AN ETHNOGRAPHIC STUDY OF THE ROLE OF EVIDENCE IN PROBLEM-SOLVING PRACTICES OF HEALTHCARE FACILITIES DESIGN TEAMS

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AN ETHNOGRAPHIC STUDY OF THE ROLE OF EVIDENCE IN PROBLEM-SOLVING PRACTICES OF HEALTHCARE FACILITIES DESIGN TEAMS

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In memory of Deniz Şengel and Ahmet Eyüce…

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LIST OF SYMBOLS AND ABBREVIATIONS

AEC	Architecture-Engineering-Construction
BIM	Building Information Modeling
CAD	Computer Aided Design
CD	Construction Documentation
CON	Certificate of Need
DD	Design Development
EB	Environment and Behavior
EBD	Evidence-Based Design
EBM	Evidence-Based Medicine
ED	Emergency Department
EDRA	Environmental Design Research Association
IOM	Institute of Medicine
IT	Information Technologies
LEED	Leadership in Energy and Environmental Design
PHS	Private Health System
PHSP	Private Health System Hospital P
PHSC	Private Health System Hospital C
POE	Post-Occupancy Evaluation
SD	Schematic Design

SUMMARY

Progressive efforts within the healthcare design community have led to a call for architects to use relevant scientific research in design decision making in order to provide facilities that are safe, efficient, and flexible enough to accommodate evolving care processes. Interdisciplinary design project teams comprising architects, interior designers, engineers, and a variety of consultants struggle to find ways to deal with the challenge of incorporating the evidence base into the projects at hand. To date there has been little research into how these interdisciplinary teams operate in the real world and especially how they communicate and attempt to integrate evidence coming from different sources into the architectural design that is delivered. This study presents an investigation of a healthcare design project *in situ* by using methods of ethnographic inquiry, with the aim of developing an enhanced understanding of actual collaborative healthcare design practices. A major finding is that ‘evidence’, as used in practice is a richly textured notion extending beyond just the scientific research base.

The description and analysis of the observed practices is presented around two core chapters involving the design process of 1) the emergency department and 2) the inpatient unit. Each design episode, which depicts the complex socio-cognitive landscape of architectural practice, introduces how evidence, with its various types and representational forms, was generated, represented, evaluated, and translated within the interdisciplinary design team. Strategically utilizing various design media, including layout drawings and mock-ups, the architects represented and negotiated a set of physical design attributes which were supported by differing levels of scientific research findings, anecdotes, successful precedents, in-house experimental findings, and intuition, each having different affordances and constraints in solving design problems over time.

Individually, or combined into larger “stories” which were collectively generated, the set of relevant evidence provided a basis for decision making at various scales,

ranging from minor details within rooms to broader principles to guide design work over the course of the project. Emphasizing the role of the architects in translation of evidence, the design episodes provide vivid examples of how various forms of evidence shape the design of healthcare environments.

The case observed in this research demonstrated that the participants formulated and explained their design ideas in terms of mechanistic arguments where scientific research, best practices, and anecdotal evidence were integrated into segments that formed causal links. These mechanistic models, as repositories of trans-disciplinary knowledge involving design, medicine, epidemiology, nursing, and engineering, expand the scope of traditional understanding of evidence in healthcare design. In facilitating design processes architects are required not only to become knowledgeable about the available evidence on healthcare, but also to use their *meta-expertise* to *interpret, translate (re-present),* and *produce* evidence in order to meaningfully engage in interdisciplinary exchanges. In re-presenting causal models through layouts or mock-ups, architects play a critical role in evidence-based design processes through creating a platform that displays shortcomings of available evidence and shows where evidence needs to be created *in situ*.

CHAPTER 1

INTRODUCTION

1.1 The Context

Recent collaborative efforts in the healthcare industry, involving healthcare providers, designers, non-profit organizations, and healthcare environments researchers, are transforming the traditional ways of delivering healthcare and the ways of designing environments where care processes take place (Agency for Healthcare Research and Quality, 2007; Horwitz-Bennett, 2011; Yundt, 2009; Zimring, Augenbroe, et al., 2008; Zimring & Bosch, 2008). The medical and architectural literatures demonstrate that the physical environments housing people, processes and equipment are vital and inseparable components of care (Kohn et al., 2000; Ulrich et al., 2008; Verderber, 2010). There have been changes not only in clinical processes, but also in the physical features of healthcare environments in order to support and enhance the care delivery processes. The proponents of the ongoing transformation of healthcare advocate an integrated approach that emphasizes all aspects of care including processes, physical environments and technologies in order to achieve better clinical outcomes in safe and efficient environments. (Agency for Healthcare Research and Quality, 2007; Ulrich et al., 2004; Zimring, et al., 2008). The progressive efforts within the industry have led to an increased interest in using relevant scientific research in everyday decision making concerning the design of physical features within healthcare facilities, thus the term "evidence-based design" or EBD (Hamilton, 2003; Zimring & Bosch, 2008). EBD paradigm promotes the vision that academic caliber investigations providing scientific evidence are to guide decision making processes in healthcare design and construction projects.

