The Research-Design Interaction: Lessons Learned From an Evidence-Based Design Studio

Saif Haq, PhD, and Debajyoti Pati, PhD

Abstract

As evidence-based design (EBD) emerges as a model of design practice, considerable attention has been given to its research component. However, this overshadows another essential component of EBD—the change agent, namely the designer. EBD introduced a new skill set to the practitioner: the ability to interact with scientific evidence. Industry sources suggest adoption of the EBD approach across a large number of design firms. How comfortable are these designers in integrating research with design decision making? Optimizing the interaction between the primary change agent (the designer) and the evidence is crucial to producing the desired outcomes. Preliminary to examining this question, an architectural design studio was used as a surrogate environment to examine how designers interact with evidence. Twelve students enrolled in a healthcare EBD studio during the spring of 2009. A three-phase didactic structure was adopted: knowing a hospital, knowing the evidence, and designing with knowledge and evidence. Products of the studio and questionnaire responses from the students were used as the data for analysis. The data suggest that optimization of the research-design relationship warrants consideration in four domains: (1) a knowledge structure that is easy to comprehend; (2) phase-complemented representation of evidence; (3) access to context and precedence information; and (4) a designer-friendly vocabulary.

Key Words: *Evidence-based design (EBD), EBD studio, healthcare, hospital, design research*

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Over the past decade, evidence-based design (EBD) has emerged as a novel approach to architectural design practice. This approach promises a closer match between design intentions and operational and organizational outcomes, because design decisions are based on the best available research evidence in addition to professional experience.

Over these years, considerable attention has been given (rightfully) to the research component of EBD—the key addition to the traditional practice model. Research-related activities have been directed to three principal areas: First is the collation of available research evidence, such as that organized by The Center for Health Design (Ulrich, Zimring, Quan, & Joseph, 2004; Ulrich et al., 2008). Second, the emphasis has been on developing the business case for EBD, amply exemplified in Berry and colleagues (2004) and in Zimring, Augenbroe, Malone, and Sadler (2008). The third direction is to identify knowledge gaps (as in the symposium and survey conducted by the Health Environment Research Summit at Georgia Institute of Technology, and the Clemson University Architecture + Health Program), and to fund empirical research efforts in those areas (such as the research grants administered by The Center for Health Design and the Academy of Architecture for Health Foundation).

The existing research focus, however, overshadows another essential component of the EBD approach—the change agent. The medical practitioner was intended to be the primary agent in evidence-based medicine (EBM). The counterpart in EBD (which is analogous to and modeled after EBM) is the design practitioner. Both represent the sharp end in their respective practices.

EBD introduces the necessity of a new skill set to the design practitioner. In addition to extensive experience and deep domain knowledge in healthcare design, the new method demands the integration of the best available research evidence into decision making. This represents a radical transformation in design behavior. It means that designers must be able to interact with scientific evidence, assess the applicability of research findings in design decisions, and in some instances engage in empirical research.

The emerging need to integrate research in design decision making constitutes a long-standing concern regarding research utilization by the environmental design research community. This began in the early 1960s in response to enhanced awareness about the environment and a perceived need for decision-making support related to users of built spaces (Saarinen, 1995). A major focus was to enhance the utility of academic research.

The increased focus on research utilization can be partially ascribed to concerns regarding the separation between the designers and the users of a building. Changing economic structures gradually reduced the interaction between the actual users of a building and its designer. Instead, architects came to learn about user needs and expectations through corporate boards and public agencies that do not occupy the final product (Sommer, 1974; Zeisel, 1984). It was contended that the integration of research and design would bring knowledge about user-environment interactions to the attention of designers. A lack of the utilization of research data and findings in design decision making was a major concern (Weisman, 1998; Zeisel, 1984; Zimring & Reizenstein, 1980). Identical discussions were occurring in the context of post-occupancy evaluations (Joiner, 1996; Kantrowitz & Nordhaus, 1980; Kernohan, Gray, Daish, & Joiner, 1992; Keys & Wener, 1980; Vischer, 2001). Reasons propounded for the lack of integration were many, including accessibility to research documents, attributes of research data, the presentation format of research findings, methods of data storage and representation, and information management.

In a separate domain of inquiry, researchers have examined the cognitive processes involved in creative problem solving, or the creative processes of design decision making (Chan, 1990; Gero & Purcell, 1993). However, although the differences in cognitive processes involving research and design are appreciated, the best way to couple creative thinking with research data has not been adequately reported in the literature.

Despite these known hurdles, industry sources imply that the EBD approach has been implemented in a large number of design firms. In a survey of the 40 top healthcare interior design firms in the United States, 92.5% of the respondents reported that they engage in some form of EBD (Cama, 2009). Furthermore, as many as 75% of them reported that they interpreted scientific evidence found in peer-reviewed journals and used it in their design decisions. In Web-based open voting to identify the most influential people in healthcare design, hosted by *Healthcare Design* magazine, the list of contenders included, among others, designers representing a large number of healthcare design firms (*Healthcare Design*, 2009).

How comfortable and effective are these designers with integrating research into design decision making? In what manner do they interact with scientific research? The interaction between

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the primary change agent (the designer) and the evidence is a crucial component of EBD that has not attracted much attention. If this critical agent–evidence interaction is not optimized, then all investments in research may fall short of the desired outcomes.

However, studying the agent–evidence interaction in a professional setting has its own challenges. Typically, professional projects are constrained by a rigid time line, which may not allow the flexibility to examine the interactions in great detail. Moreover, activities in a professional setting may occur across different physical locations, posing logistical challenges.

The Project

As a preliminary step to examine the question, the authors used an architectural design studio as a surrogate environment to examine how designers interact with evidence. The studio was conducted in a large accredited professional architecture degree program during the spring semester of 2009. The studio was open to students at the professional master's program level. It was named "Evidence-Based Design" to remove any ambiguity regarding

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the intent of the studio. The announcement of the studio also provided sufficient detail regarding the intent of the course, including the requirement to read a wide variety and large volume of literature as part of the course.

