Spatial Cognition for Architectural Design

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Symposium on

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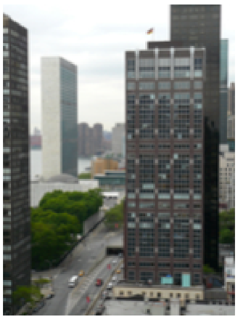

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Spatial Cognition Research as Evidence–Base for Architectural Design(ing)

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Abstract. Systematic application of research to architectural design is necessary, but often quite difficult. Besides the obvious educational and outlook differences between designers and researchers, the format of research publications hinders designer's comprehension and use. Also, the all-inclusive nature of architectural design limits detailed study of each and individual research project. This paper begins with a presentation of an experiment that was conducted to investigate how architects interacted with and used research derived evidence in design tasks. Using five lessons that were learned from this endeavor, it moves on to comment on how Spatial Cognition literature could be made more accessible to the architectural profession. To this end an emphasis is made between the two extremes of 'more-detailed-less-generalizable' and 'less-detailed-more-generalizable' information. Architecturally relevant information is visually dominant and resides at a certain point between these two extremes. Also, for a receptive designer audience, strategic alliances should be made with 'research-focused designers'.

Keywords. evidence-based design, architectural education, research, environmental elements and properties, health-care facilities

Introduction

Scientific research and architectural design do not overlap neatly. While architectural designing is mostly synthesis, research is analysis. While designing is an intuitive process, research deals with empirical data. Essentially architectural design is inclusive, while research is exclusive. Research is underpinned by a scientific method, while most architects favor art. Hypothesis and research methods are very specific, architectural concepts are vaguely defined. Small differences matter in research; they are less meaningful in design. Researchers try to control for extraneous variables, architects have to embrace them all, and design for many conditions. Research is a neat bundle but architects deal with 'messy vitality' (Venturi 1966). Finally while research ends with specific conclusions, architectural design brings forth one version of many possibilities. In this way, architectural design is more like a 'beautiful' hypothesis in three dimensions, obviously a very elaborate and most often an expensive one[1].

Various attempts have been made to bridge the gap between research and design. The role of such organizations as Environmental Design Research Association (EDRA, established 1968), International Association for People-Environment Studies (IAPS established 1981), People and Physical Environment Research (PAPER established 1980), Man-Environment Research Association (MERA founded in 1982), immediately come to mind. These are groups of 'research-focused designers' i.e. designers who care about research and look for ways of integrating research in their designs. We might contrast this with 'design-focused researchers' who focus on ways of improving and assisting design endeavors. Cognitive scientists, computer researchers, and perhaps the now dormant 'design methods' group fall in this category. In general, there is a clear line between these two groups who have very specific research agendas. The former are mostly 'designers' interested in research and its use, while the latter are mostly 'researchers' interested in assisting designers.

The most recent and sustained endeavor in the US to encourage the integration of research in designing, is the Center for Health Design (CHD, www.healthdesign.org) and their push towards what they call 'Evidence-based Design (EBD)'. This is the process of contentious, explicit, and judicious use of current best evidence from research and practice in making critical decisions, together with an informed client, about the design of each individual and unique project. It is an ambitious idea, and perhaps learning from the experiences of 'research focused designer' organizations mentioned before, CHD has already started making strategic alliances with practicing architects/firms, owner organizations of health-care buildings, and health-care equipment manufacturers. The activities of CHD are gradually gaining momentum, and is no doubt being aided by the new challenges posed (especially in the US) by health-care legislation, changes in remuneration procedures, federal laws, and of course, evidence-based medicine. The combined effect of all of them is gradually pushing the health-care facilities design industry to be more responsible in relating architectural designs to institutional goals and objectives, and in this process, 'evidence' or research is becoming more and more prominent. However, although health-care has taken the lead at this moment, there is no reason why this process cannot be easily applied to other kinds of architectural projects. Indeed (Hamilton and Watkins 2009) makes a point that it does.