The transformation of healthcare has already begun to change building procurement processes in the healthcare industry. Healthcare organizations today try to adopt and adapt the latest research findings to provide facilities that are safe, efficient, and flexible enough to accommodate evolving care processes. Two recent trends in particular that mark a significant departure from the traditional ways of designing healthcare facilities have become evident. The first is the “integrated project delivery” approach which “brings the full building team to the table at a project’s inception, where common goals are established, risk is collectively managed, and each professional’s expertise is fully utilized to improve efficiencies, innovation and constructability” (Horwitz-Bennett, 2011: p. 28). The major benefit of enhanced interaction in integrated project delivery is to accommodate simultaneous and continuous input from all disciplines involved in the project from the first envisioning to the final construction phases.

The second trend is the utilization of knowledge from a variety of research domains concerning spaces, people, operational processes, and equipment. As indicated by literature reviews (Ulrich, et al., 2004; Ulrich, et al., 2008), there is a growing body of scientific studies providing high quality evidence that can guide interdisciplinary healthcare design teams throughout the phases of a construction project. Such research- or evidence-based design approaches are becoming a common practice, particularly in the United States where healthcare “embarks on a new era of value-based care” (Hrickiewicz, 2012) to face the challenges of the higher health care utilization by younger people, as well as an aging population (Zimring & Bosch, 2008). In a cross-cutting survey conducted of the healthcare design industry, 82% of the respondents, mainly architects and interior designers, indicated occasional or regular use of research drawn from a variety of disciplines (Taylor, 2011).

Integrated project delivery methods and the tendency to utilize research, in addition to routine complexities such as budget and time constraints or specific programmatic requirements, create a sophisticated socio-cognitive and material environment for healthcare design teams. There has been very little academic investigation into how these interdisciplinary teams operate in the real world and especially how they communicate and attempt to integrate evidence coming from different sources into the architectural design that is ultimately delivered. This study presents a long-term observation of a healthcare design project *in situ*, using ethnographic research techniques, and has the aim of developing an enhanced understanding of evidence-oriented healthcare design practices.

1.2 Problem Statement

Hospitals are, typically, complex buildings housing a chain of interrelated departments, a range of professionals, elaborate processes to deliver services, and equipment that is vital to care. Furthermore, the integrated systems, consisting of spaces, people, processes, and equipment, constantly evolve as new technologies and care methods are being introduced. Designing a hospital, therefore, is a sophisticated process, related to both the intrinsic features of collaborative design work and the progressive nature of healthcare industry and its tools, methods and processes.

This complexity is acknowledged in the architecture, engineering, and construction (AEC) industry. It is common in large architecture firms in the U.S. to have separate and sometimes autonomous studios focusing only on healthcare design operations. The significant attention paid to this special typology creates and reinforces the field of healthcare design as an esoteric sub-culture within the larger context of design. With its professional degree programs in schools of architecture, its specialized journals and magazines, its top design firm rankings and award programs, healthcare design today has its own "community of practice" (Wenger, 1999).

The healthcare design community is far from being homogeneous in terms of individuals participating in it, although the title implies involvement of a family of design-related disciplines. Considering the evolving complexity concerning spaces, people, processes and equipment, bringing an up-to-date hospital building into existence is beyond the capabilities of an individual, or even a few individuals. Today, starting from the visioning phases, it has become necessary to use multidisciplinary teams comprising of designers, healthcare experts, systems or process engineers, consultants, and even end-users to inform design decision making. According to Hamilton, contemporary healthcare design is "powerfully influenced" by the contributions of practitioners from various disciplines (Hamilton, 2003). How these practitioners, with their distinct approaches, methods, and tools influence the design of physical environments in the context of healthcare design is complicated and varies from project to project. In addition, because the integrated project delivery approach requires all participants to coordinate and communicate their contributions in a timely manner, another layer of complexity is added to the social, cultural, and material environments of healthcare design practice.

The interdisciplinary teams in industry typically include clients or client representatives, healthcare planners, designers, engineers, contractors, and consultants who may be contracted by clients, by design firms, or other organizations involved. Occasionally, user and patient representatives also engage in design work in order to try to deliver the best design solution to improve health and operational outcomes. The task of these interdisciplinary teams, then, is to merge the ideas and (evidence-based) recommendations of participants who bring a variety of resources, opinions, and experiences into extended design discussions, and to solve design problems that might differ considerably for each hospital, unit or room.

Another important dimension of healthcare design is the desire to develop innovative practices that will be broadly influential in the design of physical environments. The competitive nature of the healthcare market requires that healthcare organizations seek out more efficient and effective processes and more patient- and staff-friendly environments that lead to improved safety, efficiency, and satisfaction outcomes. In order to arrive at better solutions, the interdisciplinary healthcare design teams seek out research and established best practices in the industry. Occasionally, the research results emerging from the healthcare field, from different domains of inquiry, or from case studies of best practices in the healthcare industry provide teams with options that can be crucial to improving and marketing their ongoing design work. Another category of challenge for design teams is navigating this stream of information, to conduct evaluations concerning validity, applicability, and cost, and to translate elements of available evidence into design.

