstract freedom into the material world.

Unlike designers such as Kahn, seldom does Hadid start with Platonic solid of any other closed and regular geometry. While Kahn achieved immateriality through lightness, for Hadid immateriality is brought about by denying reality. Spanning over more than three decades, her early notebooks speculated on organizational diagrams, usually in ink, sometimes with washes. Drawn in what appears to be plan rather than perspective, the flat, map-like, planimetric sketches nonetheless imply space, like shadows projected by three-dimensional shapes on the ground.[33] For Hadid, the two-dimensional plan drawings are still paramount. While computer renderings can capture multiple viewpoints, they are restricted by frames and do not provide enough visual transparency according to Hadid.[34]

Hadid's project involves new organizational typologies such as jigsaws, aggregation, tagliatelle (weave), bubbles, multiple ground planes, folding, amoebas, and flow. She even forces the perspective of a curve and multiplies the illusion by forcing the perspective of divergent walls, creating multi-perspectival, sometimes cross-perspectival designs.[35] Norman Foster observes that Hadid exploited ambiguities where the two-dimensionality of the wall becomes three dimensions and the reliefs become two dimensions. This ambiguity leads to compositions that are poly-central and multi-directional.[36]

The spatial freedom and material transcendence of Hadid is demonstrated in the MAXII competition project, a national museum of contemporary art and architecture in Rome, Italy (Figure 6.2). The site was that of a disused military compound in the Flaminio neighborhood in which Hadid wanted to create an urban cultural center where a dense texture of interior and exterior spaces intertwine and superimpose over one another.[37] As with her other projects, the starting point for Hadid is not the building elements but the external force fields that she uses to generate her design project.[38] The design consists of a half-dozen lines curving parallel to one another along these two major urban grids. They striate the field in which they flow. These striations are composed of parallel lines that bend, branch, bundle, or intersect. These lines later intersect as walls, beam, and the ribs, as well as staircases and lighting strips. She observes that every line runs parallel or perpendicular to the existing lines of the streets so that every line as it turns agrees geometrically with buildings external to the site. The gradual curves also allude to the bends of the Tiber River flowing several blocks away. The strong diagonal thrust from the adjacent diagonal grid moves toward the striation like a vector, described by Hadid as "crashing into the diagram." The impact of the force bends the striations, while the thrust of compressive forces reverse the direction of their bend, generating a field of boomerang-like forms facing opposite directions.[39]

For Hadid, the field is a force field of lines. The wholeness in her design comes with the idea that lines, planes, and fields cannot be arranged individually, like elements in a modern composition.[40] Within a field, the single element is never concern. What matters are field qualities that emerge from the interplay of a multitude of elements creating deep layering and simultaneity. For Hadid, the object and the field unify. The skill of thinking of building as a dynamic force field requires one to imagine beyond the material yet be able to cohesively bring it back to the wholeness of the measurable.[41]

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7 Bodily-kinesthetic skills

Holl's Parallax and Hertzberger's social activation

Bodily-kinesthetic skills involve the ability to think in terms of body movements and use those movements in skilled and complicated ways for expressive and goal-directed activities. These include one's sense of timing, coordination of whole-body movement, and the dexterous use of hands for detailed activities.[1]

In his influential book, *Embodied Image*, Pallasmaa suggests that the act of thinking itself is a fundamentally embodied act and one's entire neural system participates in processes of thinking, hence the body's indisputable role in the very constitution of architecture.[2] According to Pallasmaa, alongside the prevailing architecture of the eye, the muscle and the skin possess a haptic (i.e., sense of touch) architecture that cannot be disregarded.[3] Such a body-mind fusion thesis is particularly important in design because design involves creation of space through visualizing body posture, human scale, body movements, and the existential conditions of humans inhabiting the space. In their seminal book, *Body, Memory and Architecture*, Bloomer and Moore revert back to the role of senses and bodily experience in architecture, which include haptics, orientation, pressure, temperature, and kinesthetics, as well as physical contact inside as well as outside the body.[4]

Commenting on the importance of body in the envisioning of design, Perez-Gomez observes that the experience of architecture is never merely spatial, yet what passes today for architectural design is often no more than a manipulation of geometric spatial concepts.[5] He argues that our lived world is rich in sensations and emotions that arise from our bodily actions and engagement in the world. Perez-Gomez argues that perception is never simply passive reception but is active, and the motility of our embodied consciousness provides a dimension of time.[6]

As bodily-kinesthetic skills are implied rather than tangible, mapping them within conventional design presents a dilemma. According to Bloomer and Moore, a notion of choreography is more useful than design composition in terms of describing the bodily experience because such experiences cannot be entirely represented through traditional methods.[7] Given the limitations of representation, for the purposes of this book, I evidence bodily-kinesthetic skills primarily by way of their distinction from spatial skills, which I address in the forthcoming chapter. While spatial skills have much to do with conceptualization of the environment in terms of its material quality, bodily-kinesthetic skills involve the conceptualization of the environment with relation to the human body. This aspect is more elegantly described by Bloomer and Moore who make a distinction between "feeling" of space developed by the whole body (e.g., bodily-kinesthetic skill) and the "objective" space captured through mathematic or graphic measurement (e.g., spatial skill or logical skill).[8] It is within this context of design that I explore bodily-kinesthetic skills in terms of three subskills: sensitivity to human scale; awareness of body movement; and the ability to activate social performance in space.

Sensitivity to human scale

Since buildings are created for human habitation, human scale determines how space should be modulated, amplified, or diminished. The scale refers to the relative size of an object as perceived by the viewer. This relation is typically established in architecture by elements such as doors, walls, stairs, and handrails, which stand in relation to the human figure and can be manipulated by the designer to make a building appear smaller or larger than its actual size. If the scale has been amplified, then it can provide a sense of monumentality. If, on the other hand, the scale has been diminished or played down, then it can provide a sense of intimacy. Human scale can involve more than objective or aesthetic attributes but also psychological attributes (e.g., crowding, privacy, and solitude), cultural factors (e.g., rules of behavior, belief systems, and values), or even pragmatic and functional concerns (e.g., universal design, ergonomics, and accessible design solutions).

The physical dimensions of humans have inspired architecture in the past as far back as Leonardo da Vinci's Vitruvian Man[9] based on the ideal human proportions. This work inspired the use of the systematic relation of parts of the human body as a measure for architecture, which formed the principal source of proportion among the classical orders of architecture. Designers such as Le Corbusier developed another device for measuring human proportions called the "Modulor," which consists of a range of harmonious measurements to suit the human scale, universally applicable to architecture and to mechanical things.[10]

Bloomer and Moore believe that haptically perceived landmarks within the body are the domain perhaps most neglected by the graphic and geometric models of the 20th century.[11] They argue that such landmarks constitute a vast and intricate psychological realm of inner feeling that are much more influential on our comprehension of the environment than we generally recognize in conscious thought.[12] Bloomer and Moore contend that the standing body/observer is not only a symbol but an element of the vertical axis of the architectural design. As the implicit link between earth and sky, humans mediate the communication between the two realms, and because these realms have radically different properties, the body serves as the matrix for both the synthesis and resolution of this polarity. We associate "up" and "sky" with the divine, spiritual, ethereal, light, rarefied, spreading, and canopy-like, whereas "down" and "earth" are associated with the material, mineral, dark, compact, firm, a solid, and like a cave. Upward movement takes on the metaphor of growth, longing, and reaching, while downward movement is one of absorption, submersion, and compression.[13]

Similar views are also expressed by Gaston Bachelard in his seminal work *The Poetics of Space*.[14] Using a phenomenological perspective of a country home serving as the unit of analysis, Bachelard contrasts the higher attic with the lower cellar. The attic exists as a rational place that protects one from the weather, while the cellar is an irrational place harboring darkness and fear.[15] Similarly, Norberg-Schulz uses the concept of "spirit of the place" (genius loci) to represent the sense people have of a place, understood as the sum of all physical as well as symbolic values in nature and the human environment.[16] Norberg-Schulz provides the example of the standing column (axis mundi) and its verticality as a common representation of a connection between the heaven and the earth.[17]

According to Pallasmaa, the authenticity of architectural experience is grounded in the tectonic language of building and the comprehensibility of the act of construction to the senses.[18] We behold, touch, listen, and measure the world with our entire bodily existence, and the experiential world becomes organized and articulated around the center of the body. Pallasmaa observes that our existence is the refuge of our body, memory, and identity. We are in constant dialogue and interaction with the environment, to the degree that it is impossible to detach the image of the self from its spatial and situational existence.[19] Pallasmaa describes the work of designers such as Alvar Aalto, who he feels exhibits a muscular and haptic presence in design. Pallasmaa observes how Alto's architecture incorporates dislocations, skew confrontations, irregularities, and polyrhythms to arouse bodily, muscular, and haptic experiences. His elaborate surface textures and details, crafted for the hand, invite the sense of touch and create an atmosphere of intimacy and warmth. In contrast to the disembodied Cartesian idealism of architecture of the eye, Pallasmaa suggests that Aalto's architecture demonstrates sensory realism.[20]

Awareness of body movement

In addition to human scale, the ability to visualize and represent the unfolding of space with respect to human movement and exploration of space/time relationship is an important feature of bodily-kinesthetic skill. In his comprehensive paper, Douglas Aguiar explains the concept of body movement in terms of spatiality and provides a historic discussion on the instances in which body movement has been used in architectural discourse.[21] He traces the roots of the concept of spatiality to the German art historians of the 19th century who assessed the architectural promenade and the inherent directionality given by the body's performance in space. Spatiality hence combines the concepts of space (geometry) and movement (topology) and eventually views architecture as a social art.[22]

Aguiar summarizes various concepts that emerge from his definition of spatiality. He attributes the initial influence of spatiality from perceptual psychology and the theory of empathy, which both emphasize the role of the body and its kinesthetic disposition to the processes of perception and cognition. Subsequent definitions of spatiality have linked perception of space to "axiality," the directional axis corresponding to the movement of the body. In this regard, depth is treated as a measure of axiality.[23] Aguiar refers to Zevi's idea that architecture can only be known and explored through direct experience. In other words, the lived experience of architecture is an event that requires time and movement. Others envision the kinesthetic condition as a network rather than an isolated event. Hildebrand, for example, refers to the kinesthetic condition as a sequence of frames in which objects must be used to build up a total space and create a kinesthetic framework, one which, although discontinuous, implies a continuous total volume.[24]

According to Aguiar, Le Corbusier and Siegfried Gideon were the two major players in the development of spatiality in the modernist movement. Le Corbusier's architectural promenade represents a new mode of composition involving the presence of the space-time dimension. Similarly, Gideon, in his book *Space, Time and Architecture*, alludes to the concept of plasticity in which architecture would find its way back to the arts, moving beyond functionalist design and engineering.[25] To highlight bodily movement, Bloomer and Moore provide the example of Moore and Turnbull's Faculty Club at the University of California, Santa Barbara, where they observe people and their paths spin out a somewhat frenetic and highly energized spatial configuration.[26] They also refer to Le Corbusier's elegant weaving of different kinds and patterns of movements in Villa Savoy, with one clock-wise spiral stairway, curvilinear and incremental in its vertical progression, and the other counter-clockwise ramp, which is rectilinear and continuous in its vertical progression.[27]

In his book *Architecture and Disjunction*, Tschumi (1994) demonstrates the importance of choreographic aspects of bodily experience of architecture.[28] Sometimes this aspect is described as cinematic to stress the dialectic between movement and temporal dimensions. Tschumi proposes a way in which architecture can be explored as an instrument to express the body's experience. Similarly, Aguiar emphasizes Tschumi's conception that bodies not only move in space but generate space through movement.[29]

In other words, the body is not a passive receptor but an active participant in the making of space.

Bloomer and Moore speak to the importance of body-image theory and haptic sense in design, arguing that an essential and memorable sense of three-dimensionality originates in the body experience and that this sense may constitute a basis for understanding spatial feeling in our experience of buildings.[30] *Body-image theory* explains that experiences of movement and settlement within three-dimensional space depend on the unique form of the ever-present body. Our images of our own bodies are constantly changing, which is separate from what we know objectively and quantifiably about our physicality.[31] According to Bloomer and Moore, all architecture functions as a potential stimulus for movement, real or imagined, and a building is an incitement to action, a stage for movement and interaction, and a dialogue with the body.[32] However, the fit and movements of our bodies within and around buildings are also significantly affected by our haptic sense, by the tactile qualities of the surfaces and edges we encounter. Smooth surfaces invite close contact, while rough materials such as hammered concrete generate movement. However, bodily alienation can also occur if the space is not intimate or if the body is overly manipulated within the space.[33]

New digital technologies, such as virtual reality and immersive environments, have brought alternatives to engage bodily-kinesthetic experiences in design.[34] According to Aguiar, movement is once again a central ingredient in parametric design. He adopts Lynn's view that if architects are going to participate in the mobile, often immaterial, forces shaping the contemporary city, they must embrace both an ethics and a practice of motion.[35] In in his book *Animate Form*, Lynn suggests that the abstract space of design is imbued within the properties of flow, turbulence, viscosity, and drag.[36] Using the example of marine architecture, he observes that much like form of the hull can be conceived in motion through the water, the curvilinear appearance of parametric design also indicates gradient forces through deformation, inflection, and curvature.[37]

At a pragmatic level, awareness of body movement in space has implications for the legibility of space. Researchers have long grappled with the issue of architectural legibility in terms of human mobility and wayfinding strategies.[38] In such research, sensitivity to human movement has been found to be dependent on human judgment, such as cognitive clarity of a building plan or the number of possible connections between different parts of the building.[39] Passini's concern is for spatial orientation as defined by *wayfinding*, which is a person's ability to mentally determine his position within a representation of the environment through cognitive maps. Wayfinding includes cognitive-mapping ability, information-processing ability, and decision-making ability.[40] In this context, Tversky and colleagues conceptualize spatial problem-solving through three different frames of reference: space of navigation (which is the movement of body in space); space around the body (which is the relationship of the body to the immediate visible spaces); and space of the body (which is the significance of body parts to self).[41] Cullen has also explored the importance of understanding bodily-kinesthetic in design of urban landscapes.[42] In the book *Townscape*, he writes about the experience of space in terms of serial vision of existing views and emerging views. *Existing views* are those that are immediately apparent to us at any given point, while *emerging views* are what we glimpse or sense as lying ahead. Tension between the two views creates a sense of excitement and pleasure.[43]

Ability to activate social performance in space

Another important aspect of bodily-kinesthetic skill is the ability to activate social performance in space. Reid observes that each decision by an architect, like those of a director, affects what happens in space intuitively.[44] She observes that while a director's vision emerges with and through actors, the architect's vision evolves within the social and physical practices of drawing and construction. Buildings are created to act and perform within the city and thus accumulate rich meaning – much like architect Bernard Tschumi's conception of architecture as made up of an event. She observes that for Tschumi, the event is something that happens in a place and for a duration of time, so the emphasis is placed on action rather than static object.[45] At a more profound level, Reid observes that a conception of architecture as a performance, places the buildings back into time, and speculates how the physical design plays out among people in short and long duration. This shift from identity toward action moves away from treating buildings as autonomous objects to be seen or experienced by well-behaved viewers.[46]

Phenomenologist David Seamon utilizes the concept of "place ballet" to describe the essence of place where the body and everyday routines blend together spontaneously.[47] Fundamental to this concept is the "body-subject," which represents the inherent capacity of the body to direct behaviors of the person intelligently, functioning as a special kind of subject that expresses itself in a preconscious way. Seamon characterizes the body-subject as an intentionality that is habitual, automatic, and involuntary. The body-subject can complete countless acts and gestures that accumulate into compositional activities, sustaining a certain purpose or intention, otherwise known as "body ballets."[48] Multiple body ballets usually mature into strings of successive habitual behaviors, or time-space routines. Body ballets and time-space routines harmonize in supportive physical environments.[49]

Environmental psychologists have long studied the behavioral dimension of space including the concepts of personal space and territoriality among others.[50] According to Sommer, a *territory* is a defined boundary to reduce conflict, while *personal space* is an area of invisible boundary surrounding a person's body through which intruders may not enter. Sommer also makes a distinction between personal space and individual distance in that individual distance is based on societal expectations, while personal space is defined by a person's self-boundaries.[51] Similarly, cultural anthropologist, E.T. Hall coins the word "proxemics" to describe personal space that offers important insights into use of space in behavioral communication.[52] Proxemics is one among several subcategories in the study of nonverbal communication, which includes haptics (touch), kinesics (body movement), vocalics (paralanguage), and chronemics (structure of time).[53] According to Hall, the study of proxemics is valuable for evaluating not only the way people interact with others in daily life but also the organization of space in houses and buildings, and ultimately the layout of towns.[54]

Aguiar alludes to the seminal study of space syntax by Hillier and Hanson as a potential framework for analyzing human behavior.[55] Using the syntax of an axial map, Hillier and Hanson created a system of interconnected lines, with each line having a specific degree of accessibility. The lines of movement using a computer program were organized based on the gradations of accessibility – from the more accessible or integrated to the less accessible or the most segregated.[56] Recent advances in computer technology, such as crowd-simulation software and behavior-modeling techniques, have further contributed to new ways that designers and researchers can visualize people behavior in controlled settings.

Bodily-kinesthetic skills of Holl and Hertzberger

To demonstrate bodily-kinesthetic skills, I have chosen two designers with perhaps differing design philosophies: Stephen Holl and Herman Hertzberger. Holl's design process evokes the idea of bodily-kinesthetics in terms of space and movement as demonstrated by his idea of parallax, while Herzberger's design process involves thinking of users and their social performance.

One feature of Stephen Holl's design process is the focus on the interior space very early in his conceptual design.[57] Holl contends that in most of his designs the internal view precedes the external envelope. His emphasis on the interior space begins with his watercolor sketches, which for him most often present spaces seen from within and from the point of view of the inhabitant.[58] Even while working inside out, Holl maintains that in contrast to the artist who works from the concrete to the abstract, a designer works inversely from the abstract to concrete, gradually incorporating human activities, yielding a new sense of experience and meanings.[59]

Tracing back Holl's technique of watercolor drawings, Jordi Safont-Tria observes that very early in his career, Holl started to draw his projects in pencil, consciously choosing to explore his skills only in black-and-white renderings.[60] It was as if his respect for color prohibited him from fully utilizing color. Holl would start with several shades of grey on the spectrum from black to white on white cardboard, calling them his color palette. The pencil enabled Holl to investigate a personal language by translating the changes of light and shadows into graphite on paper. Safont-Tria further observes that these black-and-white drawings explored not only the shapes and volumes of Holl's projects but also the lighting and saturation qualities of the environment where the buildings would be located, as well as the texture of the surfaces and the passing of time.[61]

In describing the complexity of these sketches, Sanford Kwinter observes that Holl's painterly thought-experiments function as meditations on escape from the dull typological thinking that was more fashionable in his day.[62] Kwinter observes that Holl's use of paint with water and pigment on a blotting surface, especially in an era when other architects worked with pencils, radiograph on vellum, or with layered transparent film, denoted a refusal to produce space in the conventional ruled manner. Kwinter suggests that these sketches were not simply warmup techniques for a more advanced design but precisely where Holl's architecture unfolds.[63]

One of the devices that Holl uses to create a bodily-kinesthetic experience is the idea of "parallax," which he defines as a change in arrangement of surfaces that define space because of the change in the position of a viewer.[64] Using the example of Museum of Contemporary Art in Helsinki, Holl presents depth and multiple overlapping views from both horizontal and vertical axis. The body becomes a living spatial measure in moving through the outstretched overlapping perspectives. At the building entrance, space curves, and vanishing points disappear.[65] Parallactic angle change with altitude so that when visitors are presented with various angles of view as they move (Figure 7.1).

Holl believes that parallax is redefined as it becomes sectional and is transformed when movement axes leave the horizontal dimension creating several points of view and several horizons. He observes that the historical idea of perspective as enclosed volumetric based on horizontal space gives way today to the vertical dimension. Vertical and oblique slippages are key to new spatial perceptions and multiply our experiences.[66] According to Holl, the core of spatial expression of architecture resides in the turns and twists of the body, engaging in a line and then a short perspective, up-and-down movements, amid the open-and-closed or dark-and-light rhythm of geometries.[67]

Holl contends that architecture's power to exhilarate lies in the intertwining of the larger space with its forms and proportions and the smaller scale of materials and details. He observes that such phenomenal territory cannot be revealed through traditional plan/section methods. While photography can only present one field clearly, excluding changes in space and time, the traditional drawing of a plan is a blind notation, non-spatial and non-temporal. The parallax idea, which includes perspectives of overlapping fields of space, break this short circuit in the design process, give priority to bodily experiences, and binds the creator and the perceiver. According

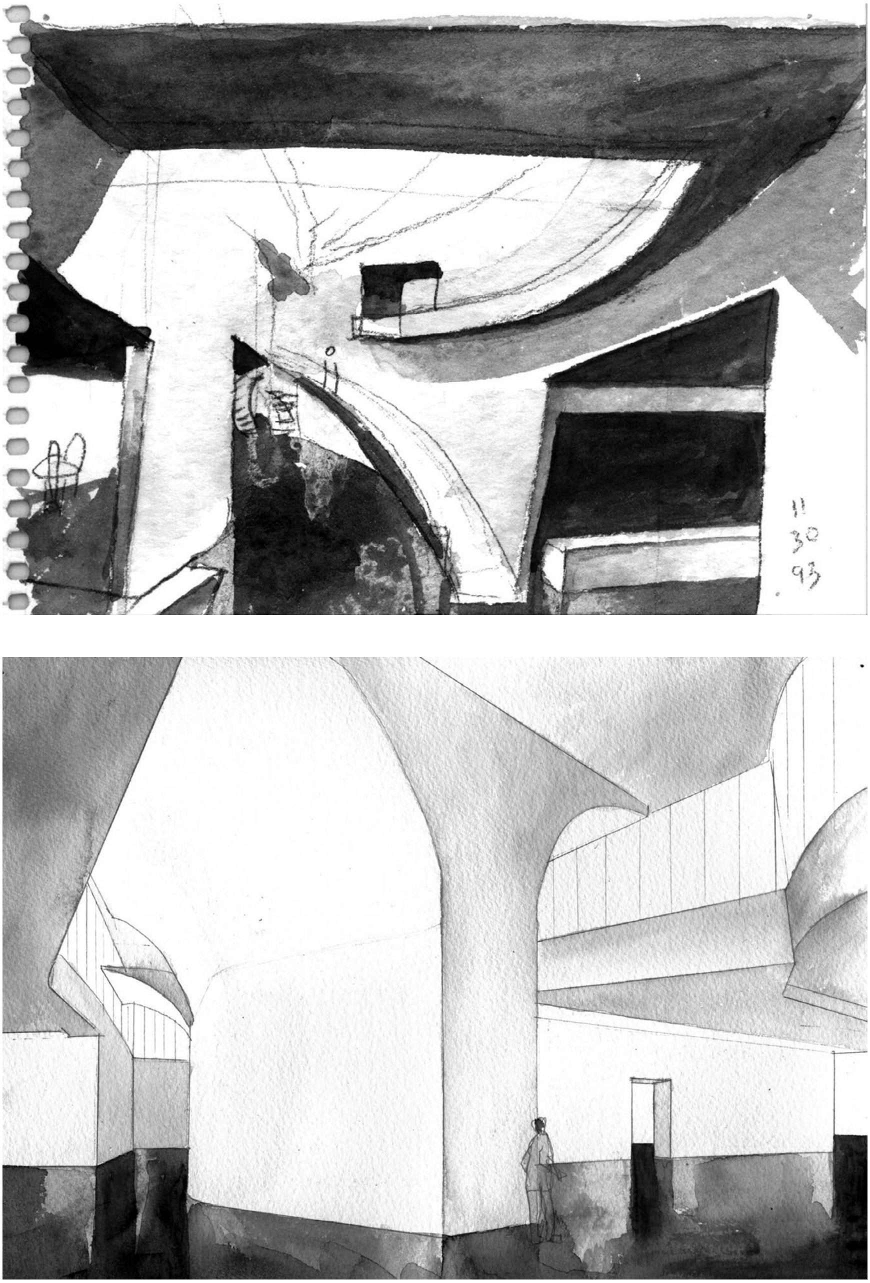

Figure 7.1a–b Steven Holl's concept sketches demonstrate the use of bodily-kinesthetic skills (a (top): parallax effect evident in the Museum of Contemporary Art, Helsinki, as one moves through space; b (bottom) and c: sketches of Nelson Atkins Museum exploring the cone of vision and parallax effect brought about by light through the glass "lenses")

Source: Steven Holl Architects

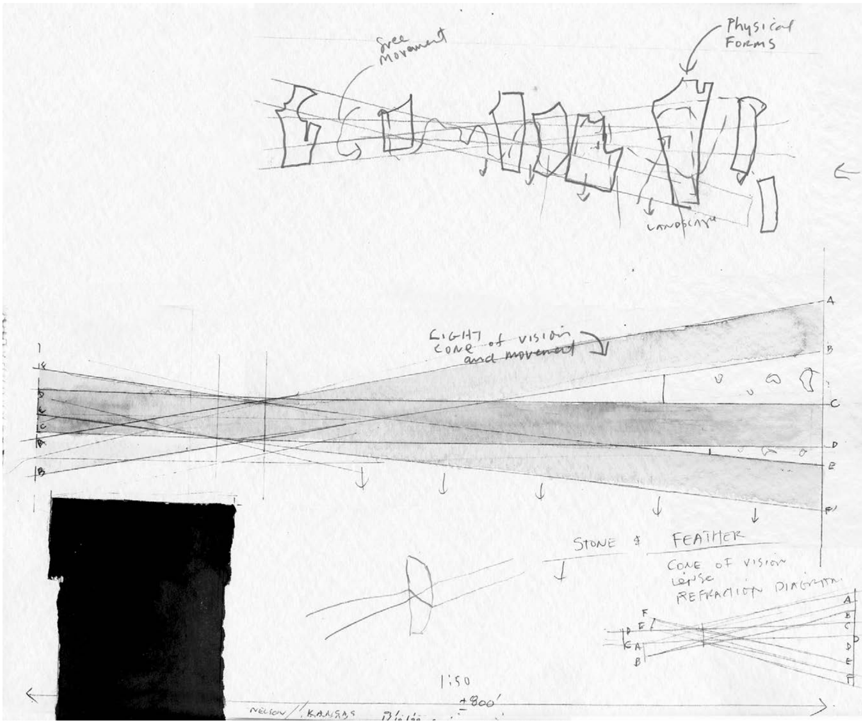

Figure 7.1c

to Holl, to work simultaneously in foreground, middle ground, and distant view, an architect must constantly anticipate the emerging smaller and larger scales.[68] The spatial, material, and phenomenological experiences of the interior serve as his inspiration for design, the determinant of the design process, and the only valid means of evaluating built work.[69]

Penny Yates observes that, unlike Le Corbusier's perspectives, which need effort from an outsider to decipher architectural experiences (especially in relation to time and space), Holl's designs effortlessly depict the changing relationship between architectural elements and the subject's point-of-view.[70] Yates contends that Holl's use of watercolors are more enticing, however, suggestive of a multiplicity of views and changing relationships between things. The presence of the viewer is implied by the eye-level station point and the presence of a strong focal point, even when hidden from view. The single point-of-view suggests a primary path from which there exist multiple spaces of co-location. Peripheral interest abounds as patches of light and dark allude to partially hidden spaces that complete themselves beyond the frame, not only to the left and right but also above and below. According to Yates, these perspective views do not represent a detached piece of the objective world but rather a momentary framing or registration of the subject's vision within the continuity of the objective world. Further, the overlapping and folding of places, the exploded surface of volumes, and the presence of ambiguous objects postulate the inexhaustible reality of the parallax – the changing relationship between objects as the viewer moves through the visual field.[71]

Holl's bodily-kinesthetic skills are evident in numerous projects throughout his long career, including over 10,000 watercolor drawings.[72] However, I will focus on one particular project, the Bloch Building addition onto the Nelson-Atkins Museum of Art in Kansas City (Figure 7.1). The addition is attached to an older neo-classical building, distinguished by what Holl calls the five glass "lenses" (building masses with facades that allows diffused lighting to enter the building), traversing from the existing building through the Sculpture Park to form new spaces and angles of vision. Rather than expanding the museum by simply adding mass, Holl wanted a complementary contrast to the original building.