The difficulty of adopting EBD lies perhaps not in the process itself, nor in the building types, but rather, in changing the perspectives that many architects develop, and undoubtedly the formative stages are in their education. Professional architectural education in the US is accredited by the National Architectural Accreditation Board (NAAB), and to date more than 100 schools are accredited. As part of this process,

[1] Many architects consider the final design proposal as the end of the process. Others undertake post occupancy evaluations to learn from them. However, evidence-based designers, (described later in this paper) consider design as a hypothesis to be tested later using appropriate research methods.

schools are required to address as many as 32 criteria that are considered relevant for successful practice. Each criterion again has to be met at either 'understanding' or 'ability' level as specified by NAAB[2]. Among the criteria listed, only three, i.e. less than 1% seems to be of direct relevance to our concern here. They are 'applied research' (understanding), investigative skills (ability), and human behavior (understanding). Granted that NAAB criteria are effectively the 'least common denominator' in the standards of professional education, and universities have a higher goal of providing education of value, one can easily argue that training for architectural practice is focused more toward the 'intuitive' side of architecture, and less towards research, or even research-based design.

One group of professional architects who value scientific research and try to use it are those who practice EBD. Regarding this group, Kirk Hamilton (2004) have suggested that they operate at four levels of practice. Level one designers stay current with literature in the field, follow the evolving (environmental) research related to the physical settings, interpret the meaning of evidence as it relates to specific projects, make judgments about the best design for specific circumstances, use design concepts based on bench mark reviews of other projects, and produce work that advances the state of the art by developing tangible examples of improved design (see figure # 1). Level two practitioners do all of the above and also hypothesize and measure design effects; level three practitioners report the results in an unbiased manner, and level four practitioners publish their findings in 'peer-reviewed' scientific journals. While an implied intention of EBD (and CHD) is encouraging more and more level four practitioners, in reality level one is the biggest group. In a recent survey of 40 top health-care design firms in the US, a full 92% of the respondents reported that they engage in some form of evidence-based design (Cama 2009). However, as many as 75% of them also reported that they only interpret scientific evidence found in peer reviewed journals and use it in making design decisions. This means that a avst majority of EBD practitioners are at level 1, and to assist this large group, one has to reflect on the translation of evidence or research to appropriate design moves. The first factor in this endeavor is the identification of 'architecturally relevant' evidence/research. This suggests on one hand, to the process of finding appropriate research and its comprehension, evaluation, and translation; and on the other, to the presentation of research for architectural consumption.

1. Study to examine the 'sharp-end' of evidence-based hospital design

To understand this situation in a bit more formal manner, a study was undertaken to examine the process of evidence-based design, especially from the point of view of the 'change-agent', the architects, who are at the 'sharp-end' of implementing the evidence-based design process (Haq and Pati 2010). In this study, a graduate level architecture design class, called a studio, was used as a surrogate environment to examine how designers interacted with, and used research based evidence. Twelve

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[2] Ability is proficiency in using specific information to accomplish a task, correctly selecting the appropriate information, and accurately applying it to the solution of a specific problem, while also distinguishing the effects of its implementation. Understanding is the capacity to classify, compare, summarize, explain and/or interpret information. (http://www.naab.org/accreditation/2010_Procedures.aspx, accessed 31st Oct 2011)

enrolled students were all working towards their professional architectural degree and were within a year of graduation. Since the difference of these students with young architects in professional design firms were only a year or so, the students were considered representatives of the young professional group. The studio class included a nursing professor and a health-care researcher, in addition to the main studio professor.

1.1. Method

The overall studio-class was divided into three phases: knowing a hospital, knowing the evidence, and integrating them into architectural design proposals. In the first phase, students were guided through ethnographic studies of all departments of general acute care hospitals, taken to visit two large general hospitals, and were provided lectures about the functions and design of hospital buildings, including workflow processes, space needs, equipment specifications, and viewpoints of various stake-holders. The students also independently investigated concepts, spaces, and technology; and were asked to study four program areas of a hospital and their relationship to the larger hospital in greater detail.