Most teams benefit from internal and external experts or consultants to find ways to deal with these challenges as they apply to the specific projects at hand. In addition to consultants typically hired for projects in the AEC industry, healthcare projects employ professionals with specific expertise in spaces, processes and technologies, each contributing significantly to the design of healthcare delivery systems. In general, these experts are individuals who are connected to the broader community of healthcare design practitioners, and have the ability to *access* and *translate* relevant information to the rest of the team, playing a central role between participants with different disciplinary backgrounds. There are multiple ways that these research-oriented professionals engage in projects in healthcare design practice. In some occasions, architecture firms, who have their own in-house experts, may bring in their own set of consultants. Clients, on the other hand, may prefer to "unbundle" the set of consultancy services and structure their own interdisciplinary teams (American Institute of Architects, 2008: p. 852). How these consultant groups engage in a given project, how they are rewarded, and how responsibilities are distributed change from one project to the next.

In addition to usual participants in architectural design projects, particularly within healthcare design, the role and contributions from users of future buildings (i.e., hospital staff and patient representatives) are also recognized. However, the rules of user engagement, negotiation strategies, and the issues concerning the utilization of what is being produced through these interdisciplinary interactions varies from one project to another. Even in an era of accelerated and continuous change and the trend toward evidence-oriented practices, users' engagement and the contributions to cultural and architectural interventions within interdisciplinary design processes is yet to be empirically investigated.

While individuals from a range of disciplines have for some time been part of design teams, architects are the ones expected to process and translate all sorts of emerging concepts into concrete designs for physical environments. However, our knowledge about these *translational* processes is very limited. At present we only have anecdotes and brief narratives on how knowledge gleaned from scientific research or ideas developed through interdisciplinary collaboration inform design work to improve healthcare delivery processes. How individuals within interdisciplinary teams communicate, negotiate, solve problems, and deliver these complex architectural structures remains as a challenging question. The proposed research will explore the nature of interactions occurring among individuals with diverse backgrounds in the context of healthcare design practice by tracking the activities of an interdisciplinary team *in situ*. More broadly, this study aims to explore the little-understood between design and research within actual practice of architecture.

1.3 Research Questions

The questions that I plan to pursue in this research are:

1. What is the nature of the research-design relationship in the context of healthcare design?

    a. How is evidence represented by different communities within the socio-cognitive landscape of architectural design?

    b. How do those representations afford, constrain, or impede problem solving in context?

    c. Do those representations support and sustain interdisciplinary interaction? And, if so, how?

2. How are various forms of evidence being transferred/produced, negotiated, propagated and translated within interdisciplinary design teams?

Briefly, the first question and associated sub-questions indicate an investigation of where the evidence is in situated practices, of how various representational forms of evidence are employed within instances of design decision making. The second question, on the other hand, involves studying translational processes within interdisciplinary teams. This dissertation aims at providing detailed descriptions of instances of interdisciplinary exchanges involving people, representations, and tools, through which the environments of a future healthcare facility is shaped.

1.4 Structure of the Dissertation

The current dissertation is organizaed into 8 chapters. Chapter 2 sets the stage for this investigation by presenting a background involving three domains. The first sub-section in Chapter 2 provides a brief introduction to “the utilization gap” which has been a topic concerning research and practice in architecture since 1960s. The second sub-section accounts for evidence-based design (EBD) which is introduced as a framework to infuse scientific research findings into design decision making. The third sub-section in Chapter 2 presents the approach employed by this study to characterize and investigate interdisciplinary problem solving in architectural design. Chapter 3 introduces the methods employed in this study, and provides descriptions of the firm and project observed through field work. A set of frequently used concepts in this dissertation is then introduced in Chapter 4. The descriptions of these concepts are grounded in the field observations conducted in this study, and presented in order to guide readers through subsequent chapters. Chapters 5 and 6 present the two core descriptive episodes for this study. The two chapters, one on the design process of the emergency department and the other on the inpatient unit of the future hospital, involve descriptions of a series of design decision making processes. Chapter 7 discusses the framework of evidence-oriented practice in the light of the descriptions provided in earlier chapters. Finally, Chapter 8 concludes by summarizing the findings of this dissertation and provides recommendations.

CHAPTER 2

BACKGROUND

Three areas provide a background for the set of research questions that are pursued in this study. The first sub-section will present the relationship between research and design, as it has been developed in literature, accounting for the issues around environment-behavior oriented research and its utilization. The second briefly explains evidence-based design, an emerging approach within healthcare design community. The third section will summarize the body of research literature on collaborative design efforts and interdisciplinarity. The third section will also provide a framework for an approach to study collaborative problem solving in context.

2.1 Research and Design

The crisis does not result merely from problems but from the feeling of proceeding down a blind alley. New generations of architects lacked significant, systematic knowledge of any of the sciences prerequisite to learning how space ought to be devised in order to obtain desired space impressions and to accommodate the spaces' social use (Ankerl, 1981: p. 2).

A vast body of research engages the history, theory, and technology of architecture. Here, ***research literature***, is restricted to the body of work on the "man and environment relationship" (Zeisel, 1975), with specific reference to environment and behavior studies. By definition, environment and behavior, which was mainly developed after the 1960s, is an interdisciplinary field of research concerned with the interactions between people and their natural and technological environments (Bechtel, 1997). Providing a finer-grained definition might introduce some problems since, currently, there are at least three theoretical approaches offering competing formulations of the larger field of environment and behavior (Canter, 1997).

The frameworks and methods that researchers employ are wide-ranging, but when it comes to the programmatic goals, the spectrum is narrower. One of the prime goals of environment and behavior research is to provide design professionals with the tools to create a better fit between people, space and activities. However, the gap between theory and practice and between researcher and design practitioner has been one of the most frequently mentioned issues since the emergence of the field (Bechtel, 1972; Becker, 2007; Reizenstein, 1975; Seidel, 1982; Sommer, 1997; Zeisel, 1975, 2006).