The lobby of the addition comprises the first of five glass lenses used. A cross-axis connects the original building's grand spaces to the newer, bright, and transparent lobby with a café, art reference library, and bookstore. The lobby invites the public into the museum, encouraging movement via ramps toward the galleries as they progress downward into the garden. During the day, the lenses inject varying qualities of light into the galleries, while at night the sculpture garden glows with their internal light.[73] Circulation and exhibition merge as one can look from one level to another and from inside to outside. The meandering path of the sculpture garden is contrasted by the open flow of the new galleries. Glass lenses bring different qualities of light to the galleries, while the pathways promote a meandering through the art exhibits of the garden.[74] At night, the glowing glass volume of the lobby provides an inviting transparency, drawing visitors to events and activities. The lenses' multiple layers of translucent glass gather, diffuse, and refract light, at times materializing light like blocks of ice.

McCarter compares Holl's conception of the body moving through space in the Nelson-Atkins Museum to Le Corbusier's La Tourette monastery, particularly how crisscrossing movement of the water exhibit spaces across the central garden to Le Corbusier's crossing passages at La Tourette.[75] As he starts most of his designs, Holl designed the Bloch Building addition from the inside out. For instance, he made the watercolor view from the Noguchi room inside to the Kiley sculpture garden before making either the plan or the section of the building. As Holl feels that the inside is always more important than the outside, once he settles on a concept and a strategy, he works his way from the main interior spaces out to the façade of the building.[76]

The new addition to the original neoclassical stone museum of the Nelson-Atkins was inspired by an idea of complementary contrast in time, in space, and in materials. In his sketches, Holl describes this condition as a contrast of "stone to a feather," where the original structure is heavy while the new addition is light. The original has directed circulation, while the new has open circulation. The original is grounded, while the new merges ground and building. The original has inward views, while the new has views of the landscape. As Holl describes, as we engage the open-ended geometry of the new architecture of the Nelson-Atkins, we experience its spatial energy personally, from the viewpoint of our eyes positioned in over moving bodies as they glide through the new spaces.[77]

Holl refers to this experience as the "hapticity of the unconsciousness of vision" because vision contains an unconscious reading of surface texture, temperature, and weight.[78] The sense of touch opens the haptic realm in the experience of architecture, where the material and detail are critical as sensory experiences are intensified and psychological dimensions are engaged. Holl believes that anyone, regardless of training, can sense the ordering principles of proportion and scale. The human scale – as opposed to proportional scale and urban scale – is extremely important to architecture and yet has been especially neglected in the last two decades.[79] Holl observes that in the experience, we play in unqualified delight with our eyes open, our legs moving, our arms and torso engaged and that the dimensions alone do not create this space; rather, the space is a quality bound up with perception.[80]

McCarter observes how Holl has consistently emphasized the experiential qualities of surface, space, and light by way he places the occupant in an experiential "walk-through," placing the reader within the spaces and describing how s/he acts to engage all the senses.[81] According to McCarter, Holl's use architectural space can be characterized as carved, as opposed to modeled – in that the carved and topographically embedded spaces of Holl's work engage and reveal the nature of the materials from which they are made.[82]

While Holl's bodily-kinesthetic skills are evident in his ability to manipulate space for human movement, Herman Hertzberger's bodily-kinesthetic skills are evident in how he activates social performance in space, which reflects a philosophy of space as embodied and brought to life in our experience of inhabitation.[83] Hertzberger's ability to place the body at the center of his designs can be attributed to his three-dimensional mode of thinking initiated in "proto-form," which is an initial idea that does not take on the same form as it does in the end.[84] Most of his ideas that eventually manifest in his projects stem from a deep focus on sectional thinking, often including the role of human figures in social activities. In his monograph on Hertzberger, McCarter observes that photographs of Hertzberger's work almost without exception have people in them as he is rarely interested or willing to present the entire building as a free-standing object. Instead, the photographs are always partial views, details, and episodes in the life of the building, based on people's un-choreographed actions in space, documenting the inhabitants' responses to and engagement with the building in daily use. McCarter concludes that more than any other architect of his generation, Hertzberger has emphasized the experience of the inhabitant as paramount in the evaluation of architecture.[85]

Hertzberger's design philosophy of incorporating users into the expression of space can be traced back to the Dutch structuralist movement of the 1960s in which architecture was considered not having any predetermined programs but left room for users to interact in their own way. Influenced by anthropologist Claude-Levi Strauss, the focus of structuralism and its influence on design thinking was through systems and relationships. One of the figureheads of the movement, Aldo Van Eyck rejected functionalism, replacing its concepts of "space" and "time" with those of "place" and "occasion," the latter having clear connotations to inhabited rather than abstracted space. Van Eyck's empirical research of indigenous settlements of Dogon settlements of Africa made him realize the value for flexible and interchangeable spatial units rather than the prevailing modernist language of composition and monumentality.[86] The so-called "mat-buildings" found in the settlements could be characterized by the use of modules as components in a larger coherent whole, capable of accommodating changing functions, with special attention given to transitions between outside and inside, encounters, identity, livability, flexibility, and extensibility. This afforded the architect a controlled framework in which others retained a freedom to develop user-friendly forms.[87] Hertzberger's own Centraal Beheer office building in Apeldoorn consists of a number of equal spatial unit (i.e., building blocks) that, due to size and arrangement, are adaptable to various programmatic requirements. Hertzberger has described the building as the poeticized version of the mat-building, sacrificing compositional ideas for provisions of individual space-making.[88]

According to Aguilar, Hertzberger has further developed his work to account for the needs of elderly people in their seventies and eighties, such as in situations where he utilizes the concept of "gradations of accessibility" in the creation of either more integrated or more segregated spaces, relating spatial accessibility to the nature of activity.[89] Subsequently, spatial gradations are naturally described in the movement of the bodies and territorial differentiation. According to Hertzberger, the spatial structure, if it is to be in tune with the movement of the bodies, should consider the gradations of accessibility that will structure spatially in the architectural program. To operationalize this philosophy, Hertzberger assigns a numerical order to the different gradations of the spatial sequence, which can be decomposed into the fewest number of spaces.[90] Such gradations and territorial modules are visible in Centraal Beheer office building.

Hertzberger also observes that the spatial experience requires bodily movement through space, which cannot be fully surveyed from any one vantage point because the as-yet-unseen areas create expectations. The feeling of space that arises with the expected image and the image of one's experience are not one and the same.[91] For Hertzberger, space relates to competence and place to performance. Space represents a longing, of outside, of a journey, always dynamic and open, and an expectation of possibilities. On the other hand, place represents a pause, of inside, redemption, home, and at rest. Space and place, according to Hertzberger, therefore cannot exist without each other.[92]

In Hertzberger's design process, drawing is a critical activity but of a different kind than that created by an artist. For him, drawings are a means but not an end in itself. When it comes to the role of ideation drawings, Hertzberger makes a distinction between mental thought processes and drawings, and many of his concepts are rather advanced before he puts them to paper. According to Hertzberger, the idea precedes the drawing, while the inverse is more likely to be the case with the artist.[93] Contrasting Holl and Hertzberger, McCarter observes that Holl approaches space as a sculpture to be carved which stands apart, whereas Hertzberger engages the ancient analogy of architecture as "weaving" as a making of spatial fabric that encloses.[94]

To examine Hertzberger's bodily-kinesthetic skills, I have selected the Montessori College at Oost, Amsterdam, a secondary school with students from over 56 different nationalities. His bodily-kinesthetic skills are fully matured in the school typology in which he cleverly designs unassigned spaces, such as stairs and gaps, to maximize social and interactive behavior (Figure 7.2). The school design is reminiscent of a city with streets and spaces that allow for creative and social outlets.[95] His concept of "street" as a public space that the students can inhabit informally seems to promote a sense of ownership, pride, and respect among the students.[96] This is further demonstrated with the placement of classrooms on the edge of the buildings, with a centralized spine of circulation and social functions. The building is divided into half levels to maximize visual connections. Students are encouraged to spill out of their classrooms and utilize the meeting spaces. Each classroom gallery is a short half-level diagonal transition from the classrooms above and below, making for easy visual and physical connections, thus providing almost endless possibilities for communicating with friends on different levels.[97] Finally, the urban intensity of the school's interior spaces draws students in from the banal suburban surroundings, providing a seemingly endless variety of places to gather and meet.[98]

Hertzberger calls on designers to fully utilize the habitable space between things, rather than leaving behind any gaps or corners that go unused, which essentially serve no purpose and become uninhabitable.[99] As Ana Luz observes, unassigned spaces or in-between spaces are equally important in Hertzberger's designs.[100] Using the example of a bench, Luz observes that while the concept of bench is maintained by a series of associations (e.g., to sit, to rest, etc.), other spaces have uses that are less prominent, such as sitting on a doorstep, at the base of a column, on a windowsill, or leaning on a railing and resting near a wall. Hertzberger's humanistic concerns brings attention to what is already there and facilitates users to engage in their spaces in different ways, creating flexibility to accommodate the unexpected. Hertzberger equates the opportunity to seat oneself having everything to do, linguistically, with settlement.[101] He also suggests that if form is designed to serve only one function and to be used one way, it is inevitably less inviting and evocative than forms that are polyvalent, serving multiple functions and used in many ways.

In the design of the Montessori College, the use of in-between spaces are made possible by Hertzberger's use of stairs as a social device. The numerous stairways have diverse characteristics, one containing stairway contains seating and tables and another housing a theatre, while one large stair spans the central atrium and is capable of accommodating informal lectures as well as negotiating the change in level between the staggered floors. Social performance is activated by stacked and stairs and staggered galleries and people in action using gradations of accessibility and territorial differentiation (Figure 7.2).

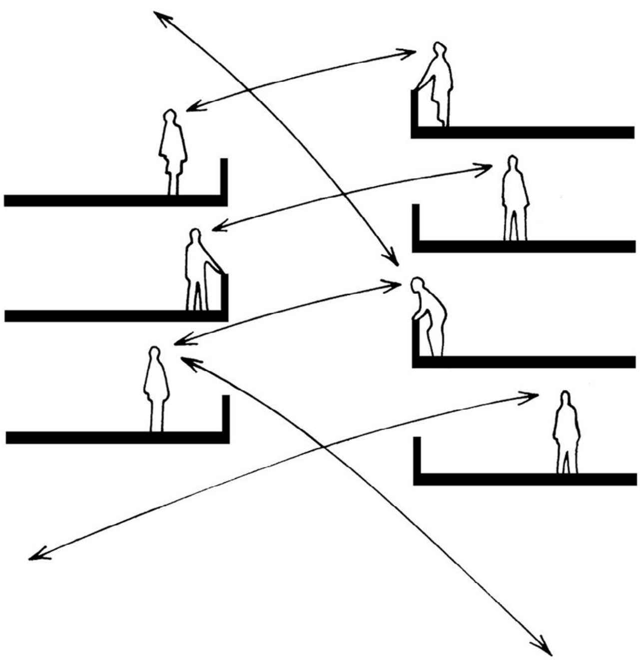

Figure 7.2a Herman Hertzberger's concept drawings for Montessori College of Oost demonstrating the use of bodily-kinesthetic skills (a: activating social performance facilitated by stacked stairs and staggered galleries; b: perspective of people in action through gradients of accessibility and territorial differentiation center; c: sketch of work-balcony)

Source: AHH

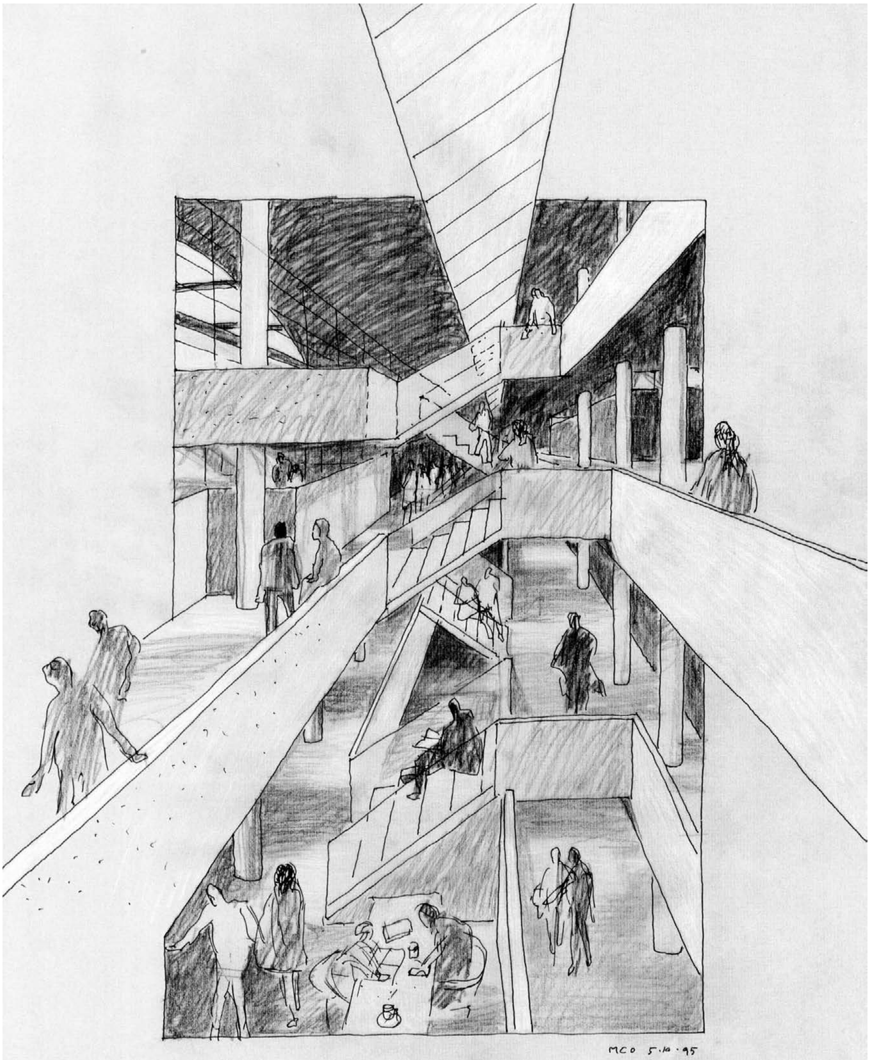

Figure 7.2b

(*Continued*)

Hertzberger decries the extreme polarity of spaces in distinct oppositions, such as private and public, observing that too much emphasis is placed on these two poles; instead, one has to consider people and groups in their inter-relationship and mutual commitment. For Hertzberger, the in-between spaces mediate between various territories within the city, and they form the primary place for meeting and dialogue between inhabitants.[102] These in-between spaces create threshold spaces in a setting for

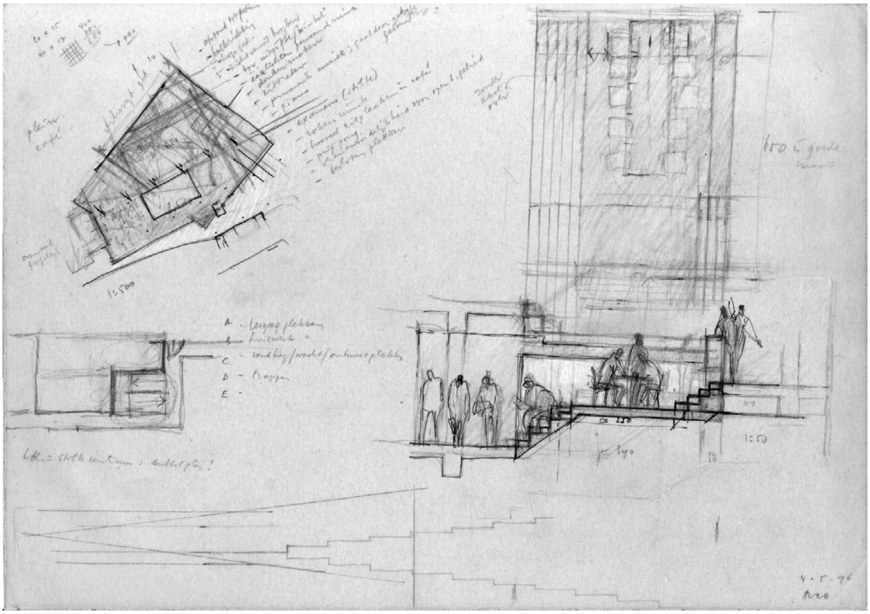

Figure 7.2c Herman Hertzberger's concept drawings for Montessori College of Oost demonstrating the use of bodily-kinesthetic skills (c: sketch of work-balcony)

welcomes and farewells and therefore can be translated into architectonic terms of hospitality.[103]

McCarter observes that from this understanding of the city, the concept of shaping public space has emerged as one of the most fundamental principles and consistent intentions of Hertzberger's practice.[104] This idea of the social enactment of a school as a city block can be traced to Hertzberger's experiences as a small boy, where he lived in the urban housing project Plan Zuid in the South of Amsterdam designed by Hendrik Berlage. Hertzberger described his childhood home as a special place with broad sidewalks and streets where he could play outside safely, even in the middle of the street. Such neighborhoods featured sculpted, softly rounded corner stones at the entry points of homes, where one could informally be seated or explore other activities. Hertzberger's sense of detail in public spaces even extends to such minute details as the handrail, which he observes should afford multiple conventional behaviors and other unanticipated behaviors.[105]

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8 Naturalistic skills

Geoffery Bawa's bio-climatic scenographies and Chris Corenlius' landscape narratives

Naturalistic skills involves a keen awareness of the surrounding environment through discerning patterns of life and the natural world. This includes the ability to identify and classify the natural environment, as well a superior understanding of its components, such as plants, animals, and the ecological relationships among them.[1]

The act of design affects the natural world, whether directly or indirectly, hence a designer's naturalistic skills are evident in how they choose to act on natural features, topography, and the expressive nature of materials. Architects such as Wright, Hitchcock, and Zevi have taken an *organic approach* to design in which the distinction between the built-form and nature is reduced.[2] In such projects, natural elements such as water and trees are integrated and utilized as expressive forms in buildings. More systemic approaches to architecture and nature have also been undertaken in the "sustainable design" and "ecological resiliency" movements.[3] These approaches adhere to a more thoughtful use of natural resources, reducing energy consumption, improving environmental quality, and considering nature and built form as a more holistic system.

Within the context of design, naturalistic skills could be described in terms of three subskills: design sensibilities that consider natural features such as topography, flora, and fauna; the ability to incorporate expressive and functional qualities of nature; and the ability to pursue ethics of sustainable design and ecological resiliency.

Design sensibilities that consider natural features such as topography, flora, and fauna

Successful designers are keenly aware of the surrounding landscape, such as trees, water bodies, geological features, and sun orientation, and understand the importance of site history and specificity of a design context. Yi-fu Tuan and Norberg-Schulz have referred to the concept "topophilia" to describe the broad range of our affective ties to the material environment as it specifically relates to characteristics of both natural and man-made landscapes.[4] Topophilia is the ability to experience a given context through the totality of sensory perceptions, especially perceptions of those conditions unique to a given context. Another movement called "biophilic design" emphasizes the necessity of maintaining, enhancing, and restoring the beneficial experiences of nature in the built environment.[5] Recent studies have shown that biophilia promotes human health and well-being through the direct experience of nature, exposure to natural light, and the restorative qualities of water, among other facets.[6]

Architectural designers such as Snozzi have identified natural characteristics or remnants of the site's history as important sources of design generation.[7] In such projects, these elements are extracted and then formulated into clear architectural intentions that intensify one's perception of the specificity of place. Frank Lloyd Wright, for example, used the topographical features of the site to create a dramatic integration of water and trees in Fallingwater project. Similarly, his protégé architect Fay Jones subtly blended nature and built form in the Thorncrown Chapel by using glazed openings to emphasize the natural materials and capture the Ozark mountain scenery. Others such as designer Glenn Murcutt brought increased awareness to the sensibilities to topography with his motto, "touch this earth lightly," paying attention to aspects of the environment such as wind direction, water movement, temperature, and light.[8]

Ability to incorporate and express functional qualities of nature

Naturalistic skills can also include the ability to be inspired by nature and borrow from its expressive and functional qualities. In her book *Biomimicry: Innovation Inspired by Nature*, Janine Benyus suggests that architects, rather than think of a building as a machine in which one lives, instead think of the building as a living thing for living beings.[9] In this respect, "biomimetic architecture" is a design philosophy that seeks inspiration from the function of natural forms through understanding the rules governing them. It is part of a larger movement known as "biomimicry," which is the examination of nature, its models, systems, and processes for the purpose of gaining inspiration in order to solve man-made problems.[10] The famous Gherkin building by Norman Foster and associates, for example, consists of a hexagonal skin inspired by the Venus' flower basket sponge, with its lattice-like exoskeleton that disperses stress throughout its round shape.[11] Similarly, as a protection against seasonal flooding, HOK architects designed a city in India with rooftops mimicking the native banyan tree fig leaf that allow water to run off while simultaneously cleaning the surface.[12] Elsewhere, Japanese designers have promoted "metabolist architecture," which applies the idea of endless change in the biological world to a changing urban environment.[13]

Jenny Sabin, an architecture professor and director of Sabin Design Lab at Cornell, has focused on knitting as an analogic bio-inspired device, producing photo luminescent webs which mimic cellular structures.[14] Her eSkin project incorporates structural color to change a material's opacity and color in response to sunlight levels. For example, imitating the wings of the blue morpho butterfly, the eSkin team harnesses material features and translates them into scalable building skins, which then use feedback loops provided by sensors to adapt to environmental cues.[15]

Ability to pursue ethics of sustainable design and ecological resiliency

Sustainable design is the rational use of natural resources and appropriate management of the building stock to contribute to saving scarce resources, reducing energy consumption, and improving environmental quality. It involves understanding natural processes, such as the byproducts of organisms and how natural cycles are sustained. Sustainable architecture thus promotes healthy processes powered by renewable energies and site-specific resources, including air quality, illumination, thermal conditions, and acoustics.[16]

In their seminal book *Cradle-to-Cradle*, Braungart and McDonough propose a biomimetic approach to the design that models human industry on nature's processes.[17] They argue that industry should protect and enrich ecosystems and nature's biological metabolism, while also maintaining a safe, productive technical metabolism for the high-quality use and circulation of organic and technical nutrients.[18] Such a model can be applied to many aspects of human civilization, such as urban environments, buildings, economics, and social systems. Furthermore, McDonough's design is often categorized as "green architecture" and is known for minimizing the negative environmental impact of a building. In his design of the Flow House, for example, he uses solar and other passive energy efficiency techniques, incorporating deep overhangs, multiple connections with exterior areas to allow for natural ventilation and daylight, roof-mounted PV panels, water cisterns to harvest rainwater runoff, and rain gardens to absorb storm runoff.[19] Other design activists such as Randolph Hester have advocated a sustainable approach that preserves natural habitats and forges connections between citizens and their natural environment.[20]

Aside from such approaches, ecological resiliency can also be achieved by thinking of built environments at a global and even ethereal level, where naturalistic skills extend beyond into the cosmic world. Daniel Glenn observes that indigenous design has a long tradition of working with nature and categorizes these practices into three types: the iconographic approach, which expresses culture through the built expression of emblematic icons; the naturalistic approach in which indigenous architects design buildings to express the spirit of nature; and the cosmological approach in which the spiritual, universal worldview of a tribe is used to inform the tectonics and siting of structures.[21] The cosmology of the tribe is a primary tool in generating the form of the building.[22] Traditional and historic uses of cosmology, such as *Feng Shui* in China,[23] *Zen* architecture in Japan,[24] *Vastu* principles in India,[25] and native Indian indigenous architecture,[26] involve culture and site-specific design philosophies that aim for harmony between the built environment and nature.

Naturalistic skills of Bawa and Cornelius

To demonstrate how naturalistic skills can be used in design, I present two architects with very different approaches to designing with nature: Geoffrey Bawa, a Srilankan architect who uses a scenographic approach to design, and Chris Cornelius, an indigenous designer who uses a narrative approach to landscape. Both demonstrate how architecture can be approached from a very deep-rooted understanding of nature.

Bawa's designs must be understood within a new language of architecture that adopts modernist approach and applies it to the context of tropical regionalism of South Asia. According to David Robinson, the tropical architecture of the hot humid zones involves enduring alternative bouts of burning equatorial sun and beating rain.[27] Indeed, the very existence of the term "tropical architecture" suggests that geographic location and climate can be major determinants of architectural form. In response to such climatic conditions, Bawa utilized building elements such as open-to-sky courtyard, double-skin tile and sheet roof, large overhangs that protect from the elements, and latticed bay windows that diminish the harsh glare of the sun.[28]

Although initially starting his career as a qualified lawyer without any formal training in architecture, Bawa was inspired by his stay at older brother's garden retreat in Sri Lanka, which served as a meeting ground for many artists and as a plant nursery. Bawa later enrolled at the AA school, where his contemporaries included other well-known architects and writers, such as Kenneth Frampton and Dennis Scott-Brown, among others. He later purchased his own garden retreat, a long-abandoned rubber estate near a lake called Lunugunga, which kindled his imagination and gave him a new sense of purpose as he converted the exhaustive plantation into a magical landscape.[29] Bawa's general sensitivity to nature is evident with his observations of the native landscape, where he notes changes in the mood of light, enriched greenery brought about by rain, and the clarity of light. In such landscapes, Bawa observed that village houses would disappear behind foliage, with the greatest beauty to be found in the experience of sunlight filtering through leaves.[30]

Just as a new sensitivities toward tropical architecture were starting to bloom, the AA school established its own department of tropical architecture.[31] During this time, Bawa was inspired by the connection to nature he observed throughout his travels, such as English county houses with their picturesque landscapes, the renaissance gardens of Italy.[32] He spent much of his final year in Rome exploring and admiring the work of great mannerist architect Vignola – especially the Villa Lante gardens at Bagnaia, with shaded terraces that traced the progress of an imaginary river from its mountain source into the ocean.[33]

With his partner Ulrik Plesner, Bawa incorporated new sensibilities to the monsoon environment into his designs, such as airflow control and reduced maintenance of buildings as they battled algae and seepage. Some of his design principles included: that the design should grow from the site; that the barriers between inside and outside should be dissolved to allow a building to merge with its surrounding landscape; that the spaces between buildings were as important as the buildings themselves; that the roof is the most important single building element in monsoon climates, delivering protection from the burning sun and torrential rains; and the importance of intermediate spaces such as verandahs and open-to-sky courtyards to encourage natural ventilation. In summary, his architecture played to all the senses – the smell of vegetation after rain, the sound of birds and the wind in tees, the texture of clay floor tiles and rough plater, and the taste of monsoon air.[34]

Bawa was, by instinct, a bio-climatic designer concerned with achieving optimum levels of human comfort with minimum expenditure of energy. His early work predated the widespread use of air conditioning, and he set out to create environments that were cooled naturally by stack and cross ventilation as well as protected from direct solar gain and heavy monsoon rain through experimenting with verandahs, pergolas, and overhanging eaves. He also used materials that increased the thermal mass of his buildings and provided insulation against solar gain. He pioneered the use of half-round clay tiles laid across corrugated cement sheeting to create a roofing system that was cool, waterproof, structurally efficient, and aesthetically pleasing. Boxed out lattice windows provided effective rain screens and ventilation. Bawa minimally intervened with vegetation and diffused the harsh glare from the intense tropical sun by creating diffusers.[35]

The experiential aspect of Bawa's building is captured in his 1986 *White Book*. He observes that a building can only be fully captured by moving around and through it.[36] One must pass through the verandahs, rooms, passages, and courtyards, as well as experience the views from the rooms facing the courtyards and gardens.[37] Bawa placed a high premium on the transition from shaded inner spaces to the illuminated outer courtyard.