The second phase was more related to our concern here. At this time the students were introduced to three main categories of literature – scientific research publications, industry and trade magazines, and recently published books that focused on bridging evidence and design (for example Malkin 2008). Many web-based resources of reputable institutes and organizations were also included in this list. Finally, the students worked in groups to develop detailed design proposals to fit the program for a 200-bed acute care hospital in three different pre-selected sites. At the end of the semester they were administered a questionnaire to capture their perceptions and assessments regarding their collation, assessment, appreciation, and specially application of evidence (research) in their design processes. A detailed analysis of the process, the designs produced, and survey data indicated four issues related to designer-evidence interaction, and these are relevant for our interest here.

1.1.1. Inter-relationship of evidence to one another, and to physical settings

The first challenge was to comprehend how evidence was relevant to design and how they could be meaningfully organized. The class quickly realized that there was only a handful of global issues (patient-safety, patient well-being, care-giver well-being, system efficiency, and so on). The challenge of articulating subsequent layers were two-fold. First, higher order issues do not have a 1:1 'nested' relationship to sub-issues. For instance, exterior views could be associated with relieving patient stress, reduce acute staff stress, increase staff alertness, etc. and they all address different outcomes. Crowding could be related to patient stress as well as medication errors, and perhaps other higher order issues of interest. Second, physical settings and related issues bear a many-to-many relationship. In other words, a type of setting (such as an inpatient unit) could be associated with more than one issue. For instance, stress is a factor in in-patient setting, as well as in imaging, emergency, critical care and so on. Articulating issues and sub-issues and relating them to physical settings in a comprehensive and meaningful format quickly became formidable to the participants. They abandoned the task and resorted to creating single page reports of key evidence and their translations into design. In total, the class created 232 reports which were obviously non-hierarchical (or non-nested). These later became data for analysis.

The difficulty of collecting and organizing the available evidence for reference in a meaningful way is also reflected in the survey responses of the students. They rated the evidence collection task at 53%, i.e. halfway between 'very easy' and 'very hard', despite the fact that the students were assisted in finding relevant articles, and were even supplied with literature from which to extract the evidence from.

1.1.2. Phase-complemented evidence

The facility procurement process has a number of phases through which a project is envisioned, programmed, preliminary ideas are sketched out, design is developed, construction documents are produced, building is constructed and so on. Obviously, different groups of experts play different roles in these stages. In general four facility procurement phases are related to design: conceptual design, schematic design, design development, and construction documentation. In each of these, certain evidence may have greater or lesser relevance. Thus one that is highly relevant in the visioning or the programming phase may not be so important in a subsequent design phase. For example, the decision to incorporate single rooms with views in a hospital is usually decided early on, with optimization being of concern during subsequent design phases. On the other hand, the role of color and its effects is considered at a very late stage of design, and perhaps by an entirely different group of designers.

Filtering evidence relevant to a specific facility procurement stage can be difficult. In the survey response the students noted that only 20% of the evidence examined was informative at the schematic phase. This is of significance, especially when we realize that the schematic phase is the most crucial part where major concepts and architectural ideas are formulated and do not change substantially in later phases. Judging by the results of this small study, research investment contributes to only about 20% of design decision making; a number that should be of concern to researchers.