2.1.1 Environment, Behavior, and Design

Zeisel (1975) briefly summarizes the emergence of research efforts during 1960s by “self-styled” researchers in different fields including anthropology, psychology, and sociology. Based on the background disciplines of researchers involved, several names have been utilized to classify the set of inquiries being pursued. Zeisel (1975), for instance, called it “man-environment relations,” whereas, according to Proshansky et al. (1970), it is the field of “environmental psychology” encompassing the study of man and his physical setting. Eventually, “environment and behavior” emerged as the “eclectic field,” according to Bechtel (1997), absorbing contributions from relevant disciplines. Similar to Moore’s categorization (1997), I will use “environment-behavior” (EB) research to refer to the body of studies emerging from various fields including environmental psychology, behavioral and social geography, environmental sociology, social and behavioral factors, exploring the interaction between humans and their natural and technological surroundings. The Environment and Behavior Journal, the flagship publication in this domain, notes that the field brings interdisciplinary perspectives through research reporting rigorous experimental and theoretical work focusing on “the influence of the physical environment on human behavior at the individual, group, and institutional levels.” One of the main tenets of EB research, according to Bechtel (1997), is to "create new and useful research findings" to be utilized in a range of other disciplines including design.

Gifford et al., write that "the dream of improving environmental design by collecting and examining the results of independent studies is as old as the field of environment and behavior" (Gifford et al., 1997: p. 223). The necessity and the potential of the relationship between research and design has been mentioned frequently in the literature since the early 1960s (Kuo, 2002; Reizenstein, 1975; Sommer, 1997; Zeisel, 1975). The issue, as an intellectual problem, became apparent within both the domains of research and practice during the dawn of "man-environment relations" studies (Zeisel, 1975). Referring to the early efforts to link the two domains, Sanoff and Cohn briefly summarized the emergent interdisciplinary collaboration that occurred between researchers and designers:

> *Faced with increasingly complex environmental problems which defied satisfactory solution, a few designers came to realize that both their traditional problem solving methodology and their knowledge of the man-environment system was highly inadequate. They realized that their training as designers left them un-equipped to understand the problem or to develop effective solutions. Seeking to improve this state, they sought the assistance of scientists, for example in psychology, sociology, anthropology, medicine-all concerned with the study of man.*
> *…Fortunately, however, they found a few scientists interested in studying this problem area.* (Sanoff & Cohn, 1970: p. V)

Although Sanoff and Cohn reflect a designer-dominant point of view, the majority of actors who tried to advance knowledge concerning the relationship between people and built and natural environments were academics coming from other disciplines. Following the fertilization of man-environment oriented research in various fields, the efforts of scholars led to a period of "convergence of disciplines," as Bechtel calls it, where the critical mass of studies had reached "a high level of practical knowledge" (Bechtel, 1997: p. 76). As knowledge emerging from field studies accumulated, the new sub-areas began to flourish, addressing particular issues including crowding, way-finding, environmental quality (Bechtel, 1997). Researchers utilized various tools to evaluate physical environments and to survey users in order to gauge the performance of buildings. Environmental Design Research Association (EDRA) conferences, initiated in 1969, made a set of approaches, methods and findings available to all interested parties including researchers, design practitioners, and facility administrators. Although the field has evolved significantly over the decades, EDRA conferences have drawn significant attention, and have remained one of the main venues to present, discuss and disseminate methods and research findings (Bechtel, 1997; Becker, 2007).

In the earliest research, academics, often social scientists, typically studied building types to which they had easy access, such as public housing, student dormitories and office spaces, and published their findings for a mainly academic audience. Studies were often conducted as unique, stand-alone evaluations (Zeisel, 1975; Zimring, 2002). The body of research was presented under the banner of *post-occupancy evaluations* (POEs) which were seen as a way to convey knowledge about existing buildings to inform both managers and practitioners about certain relationships between users and their physical environment. Data emerging from such evaluations is used to develop benchmarks, design guidelines, and guide-plates which are template-like floor plans for individual room types or parts of buildings (Zimring, 2002). Ultimately, the research reports and academic publications coming out of building evaluations, prepared mostly by multidisciplinary teams, try to provide useful information to be utilized by designers in design or renovation processes. As Zeisel denotes, post-occupancy evaluations hold "special potential for building a body of tested EB knowledge" (Zeisel, 2006: p. 64). In addition to the practical knowledge emerging from building assessments, as the field of EB developed over the years, POEs also became tools for testing hypotheses and innovations concerning the relationship between people and their physical environments.

Expanding its traditional assessment models, POEs are now perceived as critical “feeding forward” mechanisms aimed at informing future practices (Zimring, 2002).

In addition to the tradition of building evaluation in EB research, there are also other kinds of formal studies providing evidentiary support for the ideas to be adopted in the design of physical environments. In a recent article, for example, Pati (2011) summarizes the experimental, quasi-experimental, and qualitative studies which provide a rich source for decision making in the field of healthcare design.