While Bawa's conceptual sketches are difficult to procure, his documented design drawings clearly indicate the expressive forms of nature. He relied mostly on his gifted draughtsman to induce these expressive qualities. Donald Friend, an artist and a family friend of Bawa whose landscape drawings were displayed quite extensively at this time, played a big role in the development of a very particular drawing style among designers and draughtsman in Bawa's office. The examples of expressive drawings of the landscape was not incidental to the architecture of the Bawa office but an essential expression of his whole philosophy of design. First published in the *White Book*, Bawa's style of representations was much imitated and became a common language of monsoon architecture.[38]

Laki Senanayake, one of Bawa's assistants, adapted Friend's technique to draw what would be the first series of plans of the Lunuganga estate, carefully rendering the trees and adding his own version of drawings. The drawings were not intended as blueprints to instruct the builder how to build nor did they follow accepted architectural conventions. Instead, they challenged the language of modern architectural representations as the trees were drawn as abstract shapes. Senanayake drew each separate species of tree in meticulous detail and succeeded in capturing a sense of space as well as the interconnectedness of building and landscape.[39]

The work of Ismeth Raheem, another one of Bawa's assistants, was more stylized and captured the panoramic views of the landscape in painterly quality. For instance, in his sketch of the Club Méditerranée building, the hotel is depicted with animated landscape, with a catamaran boat crashing through the waves toward the beach and cotton-wool clouds hang over the hotel (Figure 8.1).[40] In another example, draughtsman Anura Ratnavibushana depicted the Beruwana Estate Bungalow project with a largely elevated terraced hillside, a house sitting at the top, and a group of Buddhist monks (bikkhus) walking single file across the paddy field near the bottom (Figure 8.1). In each of these examples, one can see the naturalistic sensitivity is expressed beyond the built form.

Ena Desilva's home, one of Bawa's earliest works, best captures his philosophy in its purest form.[41] In his sketch of the home, Bawa's draughtsman Senanayake minimized the distinction between inside and outside space and depicted three of the actual trees in great detail, even including a tiny tortoise scuttling along the verandah. The plan for the home is introspective, forming a pattern of linked pavilions and courtyards disposed around a large central court or *meda midula* contained within a perimeter wall (Figure 8.1). The house was influenced by Kandyan courtyard houses, which allow for the generous circulation of air through the use of open courtyards and wide, arched verandas held up pillars. The main elements are arranged in layers of increasing privacy as they progress away from the street. First, there is a long loggia, formed by huge timber columns supporting a cane screen. Behind this high wall, which contains openings for the main entrance and carport, sits a long garden court in front of the pavilion that serves as a buffer zone between the house and the street. The pavilion contains the office and studio, the garage and the guest suite, and looks onto a large central court occupying the heart of the plan and is surrounded on four sides by an open loggia. The courtyard is finished with a combination of cobble stones and gravel, with four large grinding stones and shaded by gnarled Plumeria and a large mango tree.[42]

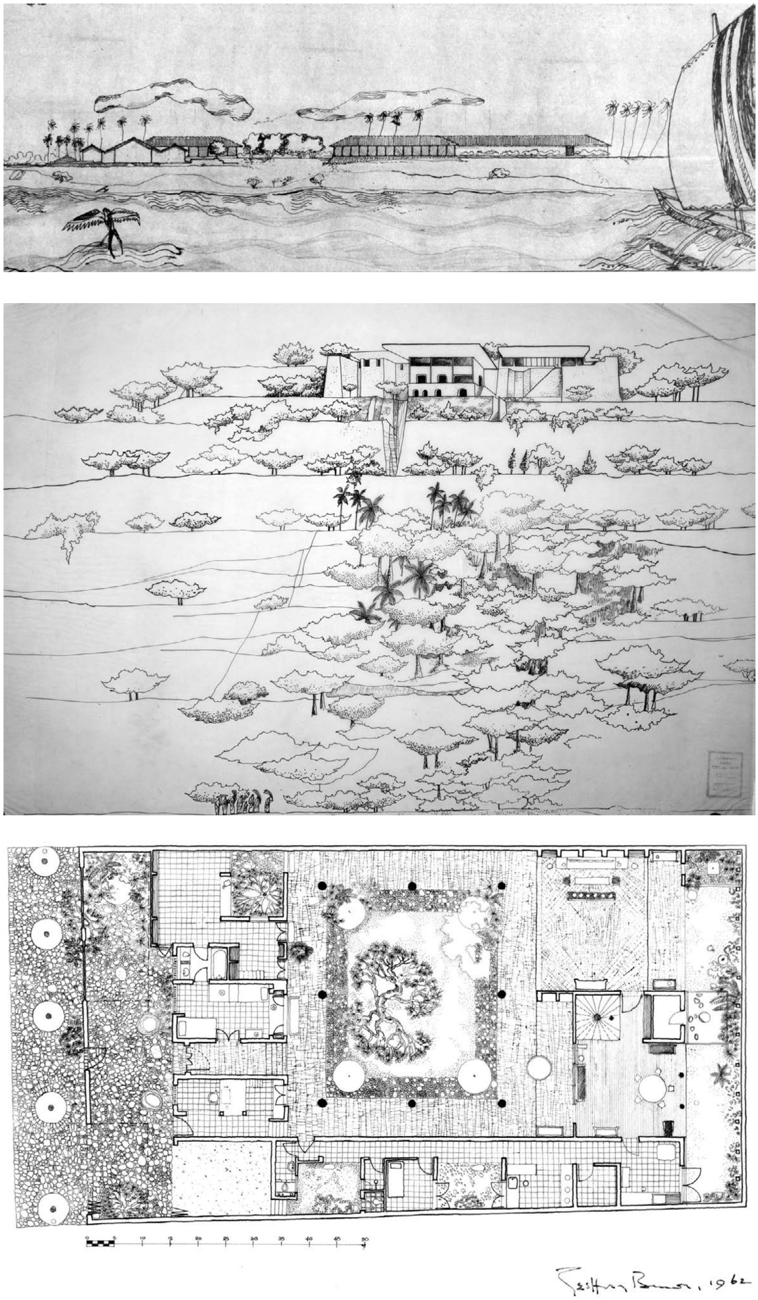


Figure 8.1 Geoffrey Bawa's drawings demonstrating the use of naturalistic skills (top: Bawa's assistant, Ismeth Raheem's drawing for Club Méditerranée depicted with animated landscape including a catamaran crashing through the waves and clouds hanging over the hotel; center: Bawa's assistant Anura Ratnavibushana's depiction of Beruwana Estate Bungalow using the elevation of the terraced hillside with the house at the top and a group of Buddhist monks walking single file across the paddy field at the bottom; bottom: Bawa's assistant Laki Senanayake's drawing for Ena a house sketch representing the three actual trees and foliage in graphic details)

Source: Geoffrey Bawa Art & Archival Collections, The Lunuganga Trust

Visitors to the Desilva's house entered along one of Bawa's scenographic promenades. The front loggia appears obliquely in line with the street, gradually revealing the main entrance on the center line of the second of its four bays.[43] The design embodies the idea of prospect and refuge, as Bawa took great delight in setting up a system of formal axes, only to deliberately knock them out of kilter in a way reminiscent of old monastic plans.[44] The building is made up of local materials with an overpowering presence of the tiled roof. Space flows from inside to outside and long vistas range across a series of indoor and outdoor rooms to create the illusion of infinite space on a relatively small plot. Every room is naturally ventilated on two sides, an important aspect of cross-ventilation that is needed in buildings without air conditioning.[45]

As one must understand Bawa's design sensitivity through the lens of tropical architecture, designer Chris Cornelius's naturalistic sensitivities must be understood in terms of his identity as a member of the native Indian tribe of Oneida Nation. Not unlike Bawa's creation of a new language of expression to depict naturalistic architecture, Cornelius uses his own unique techniques to represent the layered histories of his native Indian culture. Incorporating stories and traditions, his affiliation to naturalistic skills are more implicit than explicit. For instance, in the Oneida Veterans Memorial, he uses a scaled timeline stretching though three acres of prairie grass to express the Oneida's service to the United States.[46] In another project, the Oneida Cultural Heritage site, he portrays Oneida cosmology pertaining to "Sky Woman,"[47] a mythological Iroquois sky goddess that fell to the earth at the time of creation and gave birth to Earth Mother[48] (Figure 8.2).

As a member of the Oneida Nation, Cornelius developed an inherent connection to nature that has enabled him to view the world differently, including an unconscious absorption of naturalistic elements. Referring to the current discourse of sustainable design, he suggests that sustainability should entail a "kind of respect for the earth," rather than a label that one seeks to attain. He seldom feels the need to innovate for the purposes of sustainability but instead chooses to situate his naturalistic sensibilities within the values of Native American culture. For him, sustainability is more of a way of thinking than any kind of deployable strategy.[49] For instance, as is often practiced in Native Indian cultures, Cornelius tends not to "break out things" into distinctly separate phenomenon, such as "religion," "family," or "farming." Instead, he suggests that these aspects all are part of his culture and that his culture provides direction in terms of a way of seeing the world and describing it. He contends that when one describes nature in the way of Native American traditions and culture – such as "the earth is my mother, stones are my grandfather, the moon is my grandmother" – it makes explicit the relationship between different elements of nature. Ecological responsibility and integration with nature thus emerge out of such ways of thinking.

The idea of storytelling and the implicit centrality of nature in all its manifest forms are critical aspects of Cornelius's design process. According to him, design representations are essentially stories made graphically evident.[50] A story may be about the place or about things related to the program of the space or an event, and so his style of drawing helps to cognitively sort the situation (i.e., to get his head around it) to translate a story into an architectural solution. For Cornelius, drawings are a kind of visual sieve where he can collect ideas, themes, and visual wonderings.[51] A drawing is not so much a completed illustration in and of itself but a way of thinking.

Another project that exemplifies Cornelius's commitment to storytelling is the Oneida Maple Sugar Camp, which was his first project when he

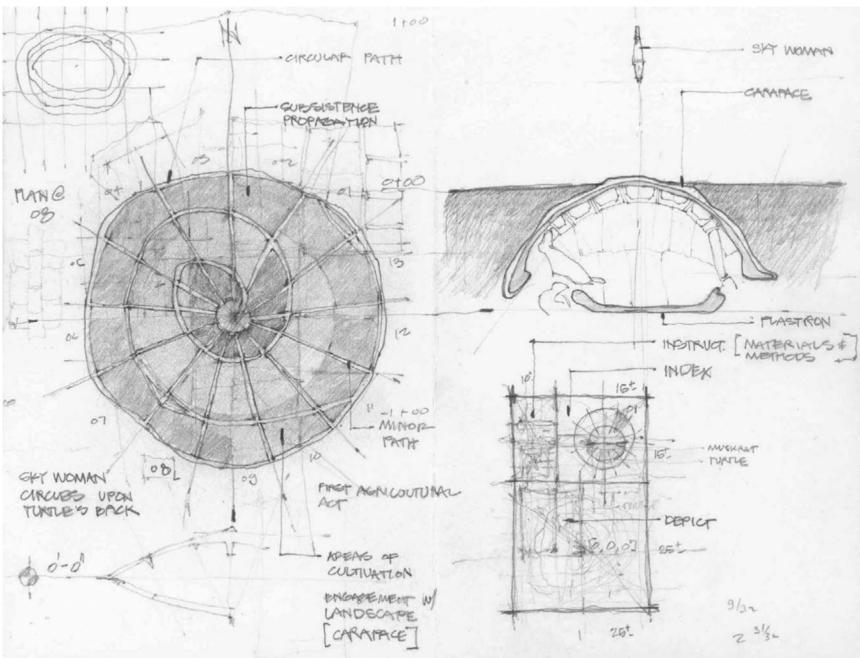
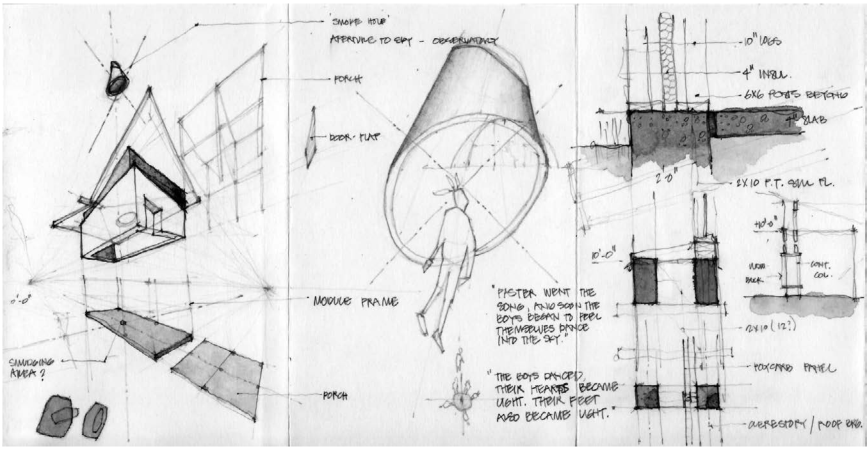


Figure 8.2a Chris Cornelius' sketches and representations demonstrating the use of naturalistic skills (a: Skywoman creation story sketch image as an inspiration for Oneida cultural heritage site, Wisconsin; b: intertwining cosmological stories in the project for Oneida Maple Sugar Camp Project, Wisconsin; c and d: "Planimate" – cultural laminates in plan, a representative media that Cornelius feels expresses the blend of cosmology, nature, and culture for Indian Community School, Milwaukee)

Source: Studio: Indigenous



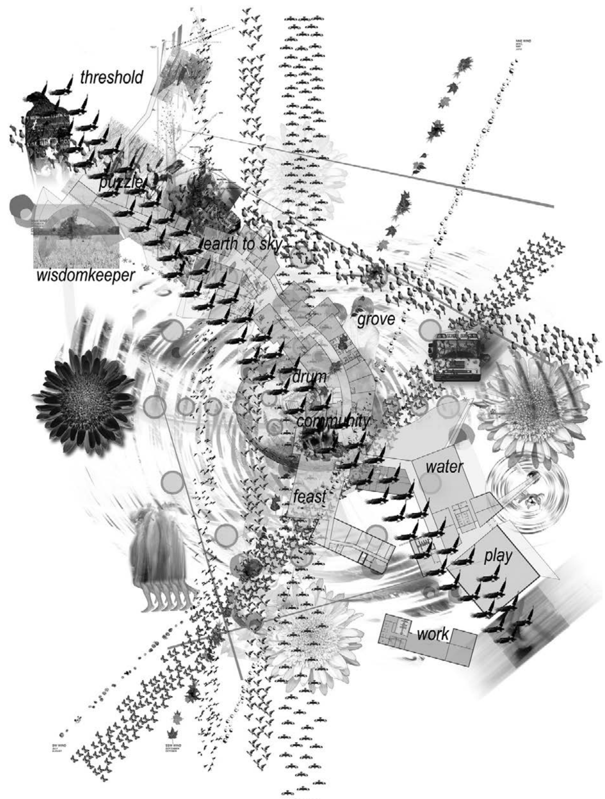


Figure 8.2b–c Chris Cornelius' sketches and representations demonstrating the use of naturalistic skills (b (top): intertwining cosmological stories in the project for Oneida Maple Sugar Camp Project, Wisconsin; c (bottom): "Planimate" – cultural laminates in plan, a representative media that Cornelius feels expresses the blend of cosmology, nature, and culture for Indian Community School, Milwaukee)

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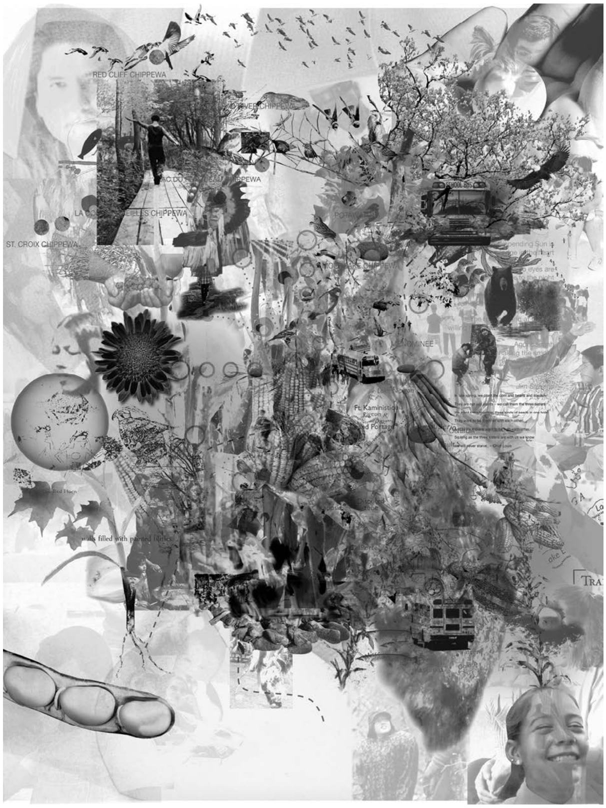

Figure 8.2d

began his independent practice. Although this project was unbuilt, it was meant to serve as a place where the tribes could boil fat to create maple syrup.[52] The camp teaches its students the cultural importance of gathering sap, boiling it down, and making maple sugar. They also show how maple sugar can be integrated into the diet as a natural sweetener for foods before the advent of refined sugars.[53] Cornelius notes that the boiling down of the sap is not only an important cultural aspect of Oneida life but has an environmental significance in terms of looking to the natural world in order to know when this act is to occur.[54]

When the clients first approached him to come up with a design concept for such a place type, Cornelius took note of the cosmic stories told by one of the elementary school teachers about the sky, stargazing, and constellations, including a story of "the seven sisters" who rebelled against their parents to dance into the skies. The Seven Sisters is a star cluster, also known as Pleiades, that signals the time for the midwinter ceremony when directly overhead.[55] Cornelius maintained a sketchbook to capture these stories. For instance, in the story of the seven sisters, he sketched out a floating body, one dancing so vigorously it seemed to fly into the sky (Figure 8.2). From this sketch, Cornelius conceived a structure that was also an observational site, oriented in such a way as to permit a viewing of the star cluster. A ventilation hood gives form to this aperture but also serves the function of the building through the process of boiling down sap and offloading steam. In this respect, Cornelius used architecture as a storytelling device in which the clients could actively participate in the process of design, rather than passively observe it.[56]

In Cornelius's design process, he prefers sketches to digital mediums, often drawing over previous sketches to create multiple layers of drawings using a variety of tools, such as graphite, colored lead, image transfer, rub-on lettering, patterned paper, adhesive transparencies, and vinyl stickers.[57] He finds that while digital mediums are useful for performing some of the heavy lifting of design, such as generating forms quickly, sketches forge a cognitive link between the brain and the hand. For Cornelius, drawing is a way to gather and document nascent ideas for which he does not quite have a plan – a form of graphic meandering and indexing as a means of ideation.[58] He often creates drawings within drawings, some containing small notes, calculations, and other preliminary thoughts. Other times, drawings are more developed and complex, with details of foundations or roof edges. Each element within his drawings is carefully curated, utilizing both the front and back sides of the Mylar sheets. This process allows his preliminary ideas and more refined ideas to co-exist. Cornelius suggests that this iterative way of working is not only practically useful but that his layered techniques embody the long and complex histories of Native Americans. Rather than emphasize causalities or contingencies, Native American cultures are more likely to think in terms of networks of reciprocity. For Cornelius, one cannot understand a graphic by simply relying on their retinal image but instead must unpack and metabolize it.[59]

For a project exploring the Native American occupation of Alcatraz Island, Cornelius used multiple traces of Mylar paper to represent nautical, aeronautical, and weather maps, overlaid on building footprints and other historic information. His goal was to represent the physiographic and the politico-cultural territories that existed on the Alcatraz island. For Cornelius, Mylar paper is a chosen medium as it affords transparent layers of information that could be drawn both on top and on the bottom of the paper. The project also utilizes graffiti as a rhetorical medium to reclaim the territory that once existed during the Native American occupation of the island.[60]

One project that most exemplifies Cornelius' naturalistic design sensibilities is the Indian Community School at Milwaukee.[61] Originally designed by architect Antoine Predock, Cornelius served as a cultural design consultant, often translating native Indian stories into built form. To engage with the client's worldview, Cornelius devised a series of conceptual drawings called "planimates" (laminates in plan), consisting of large vertical graphic drawings (three-foot-by four-foot transparencies) that depicted the earthly and cosmic creations that Native Americans hold in reverence (Figure 8.2). For Cornelius, planimates are less about drawing and sketching as much as "image making," one which forms the basis of his design thinking.[62] During the client briefing, the planimates were presented to the community through a large light-box so one could read it both as an individual piece as well as in aggregate layers. According to Cornelius, the transparent properties of the laminates, that they were interchangeable and illuminated through light box, helped to reinforce the interconnected nature of things and facilitated a dreamlike quality that further engaged the clients.[63] These planimates were able to convey cultural values in the form of dance, feast, music and oral storytelling traditions. For example, in one of the oral traditions, named as the "Three Sisters," the community embraces traditional spiritual scientific knowledge of the universe and applies it to agricultural planting rituals.[64]

These stories then become translated into the built-form of the school. For example, the design of the sweat lodge changing room was inspired from stones found on-site and to create a sensation of the building emerging out of the earth, as though it had already existed rather than being imposed. A series of angular wood furniture pieces for the school was made to reflect the landforms of the American southwest: the mountain, mesa, and mound.[65] Other cosmological ideas were also used to pay homage to the site-specific creatures. For instance, the brass bands etched on the floor and the ceiling of the student entry hall represents creatures that migrate across the site, like ducks, geese, robins, cardinals, butterflies, and eagles.[66]

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9 Spatial skills

Frank Lloyd Wright's destruction of the box and Tadao Ando's spatial nothingness

A person with spatial skills can perceive, transform, and modify spatial information easily. Spatial skills involve solving problems of spatial orientation and putting objects together.[1] Core capacities of spatial skills include mental imagery, spatial reasoning, image manipulation, graphic and artistic skills, and active imagination. Notably, different architectural design paradigms tend to conceive architectural spaces differently. For example, the solid-voids and figure-ground conception of spaces of the modernist paradigm (as seen in designers such as Louis Kahn or Le Corbusier) has been replaced with poly-central and multi-directional views of space today (as seen in designers such as Zaha Hadid and Greg Lynn). While there are genuine debates about the meanings of architectural space in itself, it suffices to say that spatial manipulation skills are valuable in any paradigm because designers primarily work with and conceptualize space. Spatial visualization in this context involves not just thinking about a specific style but full engagement with light, atmospherics, materials, and tactile nature of space. In this case, spatial skills encompass four specific subskills: the ability to imagine and manipulate space in fluid and unrestrictive ways; the ability to conduct spatial choreography; sensitivity to spatial transparency and the creation of tactile sensations; and the ability to conceive space as strategic wholes.

Ability to imagine and manipulate space in fluid and unrestrictive ways

Designers primarily work through cognitive modeling, manipulation and evaluation of visual images, and externalizing abstract concepts through models and drawings.[2] Psychologist Donald Mackinnon's study of creative architects in the 1950s demonstrates that most creative architects do not merely use logic in the design but are willing to explore more flexible faculties of artistic imagination. He found that the creative architect's personality is positively correlated with cognitive flexibility,[3] which involves the mental ability to switch between thinking about two different concepts and think about multiple concepts simultaneously.[4] Gazzaniga and Le

Doux use the term "manipulospatial" to refer to the combination of mental and motor processes involved in drawing, arranging, constructing, and manipulating forms to ensure they are in appropriate relationship to one another.[5] While some designers such as F.L. Wright had the gift to manipulate space entirely in their minds before having to put it paper, others such as Louis Kahn generally consider sketching and drawing ability as an important factor in articulating design ideas.

Diagramming tools, when used effectively, can also help to clarify design representations. The ability to represent and conceive ideas through diagrams is known as "graphicacy" and is considered an important aspect of design in terms of the advancement of ideas and design communication.[6] Graphicacy is a skill necessary for the communication of relationships that cannot be successfully communicated by words or mathematical notation alone. It is a skill that is needed, both on the part of those wishing to communicate as well as those attempting to understand the media of communication, especially visual aids such as maps, photographs, charts, and graphs.

Ability to conduct spatial choreography

According to Pallasmaa, space predetermines patterns of movement and behavior. It guides one's experiential characteristics, perceptions, imageries, emotions, and feelings.[7] A sensitive and empathic designer facilitates architectural scripting that resonates with the user's natural and instinctual needs. For instance, a correctly placed window is located exactly where the occupant wishes to look out into the garden or where daylight is needed. The stairway is located where the user wishes to enter the floor above or below. According to Pallasmaa, successful architecture reveals its very use in an embodied manner through "spatial choreography" to serve as almost like an extension of the human body and both mental actions and capacities.[8]

Spatial choreography allows designers to conceive spatial experiences by invoking a greater sensibility beyond the mere geometric logic of shapes and planes. It presents a deliberate sequence of spatial experiences through an architectural composition.[9] It also involves the ability to convey mood and ambience appropriate to a particular context. Spatial choreography need not focus on primary spaces alone but involve secondary transition and threshold spaces and include change of features when one moves, for example, from a from private to public space, open to closed, large scale to small scale, among others. Designers have used these contrasting spaces either to dramatize the effects or harmoniously blend the spaces. For example, Libeskind's Jewish Museum demonstrates a contrast from the old to new spaces, while Richard Meier's High Museum of Art demonstrates the harmonious blending from monumental to intimately scaled spaces. Concealing and revealing of spaces also add to the mystery of spatial choreography and creates interest. F.L. Wright's Unity Temple demonstrates this idea through his use of closed compressed space and expansive open spaces. Grant Hildebrand has suggested that Wright's spaces are pleasurable because of their use of "prospect and refuge," which involves our biological tendency to prefer environments with unobstructed views (prospect) and areas of concealment (refuge).[10]

Spatial choreography could also involve strategic sequencing of spaces to reveal a final destination. For example, in the Shrine of the Book wing of the Israel Museum, designers Bartos and Keisler place the most significant object in the museum – the Dead Sea Scrolls – at the end of a sequence of exhibit spaces that provide context leading up to the final destination.