1.1.3. Evidence vis a vis context and precedence

Precedent analysis is ubiquitous in architectural design. Even the NAAB student performance criteria list 'use of precedents' at an 'ability' level, in addition to 'investigative skills'. To take advantage of this designer skill not only should research be presented as related to specific environmental elements, it should also be coupled with information about how it might fit into different contexts, and instances of its use in previous examples, i.e. precedents, if available. In short, how was the particular issue dealt with by previous architects? What were the physical conditions? What was the impact of design interventions? And so on. Since precedent analysis of evidence is not available in scientific research publications, our students appeared to have gravitated towards trade journals for this purpose. Although they have reported that they found more evidence (54%) in peer reviewed journals as compared to trade publications (46%, see figure 2), an examination of 232 single page reports that documented how evidence was translated into design showed that 60% of the evidence was extracted from industry sources, while only 23% was taken from scientific journals, and the remaining

17% from experience, anecdotes and interviews (see figure 3). This indicates a key challenge that designers face. While they perceive to find more evidence from scientific publications, they have difficulty in transcribing them to design moves, and so fall back on publications that may not be 'scientific' enough, but nevertheless has images and context, and in this way provide precedence.

1.1.4. Vocabulary

The students' greater comfort with industry and trade publications may be understood by the stark differences in vocabulary between designers and researchers. Knowledge representation through drawings and diagrams as they appear in professional journals, books and trade sources was more conductive to design learning as was seen in our experiment. It seemed that the students approached different sources selectively: scientific publications for evidence, and non-scientific sources for precedence. Recent books that attempt to provide more visual information was very helpful. For example, Malkin's book (2008) has a chapter on patient units that is presented in both words and diagrams. This serves as a possible direction for information representation. Designers think, analyze and synthesize evidence visually (Sanoff 1991). This is an important consideration and seems to be a prerequisite for greater and more appropriate use of scientific research in design.

1.2. Lessons learned from the studio experience

From the small study described above we see that a focus on environmental factors (elements) is an important concern for architects. Additionally, we note that:

1. Visual and/or diagrammatic representation of research results is significantly better than textual representation. This suggests two things: identification of environmental elements and description of the properties of those elements. Environmental elements have to be specified in a manner in which they can be sketched, diagrammed, or photographed (i.e. visualized). Additionally, their properties have to be matched to both their physical features and design outcomes.
2. Textual descriptions in a flat hierarchical format as found in most scientific publications may not be intuitive to designers, and may even hinder extraction of relevant information in a timely and cost efficient manner.
3. The relationship between higher and lower order issues needs to be clarified and explained. In other words, the relationship of outcomes not only to physical factors, but also to one another has to be clarified.
4. The relationship between research findings and its applicability to specific physical situations should be stated in the form of a 'precedent', a research method that is well known to architects.
5. Facility procurement-phase complemented evidence filtering system should be an essential component of research presentation. This will make the search and retrieval processes provide the 'right information at the right time', and will allow a better adoption of research results.

We will now turn our attention to Spatial Cognition and consider its research findings with special emphasis on the five points mentioned above. At the outset, we declare that it is not our intention to provide a comprehensive review, but to highlight what we consider to be important characteristics of research information that is valuable to architects.

2. Spatial Cognition research for architectural design(ing)

We begin with the distinction between the profession and the discipline of architecture. Although this division is subtle, the previous study may have identified a gap between them. Additionally, the discipline of architecture is enriched by contributions from other disciplines and because of this too, the question of translation for the profession (designers) become paramount. The discipline is broad based and its research includes many spheres, or, it learns from research in many disciplines. Schwarz (2011) has identified seven such spheres, namely: environmental research, cultural research, social research, technological research, design research, organizational research, and educational research. Although cognition research is not listed here, he does bring it forward as a valid response to criticisms of environment-behavior studies, which were broadly based on social research. Cognition studies have addressed the criticism that a study of human external behavior, without understanding the cognitive processes involved, is simply treating the built environment as an incidental stimulus array, rather than a meaningful environment for the immersed person. Whether or not cognition is a separate research domain within architecture is irrelevant for this paper, but we do want to acknowledge, at the outset, that it has been beneficial to both ‘research-focused designers’ and ‘design-focused researchers’.