Pati mentions the set of challenges to conducting experimental studies in healthcare environments, and refers to “natural experiments” that attempt to find “naturally occurring variations between settings” (Pati, 2011: p. 54). As an example to “natural experiments” where “attributes of the environment other than the environmental element of interest, processes, and users are identical between settings,” Pati refers to Ulrich’s (1984) frequently cited study on the link between the features of the physical environments and medical outcomes. The hypothesis in Ulrich’s paper is that patients having rooms with views to nature will recover more quickly from surgery when compared to the ones having a view of a solid brick wall, which is not considered as a positive distraction for patients. The causal argument is that the natural scene view had affected patients’ emotional states positively, thus leading to shorter recovery periods (or length of stay in the facility). Ulrich influenced and fueled more research studies that depended on similar causal arguments and demonstrated scientifically rigorous methodologies.

Pati also describes the quasi-experimental studies that are commonly utilized in studying actual environments where the set of controlled variables is limited compared to experimental studies. The before-and-after studies, in which researchers collect and compare two sets of data based on same measures, are examples of such quasi-experiments. Since an array of intervening factors, including physical environment features and processes, may change between the old and the new setting, there is always room for alternative explanations in these kinds of studies. According to Pati, while "these studies are weaker for examining causation, and they warrant logical arguments on a case-by-case basis to identify and eliminate alternative explanations," they "constitute a rich source for exploring and identifying new phenomena or relationships between built environment and outcomes related to people and processes" (Pati, 2011: p. 57). Quasi-experimental approaches continue to be undertaken, particularly in healthcare environments research.

Another type of inquiry providing evidentiary support for design is the qualitative research. Through interviews, focus group discussions, field observations, and other methods, qualitative research has the potential to explain some phenomena, such as flexibility (Pati, Harvey, et al., 2010), that might hold different meanings to different groups in the industry. The usefulness of qualitative research to inform design has been acknowledged in the EB literature (Johnson & Barach, 2008; Zeisel, 2006). For example, Johnson and Barach (2008: p. 191) emphasize the appropriateness and value of qualitative studies in the healthcare design context:

> *Health care is provided in complex environments with intricate webs of relationships, which represent the multiple interactions with people, information, technology, culture, and the physical environment in which the care is provided. Qualitative research methodologies can play an important role in health care design as they can provide contextual data about health care settings—specifically the people, processes, and patterns that make up the daily work of providing health care.*

2.1.2 EB Theories

What is being produced within the domain of EB studies, by different methods, varies in terms of form and scope. Moore, for instance, discusses four different levels of theoretical constructions in the field of EB research and the potential links to design theories (Moore, 1997). According to Moore, in a nested hierarchy, the field now operates within a system comprising of worldviews, frameworks, models and theories.

Explanatory theories within the field of EB, based on Moore's classification, are the smallest theoretical constructs and are "systematic and testable constellations of concepts explaining aspects of behavior in relation to aspects of environment" (Moore, 1997: p. 14). Alongside ***big T theories*** that are "intended to account for a wide range of data" ***and little t theories*** that are "coherent and explicit theories that do not attempt to stretch beyond the substantive subdomain of phenomena," Moore puts special emphasis on a type of theory, ***theories of the middle range***, which are the intermediate constructs between localized theories and grand theories. Moore contends that the EB community needs to be focusing on developing integrative middle-range theories (Moore, 1997: p. 35):

> *Conceivably the time is ripe for the development of the construction and test of theories of the middle range, working upward from more particular, little t theories toward middle-range integrative theories, toward the unification of principles.*

Moore's conceptualization, following Merton's work (1968), captures a certain line of production within the field of EB while it also accounts for the utilization of the knowledge that emerges from it. The middle range theories that Moore mentions are strategic constructs that have permeated both research and design following their development within the field of EB. On research side, a certain level of abstraction is possible for the middle-range theories allowing them to link to other theoretical constructs, whereas they also have the flexibility to permit empirical testing through field research. The strategy adopted by many researchers in the field is to develop theories of this kind, and consolidate them over time and across case studies. Empirical testing for middle-range theories, on the other hand, creates opportunities for "sufficient applicability to make their claims useful within a discipline" (Groat & Wang, 2002: p. 80). The empirical results emerging out of field studies, then, provide evidentiary support for design practitioners in their everyday decision making. These integrative properties make the middle-range theories a special class of theoretical constructs that draw attention from both research and design domains.

The literature reveals a debate over whether efforts to classify and organize existing EB knowledge and to make it more useful to design practitioners have been successful. It is clear, after more than thirty years of progress, that the field has accumulated methods, findings and theories. EB supporters claim that this intellectual output has “profoundly influenced the practice of architecture, design, landscape, and planning through practitioners who have either directly studied it or who are more aware of popular trends towards people-centered, and evidence-based design” (Zeisel, 2006: p. 13). However, doubts about the utilization of EB knowledge have been repeatedly mentioned in the literature (Cole & Cooper, 1988; Kuo, 2002; Seidel, 1982). On theory side, as Kuo (2002) clearly depicts, some critics have professed the idea that “the twain shall never meet” concerning the gap between research and design. The emphasis in this argument is that the social sciences, with their different conceptualizations and methods, are “inherently unsuited to informing practice” (Kuo, 2002: p. 336). This skepticism and criticism has been sustained by both academics and practitioners within the field over the years.