A total of 12 students enrolled in the studio; two of them were graduating at the end of the semester. The rest were in various stages of finishing their professional master's degree.

The studio involved an expert panel, which included an expert in nursing and a second expert in healthcare design research, in addition to the main instructor.

The studio used an existing program for a 180,000-square-foot 100-bed general hospital. Three local sites with different physical characteristics were chosen to create three separate sets of design challenges. One was a tight urban setting beside an elevated expressway; the second was a typical suburban site with very few distinguishing features; and the third was a hilly site beside a scenic lake. Topographic maps and all program details were provided at the beginning of the class with instructions to use them as the context for research.

Method

The overall studio was divided into three phases: (1) knowing a hospital; (2) knowing the evidence; and (3) designing with knowledge and evidence.

The objective of the first phase—knowing a hospital—was to provide a holistic perspective of hospital design. The intention was to give the students sufficient knowledge to enable them to be productive beginning healthcare designers in a professional firm. The semester began with ethnographic studies of all departments of general acute care hospitals, including site visits to two large nearby hospitals, one with 702 beds and the second with 328 beds. The expert panel provided lectures about the functions and design of hospital buildings, including workflow, processes, space, equipment, and the viewpoints of various stakeholders. In this phase, students were also required to investigate independently key concepts, spaces, and technology, such as point-of-care testing, robotic surgery, magnetic resonance imaging, electronic medical records, pneumatic tube systems, automated medication dispensers (Pixus), and so forth, to become familiar with the systems and spaces they will encounter during design. They provided verbal and written reports on these topics to the class. Illustrations were emphasized so that equipment, clearances, and spatial relationships were captured.

In the second half of the first phase, students engaged in an in-depth examination of four program areas of the hospital, which they were then asked to design in greater detail in the studio. Special emphasis was placed on the global-level circulation systems and the relationship of each program area to the hospital as a whole. The four program areas were (1) the medical-surgical unit, (2) the birthing/postpartum unit, (3) the emergency department, and (4) the diagnostic and treatment unit.

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In the second phase—knowing the evidence—students were introduced to three main categories of literature. The objective of this phase was to collate and digest the available evidence, and get the evidence ready for use in design decision making. The first class of information was scientific research publications. Students were introduced to the two literature surveys conducted by The Center for Health Design (Ulrich et al., 2004; Ulrich et al., 2008). Additionally, they were directed to pertinent scientific journals, such as the *Health Environments Research & Design Journal* (HERD), *Environment & Behavior*, and so forth. They were also directed to Web-based resources such as The Center for Health Design, the AIA Academy of Architecture for Health, InformeDesign, and Informaworld. The second class of information comprised industry and trade magazines, such as *Healthcare Design*. The third source of information was from recently published books on EBD, such as Malkin (2008). Students were encouraged to expand their search beyond readings provided as part of the curriculum.

In the last phase, the students worked in groups of four to develop designs for the three selected sites. For each proposal, they were required to articulate the specific evidence they were using and the corresponding implications for design decision making. Areas of the hospital not studied as part of the earlier exercise (such as administrative areas, the support core, and so forth) were researched and designed collectively. The outcome of this phase was three completely integrated hospital complex designs. A sample of the final stu-

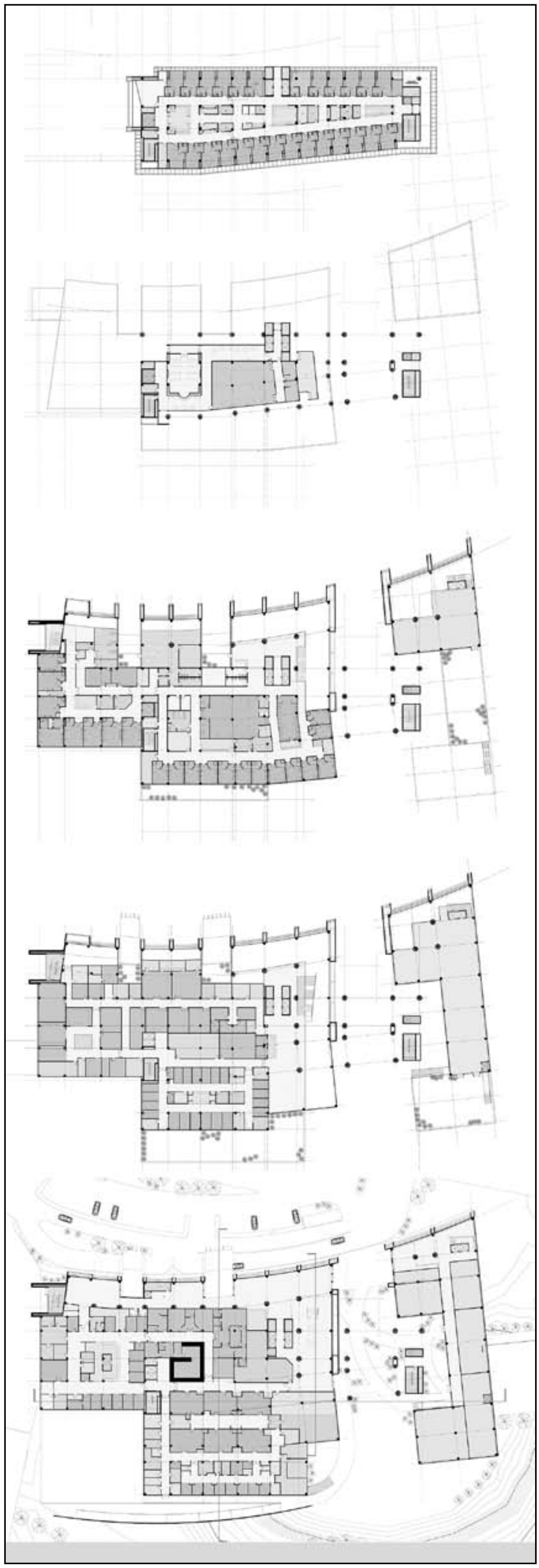

Figure 1a. Hospital plans done in the final phase of the studio (Student Group A).