One might speculate that the requirement for a bridge between today’s cognition researchers and architects is a relatively late phenomenon, but in its inception spatial cognition was integral to architecture. This was of course rooted in the pioneering work of Kevin Lynch. This Frank Lloyd Wright trained architecturally savvy MIT professor of planning perhaps did not consider himself a cognitive researcher, yet his book, ‘The Image of the City’, (1960) remains a classic in both disciplines of spatial cognition and architecture. The notion that certain physical elements of a city make up an individual’s ‘generalized mental picture’ of the exterior physical world, that it is a product of both immediate sensation and memory, and that it guides behavior (especially wayfinding), comes from Lynch; and these are also the founding concepts of the later field called ‘Spatial Cognition’ (Gifford 2002).

2.1. Two models in Spatial Cognition

Spatial cognition has had other influences too, and over the years has been enriched by interdisciplinary contributions. Therefore, it is not unexpected to find two dominant models in it. One is a human model that investigates internal processes such as action plans, strategies, cognitive information (cognitive maps) and so on, including their formation and development across the life span, interpersonal variances, cultural effects and such (see table # 1). The other model, more relevant to architecture, is the environmental model. This seeks to identify physical elements and properties that have cognitive significance. It seems that the environmental model of Spatial Cognition is specifically based on Kevin Lynch (1960), who proposed that a generalized mental picture (or a 'cognitive map') depends on an environmental property called 'legibility', i.e. the ease with which parts are recognized and organized into a coherent pattern. Lynch also identified five physical elements that are significant in this process; i.e., nodes, paths, landmarks, edges and districts. An important aspect to note is that Lynch's descriptions of these elements (and his sketches) are not very detailed. He seemed to understand that as descriptions get more detailed; they become less generalizable, and therefore less useful to designers, for whom innovation is crucial. Researchers of course favor more detailed (and therefore less generalizable) information, and hundreds of subsequent studies have sought to find exact descriptions of the proposed five elements (see Appleyard, (1969) among others). It may not be unfair to state that the subsequent studies have not featured quite as favorably in architectural curricula or literature.

2.2. Unit elements of the environment

Perhaps the most relevant aspect of Lynch's contribution in regards to architectural design is the distinction that emerged between environmental elements and properties (table #1). Not only that, his book is infused with sketches and diagrams which assist visualization of those elements. In other words, Lynch spoke the architect's language. It is therefore of no surprise to see the influence of Kevin Lynch in architecture and urban design, where even today, more than fifty years later, published books in the subject do not, and most likely cannot, omit references to his contributions. See for example Carmona, Tiesdell et al. (2003), LeGates and Stout (2007) etc.

The distinction between environmental elements and environmental properties is an important one, and is perhaps at the crux of the relationship between spatial cognition and architectural design. Is this distinction explicitly made by scholars in Spatial Cognition? Perhaps not. Encyclopedia definition states, "Spatial Cognition concerns the study of knowledge and beliefs about *spatial properties of objects and events* in the world" (Montello 2001, authors italics). It then goes on to provide examples of these properties and relate it to the second model of spatial cognition, human aspects. Identification of environmental aspects whose properties are being studied do not seem to be well addressed.

This I believe is an important concern because a quick literature survey to isolate the environmental elements used or identified by Spatial Cognition researchers yielded a very limited set (see table # 2). Most importantly, the five elements discussed by Kevin Lynch seem to be the 'paradigm' on which subsequent researchers have sought to identify environmental elements. Noteworthy is that the notion of 'edges' became less relevant, and the notion of 'districts' and 'nodes' were integrated into concepts of 'domains' or 'places'. In other words, cultural values were being associated with physical descriptions. Later, in a discussion of micro-genesis, Montello (1998) summed up these efforts into a triad of environmental elements: landmarks, routes and layouts; and this he suggested had been the 'dominant framework' for quite some time. To this list, Weisman (1981), a professor of Architecture who studied wayfinding, added 'signage'.