2.1.3 Utilization

The limited interest of designers in utilizing research has often been mentioned in the literature, as “repeated efforts have been made by the profession both to filter and repackage information in order to make it more easily usable as well as to restructure architectural education in order to make designers more scientifically literate” (Cole & Cooper, 1988: p. 110). Even though designers are considered the target community to consume research findings, there is a significant number of cases reported in the literature that shows that designers “do not engage with research findings in a meaningful way and rarely apply them in practice” (Robinson, 2001: p. 69). The main strategy that designers employ during design processes is reported be that of depending on their own experience and expertise (Tetreault & Passini, 2003). However, it remains to be empirically determined what knowledge beyond the designer's own experience that is considered as legitimate.

Architecture and the EB studies are not the first or the only fields suffering from the applicability gap, or from the utilization problem in general (Seidel, 1982). Concerning the issues around research utilization in policy making for example, there is a deeper and more elaborate literature that examines the disparities between the "two communities" that has emerged since the 1970s (Caplan, 1979; Jacobson, 2007; Rich, 1981). These studies have dissected the issues around knowledge utilization, and provide a rich theoretical foundation for work in both public policy and other disciplines such as design. Based on what has been documented in the knowledge utilization literature over the years, Seidel (1982) identified three main areas of concern that can improve the divide between the two communities of research and practice. First, there is the group of issues concerning the difficulties in developing effective communication between the two communities. Referencing both to social and cognitive factors that are part of communication, there are studies that account for an array of problems concerning the ways individuals or groups present, disseminate, and translate knowledge between research and practice (Seidel, 1982). Reizenstein (1980), for example, refers to some "costly" techniques for EB researchers to convey their findings to practice. According to Reizenstein, improving the language of presentation or employing multiple modes of presentations including photographs, floor plans and narratives, will make information more accessible for the consumers of EB research (Reizenstein, 1980).

There is also a set of studies that put emphasis on solving the linkage problem between the two communities. Mostly concerned with social factors, these studies offer more active ways of transferring knowledge to practitioners, such as employing information transfer specialists who take on the role of "middle man" between the two communities (Seidel, 1982). Everett Rogers, a prominent scholar in knowledge transfer and exchange research, elaborates on the social aspects of knowledge utilization and speaks about "change agents" who are extremely influential in decision making processes and in the adoption of innovations (Rogers, 1995: p. 335). In the AEC industry, the existence of these "change agents" is evident. Hamilton et al., for instance, emphasize the critical role of research staff, those holding PhDs in architecture, psychology, nursing, marketing, within architecture firms in the United States (Hamilton et al., 2010).

The third issue concerning knowledge utilization is the lack of frameworks that govern the collaboration between researchers and practitioners (Seidel, 1982). The argument holds that, without ignoring the social and cognitive factors of communication and the linkage theories mentioned above, collaborations should allow for a more "sensitive perception of needs and limitations, the mutual identification and definition of problems, and increased awareness of the unique perspective of both groups" (Seidel, 1982: p. 22). However, the literature on how and when to facilitate collaborations between researchers and practitioners is still very thin.

In addition to the three areas concerning knowledge utilization issues, there is another dimension to this issue which is currently visible in the healthcare industry. In order to improve their performance and stand out among competitors, organizations today often turn their attention to innovations. Competition in markets, local and global, requires organizations to implement such innovations, sometimes without critical and rigorous testing. Occasionally, the multidisciplinary teams, with limited opportunities for research due to time and budget constraints, are forced to make high-risk and high-cost decisions without any kind of empirical support. There are examples in the healthcare design industry of such implementations, ranging from incremental improvements to revolutionary changes involving major shifts to new technologies and processes. The adoption of 'same-handed rooms,' for instance, is one of the major innovations in healthcare design of the last decade. The follow-up research on the impact of its implementation, however, proved to be inconclusive as to whether or not it is beneficial (Pati, Cason, et al., 2010; Pati, Harvey, et al., 2010). Confusion and inconsistency in industry is evident by the fact that two prominent healthcare organizations in the United States recently implemented same handed rooms, one with left-handed approach, the other right-handed. Thus, the investigation of everyday decision making in multi-disciplinary design teams within an innovation-driven industry remains an important area yet to be empirically studied.

Although it has been more than three decades since Seidel presented an analysis of research-practice collaboration, the issues he mentioned have persisted in the field of design. Zeisel (2006), for instance, acknowledges the problems raised by Seidel and proposes a model of collaboration that responds to all problems associated with communication, linkage, and cooperation. Zeisel's utilization model is intriguing in the way it accounts for various levels of cooperation by focusing on material and social aspects of collaboration, rather than focusing on isolated problems of social or cognitive dimensions. Following the model, Zeisel provides examples of multi-disciplinary teams, including designers, researchers and "a middle-man" between design and research, negotiating, formulating and solving complex design problems through using a set of hybrid representations, such as annotated plans, that have the ability to combine perspectives of both designers and researchers. According to Zeisel, the teams in industry need to use or develop particular techniques to help participants with different disciplinary backgrounds develop a shared image, which eventually allows contributions from each member throughout different phases of design work (Zeisel, 2006).

The literature also suggests more specific models of knowledge utilization such as research-based or evidence-based design approaches. Within particular architectural typologies, such as educational or healthcare environments, relevant information is sometimes transformative in design decision making. Over the past decade, evidence-based design has become *de rigueur* in industry. The theory of utilization in the evidence-based design approach, however, lags behind its practice. Only recently, comprehensive frameworks are being published to guide knowledge utilization in evidence-driven design processes (Pati, 2011). The compatibility between utilization frameworks and actual design practices in AEC industry, in theory versus in practice, is yet to be empirically studied.