Figure 1b. Various room designs and stacking of hospital services (Student Group A).

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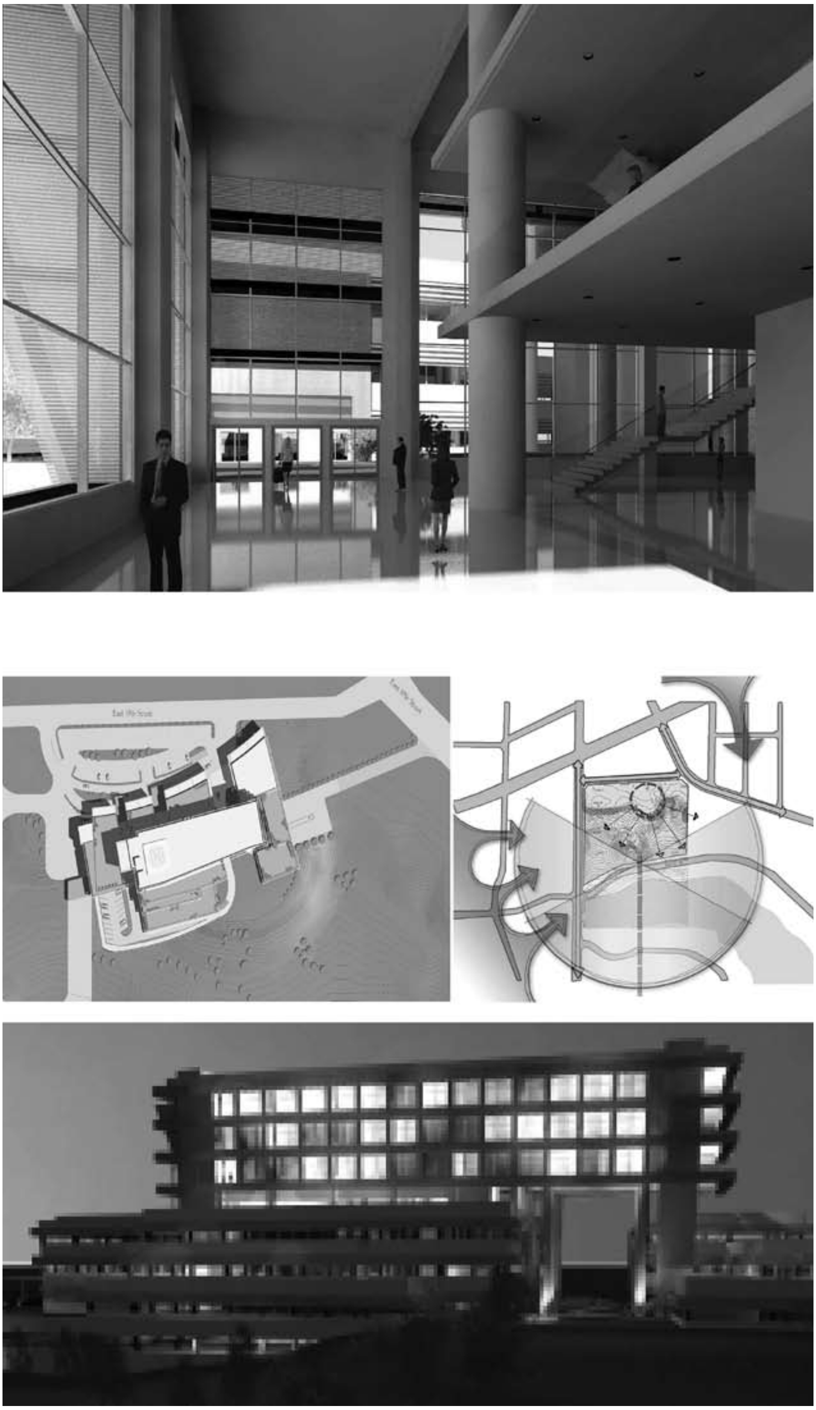

Figure 1c. Site planning and 3-D views of interior and exterior (Student Group A).

dio output is illustrated in Figures 1a, 1b, 1c, 2a, 2b, and 2c.

At the end of the semester, students were administered a questionnaire to capture their perceptions and assessment of the EBD studio experience. The main objective of the survey was to measure their perceptions regarding the collation, assessment, and application of evidence. The results of the survey are discussed below.

The Designer-Evidence Interaction

Four issues pertaining to the designer-evidence interaction warrant consideration, namely comprehending the evidence, evidence vis-à-vis the procurement phase, context and precedence, and vocabulary.

Comprehending the Evidence

A primary challenge in the second phase—knowing the evidence—was to get a meaningful grasp of the available evidence pertinent

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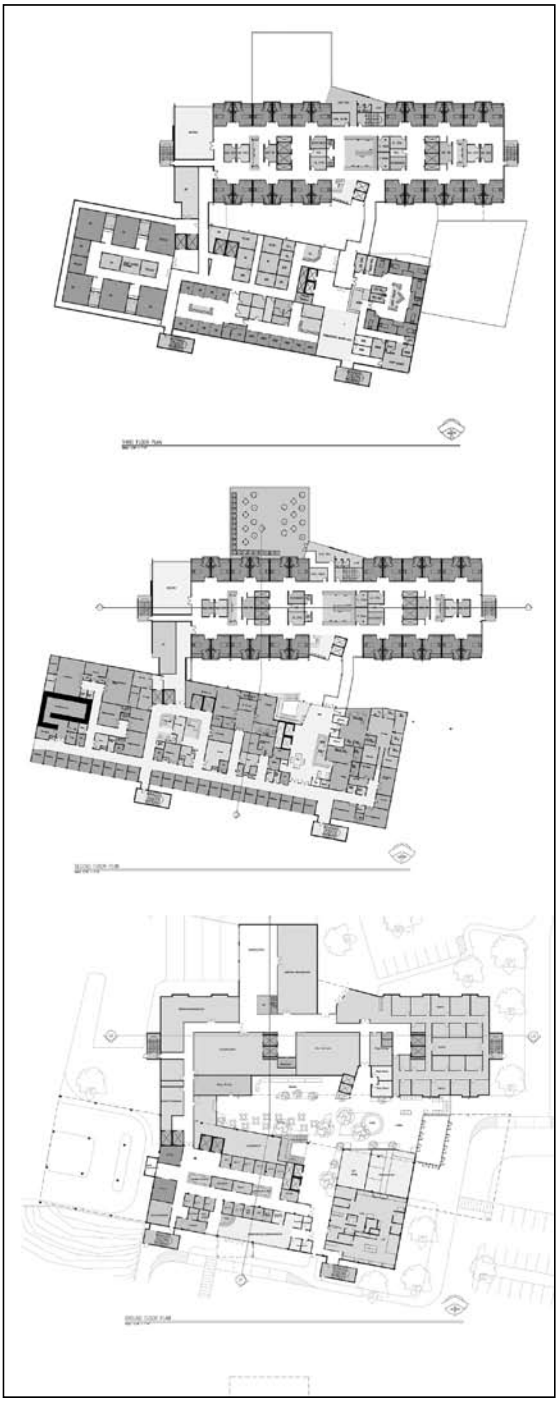