Other types of spatial choreography consist of creating spatial transitions and gradients, which have been addressed through the idea of design patterns.[11] "Design patterns" are spatial systems that have been tested over time to suit varying functions and conditions. For instance, a pattern such as "entrance transition" indicates that differences exist between the psychological state of being in the street and the psychological state of being inside a house. Therefore, a transition space is necessary between the two to move from one psychological state to another without an abrupt change. Another example of a design pattern is "intimacy gradient," which suggests that as one goes deeper into a house, one finds rooms that provide increasing levels of intimacy and decreasing level of publicness.[12]

Sensitivity to spatial transparency and creation of tactile sensations

In the works of Le Corbusier and others, Rowe and Slutzky identified an aesthetic concept called "phenomenal transparency," which is a compositional technique prevalent in Cubist paintings borrowed in architecture that allows architectural planes to overlap and create simultaneous perception of different spatial locations.[13] Unlike classical perspectival layers of foreground, middle ground and background, phenomenal transparency thrives in the interpenetration of layers in which space fluctuates in a continuous activity. Instead of clarity, there is possibility and indication.[14]

Another feature that distinguishes spatial skills from logical-mathematical skills is that they engage deeper aesthetic faculties that involve the aspect of tactility. "Tactility," as defined by Gibson, is a receptive passive sensation where significance is attached to spatial volume, texture, visual weight, and material movement.[15] Architectural space is hence not only perceived through vision but also through sensation brought about by light, movement, smell, and sound. Tactile expressions become increasingly important as the counterbalance to our visually dominated world.[16] Tactile sensations refer to whole 3D reality that can be experienced through a change in the visual weight of material, noise levels, sense of smell, or from smaller to larger spatial volume, among other changes.[17] Such tactile sensations can be observed in designers such as Tada Ando's work of Church of Light where the space experience is intensified by the interaction of daylight and material texture.

Ability to conceive space as strategic wholes

Spatial skills involve the ability to conceive space as strategic wholes, rather than an assemblage of pieces that happen to be spatially juxtaposed. Such spatial sensibilities have been described by Donald Schön as "spatial gestalts," which is to view space not as fragmented pieces but in holistic terms.[18] Schön suggested that the designers study perceived spaces in a special way, invoking a greater spatial sensibility than the geometric logic of shapes and planes. Cross and Nathenson also considered that holistic designers operate broadly, rather than sequentially, while maintaining conceptual order.[19] Similarly, Alexander suggested that one should conceive a design image as a whole at the beginning of the design process and continue to work on it such that each mental operation further differentiates it.[20]

Achieving cohesiveness in spatial organization involves both looking at the "big picture" and the details as well as thinking in different scales of space simultaneously. Designers such as F.L. Wright and the Bjarke Ingels Group (BIG) are prime examples of designers who could think in varied levels of scales and bring clarity in spatial organization from large scale to details. For example, according to Angyal, a building element such as a door can simply be a rectangular wooden board, but when seen in relation to the building scale, it can functions as a secure element to enclose an opening.[21] At another scale, the same door might be considered an element that holds a door handle, hence it demands that the designer handle macro and micro scales of information concurrently. Designer Tada Ando observed that, during the design process, the whole and parts enter into a tense relationship and architectural details are simply the traces left by architectural ideas as one bridges the gap between wholes and parts.[22]

Spatial skills of Wright and Ando

Having built more than 1,100 buildings during his lifetime, Wright could serve as an exemplar of several skills mentioned here, including naturalistic skills and bodily-kinesthetic skills, among others. However, I have chosen Wright to exemplify spatial skills because he was perhaps the most gifted architect in terms of his ability to visualize and manipulate space with such control that he did not even indulge in sketch drawings until late in the process. Similarly, Tadao Ando's spatial skills are widely known in terms of his tactile sensitivity and ability to think in complex topography. Both Wright and Ando could think in multiple scales, with their drawings showing the range of thinking from master planning to design details. While

Wright thrived in creating continuous and interpenetrable spaces, Ando's projects reflect his mastery over creating self-contained intimate spaces that change character with time.

In uncovering Wright's projects, McCarter observes that Wright left behind few sketches from the early stages of the design process, implying that most of his ideas were worked out in his mind rather than on paper using visual aids.[23] This skill of conceiving design in mind rather than drawing it out, or using drawing as a way of thinking, is one of the hallmarks of Wright's cognitive imagery. As McCarter observes, one cannot escape the notion when studying Wright that he was able to visualize forms and spaces to an uncanny degree – through rotating and projecting, folding and unfolding, disassembling and reassembling, and seeing inside and outside – all in his mind so what eventually emerged on paper served more to record or double check his work rather than what is typically thought to be the function of the conceptual design sketch.[24] Even when Wright simply dashed sketched on the back of envelopes, McCarter notes that they were fully developed with dimensioning. As a testament to his talent, it has been speculated that Wright's design for Fallingwater was entirely done from scratch within the two hours it took the client to drive to Taliesin, with the initial sketches being virtually identical to the finished house.[25]

Wright recommended that designers to conceive the building using their mental imagination before putting before their thoughts to paper or on the drawing board.[26] He explained that the purpose of the drawing is modify, extend, intensify, or test the conception and harmoniously adjust its parts as needed. If the original concept is lost as the drawing progresses, the designer should discard it and begin anew. Wright also suggested that designers put their thoughts into a defined scale on paper to test and prove their assumptions. The designer should move from a small scale to a large scale and finally a still larger scale studies of parts. Wright believed in keeping straight lines clean and significant, the flat plane expressive and clean cut, but also while revealing the texture of materials within.[27]

Wright's drawing boards were covered with small perspectives and axonometric drawings, with every corner and intersection in plan and section developed in three dimensions. The plan was of preeminent importance to him because it came first and determined the development of the entire design. According to Wright, the plan was the solution, while the elevation was the expression of an organic integrated whole.[28] The plan generated the three-dimensional order, but Wright utilized perspective sketching to check the visual experience against the pure form derived from the idealized plan. One of his apprentices, John Howe, has observed that Wright endeavored to establish a harmonious relationship between ground plan and elevation, considering one the solution and the other an expression of the conditions of a problem, of which the project is the whole.[29]

This sequence of drawing plan, sections or elevations, and perspectives seem logical in Wright's work because he adjusted his process to balance the requirements of the eye and geometric order. Wright never designed from perspective because he considered perspectives to be merely the end result of the final drawings.[30] He believed that no designer was able to start a design project with a fully developed perspective and work backwards to do the plan.[31]

Wright's powers of spatial visualization are often attributed to his early kindergarten training with Froebel blocks, which consist of geometric blocks that can be assembled in any number of ways. This training, introduced to Wright by his mother in his childhood, involves rigorously organized play where the child is given a predetermined sequence of "gifts" which increase complexity and subtlety as the child grows older. Froebel training was designed to encourage the development of analytical thinking, to see things in terms of the whole, both in its organic unity and its component parts. Froebel contended: that his training methods encourage the child to establish spatial relationships and operate through inference from the general to the particular, from the whole to the parts."[32] MacCormac notes both formal and philosophical parallels and attributes it to Wright's Froebel block training, between Froebel training and Wright's designs are too numerous to be coincidental, and the Froebel training must be given some credit for the development of Wright's mature system of design.[33] Another example is the derivation of Unity Temple with a similar geometric order to the Froebelian gift, "bath" comprised of the intersecting square and the cruciform form.[34]

While the plans for most of Wright's houses are not overtly complex – it is his use of three-dimensional interlocking that demonstrates his genius[35] and partly his Froebel training. The training provided him with a "network table" (ruled by a grid) to guide the arrangement of blocks.[36] The discipline of standardization and modular grid, rather than inhibiting Wright's creativity, facilitated his imagination to connect with the larger wholes and engage in interweaving forms. The individual blocks and the spaces between them provide an illusion of being plaited together. The influence of such Froebel training is evident in Wright's sketch plans in how they are matted with exploratory lines to form a mesh that was gradually refined and tightened to correlate appropriate parts (Figure 9.1).[37]

Wright usually started his drawings by adopting a unit system that allowed the lines to cross the paper in both directions, spaced at predetermined proportions; he felt that a trained imagination was necessary to differentiate and syncopate spaces and to weave or play upon the spaces consistently. He would group the units in a symmetrical and systematic way, which was carried out through every portion of the plan.[38] Wright also used the grid system method in almost every design throughout his career, which he sometimes composed with rectangular blocks rather than square to set up a tartan grid. In Wright's alignment, the use of tartan grid was derived from both major and minor elements in the design, with one receiving more emphasis than the other.[39] MacCormac

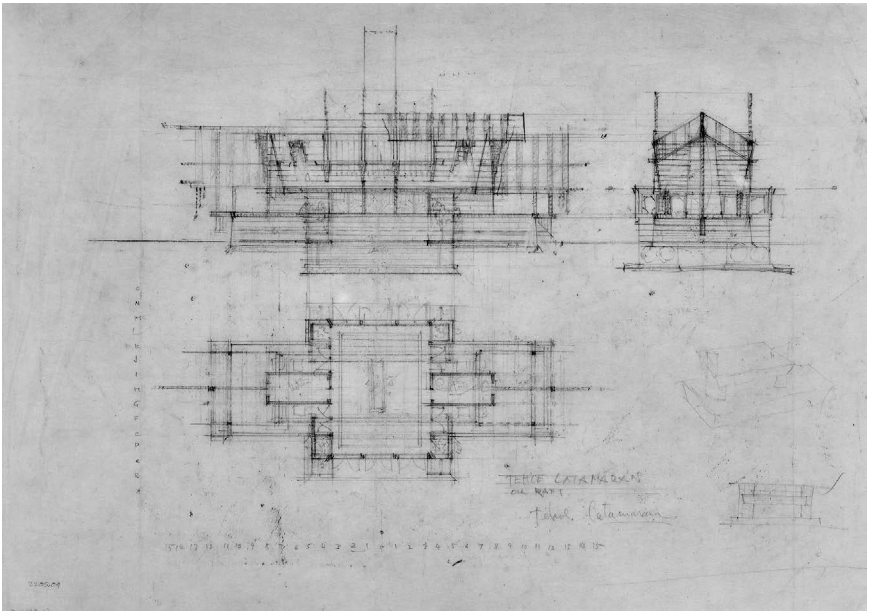

Figure 9.1 Frank Lloyd Wright's drawings demonstrating the use of spatial skills (left: family type barge, Lake Tahoe summer colony shows how plan and elevations are worked out concurrently and matted with exploratory lines)[40]

Credit: Frank Lloyd Wright Foundation

points out that Wright adopted a preference to symmetrical, cruciform plan, which can be attributed to the Froebelian precept, and that the tartan grid served as the root of all these plans.

While Wright's spatial prowess could be demonstrated in several of his projects, such as Fallingwater or the Robie House. However have selected one of his earliest works, the Unity Temple, to demonstrate his spatial skills in the form of the destruction of box, compression and release, and organic wholeness. Scholars sometimes use the "destruction of the box" concept to refer to Wright's unique conception of space, in which space was not enclosed in the traditional sense, but design elements such as walls act more like screens that define a space rather than enclosing it and room corners are dissolved using windows or cantilevered openings.[41] While more evident in buildings such as Fallingwater, Wright's destruction of the box is observable even in buildings with perfect orthogonal geometry, such as Unity Temple.[42] Given his engineering background, Wright knew that the most economical place for structural support was not the outer angles of a room but a certain distance away from the corners. By placing the support at these eccentric points, Wright created cantilevers that would set the corners free and let space emerge or extend.[43]

Wright first conceptualized his destruction of the box idea in the Larkin Building development, where it first occurred to him to separate out the stair tower at the corner part of the building and make them free-standing, individual features. Some historians suggest he was influenced by the Secession Building in Vienna, which also has corners pulled out.[44] By pulling the walls out of the roof, the building became a cantilever with structural supports no longer needed around the outside edge. Wright explained that the destruction of the box idea came to him instinctually with the Larkin Building but was consciously applied with the Unity Temple, where the overhead roof is supported by four square masses while the walls, being non-supporting, essentially serve as screens. According to Wright, since the space is not walled and the interior space opens to the outside, it creates a sense of shelter that is both extended and expanded overhead, giving the sense of protection while permitting one to see beyond the walls.[45] If this sense of freedom works for the horizontal plane, then Wright found that it would also work for the vertical plane. The destruction of the box concept is further amplified in the Unity Temple by opening up the soffit to the sky through the skylights rather than enveloping the ceiling with the traditional classical cornice feature.[46] Wright's focus on the immaterial aspects of interior space is reflected in his philosophical thought that the building does not consist of the roof and the walls but resides within the space to be lived in.[47]

According to Neile Levine, nothing appears solid in Unity Temple, and the eye is never arrested by a structural joint or a connection. The lines that articulate the space dominate and cause the overlapping planes to appear to float above and behind one another in a general expansion outward, from within. In this new spatial construct, foreground and background interrelate and become one. Space blends around the corners. Vertical and horizontal intertwine, and distinctions between container and the contained disappear. Solid and void blend in an overall continuity of space.[48] Hoesli observes that in Wright's buildings, diagonal views are invited and encouraged and the shift of the spaces make them to be individualized areas of one continuous space. Space became the elementary material to which the architect gives shape and endows significance.[49]

Aside from the destruction of the box, another conceptual device that Wright frequently utilized is the idea of "compression-release," in which spatial experience is induced by a sudden contrast of dark, compressed space that opens into an open, expansive space. According to McCarter, to go from outside street to get a seat in the Unity Temple, one makes no less than nine right-angled turns as if the passage calls for a spatial experience of a labyrinth through different levels and conditions of light.[50] Wright was arguably more attentive to human scale in the way he carefully constructed horizontal layers and datum lines so that when one moved from a standing to a seated position, it resulted in an entirely different experience of the space.[51]

The entry sequence of Unity Temple develops as a concealed, spiraling, unfolding, revelatory experience – reinforcing the sacred character of the center.[52] In this spatial sequence, one is diverted around a low wall and passages, which he referred to as "cloisters," and required to ascend several steps, turn again, be compressed beneath a low entry ceiling and turn, yet again, before being suddenly released and expanded into the sanctuary with the luminous splendor of a high, extraordinary space. In his plans, the architect becomes the choreographer.[53] The spacious wardrobes between the depressed foyers on either side of the room and under the auditorium itself were intended to provide the worshippers with an opportunity to leave their wraps before entering the worship room.[54] Those entering the room this way could see into the big room but not to be seen by those already seated within it. According to Neile Levine, perhaps the most telling aspect of the interior space of Unity Temple is the way in which Wright choreographed the means for departure. Instead of the usual practice of turning one's back to the pulpit to exit toward the street, one passes to either side of it and down a few stairs to the level of the cloisters, where sections of the panel originally blocked from the entrance unexpectedly open up into the space of the foyer. There is no retracting of steps but simply a resumption of interrupted movement.[55]

To create this experience of spatial wholeness, Wright worked through different scales of the Unity Temple, completing 34 studies to achieve harmony of the whole.[56] Salk has observed that space as a logical and social construct is celebrated as the highest expression of the Unitarian oneness of mind and body, of love and thought, of faith and reason.[57] Wright understood form and space at widely varying scales, while always employing the same ordering principles. In the plan and section of Unity Temple, the primary volume of the sanctuary is a pure cube (1:1:1 in plan and section) while the secondary spaces of entry cloister and balconies are smaller double cubes (1:2:1 in plan and section), hence secondary spaces are dependent on primary spaces both functionally and proportionally.[58] Wright also nested one form and space inside another so that his buildings were composed of similar elements repeated at varying scales.[59] The volume of Unity Temple is constructed of several spaces woven together and held in tension. The dynamic outward-directed cruciform balances the static centered square and this tense fusion of opposite spatial forms add to the spatial experience.[60] On the exterior, the independent volumes that are revealed in plan are separated, articulated, and reintegrated.[61]

The sense of wholeness is best reflected in the sanctuary space of the Unity Temple, which is at once grand and yet intimate, with a masterful composition in light and space. Its elegant articulation and warm colors stand in bold contrast to the grey concrete exterior. Devoid of overt religious iconography, the Unity Temple's precise geometric proportions declare a harmonious whole. The uppermost portion of the sanctuary is transparent and bright. A continuous band of clerestory windows consisting of Wright's signature leaded glass encircle the flat, coffered ceiling. Skylights of amber-tinted leaded glass set in a five-by-five concrete grid are intended to get a sense of a pleasant cloudless day irrespective of the actual weather outside.[62]

The sense of wholeness that Wright achieved in the sanctuary space is demonstrated in three drawings that demonstrate the evolution of the interior of the Unity Temple (Figure 9.2). In the earliest of these drawings, the ceiling is closely banded by thick, square-edged, wood molding pieces that

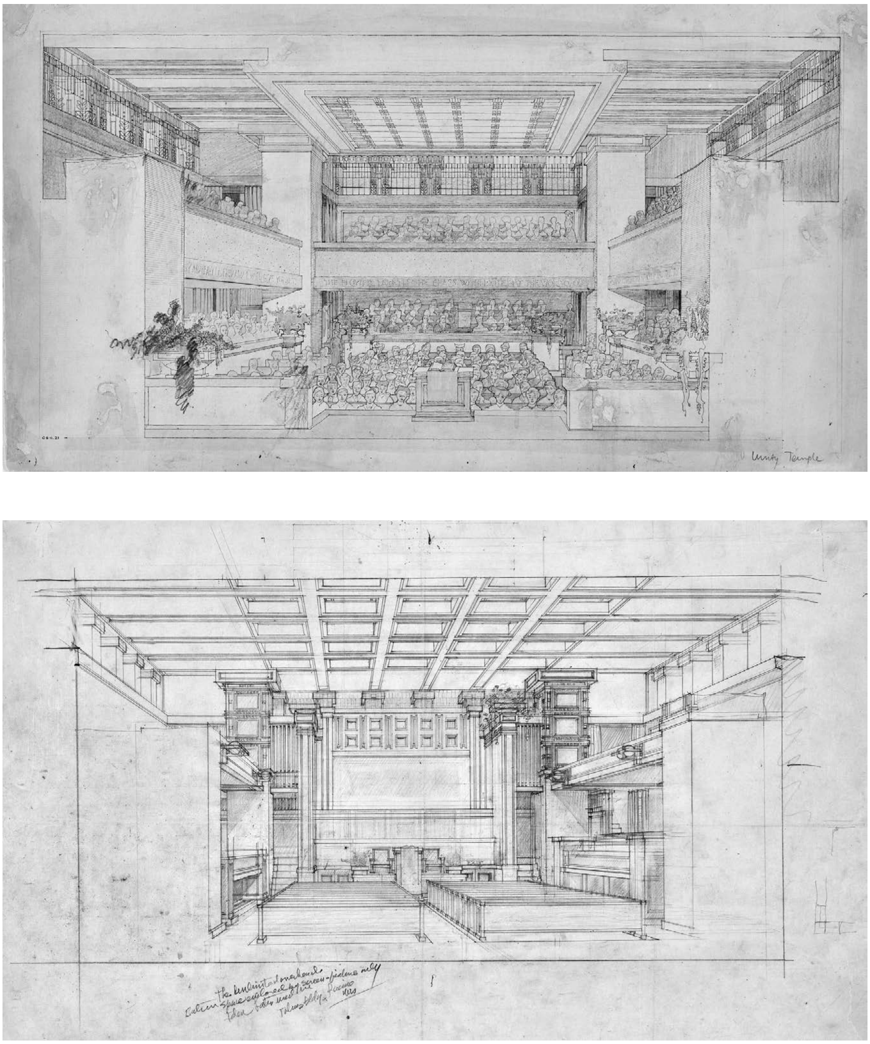

Figure 9.2 Evolution of three interior perspectives of Unity Temple, Illinois, shows Wright's demonstration of spatial skills in achieving wholeness[63]

Credit: Frank Lloyd Wright Foundation

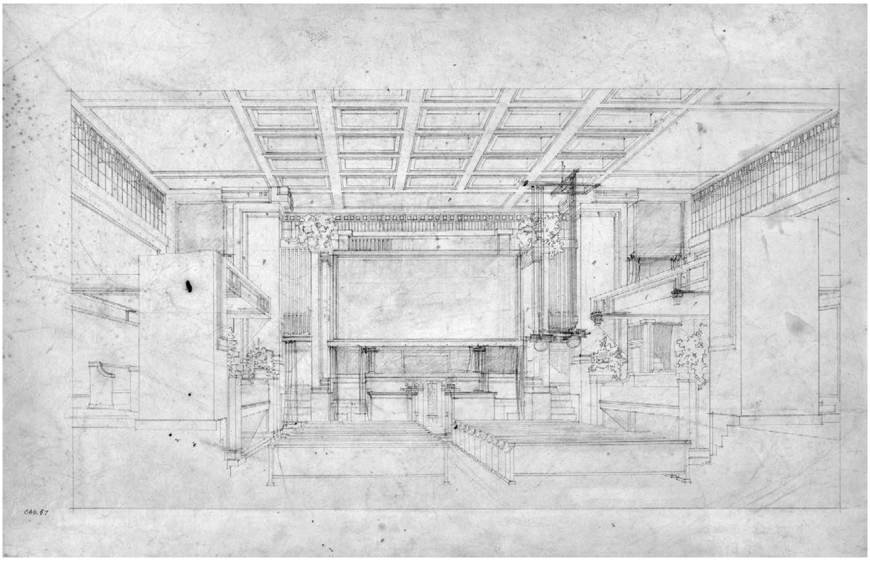

Figure 9.2 Continued

run from the clerestories to the center of the space, where a single flat skylight panel is dropped below the rest of the ceiling. The viewpoints and eye levels Wright selected for his perspective drawings were also significant for both the design and its interpretation. Siry notes that in the first articulation of the interiors, Wright utilizes the viewpoint of the preacher standing behind the pulpit, looking toward the congregation.[64] The second interior perspective of the sanctuary is the one experienced by the worshipper seated in the lower rear balcony looking toward the pulpit. The skylight now assumes the final configuration in a gridded field flush with the rest of the ceiling. Throughout, the now considerably thinner bands of wood "frame," the concrete planes, mark off and follow their edges and corners so as to create symmetrical faces for each surface.[65] The third and final perspective in this series is taken from the same viewpoint, yet here the space changes character completely, as thin wood trim turns corners, join planes, and runs across edges to fuse the varied forms into an unified whole.[66]

Wright's spatial sensitivity are similar to another designer discussed here, Tadao Ando, given their mutual roots in Japanese conceptions of space. There is adequate documentation to show that Wright's Unity Temple and his subsequent space conceptions were influenced by his visit to Japan and eastern concepts of space.[67] However, Wright's point of departure is Ando's point of arrival. As a Japanese architect, it is clear that Ando derives his spatial sensibilities from Japanese architecture, but his uniqueness rests with his fusion of Western materials and techniques influenced by his various tours to Europe and buildings of Western modernists such as Kahn, Le Corbusier, and Mies. An interesting commonality between Wright and Ando is that they were both self-taught, in that neither completed formal training in design education, and they learned their craft through interning with design firms. However, their design process is far from similar. While Wright conceived a major portion of his ideas before putting them to paper, sketching was an important aspect of Ando's design activity in contrast. Ando explains that his design framework is determined in the first sketches in which the instant movement of a hand decides everything[68] and described architecture as a physicalized process, performed through sketches.[69]

As Ando explains, drawings are of the utmost importance in terms of facilitating spatial skills in design, as the intentions of the designers have to be stamped upon the drawings, without which architecture would be impossible. He observes that the orthodox method of the architectural drawing in which the projection of three-dimensional architectural space onto two dimensions, while a time-tested method, is by no means is ideal, as architectural spaces involve the relationship between planes that cannot be understood completely from two-dimensional descriptions. Observing the limitations of individual pieces of drawings as stand-alone spatial ideas, Ando prefers to have the sum of his intentions condensed into and expressed as one drawing, with overlapping plans, sections, perspectives, axonometric, and details (Figure 9.3).[70] These types of cross-referential drawings allow Ando to think in different scales in space and induce multiple spatial experiences.

Interestingly, Ando's sketches seem more like first impression minimalist sketches and do not completely capture the visceral feelings one encounters within his completed building spaces. It is reflected in Ando's writings that sketches are mere vehicles to bridge his initial image and to final execution of architectural space.[71] Peter Eisenman also notes that Ando's drawings do not present themselves completely – one can physically sense the minimalism of the concrete skeletons, yet their unseen complexity seeps into one's intuition. He observes two types of drawings used by Ando: one which is iconic and represents the building itself (usually through graphite, hard-edged drawings) and the other merely indexical.[72] Hence, Ando's drawings double as both poetic and literal. Moreover, Fields observes that Ando's sketching is more of a form of carving than it is drawing. Although the sketches depict emotional content, they also include technical knowledge of construction. The sketches consist of lines depicting walls and space that fluctuate between materiality and voidedness. Form and space are inseparable. Furthermore, while Ando's drawings have predetermined measurements, they do not necessarily conform to the program but serve as a place holder for abstracting space based on engaging bodily experiences.[73]

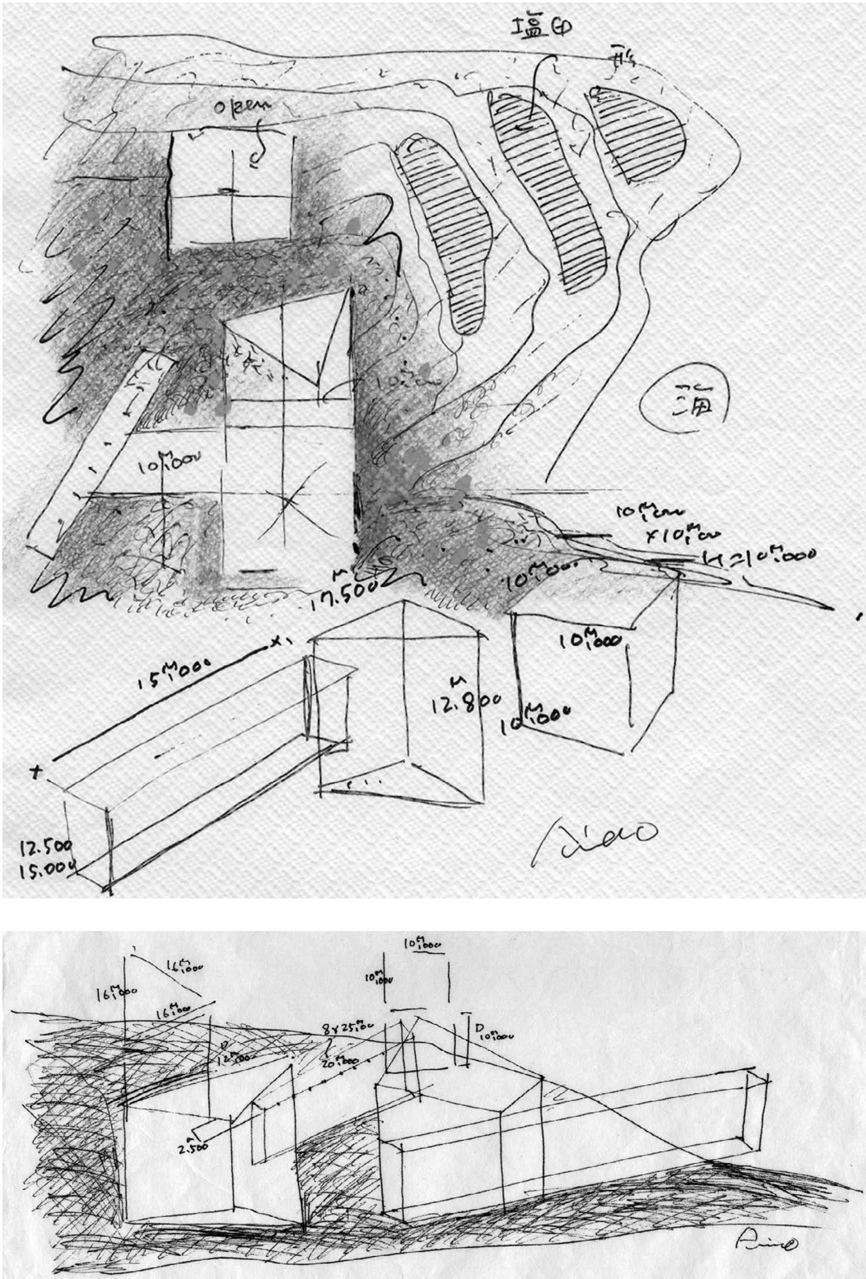

Figure 9.3 Tadao Ando's sketches for Chichu Art Museum, Naoshima, demonstrate the use of spatial skills (top left: concept sketch showing overlay of sections and views; top right: visualization of topography and macro scalar thinking of space; center and bottom: conception of space as a tactile experience interacting with daylight and material texture)