2.1.4 Precedent Work on Research Utilization in Design

Throughout the literature, cooperation between research and design emerges from the need to understand and respond to constantly evolving parameters concerning people, activities, and physical environments. In order to "solve more broadly defined problems than they can solve alone" (Zeisel, 2006), communities of research and design seek support from neighboring disciplines in addition to their own toolbox of solutions. In that sense, complex contemporary practices (i.e., designing a hospital) require teams to include a range of consultants from a variety of disciplines. The research-based or evidence-based solution strategies are gaining support in order to mesh research results with the body of practical knowledge in industry.

Healthcare design is a field where the research on relationships between people, processes, equipment, and environments is particularly important, since the integrated practices within healthcare environments determine, in most cases, the success of care in those environments. The evidence-based approach is growing in popularity in contemporary healthcare design practice in order to improve healthcare-related outcomes, although, as mentioned previously, historically "the implementation gap" has been the most persistent issue in EB literature (Becker, 2007; Carpman, 1983; Reizenstein, 1975; Sommer, 1997). The idea of making use of evidence draws attention for all interested parties, including designers, researchers, or client organizations and generate a growing interest on research to be utilized in design processes of future healthcare environments.

Several researchers have reported cases of collaboration, involving a range of building typologies, between researchers and designers in actual practice. Zeisel, for example, reports brief case studies of research-design cooperation to illustrate particular strategies to be employed by the multidisciplinary teams in industry. The methods of collecting data and forms of presenting information to designers are two main issues that Zeisel deals with in his book. Although he clearly depicts of the processes of generating and presenting meaningful information to design teams, Zeisel's cases provide very little insight about how that information has been evaluated and translated into ongoing design work. For example, Zeisel illustrates a case where designers had incorporated many concepts, such as way-finding, privacy and personalization, into the design of an Alzheimer Care Center (Zeisel, 2006). The case study documents the physical environment features alongside the set of ideas behind the design of environments aimed at augmenting residents' activities in those spaces (Zeisel, 2006: p. 380). However, the input-output presentation of the case, covering the information input and the design output, omits any analysis of the challenging processes in between, where teams, including clients, users, researchers, and designers negotiate, utilize and translate an array of knowledge throughout the process.

There are also individual articles examining, qualitatively and quantitatively, the information or knowledge use of designers in context. For instance, Tetreault and Passini (2003) interviewed fourteen practicing architects on their information sources, types and use during the design of nursing homes. The researchers reported that the architects of the study used few sources of information, which were mostly related to technical and functional requirements, ignoring the special issues concerning the typology they were designing, such as residents' particular needs within those spaces. Furthermore, the information they utilized was mostly dependent on the expertise of individuals, the client, and the functional and technical program prepared by the local authority. Due to factors such as time constraints or accessibility, the designers relied on their expertise and on whatever sources are available to them, such as the brief and clients' comments. Although most architects in this study reported that they viewed the search for information as an "essential" process in design, they were not "trained to do it," or did "tend to get bored pretty fast" during the search (Tetreault & Passini, 2003: p. 53). Some architects in this study also left it to others (client, local authorities, or a third party) to deal with information emerging from "the research sector." One alternative, according to them, is that "the information coming from the research sector could be digested and made accessible by the client and the government, whether in written form or through the presence of a resource person familiar with recent advances in the field" (Tetreault & Passini, 2003: p. 53). Although the designers in the study seldom consulted research, "they expressed a desire for supplementary information" which was "assimilated into designers' terms" (Tetreault & Passini, 2003: p. 48).

The insights provided by Tetreault and Passini are extremely valuable in understanding the knowledge base of architects and attitudes towards information and research in actual practice. However there are two important limitations to their study. First, although the researchers clearly list the internal and external sources of information for designers, the nature of the translation process, from source to design work, remained unexplored since it was intentionally eliminated from the scope of their study. The findings presented by Tetreault and Passini rely on post-process interviews during which researchers and designers tried to reconstruct the design process they have experienced. Eventually, the account falls short in informing us about the particularities of the utilization processes where, for example, the designers assigned different weights for information emerging from different sources. The article is not informative about the set of information (i.e. individual expertise versus information conveyed from other sources) which was influential in shaping certain physical features within those therapeutic environments such as nursing stations. Second, the participants involved in this research were the principal designers of each project. Arguably, focusing only on senior designers might omit an array of resources, embedded in designers' daily practices that are available to other members of those teams.

Carpman's doctoral dissertation, on the other hand, is probably the most comprehensive document available for providing information about the particularities of healthcare design practice (Carpman, 1983). By adopting a form of the participatory research method, Carpman, who acted as both the EB knowledge provider for the design steering committee and the researcher who observed utilization processes, informs us about the patterns of knowledge utilization within a multi-disciplinary team working on the design of a major university hospital in the United States. Carpman's analysis is based on the quantification of recommendations and associated tactics (including supporters of recommendations, source, frequency, format, setting, and type of recommendations), characteristics (including issue type, physical feature, department, type, timing, and impacted groups), and their individual and combined effects on adoption of recommendations. Her rigorous data collection process involved an extended analysis of participant diaries and an investigation of archives documenting the fourteen-month process.