Figure 2a. Sampling of hospital plans (Student Group B).

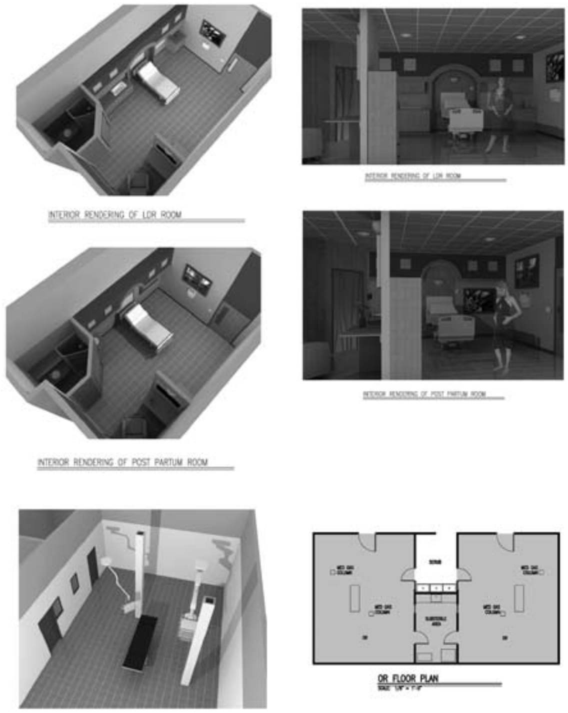

Figure 2b. Room designs (Student Group B).

Figure 2c. Interior and exterior views (Student Group B).

to the project. The project began with an examination of the evidence that was identified during this phase. How this evidence was relevant to design and how it could be meaningfully organized was discussed extensively. An immediately available approach was a classification system based on higher-order issues followed by a second (and additional lower-order) tier/s of subissues. This system also typifies how evidence is presented in the published literature.

Although identifying the main candidates for the first-tier issues was relatively simple, developing simple and easily comprehensible lower-order tiers proved to be a major challenge for the students. For the first tier, it seemed that the available evidence was easily categorized according to a handful of global issues, namely patient safety, patient well-being, caregiver well-being, system efficiency, and so forth. The challenge in articulating the subsequent layers is twofold. First, the higher-order issues do not have a 1:1 relationship with the sub-issues. For instance, exterior view could be associated with patient stress, the acute stress of staff, and staff alertness; 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 issues bear a many-to-many relationship. In other words, type of setting (an inpatient unit, for example) is associated with a number of issues. In turn, each of those issues is associated with more than one setting type (for instance, stress is a factor in the inpatient setting as well as in imaging, emergency care, and so on).

Articulating the issues and subissues in a comprehensible and meaningful format quickly became formidable for the students. The class abandoned the task after several failed attempts to arrive at a single classification structure that was meaningful to the project at hand. Instead, the students resorted to creating single-page reports of key evidence and its translation into designs (Figure 3a, 3b, and 3c). The difficulty involved in collecting and organizing the available evidence for reference in a meaningful framework is also reflected in student survey responses, where they rated the evidence collection task at 53%, more than halfway between the end points representing "very easy" and "very hard," despite the fact that the students were supplied with the literature from which to extract the evidence.

Phase-Complemented Evidence

It could be argued that a certain piece of evidence has greater relevance to a specific phase of the facility procurement process. Thus, a piece of evidence that is highly relevant to the visioning or programming phase may not enjoy such relevance to the designer involved in subsequent design phases. For instance, the size of a unit is determined early on, with limited scope for change during the design phase. Similarly, operational systems such as documentation systems, medication delivery systems, and the supply delivery system, to name a few, are determined during the programming phase, which in turn establishes the spatial provisions required for those systems. These are reflected in the space program as number and type of documentation spaces, number of medication rooms, number of clean utility rooms, and so forth.

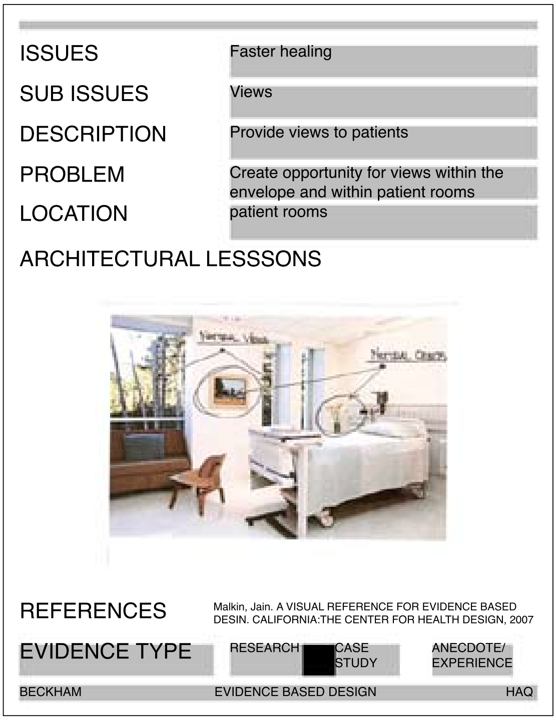

Figure 3a. Example of student-produced single-page reports of key evidence and its translation into designs (unretouched reproduction of students' work).