Credit: Tadao Ando Architect & Associates

Ando observes that during the process by which an architectural idea is realized as a building, the whole and parts enter into a tense relationship with one another that persists until the work is complete. This relationship provides the context for the architectural details, which, according to Ando, are the traces left behind by architectural ideas as they bridge the gap between the whole and its parts. Consequently, it is out of the complications encountered in this process the most appropriate details for a building emerge. The intention is to create details that activate one another and take on life.[74]

Ando deliberately chooses simple circles and squares for his architectural forms so he can manipulate architectural spaces more deeply. He observes that this strategy allows him to operate on abstract geometry and as well as natural proportions of the human body. A major objective for him is to create architecture that is simultaneously both abstract and representational by giving simple geometrical forms a maze-like articulation.[75]

Ando observes that spatiality is the result not of a single, absolute direction of vision but of multiple directions of vision from multiple viewpoints made possible by the movement of the Shintai (i.e., engagement of body and mind).[76] According to Ando, natural and human movement bring a dynamism to architecture. A person moving through multiple layers of space encounter overlapping scenes. The aggregate experience of space creates order, while the individual spatial experiences enriches the whole. Geometry as such gradually recedes from awareness, and the space alone provides emotional stimulus.[77]

Ando's spatial skills are evident in a number of his projects, such as the subtle use of spatial transition in Church of Light, the massing and spatial transparency in the Church of Water, and the spatial sequencing and borrowed landscapes in the Water Temple, to name a few. However, I one of his later works, the Chichu Art Museum, demonstrate his spatial skills much more prominently. Housing world famous art collections from Monet, James Turrell, and Walter de Maria, the museum is mostly situated underground to expose the landscape of Seto Island. Large voids dug into the landscape let in natural light, changing the appearance of artworks in the interior and allowing the experience of passage of time and seasons. Since the outer expressions of the building are invisible, Ando moves away from formal issues to creating lightscapes, using light as a guide (Fig 9.2 and 9.3).[78]

Ando described the construction of the museum as that of an organism multiplying by developing in stages. He attempted to give character to each space through the use of light. He wanted light penetrating the darkness to give direction to the architecture, and he found himself unconsciously trying to make the underground spaces purer.[79] Ando attributes his designs to the exploration of his own matrix of space, which he describes as obscure and cave-like, surrounded by thick heavy walls of earth – images of which are derived from his experiences of place as a child, such as the dusky rooms in his childhood home, subterranean houses in Cappadocia, and underground wells in Ahmedabad. His creation of space also can also be described in terms of the feeling he gets when looking up at the sky from the depths of the earth. With such subterranean structures, Ando observes that light is reduced beneath the earth's surface, the sense of depth increases, and darkness is born.[80]

A standout feature in the thinking of Chichu Art Museum is Ando's concepts of voids and time. Japanese spatial understanding of voids can be traced back centuries to the concept of "ma," which refers to a void, gap, or pause, and inculcates ideas of nothingness, incompleteness, and room for more.[81] The concept of "ji-kan" is literally read as time-space, or conceptually as "spatialization of time". Zen philosophy tends to prefer perfectly empty space to that which is perfectly complete. Similarly, in Ando's work, not only are courtyard gardens empty, but their walls seem to have been deliberately stripped of expression. He tries to create space by means of invisible, apparently non-existent things. In short, his type of space can be called a void – but ironically a void in which all things are inherent.[82] Tironi observes that the compositional procedures used by Ando move a person into a very subtle zone of transparent opacity, variable densities of nothing, and evanescent solids and voids. Without introducing any hierarchy of time and space, there is a succession of voids in which no time is wasted.[83]

Ando observes that a courtyard may draw one's attention to its blank, and interstitial quality, but rarely does it have a presence as strong as that of the building itself. He believes that such interstices should have as much significance as the buildings themselves. If a building is to have presence and individuality, these spaces must also be given their intrinsic logic.[84]

The idea of ji-kan also inculcates the forward movement of the sun or a space in flow where experiences become a part of a time-structured process.[85] By breaking down an experience into smaller sections of time, more can be observed, thus obtaining a greater value toward space.[86] This kind of spatial choreography and unfolding encompasses a delayed gratification, where like the unfolding of a scroll that is not shown all at once, segments are revealed as the piece is unrolled.[87] Space temporalized by the conjunction of natural light and shadow produces spatialized time in one's consciousness as time is made into space. In the configuration of this temporal order of space, discontinuity plays with one's imagination and memory to accentuate the awareness of lived time, with greater intensity in threshold spaces or links.[88] Some have alluded to the idea of phenomenal transparency in the works of Ando, even in a supposedly simple building such as Church on Water.[89] Others have observed that time-structured processes in traditional Japanese landscape designs, where the idea of breaking up time derives from breaking up the user's movement, are accomplished by a careful, strategic placing of stepping stones (tobi-ishi). By controlling the frequency and location of the stones, people are forced to speed up, slow down, stop, or even turn along the path, compelling the user to rush through, delay, halt, or defer from their original path. By doing so, the user is given an altered experience through nature, one that is carefully intended by the designer.[90]

Ando believes that the tactile nature of space needs to be subtly conveyed in that architecture should remain silent and let nature speak, whether under the guise of the sunlight or the wind. He observes that sunlight changes the quality of space with the passage of time, gently pervading space in one moment and cutting through like a blade in the next. At times, he believes that one could reach out and touch the light. Moreover, wind and rain are equally transformed by seasonal change; they can also be chilling, gentle, and pleasant. They activate space, making one aware of the season and nurturing greater sensitivity.[91]

According to Ando, walls play a dual role, serving both to reject and affirm. By positioning a number of walls at certain intervals, he creates openings in which walls are freed from the simple role of closure and take on new objectives. The amorphous and immaterial elements of wind, sunlight, sky, and landscape are cut out and appropriated by walls that serve as agents of the internal world. This tense relationship between inside and outside he notes, is based on the act of cutting (as with a sword), a ceremonial act of symbolizing disclosure. He observes that it provides a spiritual focus both in space and time and an object loses its definition within that tense movement.[92] Finally, Ando uses walls as framing devices for near and distant views, often bringing the landscape into his spatial vocabulary.[93]

The use of materials amplifies Ando's spatial order in how he employs concrete devoid of its solidity and weight, rather than serving to produce a light, homogeneous surface. The traces of regularly attached shuttering and separators are finished to produce smooth surfaces, unlike the use of concrete, for example, by Le Corbusier who uses it to express rational order. Ando treats concrete as a cool, inorganic material with concealed background and strength. His intent is not so much to express the nature of the material in itself, but to establish the single intent of the space. Ando observes that when light is drawn into it, cool, tranquil space surrounded by a clearly finished architectural element is liberated to become a soft, transparent area transcending materials. It becomes a living space that is one with the people inhabiting it.[94] Ando's delicate use of concrete as a material translates into the ability to transmit light along its surfaces, illuminating spaces and creating a completely different spatial quality compared to that of artificial lighting. The light along the bare concrete creates a path through which light travels and reflects onto otherwise dim spaces, similar to what a material like gold could accomplish within classic Japanese design.[95]

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10 Verbal/linguistic skills

Bernard Tschumi's narrative deconstruction and Maya Lin's prose poetry

Verbal/linguistic skills involve thinking in words and the creative use of written or verbal language in which one finds meaning and order among words, sounds, rhythms, and inflections.[1] While the use of verbal/linguistic skills can be poetic in nature, it can also be used in everyday life for expressive and practical purposes.

Aside from using language as a literal tool, Dutch architects such as Aldo Van Eyck used linguistic syntax as an analogy to design. Influenced by structural linguists, such as Saussure for instance, the structuralist movement in design sought to examine design process through syntactics, semantics, and pragmatics.[2] "Syntactics" refers to formal grammar, while "semantics" refers to the making of meaning, and "pragmatics" refers to how these meanings are interpreted in practice.[3] Other designers have used verbal tools or literary devices to construe design as a narrative bringing about a fictional quality to design.[4]

Donald Schön alluded to design as a reflective conversation with the materials of the situation and a knowing-in-action.[5] Schön observed that designers know more than what they can say, tend to give inaccurate descriptions of what they know, and can best (or only) gain access to their knowledge-in-action by putting themselves into the mode of doing.[6] Dong expanded on Schon's metaphor of design as language to a more instrumental one. Rather than serving as an accompaniment to design, Dong contended that language becomes a constituent of design as an active functional instrument.[7]

Given the instrumental role of language in design, the recent shift from studying design as a precise formal language to an ambiguous, informal one indicates that formal language in itself is inadequate to capture all the cognitive content of designing. Understanding unconventional forms of conversation is also addressed in studies which contend that vague, natural language terms can replace precise numbers and introduce interpretative flexibility[8] extending the idea that ambiguity is essential to design process.[9] Recent research on design as language have focused on other conventional language forms, such as the use of metaphors, hedge words[10] and polysemy.[11] Similarly, our own research on the design process found that designers use expressive words in the form of slangs (for e.g., awesome lighting, pop of color) or jargons (for e.g., feasibility study, materiality).[12] In this context verbal/linguistic skills in design could be described in terms of the following subskills: the ability to incorporate a design syntax; the ability to use verbal tools such as narratives to generate design; and the ability to be persuasive in the verbal articulation of design ideas.

Ability to incorporate a design syntax

Structural linguists influenced the design works of several famed Dutch architects, such as Aldo van Eyck and Herman Hertzberger, resulting in a collective movement which came to be known as structuralism in architecture.[13] Aldo van Eyck's empirical research on the indigenous Dogon settlements of Africa rejects composition and monumentality of built form in favor of flexible and interchangeable spatial units, which are categorized and then systematically combined to reflect social structures.[14] Hertzberger conceives spatial structures that are in harmony with movement of human bodies by creating gradients of accessibilities (degree to which spaces are open or closed to the users). Others, such as Peter Eisenman, have used a structuralist framework to implement geometric rules within their buildings as formal self-referential syntax, while designers such as Aldo Rossi have used typologies and morphologies rooted in specific building types and contexts.

Architectural theorists such as Christopher Alexander have outlined a "pattern language" for design, which is a special kind of syntax that could be used by architects and the lay public to make better quality buildings.[15] This language consists of a collection of prescribed solutions that sustain the holistic nature of places and can be applied to houses, cities, and towns. Each pattern language includes a syntax to describe where everything fits in the design. For example, the pattern language of the "University as a Marketplace" establishes a typology in which universities function much like a market (i.e., an active and dynamic place easily accessible to anyone). Today, architectural design firms such as Kubala Washatko continue to use pattern language as a philosophy to guide their design process.[16]

Linguistic theorists have also been influential in architectural design through their examination of the deep structures of language formation. For instance, "shape grammars" have been proposed as formal rules for design whose elements must be combined through geometric and visual logic.[17] Linguists such as Ferdinand de Saussure and Noam Chomsky, and later Umberto Eco, Roland Barthes, and Jacques Derrida, all influenced the discourse of post-modern and deconstructive architectural movements in design.[18] Derrida moved away from the notion of language as having a stable structure to conceiving language as fragmented and ambiguous, as an event and a kind of play. He contended that language production and consumption are multiple, contradictory, subject to change across settings, and fundamentally unstable (the notion of "différance"). Barthes suggested that any literary text has multiple meanings and that the author was not the sole authority of how the work will be interpreted. These linguistic theories were later adopted by architectural designers, such as Peter Eisenman and Bernard Tschumi, among others. In the Wexner Center for the Arts in Columbus (1989), Eisenman introduced the idea of "palimpsest" – conceiving architectural forms and spaces as a layered manuscript with repeated exercise for writing, erasing, and re-writing.[19] Similarly, in Parc de la Viliette (1998), Tschumi focuses on the architectural process, rather than the form, using the post-structuralist notion of "intertextuality" to challenge architecture as an isolated object. In an intertextual narrative, meanings are dynamic and become ascribed within the context they serve.

Ability to use verbal tools such as narratives to generate design

While some designers have explored the spatial implications of literary texts, narration, and quotation as design generators,[20] others have explored the use of verbal narratives and the fictional quality of design.[21] The power of design narrative can be seen in the works of designers such as Mario Botta, who wrote about his personal experiences reconstructing the Church of San Giovanni Battista in Mogno Village devastated by an avalanche.[22] Botta describes how he channeled the tragedy into the reconstruction of the church, outlining several goals for the project, such as: the need to bear witness beyond one's lifetime; the need to overcome the feeling of loneliness; and the need to bear witness to the hope in one's own time.

According to Ericsson and Simon, during verbalization, designers engage in additional cognitive processes to generate thoughts corresponding to the required explanations and descriptions.[23] Similarly, Kvan and colleagues found that in collaborative design processes, text-based exploration of alternatives caused significantly higher exploration of alternatives as those using graphics.[24] The importance of verbalization in design pedagogy is also outlined by Schön in his theory of "reflection-in-action," which refers to design process as a back-and-forth internal conversation between the designer's thought process and the action's the designer takes to advance the design process.[25] Schön uses the example of a session between a studio teacher and a design student in which the student claims to be mentally stuck, with the teacher responding by working through the problem with student and engaging in explicit verbalization.[26]

Ability to be persuasive in the verbal articulation of design ideas

A designer with strong verbal skills is able to write and speak elegantly, exhibits parsimony when articulating design ideas, and effectively communicates with others. Hoag and Smit characterize communication in architecture as essentially "persuasive" (puts forth an argument) and "multimodal" (relies on a combination of words and images).[27] This is because, as they explain, images alone can be interpreted differently according to the background and experience of those looking at them and that architects cannot rely on images alone to persuade their audience that their designs should be accepted. Hoag and Smit observe that the text in effect "cues" the audience as to how they should react and interpret the images. They suggest that written and verbal communication is so critical to practice that firms are willing to pay much more for architects with good communication skills.[28]

Some designers have highlighted the need to move away from the use of colorful language to more efficient communication. The famous architect Charles Correa once suggested that over-verbalization in the studio and design literature has led to a mechanistic reasoning that is contrary to the instinctual nature of the creative process.[29] Similarly, Hugh Pearman criticizes architects that have retreated into "Archi-speak" (architectural jargon which is unintelligible outside the architectural community), suggesting instead that they take on more conversational and straightforward linguistic styles, without the pretention.[30]

Verbal/linguistic skills of Tschumi and Lin

To demonstrate verbal/linguistic skills, I present the works of Bernard Tschumi and Maya Lin. While Tschumi's verbal skills can be identified by his use of literary text in his design projects and his ability to deconstruct a macro narrative, Lin is influenced by prose and poetry in the literal sense with her architectural projects conceived in writing.[31]

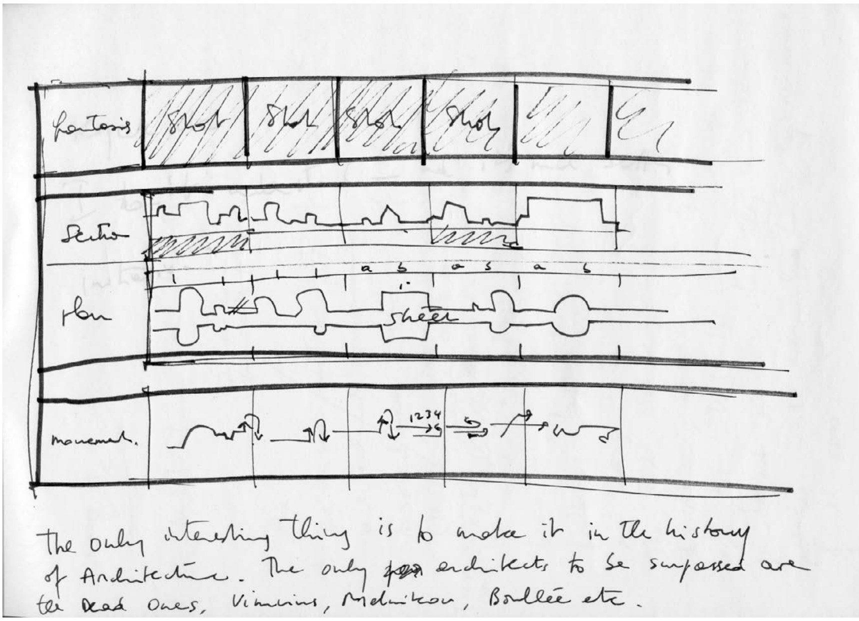
Tschumi's affiliation to literature derives from what he sees as the limitation of conventional design representations, such as perspectives, axonometrics, plans, and sections, in terms of capturing the core of architecture – that is, an architecture that facilitates a series of events. Tschumi therefore borrows notations (a descriptive system of representations) from other disciplines where the idea of events have been extensively documented, such as dance, sports, film theory, and performance arts.[32] For Tschumi, this new form of notation in design encompasses the description of architecture and the city, an archeology in which diverse discourses can be facilitated.[33]

Tschumi's use of verbal skills can be traced back to the 1970s at London's Architectural Association (AA), where he held his first teaching position while developing his own vocabulary and taught alongside with other reputed architects, such as Rem Koolhaas and Zaha Hadid. At AA, he developed a reflection on the language of architecture, which was deeply influenced by French post-structuralists, notably Roland Barthes and Jacques Derrida. He subsequently introduced the notion of deconstruction to architecture as a new language and way of conceptualizing architecture.[34] The deconstructive movement is characterized by fragmentation and discontinuity based on the notion that design can never be fully controlled or interpreted as a whole. Tschumi also realized at AA that, instead of the conventional role of the architect as a service provider who translates program and needs into built form, the architect should be the author of the program or the brief itself. The architect's role in inventing the design problem was controversial at the time, of Tschumi, who began incorporating literary texts as programs for his projects. Rather than starting with the conventional list of rooms and square feet, Tschumi referred to the literary texts of Italo Calvino, Edgar Allen Poe, and Franz Kafka, to create, their narratives, in place of the program.[35]

An exercise Tschumi often employs is that of taking a text on literary theory and simply replacing the word "literature" with that of "architecture" to see what happens.[36] Tschumi likens the architectural design process to that of creating a work of literature, as though someone is writing a chapter and only has a vague idea of the next one. In essence, his writing and drawing influence one another. Since the concepts he derives from writing are not quite the same as the ones he derives from drawing, he finds it exciting when they reinforce one another. This is not necessarily a sequential process, as concepts can either precede or follow projects.[37]

Tschumi's Joyce's Garden (1976–77) project, which is located in London's Covent Garden, uses literary text as program, inspired by the complex language games of the Irish writer, James Joyce (Figure 10.1).[38] Using a de-structured narrative of Joyce's *Finnegan's Wake*, Tschumi tackles the semantic complexity of the architecture, exploring social activity and literary text.[39] Like the reader of Joyce who must participate in the fabrication of writing, Tschumi believes that one must be active participant in the architectural process of the city. Philippe Sollers notes that the reader of Joyce's Garden is involved in the act of decipherment, which is never exhaustive or definitive but reveals itself through a circular metamorphosis and slippage.[40] In the project, Tschumi experiments with a point grid system as a territory to define a set of rules, a series of repeated imprints with a regularity that brings out the diversity and complexity of the city. This active reading of architecture allows the reader to experience the acts of translation and transfer and to deconstruct the experience of architecture.[41]

For Tschumi, signs and space, words, and figuration are closely related. The distinction between talking about space and the creation of space vanishes, as well as any primacy of either the visual or the verbal. Ultimately, according to Tschumi the "words" of architecture become the "work" of architecture.[42] Tschumi also embarked on a project Advertisements for Architecture (1976–1977), inspired by advertisements found in fashion, news, or design contexts. In the project, the original words of various advertisements are replaced with words with architectural connotations. The new



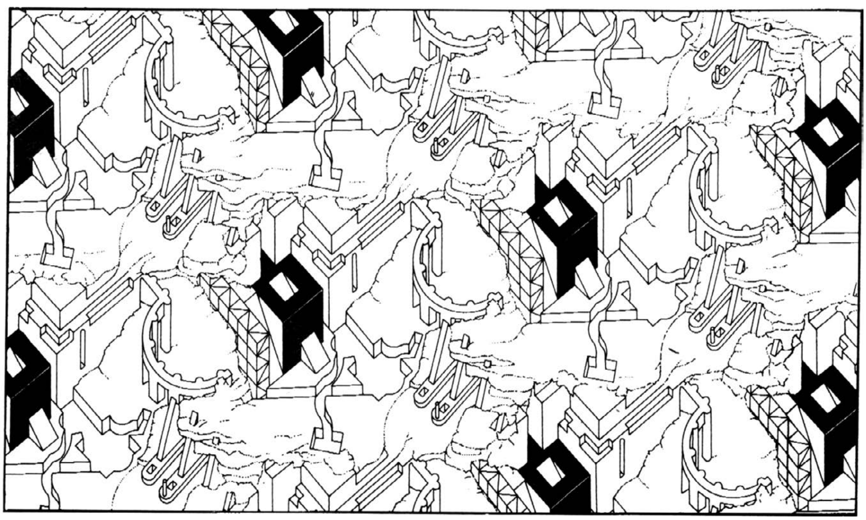


Figure 10.1a–b Bernard Tschumi's drawing demonstrating the use of verbal/linguistic skills (a (top): Manhattan Transcripts, Manhattan, NY; b (bottom): axonometric drawing for Joyce's Garden, London; c–d: sketches for Cinematic promenade for Parc de la Villette, Paris)

Source: Bernard Tschumi Architects

(*Continued*)

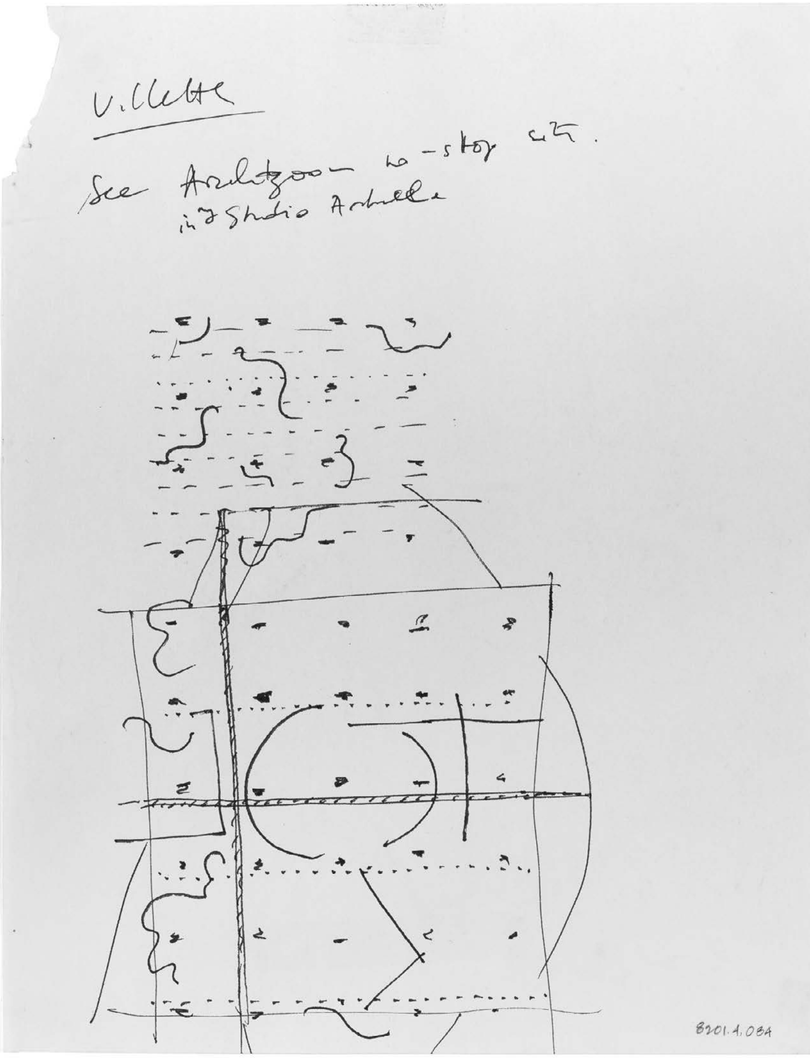


Figure 10.1c

texts are then juxtaposed with images that would amplify their meanings. Given that it was before the widespread use of computers or the help of expensive typographers, Tschumi composed all text by hand, character by character, with an adhesive sheet called Letraset. A series of postcards were published, and several thousand copies were sold.[43]

Aside the use of literature as a medium to generate design, Tschumi also utilizes cinematic medium and film theory to extend the scope of

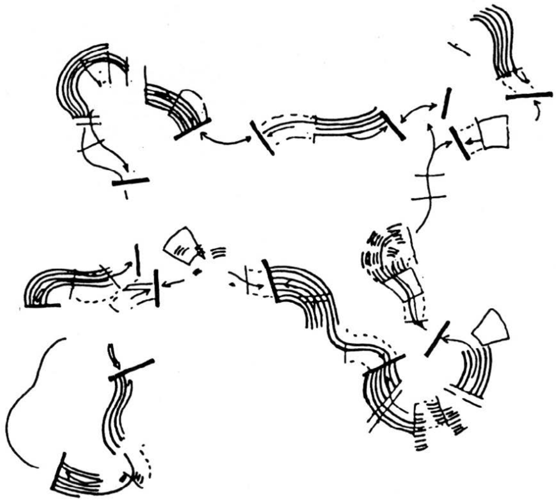


Figure 10.1d

architectural representation. This is most apparent in his Screenplays (1976) project. He contends that by substituting the word "screenplay" with that of "program," architectural space can be charged with the same dynamism and movement as of a movie.[44] For instance, he sees parallels in the unfolding of events, whether in a film sequence, a football player's tactic, a skateboarder's path, or an architectural event.[45] Just like in film medium, architecture becomes an interaction between space, movement, and event. Each screenplay consists of quick exercises, generally completed in the span of one night, in which he applies various techniques and devices to film – for example, the tactic of "fade in/fade out" – and determine its architectural equivalent. The preliminary ideas explored in the screenplays project is further expanded in another project, namely, The Manhattan Transcripts (1976–1981) (Figure 10.1). Tschumi observes Screenplays as analogous to a collection of short stories or mini essays, while Transcripts take the form of a novel. All the devices explored briefly in the in the former crystallize in a more substantive way in the latter by using techniques such as superimpositions, juxtapositions, movement vectors, and so on.[46]

The Manhattan Transcripts consists of four episodes that explore the multiple relationships between architecture, body, and real space.[47] The purpose of the project is to transcribe things that are normally removed from conventional architectural representations: the relationship between space and its use; between the set and the script; between type and program; and between object and event.[48] Tschumi takes a program, dismantles it, cuts it up, and reconfigures it, much in the same way as one might do with any visual material.[49] According to Tschumi, Transcripts focuses on architecture rather than what happens in the story. He begins with a murder in New York City's Central Park and uses a conventional formula plot – the lone figure stalking his victim, the murder, followed by a search for clues, detecting, and capturing the murderer – and juxtaposes it with an architecture that is both linked to and transformed by the actions taking place. A special mode of notation, the three-square principle, underscores the relationship between the search for the suspect and the ever-changing architectural events: photographs indicate actions; plans reveal changing architectural manifestations; and diagrams show the movements of the different protagonists.[50]