2.3. Properties of physical elements

Environmental elements gain cognitive presence because of certain 'memorable' characteristics. As mentioned before, a majority of cognition research has sought to identify and verify these properties for cognitive presence, and in this way has established the elements themselves. Properties are understood either as residing within an element itself, or in its relationship with others. For example 'vivid color' may be a property of a wall, which makes it memorable and act as a landmark. A higher order property is the relationships between elements. They have been variously described as 'choices' (Norberg-Schulz 1971), 'visibility' (Braaksma and Cook 1980), 'visual access' (Weisman 1981), 'connectivity' (Hillier and Hanson 1984), 'integration' (Hillier and Hanson 1984) etc. Properties of physical elements understood by looking at relationships to others bring forth the notion of configuration (Siegel and White 1975; Weisman 1981; Hillier and Hanson 1984).

The next development along these lines is predictable; aspects of relationships i.e. what is being related and the nature of these relationships are investigated. Thus we see the use of various computerized tools to map the relationships between elements, mainly focusing on topological and metric relationships, and experiments to investigate the cognitive correlates of these environmental properties (Haq 1999; Kim and Penn 2004). How useful are these for architecture? That will be discussed next.

3. Implications of cognition research mapped to the studio experience

At this point we return to the lessons learned from the studio experiment reported earlier and use them to contextualize the relevance of spatial cognition research on architectural designing.

1. We have noticed that visual and diagrammatic representation is appreciated by architects. It is far easier to diagram environmental elements, than their properties. This is perhaps the most important reason for the predominance of Kevin Lynch's five elements. While his five environmental elements are well explained, they were also profusely illustrated. In general, cognition researchers are less focused on environmental variables and usually do not discuss architectural relevance. As we develop more and more sophisticated visualization techniques and computerized tools, we might begin to think of transforming or extending existing research to visuals and diagrams. This does not imply that research is simplified or 'dumbed down'. Rather, it is the findings in visual form that provides the architect a very quick summary of research and allows him/her to think about its significance to the task at hand. In this regard, Space Syntax computer program generated map output, which clearly shows the distribution of values in a plan layout is noteworthy.
2. Research publications are not the forte of architectural professionals, to whom the results are useful, but only for one aspect of the numerous overlapping

issues that they deal with at any given moment. Researchers usually worry about external validity; architects are concerned with architectural validity. It would be a good idea to make arrangements so that as results get validated with more and more research, their architectural implications are published in a separate format.

3. The relationship between higher and lower order issues need to be explicitly explained. These may appear in different publications, and perhaps addressed by different researchers at different times. Nevertheless, a compilation, comparison, and publication of these interrelationships is important. These should also include notes regarding conflicting information. In spatial cognition literature, one important development could be clarifying the relationships between environmental elements and their many properties.
4. As more and more cognitive research is applied to design, they must be recorded as precedents for later designers. Some concepts have been in use for quite some time, especially in urban design and wayfinding design. Recently, findings from Space Syntax research has been used to comment on existing building layouts (Brosamle, Mavridou et al. 2011) and buildings elements (Brösamle, Mavridou et al. 2009), at least theoretically. A good strategy would be to use architecturally significant buildings for these academic endeavors, as was recently attempted by Carlson, Holscher et al. (2010). Additionally, interpretations from Post Occupancy Evaluations might also be helpful in making the link between research findings and design applicability.
5. Facility procurement phase complemented filtering system for cognition research may not be too difficult. While at the predesign stage concepts of environmental elements may be useful; in later design stages (where optimization becomes important), their properties and effects could be studied. For example, at the pre-design phase the concept of landmarks could be introduced, and as the design progresses, more and more properties could be studied as it relates to the problem at hand.

4. Final comments

We began by stating clear differences between research and design. While researchers are considered experts in their own domain, designers have to rely on many kinds of information, while their own expertise is the ability to quickly understand research results, manage diverse and often conflicting materials, think of applicability to the specific problem at hand, and then move on to consider other evidence. Architects are also visual thinkers and visual problem solvers. Among them, those who are research-focused designers are more willing to consider research in their design processes. Finally architecture is about designing a new condition that satisfies many criteria, and doing it in an aesthetically pleasing manner. To help in this gargantuan task, the more specific research results are with respect to architectural applicability, the better it is. If presented visually, it becomes easier to comprehend and use. Finally, research derived ideas need to be neither too general, not too specific. The former presents difficulty of physical definition while the latter reduces the ability for novelty. In other words, if too general, then it will not be very applicable, if too specific, then it cannot be used to make a new design condition.