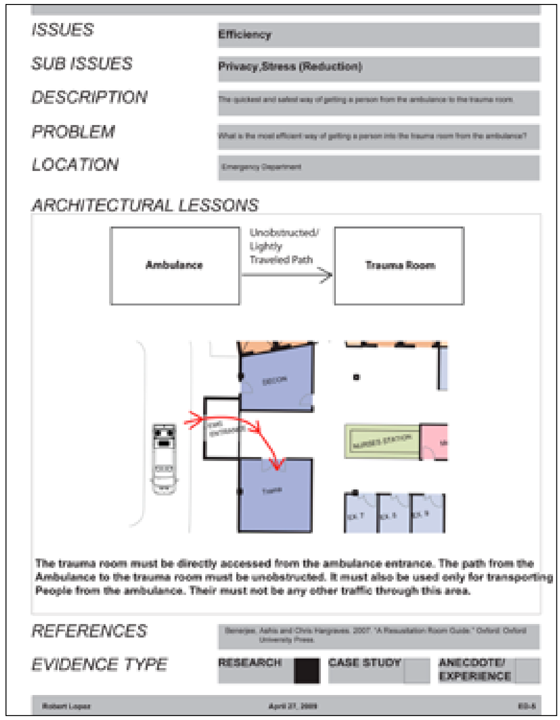

Figure 3b. Another example of a single-page report (unretouched reproduction of students' work).

Consider the evidence for single-patient rooms:

> …[T]here is a convincing pattern of evidence across many studies indicating that single-bed rooms lower nosocomial infection rates. Singles appear to limit person-to-person and person-surface-person spread of infection in part because they are far easier to decontaminate thoroughly than multibed rooms after patients are discharged. Also, single rooms with a conveniently located sink or alcohol-gel dispenser in each room may heighten hand washing compliance compared to multibed rooms with few sinks. Finally, single rooms are clearly superior to multi-bed rooms with respect to reducing airborne transmission of pathogens.
>
> (Ulrich et al., 2004, p. 11)

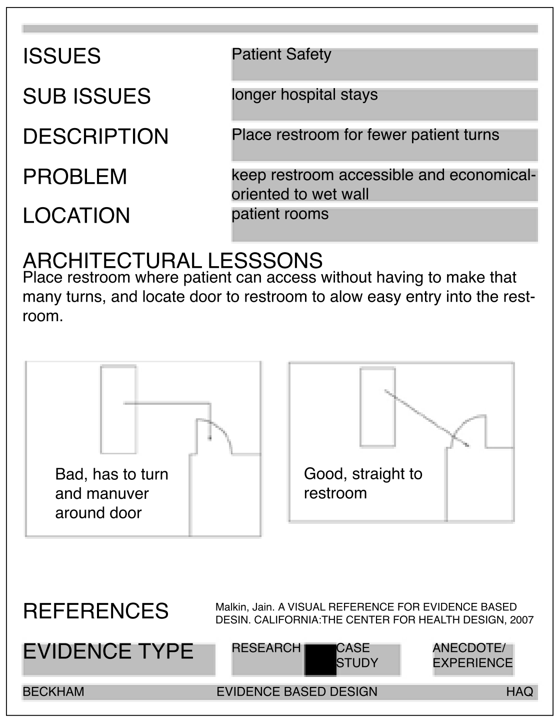

Figure 3c. Student single-page reports of key evidence and its translation into designs (unretouched reproduction of students' work).

It is also demonstrated that nurses prefer single rooms for collecting patient history (Chaudhury, Mahmood, & Valente, 2005). Each of these separate studies indicates the different ways in which single-patient rooms are important. The decision pertaining to single-patient rooms, however, is made during the programming phase. In the subsequent design phases, all the evidence supporting single-patient rooms is less relevant to the designer. Similarly, studies of furniture, color, and similar factors may not be immediately relevant at the schematic design phase. Some evidence—such as that for air filtration systems—may not have any major architectural implications.

Typically, information relevant to the schematic design phases deals more with optimization than with provision. For example, although the provision of natural light is dictated by the program, a designer contributes by optimizing natural light and view in a particular context. Similarly, whereas operational flexibility is built into the program, a designer optimizes operational flexibility by focusing on design attributes that impede or promote it. Thus, all evidence does not enjoy the same degree of relevance to all phases of facility procurement.

The evidence available in literature, however, is not categorized according to its relevance to the procurement phase. The absence of a phase-complemented evidence representation structure (perhaps delineated along professional boundaries) was an additional burden for the students. The class identified at least five different domains of applicability: at the programming level, the schematic design level, the design development level, the interior-design level, and the building engineering level. For example, although windows or daylighting in patient rooms may be a programming and schematic design requirement, the color of the rooms or the artwork in them is a consideration for interior designers. Similarly, while the number and location of hand-washing sinks has an architectural dimension, it also relates to the operational policy of a hospital. The preliminary effort of the studio to create a phase-complemented evidence domain structure is shown in Table 1. The accuracy of Table 1 is of secondary importance. Rather, the table reflects the external manifestation of internal thought processes of the design students during EBD problem solving.

This suggests a 20% return on investment in evidence examination for the students who were specifically dealing with the schematic design phase.