According to Tschumi, his theoretical projects culminate with the competition project Parc de la Villette (1987) in Paris (Figure 10.1). At a time when he thought he needed to test his concepts on real projects, the park provided the ideal opportunity to bring his ideas "from paper space to social space."[51] He entered the competition with minimal work experience, aside from a few months with Candilis-Josic-Woods in Paris. Tschumi observes that this sudden transition from the purely theoretical to actual building made everything tentative – a constant process of trial and error.[52] The influences of his past projects are evident, for instance, the point grid used in Joyce's Garden as an organizational system and the fade-in/fade-out used in Screenplays, Similarly, the ideas of montage, frame, and sequence used in Transcripts contributes to the "cinematic promenade" of the gardens.[53]

Parc de la Villette was designed to appeal to the needs variety of stakeholders, including the young and the old, the active and the passive, the working class and the young elite, the rich and the poor, which was a requirement made by the young socialist government in power at the time. The park served as the launch of the Grands Projects of Francois Mitterrand in Paris, which aimed to revitalize the nation's culture and the city's neighborhoods with major architectural projects.[54] The program asked for several cultural facilities, from cinemas and outdoor theaters, to workshops for painting and sculpture, but also including community gardens, restaurants, and soccer fields. In his early sketches, Tschumi superimposed different organizational diagrams onto the park site, envisioning Parc de la Villette primarily as an urban project, rather than a project about nature, as many of his competitors had actually done.[55]

In preparation for the project, Tschumi constructed several small, low-budget structures with his bare hands using only saws, hammers, nails, and sheets of plywood. His thinking was that building full-sized, essentially useless structures with almost no budget and on barely legal urban sites would be foolish.[56] He sarcastically referred to these experimental structures as "follies" (absurdity). Tschumi uses a point grid system without any exterior points of reference, marking it out which themselves are informed by grids, generating a complex diversity of forms and open spaces, free of any program. The project was constructed by superimposing three systems: the system of points that contain the programmed activities, a system of lines that directs the movement of people through the park, and a series of planes or unprogrammed spaces to be appropriated by the public in unexpected ways.[57] The follies consist of twelve-by-twelve-meter cubes that house first aid centers, a restaurant, a theater, a cave, and a TV studio for children, along with many other distinct programs. Since the follies are the most important structuring element of the project, Tschumi wanted them to function as an "activator" (i.e., as visual devices that represent a strong presence). In this regard, Tschumi used primary colors to code and distinguish the intensity of events.[58] The follies are relatively small, but in the case that a program needs more space, they can be expanded using "maisons," which are larger three-story buildings to be potentially designed by future designers.[59] The grid on which these follies are placed are designed to be extended indefinitely – the follies can be continued beyond the park, into Paris as well as beyond, simply by following the line of existing 18th-century canal bisecting the site. Parc de la Villette has no boundaries, hence no beginning nor end, and so it has the potential to continue endlessly.[60]

Tschumi's intention for Parc de la Villette was not to conceive a self-standing "composition" nor to create a balance or a "complement" to the existing context. Instead, he sought "mediation" between the old and the new with the grid of follies serving the meditating function.[61] Referring to the architecture of Follies, French philosopher Jacques Derrida observes that the moment one enters the space, the architect's original intentions and imposed meanings break down, bringing about a general dislocation. The building, makes it presence felt through the immediacy of the encounter (which he refers as "maintenant").[62] This experience is enriched through Tschumi's economy of representations (i.e., through the use of notation, words, and active signs) in the making of his architecture.[63]

Much like Tschumi's verbal/linguistic skills the medium of literature influences the creation of forms of architect and sculptor Maya Lin. While Lin has not created as many architectural buildings as she has sculptural works, she feels that this dual practice has helped her to traverse through two different genres of expression, characterizing it as "prose poetry." Her affinity for the merging of genres was inspired by the work of 19th-century French poet Charles Baudelaire, who composed radical new texts with aspects of both prose and poetry.[64] She suggests prose is similar to architecture in that the latter functions like a novel with heavily planned composition of work and developed themes, while poetry has more in common with sculpture because it is similarly more intuitive.[65] In her architectural works, she maintains functionality and programming throughout her design process while preserving an underlying idea, whereas in her sculptural works she tries to retain a simple gesture or thought as pure as possible.[66]

Lin's design process begins by imagination of an artwork verbally and later a description through writing about the nature and goals of the project.[67] She speaks to the importance of understanding the artwork without giving it a specific materiality or solid form, and she tries not to find the form too soon. Instead, she tries to think about it as an idea without a shape.[68] Her use of words over iconography is a result of her comfort in verbal thinking, as well as a deliberate deliberate affinity to employ a literal mode. Her spatial imagination is driven by narrative or historical modes of thinking and typically used to emotional ends. The incorporation of text in her design is one apparent narrative device.[69] As demonstrated in many of her projects, Lin incorporates words into physical features, such as in Women's Table (1993), The Civil Rights Memorial (1989), Storm King Wakefield (2009), A Shift in the Stream (1995–1997), and the Vietnam Memorial.[70]

Among all of Maya Lin's work, the Vietnam Veterans Memorial competition project perhaps demonstrates the value of her verbal skills (Figure 10.2). The winner among nearly 1,500 entries, Lin was then a 21-year-old student at Yale University. According to the Vietnam Memorial competition brief, the purpose of the project was to recognize and honor those who had served and died in the Vietnam War. The submissions were to be reflective and contemplative in character as a catalyst for a process of healing and reconciliation.[71] Artists and architects were required to submit two rigid 30″×40″ panels with their concepts, including a visual representations of their idea, a description, and a statement of purpose. The description had to be handwritten, rather than typed or printed.[72]

Lin was inspired by the Thiepval Memorial to the Missing of Somme by Sir Edwin Lutyens, which commemorates servicemen who died in the Battles of the Somme during the First World War. The memorial was later elaborated to her in a class by the famous Yale Professor Vincent

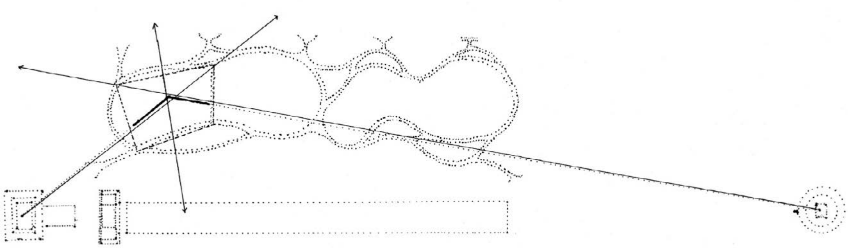


Figure 10.2a Maya Lin's competition entry for the Vietnam Memorial demonstrating verbal/linguistic skills (a: visualization of vistas; b: concept sketch for naming of fallen soldiers)

Source: Library of Congress, courtesy Maya Lin Studio

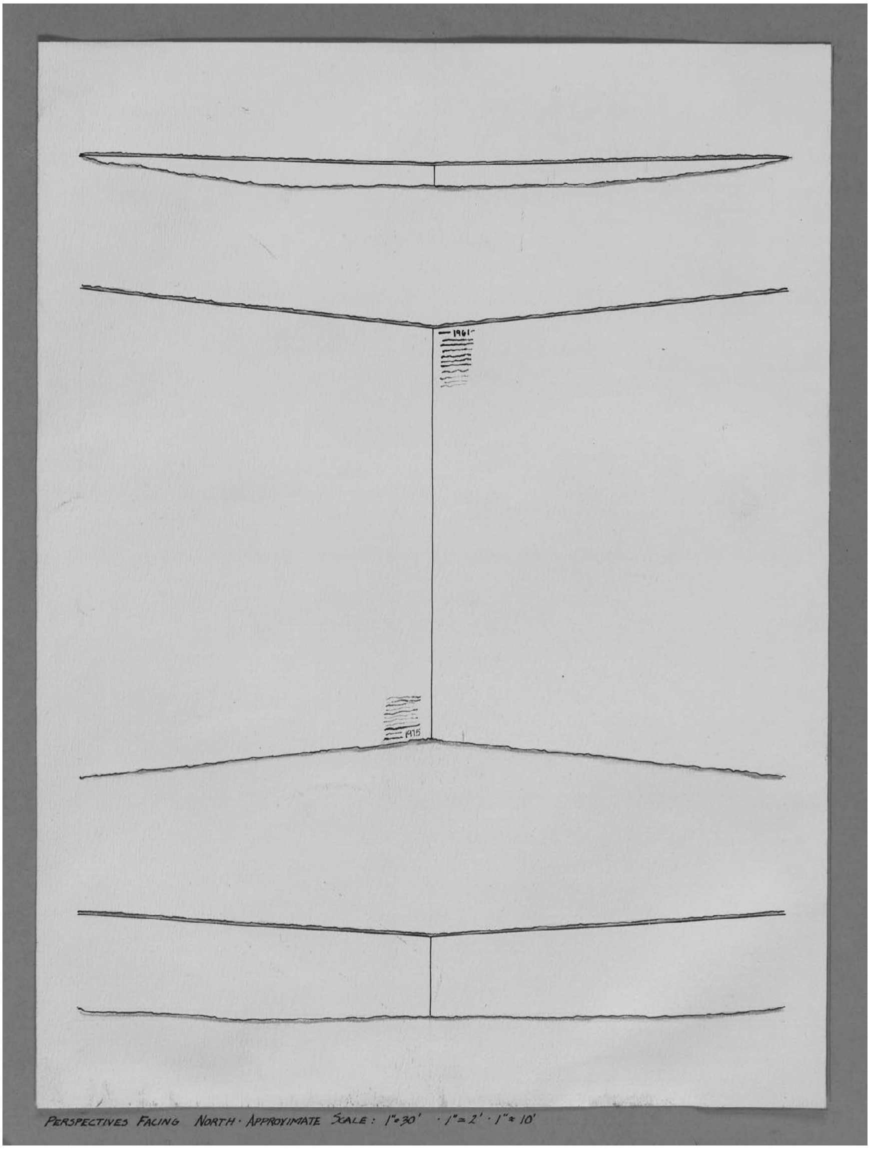


Figure 10.2b

Scully, who described the experience of this cemetery as passing through a yawning archway in which nearly 100,000 names of the missing were carved, thereby bringing an awareness of immeasurable loss. The inscription of names on monuments would later become a major feature in

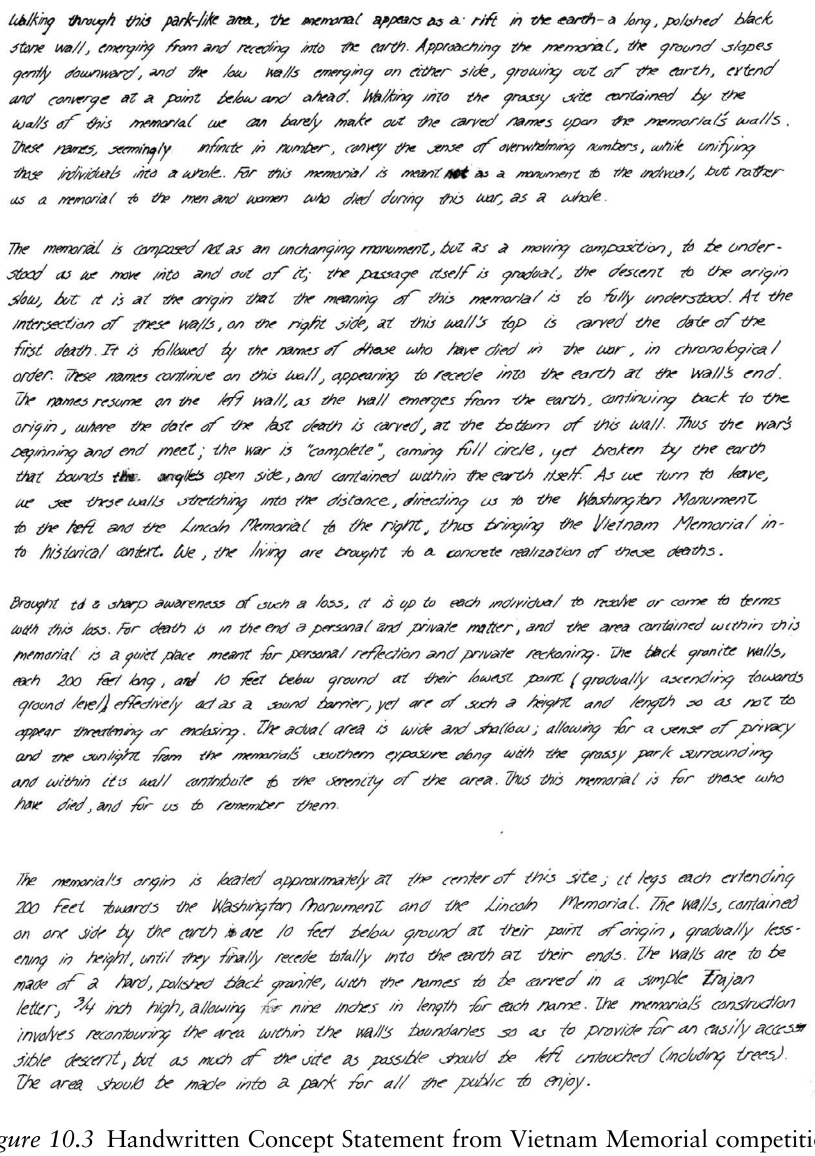
Lin's design. As she observes, to walk past those names and realize the extent of lost life contributes to the strength of the design.[73]

Lin recalls herself writing furiously in Scully's class about the subject of loss.[74] On a personal level, she wanted to focus on the nature of accepting and coming to terms with a loved one's death. Simple as it may seem, she felt that accepting a person's death was the first step in being able to overcome that loss.[75] She felt that names had the power to bring back every single memory one has of that person far more realistically than a still photograph.[76] For the memorial, she proposed that the names be listed chronologically, by order of death, rather than alphabetically. The names would commence at the apex joint of the two memorial walls and conclude at the joint base full circle. They would disappear into the ground to the east then resume at the west. The simplicity of the V-shaped wall design project that blended in its context swayed the competition jury to declare it as the winner.[77] They saw her design as neutral, contemporary, minimalistic, and with no determinate meaning.[78]

Interestingly, Lin originally conducted the project for a studio run by Professor Andrus Burr at Yale in her senior year and not for the purposes of the competition. The class, which was on funereal architecture, had spent the semester studying how people, through the built form, express their attitudes toward death.[79] Lin wrote 600 words imagining a memorial in a handwritten essay in 39 lines of level script.[80] Given this background, for the competition, she described the difficulty of trying to limit her concept to just one page. In fact, she recalls, she spent more time writing the statement that accompanied her entry than she spent designing the memorial. The description was critical to understanding the design since the memorial worked more on an emotional level than a formal level.[81]

As the deadline for submission approached, Lin created a series of simple drawings in soft pastels to make it mysterious and painterly, unlike typical architectural drawings.[82] However, the drawings of plan, elevation, and section were not drawn to the scale specified in the competition program. Moreover, the pastel renderings of the wall looked unfinished and very diagrammatic.[83] Fortunately, Lin instinctively knew that the written concept statement was the only way to get anyone to understand the design because the form was deceptively simple (Figure 10.3). She struggled to edit and rework the description, never fully completing it. At the last minute, she wrote directly on the presentation boards by freehand, as evidenced by her misprints.[84] Lin's concept statement provides a remarkably vivid insight into experiencing the memorial.

The jurors found the submission to be unique and crucially included a compelling, jargon-free written statement of how the memorial would be experienced. Lin agrees that it was perhaps the written description that ultimately convinced the jurors to select the design, demonstrating the value and descriptive power of her verbal skills.[85]



Walking through this park-like area, the memorial appears as a rift in the earth – a long, polished black stone wall, emerging from and receding into the earth. Approaching the memorial, the ground slopes gently downward, and the low walls emerging on either side, growing out of the earth, extend and converge at a point below and ahead. Walking into the grassy site contained by the walls of this memorial we can barely make out the carved names upon the memorial's walls. These names, seemingly infinite in number, convey the sense of overwhelming numbers, while unifying those individuals into a whole. For this memorial is meant not as a monument to the individual, but rather as a memorial to the men and women who died during this war, as a whole.

The memorial is composed not as an unchanging monument, but as a moving composition, to be understood as we move into and out of it; the passage itself is gradual, the descent to the origin slow, but it is at the origin that the meaning of this memorial is to fully understood. At the intersection of these walls, on the right side, at this wall's top is carved the date of the first death. It is followed by the names of those who have died in the war, in chronological order. These names continue on this wall, appearing to recede into the earth at the wall's end. The names resume on the left wall, as the wall emerges from the earth, continuing back to the origin, where the date of the last death is carved, at the bottom of this wall. Thus the war's beginning and end meet; the war is "complete", coming full circle, yet broken by the earth that bounds the angle's open side, and contained within the earth itself. As we turn to leave, we see these walls stretching into the distance, directing us to the Washington Monument to the left and the Lincoln Memorial to the right, thus bringing the Vietnam Memorial into historical context. We, the living are brought to a concrete realization of these deaths.

Brought to a sharp awareness of such a loss, it is up to each individual to resolve or come to terms with this loss. For death is in the end a personal and private matter, and the area contained within this memorial is a quiet place meant for personal reflection and private reckoning. The black granite walls, each 200 feet long, and 10 feet below ground at their lowest point (gradually ascending towards ground level) effectively act as a sound barrier, yet are of such a height and length so as not to appear threatening or enclosing. The actual area is wide and shallow; allowing for a sense of privacy and the sunlight from the memorial's southern exposure along with the grassy park surrounding and within it's wall contribute to the serenity of the area. Thus this memorial is for those who have died, and for us to remember them.

The memorial's origin is located approximately at the center of this site; it legs each extending 200 feet towards the Washington Monument and the Lincoln Memorial. The walls, contained on one side by the earth, are 10 feet below ground at their point of origin, gradually lessening in height, until they finally recede totally into the earth at their ends. The walls are to be made of a hard, polished black granite, with the names to be carved in a simple Trajan letter, 3/4 inch high, allowing nine inches in length for each name. The memorial's construction involves recontouring the area within the wall's boundaries so as to provide for an easily accessible descent, but as much of the site as possible should be left untouched (including trees). The area should be made into a park for all the public to enjoy.

Figure 10.3 Handwritten Concept Statement from Vietnam Memorial competition
Source: Library of Congress, courtesy Maya Lin Studio

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11 Logical-mathematical skills

Le Corbusier's Cartesian order and Greg Lynn's non-linear dynamics

Logical-mathematical skills involve the ability to use logical reasoning to solve everyday problems, requires one to make causal connections and to understand relationships among actions, objects, or ideas.[1] This involves the ability to calculate, quantify, or consider propositions and perform complex mathematical or logical operations. Designers use logical-mathematical skills to project man-made order on the natural world by breaking down the complexity of design into quantifiable logic. While the use of logical-mathematical skills in design as a mere problem-solving activity might be perceived as suppressing more creative and subjective facets of design, these skills are particularly valuable in an information-driven world as engineering and technology become more prevalent.

As applied to design, logical-mathematical skills may involve different types of rational reasoning. "Deductive logic" is the process of reasoning from the general to the specific, while "inductive logic" occurs from a set of specific observations to a general theory. The use of computational tools has also opened architecture up to the symbolic logic of computers, thereby increasing accuracy and standardization. In, this context logical-mathematical skills in design can be described in terms of three subskills: sensitivity to the use of number and geometry; the ability to produce variations of formal design strategies; and the ability to resolve functional and programming aspects of design.

Sensitivity to the use of numbers and geometry

Since architecture is the manifestation of design ideas in physical dimensions, numbers and measurements play an important role. They express the potential of geometry (e.g., the number of bays of a particular façade should have harmony) or the pragmatic abilities of dimensioning, area estimation, load calculations, and so on. At the pragmatic level, designers have used mathematical tools, such as set theory and interaction matrices, to achieve functional efficiency.[2] Dating back to Ancient Greece, the use of the Golden Section and other mathematical orders have been used by designers to achieve harmony and beauty in architecture.[3] Renaissance designers Filippo Brunelleschi and Andrea Palladio explored ratios and proportions in their works.[4] Centuries later, Antonio Gaudi used geometric structures throughout his buildings in the form of hyperbolic paraboloids, hyperboloids, helicoids, and so on.[5] Modernists viewed traditional architecture as disordered and irrational, so designers such as Le Corbusier used expressive geometry and grid lines to bring order to design.[6] The orthogonal lines of the De Stijl movement[7] and the shell structures of Buckminster Fuller both engaged formal geometry.[8] Eisenman's case study demonstrate the potential of design as a formal design exercise based on self-referential logical-mathematical rules.[9] The structural innovations of designers such as Renzo Peano, Norman Foster, and Santiago Calatrava are also ideal examples of how logical-mathematical skills can be used to extend the limits of architecture. More recently, designers such as Greg Lynn and Patrick Schumacher have taken advantage of technological advances to incorporate mathematical field theory, non-linear dynamics, calculus, and computer simulations to bridge the gap between building and form-making.[10]

Ability to produce variations of formal design strategies

Since there is no single correct solution in design, designers tend to produce varied and alternative solutions, from which the most satisfactory solution to a given problem could be chosen. The creation of alternatives requires analytical and divergent thinking usually guided by formal/visual logic. Such a formal logic is usually guided by a corpus of style, composition, and type.[11] The "style" is a visual code based on tectonic preference. The "composition" is the way in which parts or elements of an architectural whole are combined and typically include aspects of geometry, order, hierarchy, and proportion in the assembly of different components or elements of architecture. The "type" is a group of objects characterized by the same formal structure. Design typologies are used in architecture to introduce previously successful ideas to new situations. These proven types, which are known as "precedents," embody good design cases that can function as a heuristic device to solve design problems, assess programmatic fit, generate new ideas, and reinterpret the old. With the advancement of computing power, the large database capacity of computers, as well as rapid search and retrieve functions procedures, the traditional typological studies have led to a computing process called "case-based" reasoning. The ability to rapidly refer to design precedents have helped to undercut time and resources and optimize the design process.

The generation and analysis of formal strategies has been under much discussion in the area of shape grammar and languages of architectural form.[12] In the shape grammar method, a "shape is defined as an arrangement of lines, either in two or three dimensions. Shape rules are then applied recursively to the initial shapes to generate variations in design language. A shape grammar minimally consists of three shape rules: a start rule (which initiates the process), transformation rule (which directs the process), and a termination rule (which completes the process). Shape grammars have been applied to various designs that demonstrate consistent vocabulary such as the design of Palladio's villas or Mughal Gardens. In *The Logic of Architecture*, William Mitchell discusses shape grammar and their role in structuring design thinking.[13] He then explains how these critical languages can be transformed through graphics and computational medium. The computable implications of shape grammars are evident in parametric design in which constraints are applied to arrive at optimum design solutions. Generative and evolutionary algorithms have also been used by designers such as John Frazer to create forms that mimic biomorphic architecture. In *An Evolutionary Architecture*, he examines form-generating processes in architecture,[14] and proposes that architecture follows a DNA-like code-script through which it develops and evolves in response to the user and the environment.

Ability to resolve functional and programmatic aspects of design

As much as design can be considered artistic and creative, the ability to resolve programmatic aspects are critical in design – not only for optimal performance of function but also for ensuring life-safety. Today, functional issues are prominent in fields such as healthcare design, where many life-safety issues are integrally linked to function. Such problem-solving aspects of design was most pronounced in the "functionalist" movement of modernism. Being confronted with the technological advancement of the machine and industrial society, it was generally felt that the problems in architecture should be dealt with as the most urgent necessities of human life and a revision of conceptual issues based on increased efficiency. To abandon implicit decisions made by designers during traditional design processes, Alexander and Chermayeff propose explicit techniques such as the interaction matrix to assess how spaces are related to each other as well as using computer programs to solve them in a more objective way. Design created from a purely functional standpoint makes explicit the formal dimensions and spatial relationships using techniques, such as space planning, facility layout, and space allocation.[15] In *Problem Seeking*, William Peña observes that facility programming reduces the guesswork of designing for user needs and suggests seeking out before solving design problems.[16] Peña and Parshall outline a five-step procedure for problem-seeking, namely establish goals; collect, organize, and analyze facts; uncover and test programmatic concepts; determine the real needs; and state the problem. Each of the five steps considers the problems of form, function, economy, and time.[17]

Logical-mathematical skills of Le Corbusier and Lynn

To demonstrate how logical-mathematical skills are applied to design, I present two designers from different eras known for their prolific use of mathematics and geometry. As one of the figureheads of modern architecture, Le Corbusier organized his buildings using numbers and linear geometry. In contrast, Greg Lynn is considered one of today's pioneers of parametric design using non-linear geometry. While Le Corbusier's use of geometry reflects classical ideas and a Cartesian order, Lynn uses splines and blobs. Both use logical-mathematical skills, to create their unique sense of order.

For Le Corbusier, geometry represents the language of man.[18] Le Corbusier contended, however, that geometry and mathematical abstraction were the ultimate form of human expression; hence, his architecture reflects precise measurements and harmonic order. For instance, he created a universal proportioning system incorporating Cartesian grids in his most expansive projects, such as the Plan Voisin for the city of Paris, as well as his smaller projects, such as the Villa Savoye. In the heyday of modern architecture, he developed the "Modular," a proportional system that set architectural elements in relation to the human body for organizational and aesthetic purposes (Figure 11.1). The Modulor proportional system is based on a slightly exaggerated height of a person (1.83 m tall) with a raised hand (2.26 m). In between these two heights, Le Corbusier introduced a geometry of harmonious progression based on the Fibonacci series (adding two preceding numbers results in the third to form a series such as 1, 1, 2, 3, 5, 8, 13, etc.). However, since large gaps exist in the Fibonacci series, Le Corbusier introduced a third height corresponding to a person's naval (1.13 m). These sets of measurements result in two proportioning systems, one doubled from the other (red and blue series) and potentially scaled up or down.[19] The Modulor was hence Le Corbusier's way of introducing a universal sense of harmony and order to all architectural elements.