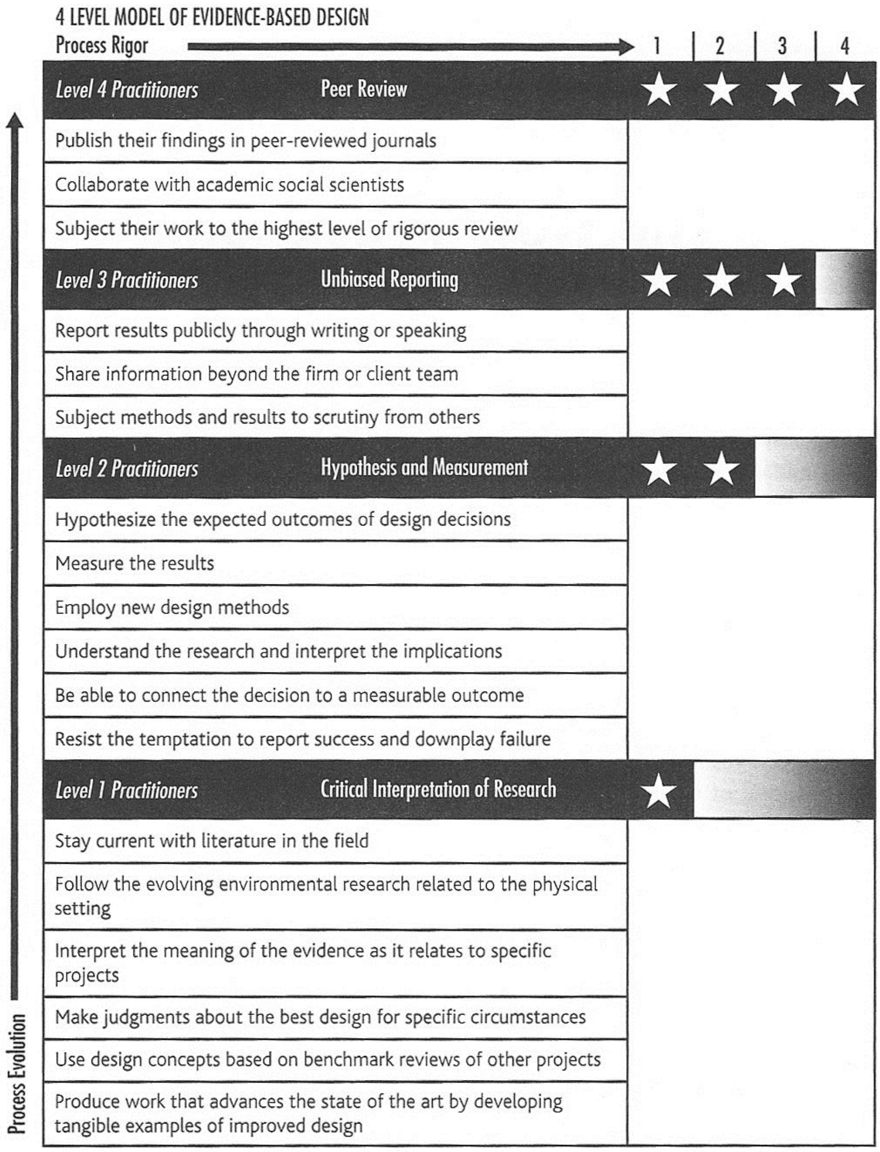

Figure 1. Four levels of Evidence-based practice

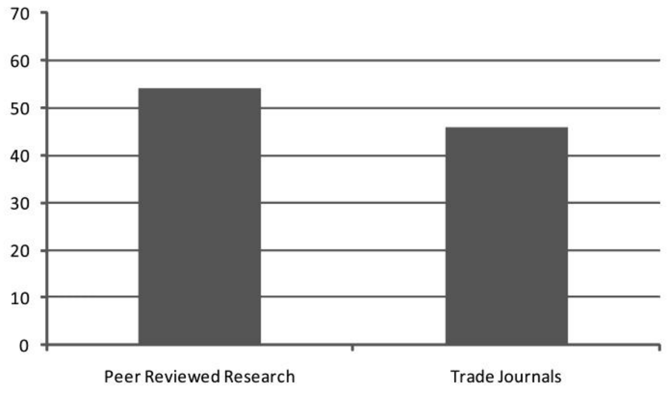

Figure 2. Sources of evidence collected by survey participants

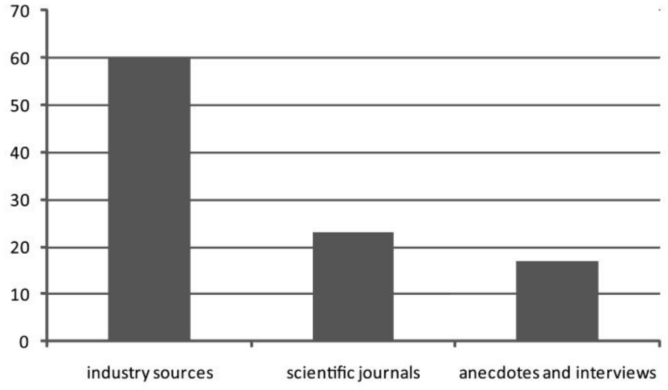

Figure 3. Sources of evidence used in architectural design

Table 1. Two models of Spatial Cognition

Environmental Model		Human Model
Environmental Elements	**Environmental Properties**	
Landmarks	Complexity	Cognitive map
Routes	Coherence	Strategies
Layout	Mystery	Action plan
Signage	Legibility	Social knowledge
	Gestalt	Schema
	Differentiation	Micro-genetic development
	Visual access	Development across the life span
	Visibility	
	Location	
	Size	
	Distance	
	Direction	
	Separation and Connection	
	Shape	
	Pattern	
	Continuation	
etc	etc	etc

Table: 2. Various environmental elements and properties that were found to be influential in cognition research.

Yr	Author	Environmental Elements					Environmental Properties
		Lines	**Points**	**Areas**	**Elements**	**Edges**	
60	Lynch	Paths	Nodes	Districts	landmarks	Edges	
69	Stea	Paths	Points			Boundaries and Barriers	
69	Appleyard	Paths	Nodes & Points	Districts	landmarks	Edges	
70	Best						Choices in a route
71	Norberg-Schulz	Paths	Places	Domains			
75	Siegel and White	Routes	Nodes				Configuration
76	Tobler						Configuration
78	Kuipers	Paths	Places				Relative Locations
78	Kuipers						Topological relations
78	Golledge		Anchor points				
80	Braaksma						Visibility between destinations (Visibility graph)
80	Evans						Color differentiation
81	Weisman				Signs		Visual access Architectural differentiation Plan configuration
83	Heft						Transitions between vistas
84	Garling et.al.		Places				Spatial relations between places.
86	Garling et.al.						Degree of visual differentiation Degree of visual access Complexity of layout
89	Leiser et.al						Node-link network
89	Rovine and Weisman				landmarks		
90	Peponis et.al						Syntax Integration
91	O'Neill						Inter-Connection Density
95	Evans et. al.				landmarks		Pathway Configuration
95	Gopal						Configuration (Neural Network Model)
99	Haq	Lines	Nodes				Integration-3 Connectivity
01	Haq	Lines	Nodes				Integration-3 Connectivity
01	Kim	Lines					Integration-3

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