Filtering the evidence relevant to a specific phase of facility procurement can be time consuming. This is amply reflected in the survey response. The survey revealed that only 20% of the evidence examined in the studio was informative for the schematic design phase. Of the remaining evidence, the students considered 30% applicable to the programming phase, 18% to design

Table 1. Phase-Complemented Evidence Domain Structure Developed by the Students

	PROJECT PHASE				
Environmental Elements Identified	**Policy and Programming**	**Schematic Design**	**Design Development**	**Interior Design**	**Engineering**
Layout considerations of units/zones such as nursing units, pharmacy, patient *R* = rooms (for less walking, fewer interruptions, less "hunting and gathering," wayfinding ease, nurse station distribution, peer visibility, etc.)	√	√	—		
Decentralized nurse stations and pharmacy	√	√	--		
Patient room layout		√	—		
Visible, conveniently located sinks	—	—	√	—	
Patient lifts			—	√	√
Rooms to socialize (dayrooms, lounges, etc.)	√	√	—		
Acuity-adaptable headwalls			√	√	√
Neutral zones for interaction		√	—	—	
Natural light (morning light/sunlight)		√	—		
Lighting		√	—	√	√
Surveillance		√	√		
Views of nature		√	—		
Healing gardens (access for patients and employees)		√			
Artwork			√	√	
Spaces for families		√	—		
Flexible/movable furniture				√	
Solid walls in exam rooms or emergency room			√		
Air quality/ventilation system			—	—	√
Noise reduction			—	√	√
Furniture design (ergonomics)				√	
Reminder posters				√	
Soft floors				√	
Cart storage areas		√	√		

√ = important, — = necessary

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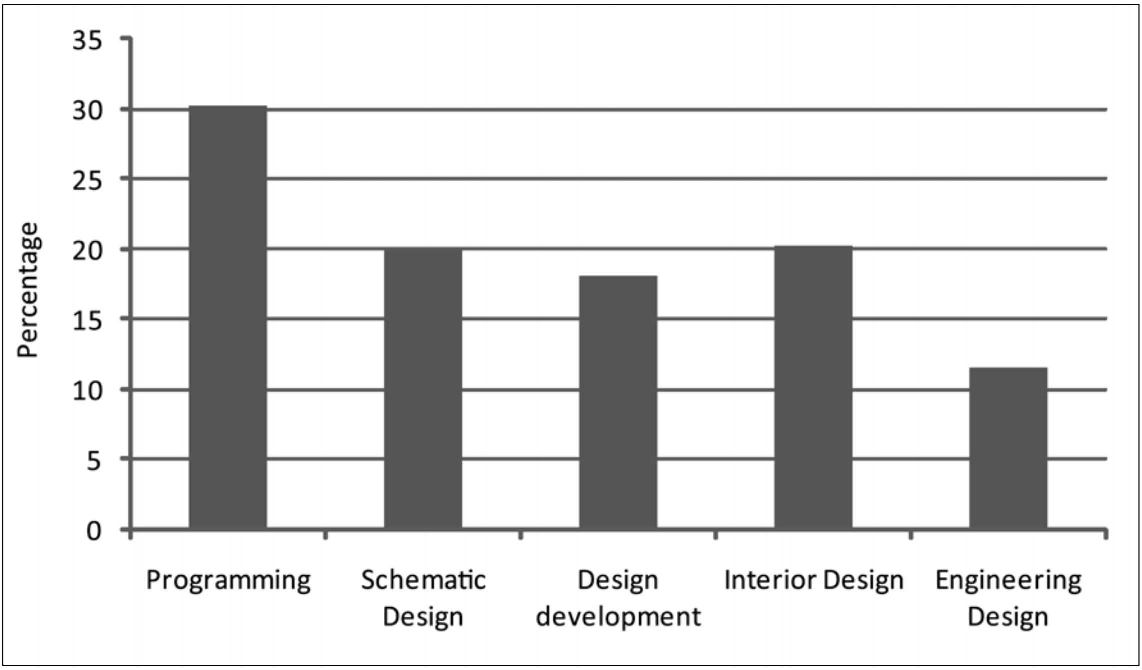

Figure 4. Phase-complemented available evidence as perceived by students.

development, 20% to interior design, and 12% to engineering design. This suggests a 20% return on investment in evidence examination for the students who were specifically dealing with the schematic design phase. (See Figure 4.)

Context and Precedence

The third noteworthy factor as it relates to the design phases is that evidence without a description of the context and precedence is perhaps less meaningful. Once an environmental factor or characteristic is identified by research as beneficial or detrimental to the quality of care, the designer's focus shifts from the evidence to the context and precedence. An architect is better served at this point if information regarding context and precedence is available along with the evidence. How was the issue dealt with by previous architects? What were the physical conditions? What are the cons of not responding to the issue? What was the impact of the design interventions? And so on. Although impact analysis and design interventions are not yet widely available, students appear to have determined that industry and trade magazines are more comfortable than scientific journals for examining precedence.

A comparative analysis of students' survey responses (Table 2) and the single-page evidence reports they produced (Figure 3) provide some interesting facts. In the survey, the students revealed that they had found more evidence (54%) from peer-reviewed journals compared to industry and trade publications (46%, see Figure 5). In

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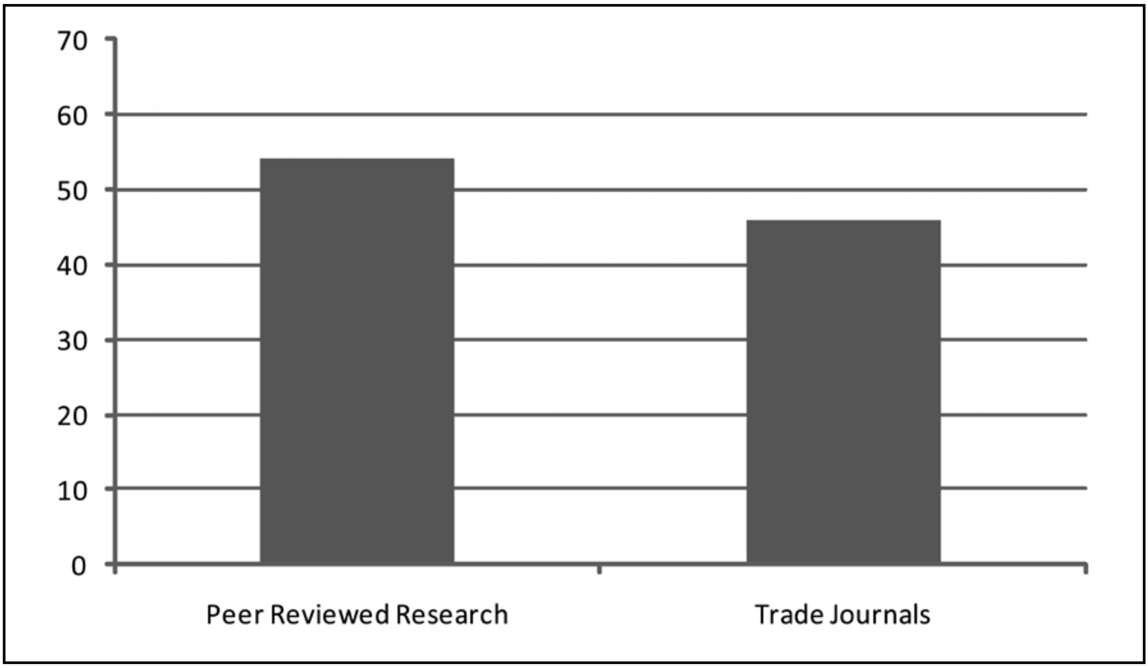