In his architectural expression, it was important for Le Corbusier to make mathematics both perceptible and legible. His explicit use of proportions is evident in the Carpenter Center for the Visual Arts, both in the larger organization of the building as well as in the little architectural details (Figure 11.1). The entire building was composed as "architectural acoustique" (the ability of the architecture to amplify sensory qualities of sound and vision).[20] In the Carpenter Center, the use of Modulor is evident at a large scale, initiated at the S-shaped ramp passing through the building (3.66 m wide and twice the height of Modulor Man).[21] The dimensioning of the ramp in Modular proportions along with its high visibility in the overall composition of the building leads to what Le Corbusier called the "promenade architecturale" (choreographing the user's pathway through the building).[22] This visual essay is heightened through the careful

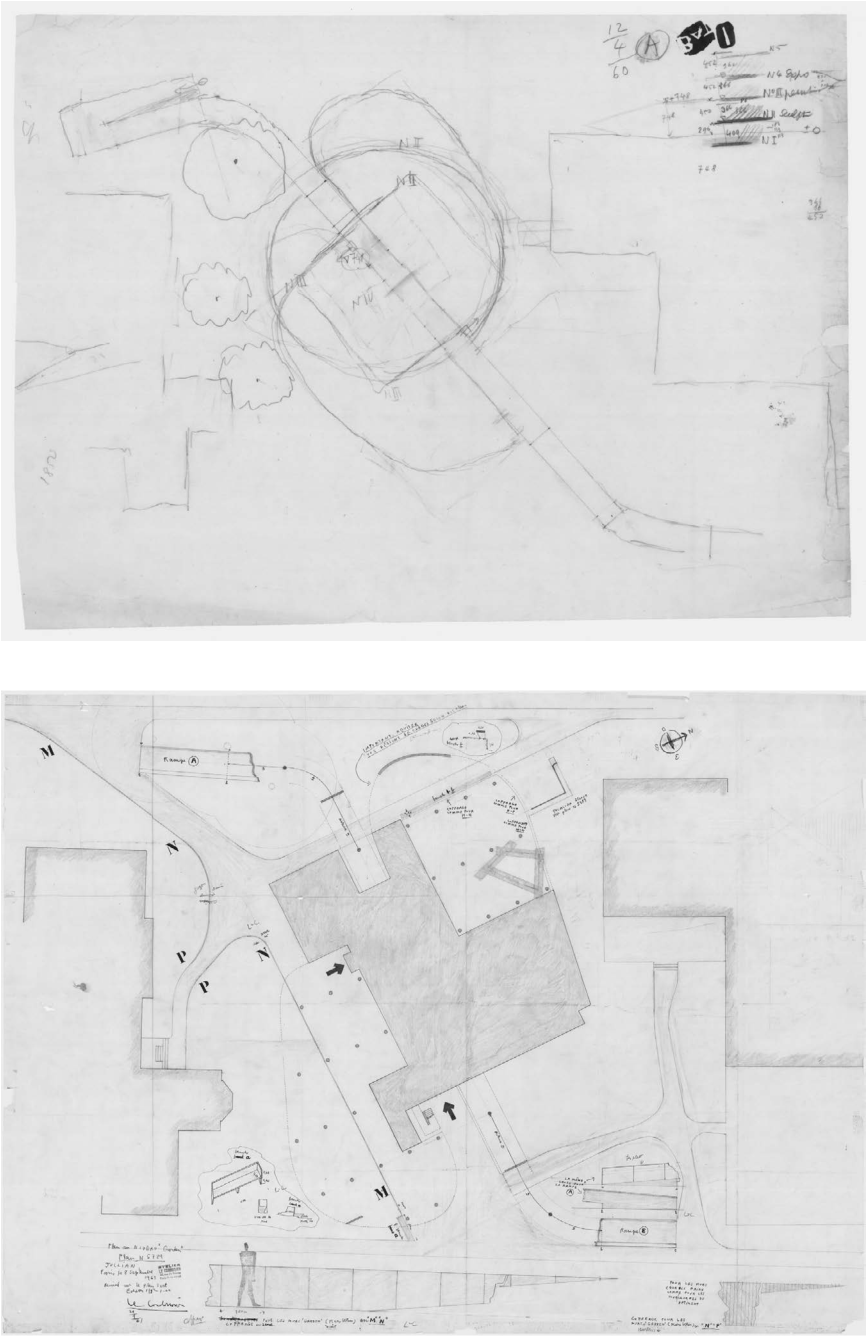


Figure 11.1a–b Le Corbusier's drawings for the Carpenter Center, Boston, demonstrating the use of logical-mathematical skills a (top): the dimensioning of the S-shaped ramp in Modulor proportions; b (bottom): Modulor system visible in the layout using along with a Cartesian grid; c: Modulor system used in Ondulatoires)

Source: The Fondation Le Corbusier

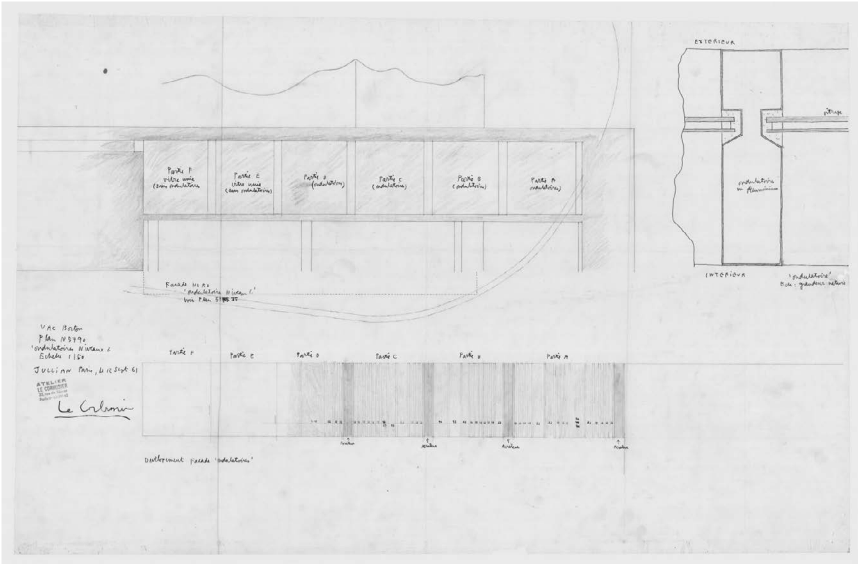


Figure 11.1c

proportioning of ramp grooves and spacing of the Pilotis (columns or piers that elevate the building from the ground level).[23]

The Modulor proportional system is also continued in the transverse bays, as well as the width and height of the Brise-soleil (sun breakers), with parallel fins spaced carefully in a continuous curve, and offset from the line of structural grid. The Modulor is also demonstrated in other apertures such as Pans de verre (panes of glass stretching from floor to ceiling), Ondulatoire (vertical undulating struts between fixed strips of glass), and Aerteur (solid pivoting doors to create open slots for ventilation).[24] The Ondulatoire, in particular, was created in collaboration with engineer and musician Lannis Xenakis and reflected Le Corbusier's interests in musical proportions and sculptural effects. Much like musical notes, the spacing of the Ondulatoire was expressed in harmonic proportions (the red and blue series of the Modulor) (Figure 11.1). The final composition is one in which the eye is pushed into rhythms that increase slowly and accelerate to a climax at the point of the maximum curvature of the Ondulatoire.[25]

The use of Modulor proportional system is also evident in the small details of the building. For instance, the grove for drainage and the width of the stair is 1.83 meters (height of the Modulor man); the distance from the bottom step to opposite wall is 2.26 meters (height of the upraised hand of the Modulor man); the railings are 1.18 meters (naval height of the Modulor man); and the parapet wall is 0.70 meters inside and 0.86 meters outside (seated position of the Modulor man).[26] The Modulor proportional system is even carried out in the shuttering lines of the concrete formwork patterns to imply a visual movement is in the horizontal direction.[27]

Aside from using the Modulor as a logical device, Le Corbusier's logical approach can be found in other aspects of the design process. His line sketches are usually accompanied by initial thoughts in writing. He typically uses crayon for later drawings, in which he explored the programmatic organization in tracing sheet overlays. Early in the design process, however, Le Corbusier has already thought about the structural grid and details of the facade, such as sun breakers and apertures. These are formalized using a set square, ruler, and sharp pencil to coordinate the structural grid and the plan organization. His final drawings lack any dimensioning other than the Modulor Man, which he believes makes his drawings architecturally purist and very readable. This type of drawing was to be distinct from the dry working drawings used by the contractors to actually build.[28]

Le Corbusier's use of a pure orthogonal grids and platonic forms was contrary to the radical experimentation of polygons by pre-war avant-gardes[29] and some Beaux-Arts academicians.[30] His disdain for the polygon suggests that he only finds architectural beauty in pure forms. However, Le Corbusier's ambitious proclamations about the purity of geometric forms is not without its critics. According to architectural historian Robin Evans, while the Modulor was an attempt to recover the rational basis for architecture, it also presents a dilemma, especially the difficulty of being both certain and free. Evans argues that Le Corbusier's use of mathematics in architecture was amateurish because he was more interested in the beauty of mathematics rather than embodying the sensibility of mathematicians.[31]

In today's context, however, the Cartesian order as described in the practice of modernist designers such as Le Corbusier has been replaced by another – that of "parametric design." The parametric paradigm is characterized by dislocation and a lack of strict adherence to the orthogonal grid. One of the principal proponents of this paradigm, Greg Lynn, uses nonlinear geometry to create architectural forms. Although he resists being branded a formalist, Lynn's calculus-based approach exemplifies the use of logical-mathematical skills in architecture in a different way than did Le Corbusier.[32] Lynn suggests that this new style of "smooth transformations" was borne out of the deconstructive movement (represented by angularity, disjunctions, conflict, and oppositions) and an inevitable reaction to modernist and post-modernist movement (which relied on classical composition, unity and order, and contextualism). Similiarly, architect and theorist Patrick Schumacher contends that much of the computational language used by parametric designers were introduced much later than the origins of the deconstructive movement. Such computational language, replacing traditional paper and pencil tools, enabled complex and non-orthogonal compositions of the deconstructive movement possible.[33]

Lynn suggests that the computer affords both a degree of discipline and freedom to the design process.[34] By strategically negotiating desirable levels of discipline and freedom, a designer can begin to cultivate creative ways of working with the mathematical logic of the computer. Making a distinction between computer tools from traditional tools, Lynn observes that tools such as drafting using adjustable triangles and compasses was based on simple algebra and made up of discrete points. In contrast, computer-based drawings use calculus and, instead of discrete points, are composed of a continuous stream of relative values.[35] Such continuous stream of data points induces the curvilinearity characteristic of parametric design, representing gradient forces of deformation and inflection. In his book *Animate Form*, Lynn observes that parametric design hence replaces traditional models of statics into a more dynamic organization.[36] Observing how other design fields had already embraced parametric language much before architectural field, Lynn observes that in naval design, for instance, space is instilled within the properties of flow, turbulence, viscosity, and drag so that the form of the hull can be conceived in motion through the water. Lynn observes that the topological surfaces induced by parametric design are not passive but store forces and energy.[37] Consequently, representations of architectural concepts of force, motion, and time have been transformed in parametric design into gradients, flexible envelopes, and temporal flows.[38]

Parametric design characterized by material smoothness and folding has generated a new context of architecture defined by "digital folds." The digital fold presents an alternative to and overcomes the rigidity of the Cartesian grid of modernism. Architect Peter Eisenman, a proponent of deconstructive architecture, observes that the concept of the fold dislocates the user by creating a dialectical distinction between the figure and the ground, which was traditionally celebrated in modernist design.[39] He acknowledges that, while the grid remains in place and the four walls stay intact, they are exceeded by the folding of space. There are no longer grid datum planes for the upright individual. According to Eisenman, in such a paradigm, the user is no longer required to understand or interpret space; in fact, the meaning of space characteristic of post-modernist architecture is no longer relevant. Additionally, two-dimensional drawings have divorced themselves from the three-dimensional reality because architectural experiences in parametric paradigm are no longer determined by the designer.[40]

Consequently, in parametric design, the craft of architecture has shifted from modernist focus on the design of an "object" to incorporating the "field." According to architect Stan Allen, today's field conditions involve a state of invisible tension created by a system of physical spatial markers (e.g., buildings, topography, etc.) within a given site or well beyond.[41] He believes that while traditional perceptions of space were based upon fixed and static geometries, contemporary culture can better grasp the complexity of the fluid, drifting, and self-organizing spatial systems as they exist in nature (such as flocks, swarms herds, or as defined social sciences, such as crowds or mobs).[42] Field conditions hence move from the one to the many, from individuals to collectives, and imply acceptance of the real in all its messiness and unpredictability.

As parametric design imbues the designed object with dynamic geometry and data, the resulting surfaces are referred to as "topological." Examples of such topological surfaces include isomorphic polysurfaces (or blobs), skeletons (or inverse kinematic networks), warps, forces, and particles. Among topological surfaces, two elements of parametric design have been critical to Lynn's early works: the spline and the blob. In the simplest terms, a "spline" is a parametric curve, and a "blob" is an amorphous shape made possible by today's digital tools (Figure 11.2).[43] Lynn observes that spline entities are intensively influenced by their context due to the fact that they are defined by hanging weights, gravity, and force. For example, the weights and directions pulling on control vertices in space can be affected by gradients of attractive or repulsive forces in which the spline is situated. Similarly, the weights of the spline surface can affect those of another spline surface. These structures form blobs as they mutually inflect one another and create composite assemblage. A blob is defined with a center, a surface area, a mass relative to other objects, and a field of influence. The field of influence defines a relational zone within which the blob will fuse with or be inflected by other blobs. These blob

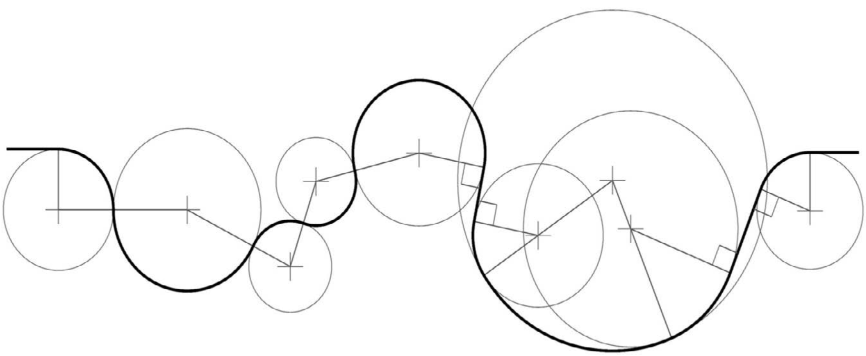
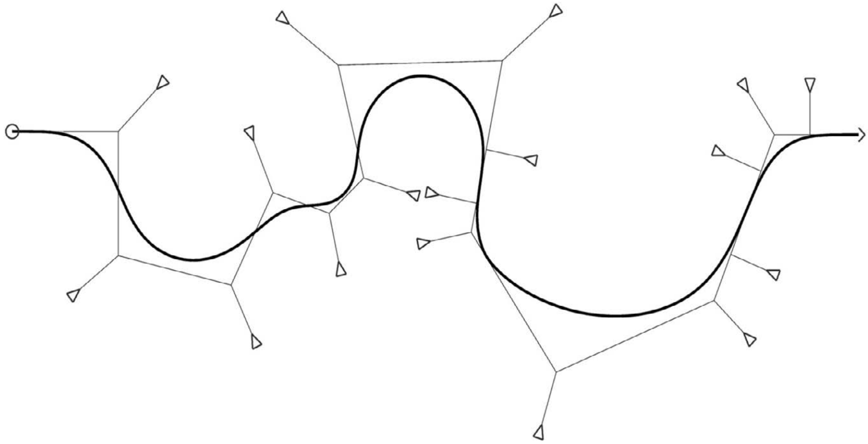
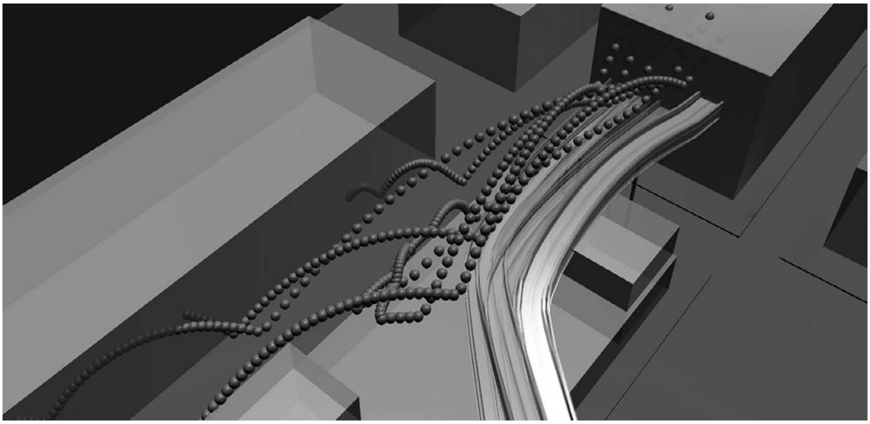


Figure 11.2a Greg Lynn's drawings demonstrating the use of logical-mathematical skills (a: example of a composite curve defined by a fixed radius; b (top): example of a composite curve using spline geometry in which radii are replaced by control vertices with weights and handles through which the curved spline flows; c (middle and bottom): the demonstration of spline curve at the Yokohama Port's center terminal showing smooth and continuous movement to organize the project programmatically, contextually, and spatially)

Source: Greg Lynn Form





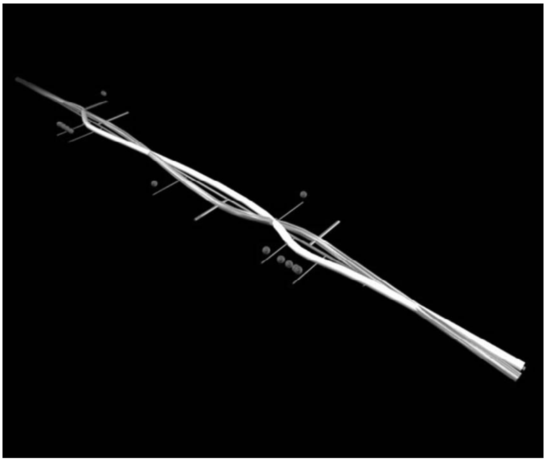


Figure 11.2b–c

assemblages are neither multiple nor single, neither internally contradictory nor unified. Their complexity involves the fusion of multiple elements into a single assembly.[44]

The use of this new mathematical approach to design is illustrated in one of Lynn's earliest use of parametric deign – his winning competition entry for the Yokohama International Port Terminal (Figure 11.2). This was one of the first architectural projects that relied on animation software for form generation. Using Wavefront Software, Lynn modeled a series of forces representing traffic and pedestrian flow. Points, or particles, rendered as spheres were then modeled with velocity, and their changing paths served as an index of site forces.[45] Lynn explains that the project was designed to capture the complex movement and interchange between passengers and citizens, between land and sea, between city and garden, and between vehicles and cargo. The emphasis on smooth and continuous movement organizes the project programmatically, contextually, and spatially.[46] In this respect, the project celebrates the experience of fluid and uninterrupted streams of movement.

In the terminal project, spline geometry is demonstrated freely. Two tubes were threaded through one another based on the docking patterns of the ships. Through the empty center of each tube the surface of the opposite tube emerges, knitting the public and transportation systems as two intersecting, alternating volumes that become surfaces. The red points locate the docking points of the boats using the terminal. Splines run through each of these points. The splines are drawn at seven degrees so that each location along the spline is determined by the adjacent seven points in the network and its proximity to each of those points. Mirrored from that spline is a second public spline that occupies the open areas of the site by alternating its trajectory opposite of the terminal programs. This spline is smoother, or less inflected, because it is a three-degree spline with at fewer adjacent points, which determine its curvilinear shape (Figure 11.2).[47]

The garden and the port terminal are each conceived as a continuous transformation from interior volumes to outdoor surfaces. These two passages, according to Lynn, complement one another along the length of the site as they move through each other in opposite directions. As these passages pass through one another, their interiors and exteriors intermingle. Thus, rather than moving along any one of these surfaces, the visitor is always moving through and between the two kinds of spaces.[48] These elements, which begin as surfaces and become interior tubes, are skinned in three materials: the terminal tube is clad in lead coated stainless steel and has the greatest interior volume; the citizen's tube is enclosed with a lightweight tent structure that filters natural light and allows for more transparent connection and a view of the water; and the garden made up of moss and stone.[49]

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12 The metaphor of an ensemble

Theoretical, practical, and pedagogical implications of multiple skills

Designers and skill affiliations

Using the multiple intelligences framework as a broad template, the prior chapters explored archival resources and documentation of practicing designers to describe the value of multiple skills in design.[1] As outlined in the multiple intelligences framework, the design examples demonstrate that not only do individuals possess numerous mental representations and intellectual languages, but individuals also differ from one another in the forms of these representations, their relative strengths, and the ways in which these representations can be changed. In this sense, multiple skills can be understood in terms of Marvin Minsky's conception of the mind as "a society," like members of a family, our different minds can work together in order to help one another, with each of us retaining our own mental experiences that the others know nothing about.[2] The power of intelligence, Minsky observes, stems from our vast diversity.

The diversity of representations is evident in the sheer breadth of design approaches. Libeskind and Zumthor demonstrate interpersonal skills through their relentless pursuit of purpose and meaning in design, exploration of metaphor and analogy, and the self-awareness of personal knowledge that they bring to bear on design. Suprapersonal skills are used by Kahn and Hadid to convey emotions that transcend the material and the personal. Their suprapersonal skills are further demonstrated in their ability to incorporate a sense of wholeness and engage in intense cognitive imagery at an abstract level. Holl and Hertzberger both rely on kinesthetic skills; while Holl evokes the idea of kinesthetics in terms of space and movement with his concept of the parallax, Hertzberger's design process involves thinking about users and their social performance. Naturalistic skills are evident in both the work of Bawa and Cornelius, with the former establishing a scenographic approach to design and the latter using a narrative approach to indigenous landscape. Wright and Ando demonstrate spatial skills, and Ando's tactile sensitivity and the ability to think in complex topography. Verbal/linguistic skills are demonstrated in the works of Tschumi and Lin. While Tschumi's verbal skills can be identified by his use of literary text in design projects and his ability to deconstruct macro-narratives, Lin is influenced by prose and poetry in the literal sense with her architectural projects conceived in writing. Finally, logical-mathematical skills are demonstrated in the designers from two different eras: Le Corbusier and Lynn. Le Corbusier used number and linear geometry to organize his buildings, while Lynn uses non-linear geometry to create his design projects.

These skills can be further mapped in a matrix that demonstrates their diversity (Table 12.1).

These skills can also be organized around common themes based on their respective functions. The "affective skills" correspond to subjective and creative responses to design and rely on personal passions and instincts. Affective skills can be intrapersonal (involving personal emotions), interpersonal (involving empathy for others), and suprapersonal (transcendental experiences).

The "corporeal skills" correspond to bodily experience in relation to the world. They can be bodily-kinesthetic (visualizing or experiencing the movement of body in relation to the external environment) and naturalistic (visualizing and experiencing nature and natural phenomenon).

The "depictive skills" involve the visual and representative aspects of design and correspond to the function of design skills that are both the medium and the message. Depictive skills consist of spatial skills (involving the ability to perform transformations and modifications upon one's own perceptions via mental imagery) and verbal/linguistic skills (involving the ability to use language effectively or expressively to articulatedesign ideas).

Table 12.1 Comparative matrix of designers, skill affiliations, and related themes

Designers	*Skill affiliations*	*Themes*
Daniel Libeskind	Intrapersonal	Affective
Peter Zumthor		
Alezandro Aravena	Interpersonal	
University-based Design Centers		
Louis Kahn	Suprapersonal	
Zaha Hadid		
Stephen Holl	Bodily-kinesthetic	Corporeal
Herman Hertzberger		
Geoffrey Bawa	Naturalistic	
Chris Cornelius		
Frank Lloyd Wright	Spatial	Depictive
Tadao Ando		
Bernard Tschumi	Linguistic/Verbal	
Maya Lin		
Le Corbusier	Logical-Mathematical	Analytical
Greg Lynn		

Finally "analytical skills," are represented by a rational approach to design including logical-mathematical skills (rational and systematic approach to design).

That many remarkable and versatile designers encompass multiple skills but could not be accommodated in the scope of this book as they did not show a strong preference or bias toward a specific skill application. Nonetheless, taken together, their prolific integrative abilities have made them successful. These include designers such as Bjarke Ingels, Renzo Peano, Norman Foster, Kisho Kurokawa, Moshe Safdie, B.V. Doshi, and Charles Correa. As I discuss later in this chapter, beyond merely possessing these skills the conceptual blending of different skills seems to be one of the major traits of successful designers.

Some design researchers such as Cross have proposed that architectural design should be regarded as a unique form of skill, separate from scientific or scholarly thinking styles but just as powerful.[3] Cross argues that design should be included among the multiple skills discussed in this book and hence are unique from other skills. While there is merit in such a view, it reduces design to an autonomous self-referential field, devoid of all the richness of an interdisciplinary profession. Hence, one could argue that the uniqueness of design rests in it being both a well-defined field with its own core but also influenced by and operating under the rules of other disciplines. My own study conducted on the relationship between design and other disciplines suggests that the design discipline is to an extent interdisciplinary (as designers show proficiency in multiple skills) but also consists of enough rigor in two skills (namely spatial and intrapersonal skills) that might suggest the makings of a well-defined discipline.[4]

Given such an argument, design skills should be considered both as general competencies and specialized skillsets through which designers choose to frame and deal with the complexities of the design world. The skills are a window into the intentionality of where designers might invest their resources while they embark on design and to acknowledge and be aware that multiple mental capacities exist in the realm of a designer. They are specific ways in which they explore and know the world.

While the book has presented illustrative examples for each skill, it might be idealistic to expect a designer to master all of the skills mentioned at a high level of competency. The mapping of skills into a comparable matrix, however, demonstrates the diversity of design skills used by designers and speaks to the validity of each skill in its own right – keeping in mind that this is an exercise in demonstrating a designers' affiliation to specific skills rather than pigeon-holding them within specific categories. Furthermore, it would unfair to compare designers across different skillsets, let alone in the similar categories of skills, because the context in which designers function is quite different. As Gardner observes, one person's generalization is another person's exception. Depending on how one defines a term or carves out a category, one can either collapse individuals together or cleave them apart.[5]

Given such complexity in skill applications, several "so what" questions emerge. If a designer has limited skills, should he broaden his repertoire of skills? Or if a designer applies multiple skills should broadly, should she focus more on specific skills? While these questions are vital, they may not apply to all cases. For example, a designer may possess limited skills and yet use those skills rigorously and effectively, while another designer might be able to compensate for scarce abilities in one area by increasing his competency in another. In other words, how designers know and frame their design world is key to understanding what skills they choose to apply. One way to examine this frame is to step back from tactical application of skills and question their underlying characteristics. Why do designers use the skills that they do, and how do they know what they know? These questions are best addressed through a philosophy of knowledge called epistemology.

Design skills and their epistemologies

Unlike purely theoretical disciplines, architectural design is an instrumental profession, one that usually results in a tangible material end-product. One of the mandates for designers is not only to visualize the future in which their building is built but also to conceptualize complex ideas in order to respond and create concrete products in which people live. The transformation of very abstract ideas to concrete products are made possible by the "designers gaze," a specific lens through which designers choose to work and one that is a unique way of paying attention to specific information.[6] No two designers go through the same mental states, even when working on the same design task, and the design gaze is uniquely defined by the designer's personal experience and memories.[7]

Along these lines, for some, design might be conceived as an objective product expressed with all its tangible materiality, and for others design might be a subjective manifestation of their personal aesthetic expression. For few others, design might be a spiritual and transcendental exercise devoid of any material, although material is ultimately needed to make the product possible. These different philosophical perspectives, or "epistemologies," are presented here in terms of objective, subjective, and transcendental worldviews as a useful guide to understand skill affiliations.[8] Epistemologies tend to describe the true nature of knowledge within our design worlds and the many approaches designers choose to solve and create their designs. They are essentially philosophical lenses through which design skills are applied and an insight into why they think the way they think.[9]

When we map the various skills through these three epistemological axes (Figure 12.1), we get a sense of the general affiliations for these skills. One axis can be representative of the objective epistemology in which a designer believes that things exist independent of consciousness or experience. In this epistemology, design is seen as a physical object existing in the world and a universal product that is experienced by everyone in a similar way. Another axis can be representative of a subjective epistemology in which a designer believes that the design is a personal statement that is created and experienced through individual perception. In this epistemology, design is seen as a subjective interpretation that exists in one's own mind. The third epistemology is transcendental in which design has no material existence and hence only experienced. While objectivism conceives design as a universal material product, subjectivism conceives design as a subjective material product, and transcendentalism conceives design as immaterial and ethereal. In summary, for objective designers design occurs in the material world, for subjective designers design occurs within our minds, and for transcendental designers design escapes any subjective or objective perception.

From the Figure 12.1, one can observe that the strongest skill affiliated with objective epistemology is logical-mathematical skill. Since logical-mathematical skill is universal in its disposition, it is located high on the objective axis, and because it has elements of abstraction involved, it is also affiliated with the transcendental axis, albeit lower. Similarly, the strongest skill affiliated with subjective worldview is intrapersonal skill and because of its spiritual nature can reside on the transcendental axis, albeit lower. Finally, the strongest skills affiliated with the transcendental epistemology are suprapersonal and spatial skills, the former residing lower on the subjective axis and the latter residing lower on the objective axis.