Figure 5. Sources of evidence collected by students.

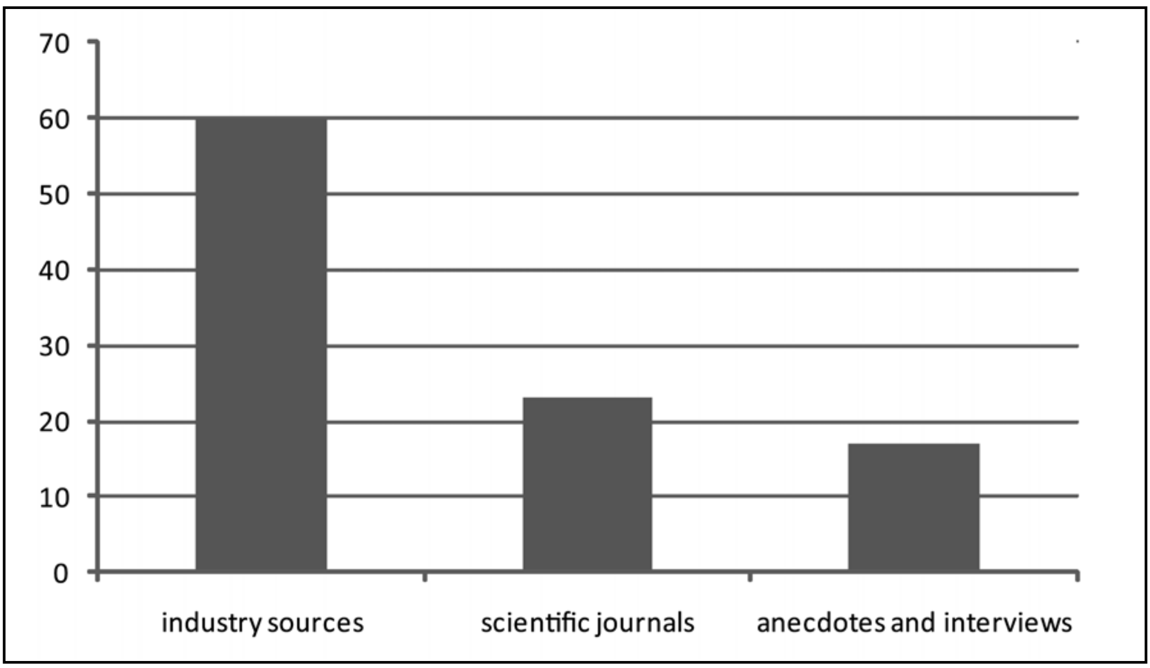

Figure 6. Sources of evidence used by students.

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Table 2. Results of the Student Questionnaire Survey

Questionnaire Item	Scale/Option	Mean Response
1. What was your knowledge level in healthcare design at the **beginning** of the studio?	0 = none; 10 = highest	1.75
2. What was your knowledge level in healthcare design at the **end** of the studio?	0 = none; 10 = highest	8.00
3. How easy was **collecting** evidence for design decisions?	0 = very easy; 10 = very hard	5.33
4. How easy was **applying** evidence for design decisions?	0 = very easy; 10 = very hard	5.50
5. What was the **source** of your evidence? Provide your estimate as a percentage.	Peer-reviewed research	53.92
	Architectural publications	46.08
6. In your opinion, what is the **percentage** of applicable evidence for the various stages of design?	Programming	30.17
	Schematic design	19.92
	Design development	18.17
	Interior design	20.17
	Engineering design	11.58

contrast, an examination of the 232 single-page reports that documented how evidence was translated to design proposals showed that 60% of the information was extracted from industry sources such as journals, trade magazines, books, and so forth, including the three books on EBD (Cama, 2009; Hamilton & Watkins, 2009; Malkin, 2008; compare Figures 5 and 6) that have endeavored to represent peer-reviewed evidence to an architectural audience in a user-friendly manner. Only 23% of the information was extracted from scientific journals. The remaining 17% was based on information gained from individual experience, anecdotes, and interviews.

This suggests a key challenge that designers face in translating research evidence, even when they perceive that they have found more evidence from scientific publications. Although the students extracted much scientific evidence from peer-reviewed research, they seem to have had difficulty translating it into design concepts or decisions.

Vocabulary

The students' greater comfort with industry and trade publications may be explained by the stark differences in vocabulary between design training and research. Knowledge representation through drawings and diagrams as they appear in professional journals, books, and trade sources, was more conducive to design learning in the studio. The students approached different sources selectively: scientific publications for evidence regarding the environment, and nonscientific sources for precedence analysis. Recent books on EBD

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are beginning to combine the scientific vocabulary of research evidence with the design vocabulary of architectural practice. For example, Malkin's book (2008) on EBD has a chapter on patient units that is presented in both words and diagrams, which serves as a possible direction for information representation. Designers think, analyze, and synthesize evidence visually. Thus, visual representation of research findings constitutes a prerequisite for greater and more appropriate use of scientific research.

Implications

This case study has numerous implications for EBD in professional practice. First, designers in professional firms, like the students in the studio, may encounter identical problems with comprehending the breadth of available information and filtering evidence that is pertinent to a project. Textual representations in a flat, hierarchical format, as in most scientific publications, may not be intuitive to designers and may not provide the best vehicle for extracting relevant information in a timely and efficient manner. The complex relationship between higher-order and lower-order issues, as well as between healthcare setting types and issues, needs to be articulated in a way that is accessible to a designer audience. Not to address this could result in a suboptimal designer-evidence relationship—and a constant drag on the momentum of the EBD approach.

A related aspect is one of a procurement phase-complemented evidence filtering system. Time saved in extracting information is directly proportional to financial savings. Thus, the quicker the search and retrieval system, the better the adoption rate of the EBD method. Currently some Web-based databases are available to access research information, such as InformeDesign (http://www.informedesign.umn.edu/) and the RIPPLE database (http://ripple.healthdesign.org/). It may be prudent to study how designers interact with such databases in a real-life project.

One fundamental concern, however, is information representation. The studio experience suggests that visual or diagrammatic representation of research evidence works significantly better than textual representation. It is noteworthy that in the absence of better options, the students sometimes worked backwards and used their own designs to illustrate what they had learned from text-based articles (Figure 3). This suggests the need for a radical rethinking of the way research information should be presented, and that considerable resources should be allocated to converting the current presentation format to a designer-friendly one.

From an academic perspective, topical studios represent a nontraditional approach. As more programs consider this studio instruction option, the three-phase format discussed in this paper (knowing a hospital, knowing the evidence, and designing with knowledge and evidence) may be an approach worth considering and examining. The student survey provides some encouraging results (summaries of the survey results are provided in Table 2). It revealed that students' per-

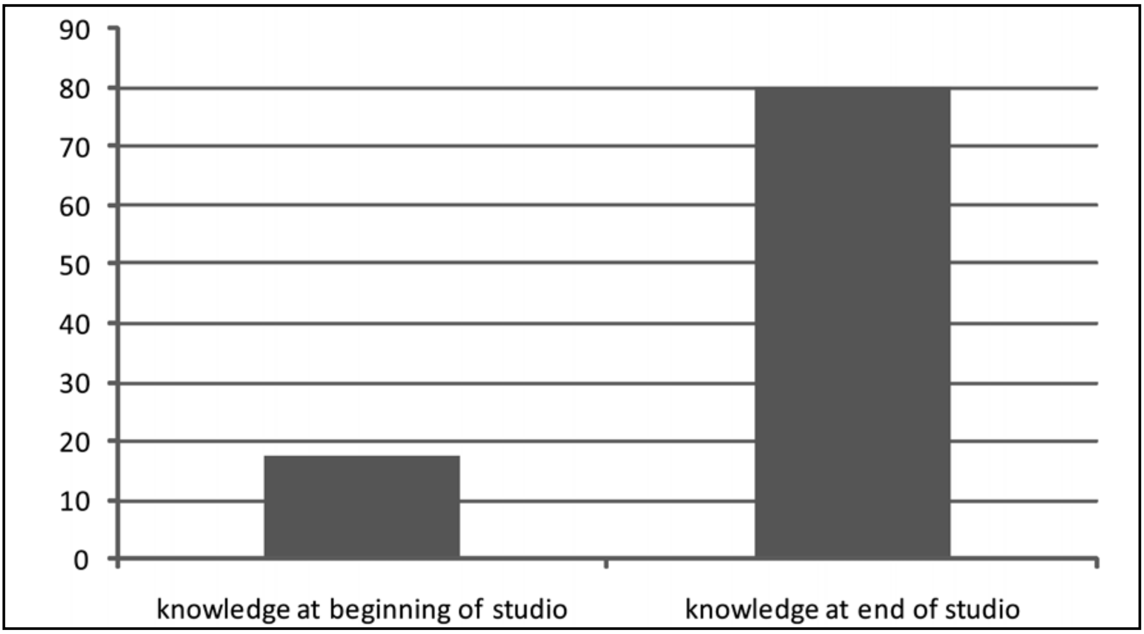

Figure 7. Growth of knowledge regarding healthcare design.

ceived knowledge about healthcare design grew overwhelmingly during the class, from 18% in the beginning to 80% at the end of the studio (Figure 7). Regarding the question of collaboration, 79% of the students agreed that it was an important skill to be learned at school. In the general comments section of the survey, too, there seemed to be a great appreciation of basing design decisions on scientific evidence and learning to work with others, especially in complex projects. The availability of experts to whom to direct questions was something many liked. Finally, a large number of students appreciated the fact that, although architecture is about creativity and the making of good forms, form and function may not be separate constructs; only by being sensitive to both can architecture be stimulating and successful.

Future Studies

The findings of this study should be viewed in context. It was conducted in an academic studio setting with a small sample of 12 students. From that perspective, this study is essentially a preliminary investigation rather than an explanatory study. Future efforts should focus on increasing generalizability by expanding the study to more design studios in more institutions, and enhancing validity by conducting the study in professional design firms.

Several important topics of academic as well as professional interest could not be addressed here, primarily owing to the study setting. One of the fundamental questions is the difference—if any—between a traditional experience-based approach to design and the research evidence-based

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approach in the final product. To study this, however, one needs a professional design office as the setting and one or more actual professional projects for data collection. This is because the outcomes of EBD are in operational domains such as length of stay, patient stress, staff stress, operational efficiency, medical errors, infection rates, and so forth. These outcomes are not evident until a facility is built. Thus, comparison of design outcomes between a traditional and an EBD approach is not feasible in a studio setting. Consequently, this study focused primarily on examining the research-design interaction (the process) as opposed to the product. Future studies can expand this domain of inquiry to other academic programs for greater relevance, and to professional settings to examine differences in the final product.

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