Among the remaining skills, the linguistic/verbal and naturalistic skills can be located toward the apex of the three axes since they are not strongly affiliated to any one in particular. Since the existence of a tangible structure, linguistic/ verbal skills can be loosely affiliated with the objective worldview, and lower on the subjective axis. Similarly, naturalistic skills can be loosely affiliated with transcendental skills, and lower on the objective axis. The final two skills can be mapped on a central location because

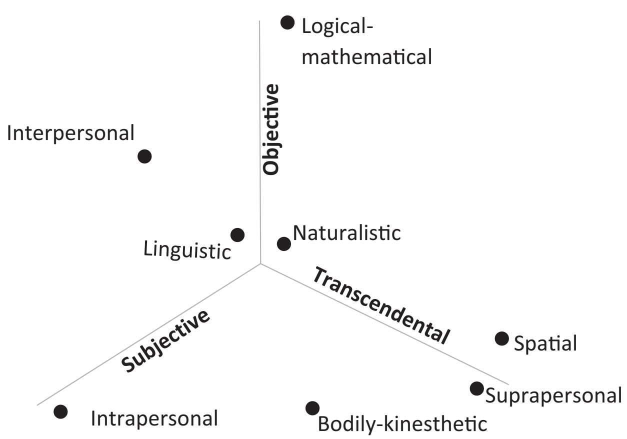

Figure 12.1 Design skills and their epistemologies

they seem to be affiliated equally to more than one epistemology. For example, bodily-kinesthetic skills can be located centrally between the subjective and transcendental axes, while interpersonal skills can be located between the subjective and objective axes. The epistemological mapping of skills, hence, provides us underlying insights into why designers might choose a specific skill.

Domain-Individual-Field Interaction in design skill application

Aside these underlying epistemologies, the application of design skills is also a product of discourse in which the designer is operating, one in which there exists an implied interaction between individual abilities and the cultural setting. Since the process and products of architecture are to an extent culturally and context specific, an interaction model that includes individual abilities and specificity of a design task is useful. As shown in Figure 12.2, a three-way interaction model has been elaborated in studies of creativity, known as the "Domain-Individual-Field Interaction" (DIFI) model.[10] The DIFI model was originally proposed to understand creativity as a social construct and is thereby useful to examine design skills embedded in a given context.[11]

The "domain" refers to the specific organized body of knowledge within which the individual operates. The use of a particular skill may depend on the perception of the individual in regard to the domain in which they operate. In design, what constitutes this body of knowledge is influenced by history, cultural, and contextual values and how a designer defines his/her role within it. For example, if a designer were to be given a commission for a museum design, the domain (which is the organized body of knowledge) might consist of precedents that focus on visual/formal museum typologies or museum standards that a designer would choose to follow. Hence, the domain of designers working in different cultures might have a very different composition. "Individual" refers to the specific personality characteristics of individuals and is dependent on skills (the major subject of this book), preferences, biases, and idiosyncrasies. For instance, the individual skills required for the design of a museum may be dependent on individual designer biases, such as a focus on spatial choreography or sensitivity to movement/light, etc. Finally, the "field" refers to the social aspects of the domain and profession, including how their work is defined by the gatekeepers within the profession. For example, the field could consist of prevalent ideas put forth by the gatekeepers of the field who are relatively well known for museum design (e.g., Calatrava). The important implication of this interaction model is that the use of design skills in a given context does not depend on individual skills alone. It depends just as much on how well-suited respective domains and fields are to the recognition and diffusion of their individual skills.

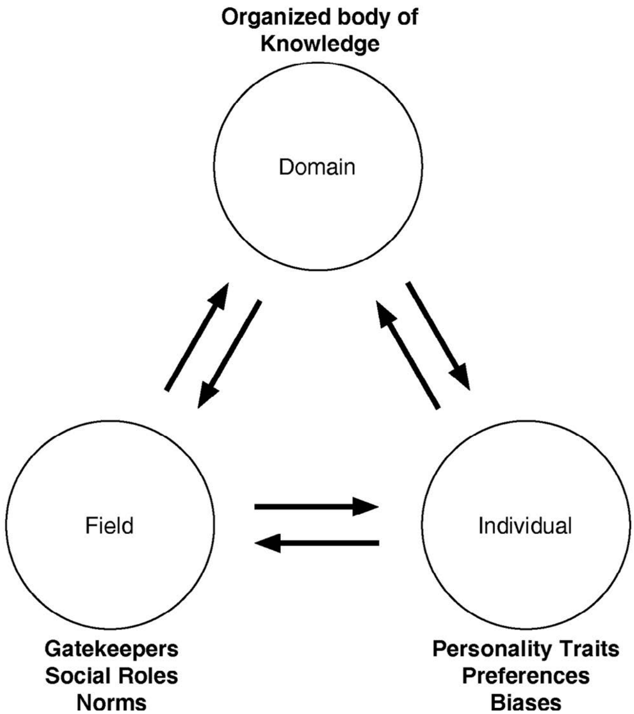

Figure 12.2 Domain-Individual-Field Interaction model[12]

Reciprocal priority of skill usage

While at a strategic level one can appreciate the origins of design skills through their epistemological lenses and the Domain-Individual-Field Interaction at a tactical level, the application of skills requires further improvisation based on specific design context. The design context might consist of site-specific features, client needs, building type, and budget, among others. For example, in one of our prior studies examining the use of multiple skills among student designers, we observed shifts in skill usage with different building types.[13] A designer confronted with a row-house project chose to use logical-mathematical skill by using a geometrically precise module. However, when presented with a different building typology, that of a museum project, she brought her own personal experiences to bear, at which point her intrapersonal skills came into play. Thus, a skill can be reciprocal to another based on the specific building type. Given that design problems are predominantly context specific, situational issues partly determine which skills are valuable and which are not.

Furthermore, the usage of skills might also change through the duration of a single design process. For example, my prior study on student designers showed that proficient designers are able to improvise within their multiple skillsets.[14] Building on the row-house design project example, we observed that the designer used a variety of different skills within the scope of a single design process. In the beginning stages of the design process, the designer explored sculptural qualities of the row-housing units in terms of proportion and hierarchy, with most of her focus on spatial skills. In the latter half of the project, she shifted her focus to precise measurements and clarity of functional zoning, so logical skills came into play. Later, she focused on addressing psychological factors, such as work and home, community, and privacy – which derived from inter- and intrapersonal thinking. That such an evolution can sometimes takes place suggests that it is not necessarily a specific skill or the number of skills that the designer possesses that leads to an effective solution but rather how those skills are blended when addressing a specific design problem.

Such an ability to shift tactically in terms of which skills are applied in a given design context can be explained through the concept of reciprocal priority.[15] "Reciprocal priority" is a term used in pluralistic philosophy to describe how multiple worldviews can (and do) exist simultaneously and that they can be reciprocally prior to each other based on the particular context. In other words, there is no one worldview that may be true or right. When design skills are considered in terms of reciprocal priority, it makes room for creativity and flexibility in action, as different priorities of skills could lead to different design products. This means that one could be proficient with diverse skills and yet find modes of translations between them.

Conceptual blending of skills

While reciprocal priority alludes to the interchangeable usage of design skills, the nature of design also allows skills to be applied concurrently. For example, an architectural task such as building a massing model requires a combination of both spatial imagination and logical reasoning, although one may be reciprocal to the other. Critics of Gardener's multiple intelligences framework point out that the existence of autonomous skills without overlaps is riddled with problems.[16] By considering a skill to be autonomous, one is assuming that the skill does not share resources with other skills. According to Klein, even a task as mundane as parking a car requires both intended acts and intended objects (e.g., spatial and logical skills must concurrently demonstrated). This is no more relevant than in the domain of design, where a variety of intended acts, such as logic, visualization, and drawing, are used to create a variety of intended objects, such as form, space, and graphics, among others. Action and object creation merge with architectural tasks, which makes it difficult to distinguish the skills, medium, and styles of designing.

Another reason for the overlap between design skills can be found in the very nature of the architectural design process. Designers think at various scales of analyses (macro to micro), various level of cognitive representations (physical to spatial) and at varied degrees of abstractions (abstract to concrete). Designers must constantly reconcile between conflicting aesthetic judgments (heavy and light, dark and bright), functional conflicts (work and live, movement and static), and conflicts in psychosocial interventions (community and privacy, safety and freedom). Different skills thus emerge simultaneously in the design process, so the conceptual blending of intelligences is a more plausible explanation than the autonomy of intelligences in architectural design process.

In the area of cognitive neuroscience, Fauconnier and Turner have defined "conceptual blending" as a general cognitive operation on a par with analogy, recursion, mental modeling, conceptual categorization, and framing.[17] They suggest that elements and vital relations from diverse scenarios are "blended" in a subconscious process, which is assumed to be ubiquitous in everyday thought and language. Insights obtained from this blending process constitute the products of creative thinking. It is not surprising that experts are said to be much more fluid in their design thinking than novices, especially when it comes to blending of ideas.[18] Conceptual blending therefore becomes a useful meta skill that distinguishes proficient students from non-proficient ones, just as design experts are seemingly more competent in conceptual blending than novices.[19]

The metaphor of an ensemble

The tactical usage of skills in terms of reciprocal priority and conceptual blending affords individual design skills to blend and flow in a spontaneous and situated manner. This phenomenon could be best described using the metaphor of the ensemble, specifically a jazz ensemble. Typically, a jazz ensemble consists of wind instruments (saxophones, trumpets), string instruments (electric guitar, piano, organ), bass instruments (electric bass guitar, double bass), and percussion (Figure 12.3). Creative musicians find a way to converge these various instruments through different modes of improvisation. Most importantly, unlike other types of musical ensembles, improvisation in jazz occurs through a spontaneous "call and varied response," which is a form of interaction between the musicians as they take turns assuming the lead while the other musicians respond. An instrument can have a reciprocal priority over the other, and the music is situational rather than having a well-defined, pre-determined structure. Not to say that the music produced by a jazz ensemble is without structure but that the structure is kept deliberately ambiguous so that spontaneous creative situations might occur.

As shown in Figure 12.3, just as an instrument such as a violin can be in the lead in a particular situation, so can a skill such as naturalistic skills be used when the design situation so warrants. This alleviates any hierarchy

DRUM	TROMBONE	CORONET	SAXOPHONE	CLARINET	**VIOLIN**	BASS	TUBA	**MULTIPLE JAZZ INSTRUMENTS**
INTRAPERSONAL	INTERPERSONAL	SUPRAPERSONAL	KINESTHETIC	**NATURALISTIC**	SPATIAL	VERBAL	LOGICAL	**MULTIPLE DESIGN SKILLS**

Figure 12.3 Top: jazz ensemble (Credit: Asha Kutty); bottom: the metaphor of design skills as an ensemble

within the instruments and allows for creative improvisation. The jazz ensemble metaphor demands that no instrument can be assigned an absolute value; it helps us understand that it is not necessarily a specific skill or the number of skills the designer that makes an effective solution but rather how the skills are applied in response to a specific design problem. The metaphor suggests that designs skills can be combined in meaningful ways to allow for unique and creative design products.

Implications for design practice

The current design profession is increasingly moving away from solo design to more collaborative efforts. Collaborative practices are upending the existing power structures by requiring that design control be relinquished to design teams and the lay public. As Sanders and Stappers predict, design practice will become synonymous with design research, creating new landscapes of opportunity.[20] In such practices, the traditional consultative model where a designer completes most of his in isolation and then outsources it for specialized consultants is becoming obsolete. Loukissas illustrates how new identities can arise around technologies such as design simulations that bring together experimental, observational, and mathematical evidence to create believable predictions. The "techie-enabled" architect will rely increasingly on emerging technologies. Already in the current era, the field of robotics is changing the role of designer yet again by altering how architecture is manufactured and made.[21]

In this changing context, the multiple skill framework affords a way for design firm leaders and team to assemble appropriate teams. Practitioners use a high degree of interpersonal skills in the form of client interaction, as well as associated skills to fit into the process of the larger community of practice. Subsequently, recognizing multiple skills in practice allows design professionals to value and nurture diversity in design thought, empathize with the variations of individual strengths, and implement diverse tools to evaluate different areas of design thinking. Communicating to resolve individual differences at an appropriate level and capacity could be a very useful tool by which strengths and weaknesses of a designer could be identified and become useful to the practice experience.

In practice, design ideas may not be clearly communicated, and there might be a lack of awareness/unwillingness to understand individual differences. Multidisciplinary participation has become inevitable given the complex nature of the technology and global arena in which organizations function.[22] Hence, communication is necessary not only to disseminate ideas to professional colleagues but also to the lay public. Today, classical roles of users, researchers, and designers in the design process merge in the co-designing process.[23]

In the co-design process, the user is considered "the expert of his/her own experience" and therefore plays a large role in knowledge development, idea generation, and concept development. The designer takes on the role of the facilitator who actively leads, guides, and provides scaffolding that requires empathy. Understanding the user and his/her experiences is a central element in the co-design processes. In an increasingly globalized design world, the co-design process also involves cross-culturally involves collaboration between countries and cultures. Designing with co-creation along with user understanding and user experiences are central elements in this design processes.

The multiple skills framework also assuages some of the debate within practice over whether designers should be generalists or specialists. In his book on reflective practitioner, Donald Schön argues that people sometimes yearn for the general medical practitioner of the early days, one who is able to treat the whole patient as opposed to the contemporary specialist who treats particular illnesses in isolation.[24] Along these lines, David Allison, who serves as the head of the healthcare design major at Clemson University, has proposed that specialist areas in design such as healthcare should strive to be generalist-specialists.[25] A designer needs to lead and coordinate, see the big picture, and do things more generally. At the same time, if a designer wants to be successful in his/her practice, s/he must avoid becoming a "Jack of all trades, master of none." Designers need to specialize in a certain domain – allowing enough time and growth devoted to a specific area to build their brand and craft – without also stretching themselves too thin.

Implications for design pedagogy

Practical considerations aside, the role of multiple skills in pedagogy cannot be understated. In a previous exploratory study (Figure 12.4), design students scored an average of 68% for spatial skills and 50% for musical skills.[26] Of course, to some extent this was expected, given that the architectural domain uses spatial reasoning extensively. However, the small margin of difference between spatial skills and musical skills (only 18 percentage points) shows that architectural students use several different skills, rather than specializing in one or two skills. Moreover, when comparisons were made with other domains (using studies conducted by Shearer),[27] architectural design students were placed at the center of these groups, suggesting that their scores were neither significantly higher nor lower compared with other domains (Figure 12.4). In other words, architectural students were placed a well-balanced range, indicating the use of several mental representations. However, they also outperformed other groups in two specific intelligences: spatial and intrapersonal. Even when the study was conducted within an educational setting and a small sample size, the results suggests that although architects need multiple skills on one hand, they also possess enough rigor in two skills that need to be given relatively more attention.

The multiple skills framework is useful for recognizing individual strengths and differences that students possess so instructors can develop better strategies to intervene on their behalf. In one of our prior studies, which involved an examination of design review conversation between students and instructors, we found that consistency and endurance in skill application were more vital to a successful design process than the frequency and duration of the skill application. We also showed that skills diversity was critical to success and that the alignment of student skillset

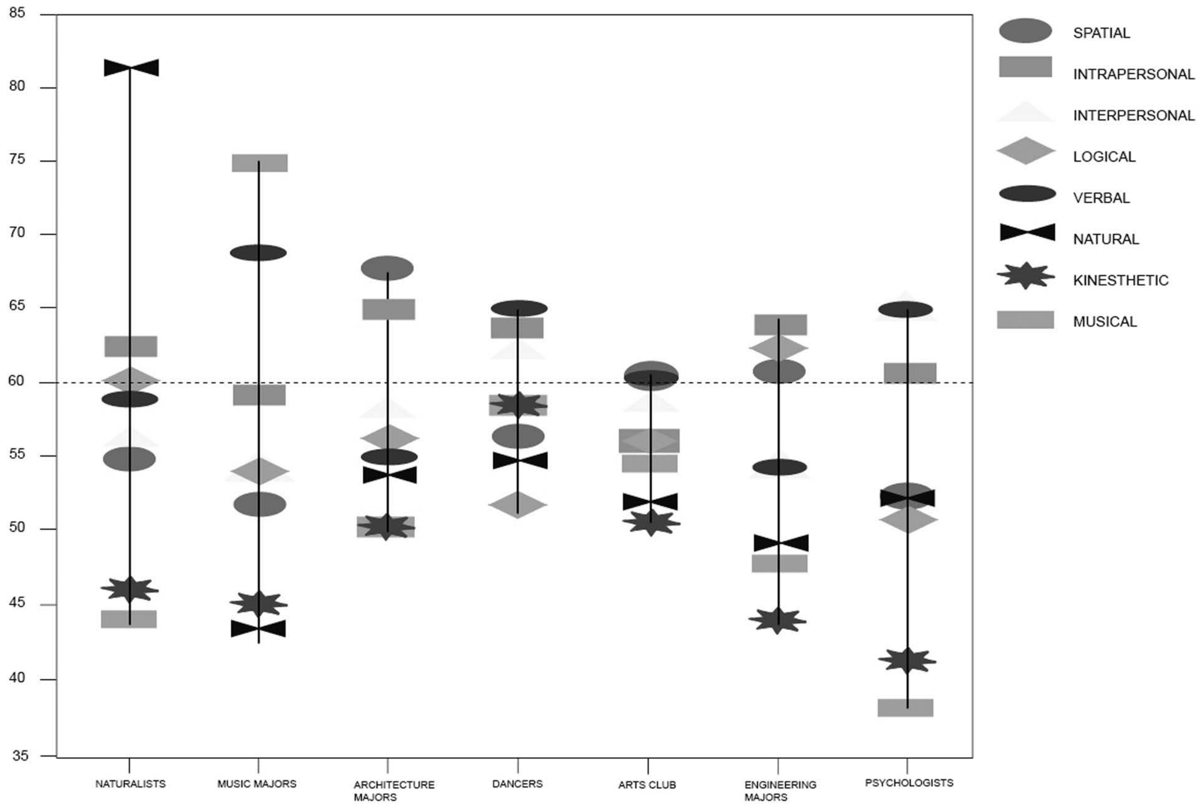

Figure 12.4 Skills of designers compared to other disciplines

with instructor and client skillset was critical.[28] If a student works with a specific skillset but is not able to make the appropriate convergence, it indicates that the student needs appropriate opportunities to synthesize. Consequently, the student might benefit from design problems that allow maximum constraints. For example, if a student is convergent to the point of using reductive ideas, the instructor might devise more open-ended problems. A better understanding of multiple skills also improves communication between students and their instructors.

Another study of mine points to the various ways in which students process multiple skills.[29] Accordingly, three types of design students emerged: the broad and rigid designers; the narrow and rigid designers; and the broad and adaptive designers. The "broad and rigid" design students were versatile and maneuvered through most of the skills across different projects but did not sustain a consistent level of intensity on any one skill. The "narrow and rigid" design students demonstrated an application of intelligence. Finally, the "broad and adaptive" design students frequently changed strategies and adapted with the nature of different design projects. They were relatively more successful academically. In conclusion, merely possessing multiple skills in design is not enough. To be successful, designers must meaningfully blend these skills to be successful but endure in their application of specific skills. Successful design solutions thus require a judicious usage of these skills to specific design situations. When students' perceptions of their own skills were compared to instructors' scores, the general trajectory of scores for these two ratings remained consistent (i.e., the top students scored higher than their colleagues in both ratings). This finding reveals that multiple skills were able to predict academic success to some extent. However, no single skill predicted studio success, although successful students fared relatively well in interpersonal skills. This finding perhaps indicates that instructors place a high value on the communication skills of designers within their evaluations.

Reinforcing skill diversity in design studios

If multiple skills are used as an explicit pedagogical tool in design, one may need to re-examine some components of the current studio model. The architectural studio in North America is built on an apprenticeship philosophy in which the learning of multiple skills is to a large extent based on the pedagogical focus of the instructors or ethos of specific design schools.

As architectural education, by nature and tradition, holds vast potential as a model for the integration in the discipline,[30] the realization of convergences in the form of integrated learning in the current studio system has much potential and needs to be incorporated much more consciously in the strategic design of the curriculum, specifically in how studios are sequenced and design problems are devised. Having multiple skillsets is not necessarily an advantage in producing successful architecture students, but it allows students from disadvantaged cultural background or those lacking specific skills to embrace alternative modes of thinking.

Most architecture schools are structured in a way that does not provide many opportunities for the conceptual blending of skills until late in the program. Generally, the focus of the first two semesters is on the fundamentals of architecture. Design learning is facilitated using formal exercises of lines, planes, and volumes. The succeeding studies teach basic architectural design, where program and pragmatic issues are brought to bear. These studios usually present real-world problems, such as designs for a museum, a library, and so on. The final sequence of courses typically allows for advanced architectural design, either in the form of specialized studios (which explore materiality, architectural details, particular building typology, and so on) or comprehensive studios where the students develop a broader worldview (cosmology, phenomenology, cultural landscapes, and so on). It is only at this stage that students are given a true opportunity for the conceptual blending of skills.

Assuming that design learning occurs cumulatively and design synthesis occurs sequentially as one moves through the different studio levels, the initial years of design school education is often stripped of all real-world complexity. While there is some benefit to this approach, it assumes that complexity of design problems can be dealt sequentially. This assumption leads to training in the beginning level studios to be limited to largely formal and compositional aspects hence, students may regard architectural complexity as something external rather than an integral part of the design problem. One of the advantages of incorporating multiple skills in the studio learning is it removes the overt emphasis on limited skillsets that are explicitly taught in design education, such as formal logic, and brings attention to more tacit skillsets such as communication, interpersonal skills, and situational problem-solving skills.[31] The challenge is then to devise design problems that afford the appropriate degree of complexity at each studio level that incorporate multiple skills and ultimately develop well-rounded students.

Another way to facilitate conceptual blending is to alternate students between specialized studios and comprehensive studios as students proceed through different levels of schooling. However, the facets of these studios are not with controversy. In the current university system, specialized studios are facilitated in a way that students are encouraged to adopt the biases, principles, and philosophies of the invited practitioner or teacher. For instance, the famed designer and educator Charles Correa has criticized the prevailing traditional guru-chela (teacher-student) relationship in the specialized studio, which requires the chela (student) to have unquestioning trust in the wisdom of the guru (teacher).[32] Correa quips that this structure represents less of an education and more of an indoctrination, resulting in a "kind of Jonestown from which the chela never recovers." Yet, for the students who take these courses, this experience is the single thing they always remember in later life, the one thing that made all those somewhat meaningless college years worthwhile.

According to Correa, a primary dilemma of contemporary design education is the apparent contrast between the specialized studio with its guru-chela system and the conventional studio in which little learning occurs. Far from balancing out one's education, Correa argues that the present system of haphazard studio options only encourages students to be as self-indulgent as they feel they can get away with.[33] Hence, Correa advocates striking a balance between specialized and conventional studies; students should be exposed to both guru studios and distancing studios taught by faculty with the appropriate temperament and talent. The guru studio is characterized by the way arts get handed down from generation to generation. Much of it is by direct instruction, but some of the learning takes place through an osmosis-like process. The distancing studio encourages students to reflect on what they just learned and re-appraise it. This structure would give gurus with their own idiosyncratic and intuitive design skills an opportunity to return to the atelier model of teaching, while the distancing studio would take advantage of a far more intense intellectual dialectic that has been ushered in by the new breed of architects (writers, historians, sociologists, etc.) whose contributions have enriched this profession.[34]

Another model to inculcate multiple skills are vertical studios that allow juniors and seniors to take part in a joint studio concurrently. This allows a cross-pollination between novice design students and more advanced ones. Interdisciplinary cross-modules courses could also be encouraged in which architectural design is viewed as resting on a continuum between different design disciplines. Ecological design, urban design, and landscape design might take up one side of the continuum, while industrial design, product design, and graphic design take up the other. This would allow translation to occur on the continuum between different design disciplines. Experimental studios could also be conducted involving faculty from apparently distance fields who come together to address a design problem, such as a performance center. Such studios would have the potential to demonstrate their various priorities, skills, and different ways of skill convergence. Lastly, study abroad studies can foster certain skills, such as interpersonal, kinesthetic, and intrapersonal skills, much more quickly than formal studio environments. Unfortunately, however, study abroad studios are usually optional, and not all students can afford to participate.

A final limitation of the studio system is the use of support courses. Currently, the support courses typically available, such as environmental systems, human behavior, and architectural theory, are not integrated effectively enough to make conceptual blending possible. A curriculum that integrates these support courses in real time with the ongoing studio projects will further lateral thinking between the different domain areas.

Implications to design career

The multiple skills framework might also be useful for thinking about prospective students who want to pursue a career in design. Currently, the admissions to design school occurs though a narrow set of admissions criteria that might not predict a student's full potential. According to an international survey of 60 schools, 55% rely on Scholastic Aptitude Tests (SAT), and 26% rely on special architectural aptitude tests.[35] Salama (2005) has identified that, by and large, admission policies reflect the tendencies of most schools of architecture to emphasize skills in drawing and form manipulation.[36] Even before students enter design schools, Gardner suggests that schools are focusing only on logical-mathematical skills without affording the development of intelligences such as art, music, and kinesthetic that could be appropriate to a particular student. This paradox could relate to the domain of architecture because architecture borrows from a host of other domains and requires diverse performance criteria.

The current tests for architecture design seem to be rigid and follow psychometric and universal forms of testing (ACT, SAT, GRE, and so on), rather than being tailored to particular architecture design tasks. Quite a few schools use intelligences testing in architecture. Compared to other domains (such as engineering, management, medicine) where standardized tests are established, there is very little empirical analysis of architectural design aptitude.[37] This has perhaps forced schools and offices to rely on oral interviews and portfolios. These tests are usually decontextualized from the natural setting of architectural design, where design is undertaken as an artificial experimental setup for a few hours. As such, very few attempts have been made to undertake a domain-specific study of architectural design intelligences and in a natural architectural setting where design is undertaken as a spontaneous development of ideas and for a longer duration.

The diagnosis of design skills takes time because it is essentially a diagnosis of cognitive styles. However, designers can self-evaluate their own skills and increase awareness of their own individual strengths and weaknesses as much as they are able to diagnose others. Multiple skill questionnaires such as the Multiple Intelligence Development Assessment Scales (MIDAS)[38] and Architecture Design Intelligence Assessment Scales (ADIAS)[39] could be partly helpful to achieve this, although these are for more general assessments. The MIDAS was created by a developmental psychologist, Branton Shearer, mainly to assess Gardner's multiple intelligences framework and has been used previously in three domain areas: educational counseling, clinical psychology, and neuropsychological assessment.[40] Based on the MIDAS, I subsequently developed the ADIAS questionnaire specifically targeted at the domain of architecture.[41]

Hence, the multiple skills framework provides a useful counterweight to the overt emphasis on graphical skills and form-making, highlighting other skills such as spatial sensitivity, kinesthetic skills, and interpersonal and linguistic skills that may prove more useful to real-world design situations. As instructors prepare to teach new generation of students, there is a critical need to continue learning and acquiring new tools because the skills and cognitive processes that students bring to design today are significantly different from those of the instructors.[42]

According to the Partnership for 21st Century Learning, we must be able to create, evaluate, and utilize information, media, and technology in order to be effective citizens and workers today.[43] Skills such as creativity, critical thinking, technological literacy, and collaboration are gaining traction over mastering content and assimilating existing frames of reference. These soft skills complement hard skills (i.e., technical skills) to bolster worker productivity and everyday life competencies.[44] Thus, laying a foundation for these soft skills has become critical for preparing our design students within the 21st-century learning and work context.

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