Carpman presents three critical findings concerning the strategies adopted to make successful recommendations. Tactics involve the gaining of support of key individuals through discussions, clarifying the source of recommendations, and the frequency of bringing particular recommendations to the team's attention emerged as the significant factors in adopting a recommendation within a design process. *To patiently negotiate with supporters, to provide empirically-generated information, and to repeat recommendations rather than making them only once* proved to be successful tactics employed by researchers to influence design work (Carpman, 1983).

Carpman also investigated another category, the characteristics of recommendations, influencing researcher-designer relationships during collaborations. The study revealed that three characteristics, including *issue type, physical feature, and* *nature of recommendation,* were significant in the success of recommendations made by researchers (Carpman, 1983). Concerning issue types, the design-related issues, in contrast to process-related issues for example, had strong enough effects to influence design work. However, Carpman reports that not all design-related recommendations of researchers were utilized. The design decisions, for example, about the areas of "core technology" where healthcare is primarily delivered were influenced primarily by physicians in Carpman's case study. Another important finding concerns the nature of recommendations. The successful recommendations in Carpman's case, "most often dealt with straight-forward issues where the connection between the behavior need and the designed solution was obvious" (Carpman, 1983: p. 419).

Carpman's inquiry is an early and rare example of research-design cooperation studies, and she clearly presented the intricacies of the healthcare design practice. Three decades after Carpman's field work, the body of studies on the (sub-) culture of contemporary healthcare design practice is still very limited, although many large-scale projects or programs, including evidence-based design or the Pebble Project[1], have been initiated in the healthcare design community. The common goal across these programs is to expand the volume of research that will eventually strengthen and enhance the influence of research-based evidence in design making in order to achieve a better match between physical design and the processes within. The nature and effects of these movements, as important as they are, have yet to be studied *in situ*. The current research adopts an integrative approach (to account for social, material and cognitive aspects of practice) and studies the research-design relationship in contemporary healthcare design practice. Recent developments concerning the relationship between research and design,

[1] The Pebble Project is "an international research initiative comprises a diverse community of progressive healthcare organizations and professionals who have committed to applying an evidence-based design process to create healing environments that improve the quality of care, promote safety and health, and increase operational efficiency (Zensius, 2008).

and the gaps within existing research into the subject have shaped the core questions of this dissertation. The ultimate aim is to enhance the understanding of the ways that evidence is presented, utilized, and translated, and increase knowledge of the role that evidence plays in facilitating interdisciplinary interactions in context.

2.2 Evidence-Based Design (EBD)

The roots of evidence-based design can be traced back to the field of clinical medicine. (Hamilton, 2003; Zimring & Bosch, 2008). Thus, accounting for the trajectory of evidence-based practice in medicine, without omitting the criticism oriented towards its framework and practices, will help to better understand the model and its implications in design.

2.2.1 Evidence-Based Practice

Starting in the early 1990s, the bold assertion of evidence-based practice within the field of medicine gained significant support. It also had been influential in many other disciplines. As Cartwright (2007) suggests, commitment to evidence-based approach is increasingly being transferred to a range of disciplines such that we can now speak of areas such as evidence-based policy making, education, and design. In parallel to what had been proposed in the evidence-based medicine framework, in the field of political science, for example, there has been an increasing pressure to make use of evidence as key to decision making processes. Because it has become the model for so many fields, it is useful to outline the doctrinal framework of evidence-based medicine itself. One frequently cited article published in the Journal of the American Medical Association in 1992 clearly shows how evidence-based approach manifests itself in the field of medicine (Evidence-Based Medicine Working Group, 1992: p. 2420):

> *A new paradigm for medical practice is emerging. Evidence-based medicine de-emphasizes intuition, unsystematic clinical experience, and pathophysiologic*

rationale as sufficient grounds for clinical decision-making, and stresses the examination of evidence from clinical research.

The epistemological stance behind this seminal work is the notion that evidence is associated with the outcomes of rigorous scientific research. The new paradigm, as proponents call it, deals with the "uncertainties of clinical medicine" by introducing extensive use of evidence emerging from clinical research. Typically, in evidence-based medicine practice, the uncertainties are eliminated by making use of research findings according to various ranking schemes (hierarchies) which partly eliminate the question of what evidence to utilize within a certain situation. The rankings in currency (e.g. levels of evidence suggested by the Oxford Centre for Evidence-based Medicine) help practitioners by answering the questions of 'what, when and how.' The similarity across these rankings is evident. On top of the list, there is the unchallenged technique of randomized control trials followed by cohort studies and case studies. According to the guiding frameworks of evidence hierarchies, the randomized control trials provide the best scientific evidence, free from biases of the experimenter. Montuschi (2009) mentions two reasons that legitimize the placing of randomized control trials at the top of the hierarchy. First, such trials provide the ability to deduce directly the ensured results, which means that the randomized control trials "have in-built assumptions which ensure the results" (Montuschi, 2009: p. 429). Second, they allow the establishment of a probabilistic relationship between the hypothesis and the finding (Cartwright, et al., 2007; Montuschi, 2009), so "the higher probability, the better the evidence" (Montuschi, 2009: p. 429). The two advantages secure the position of evidence provided by randomized control trials over other methods providing evidence for the practitioner. However, while randomized control trials are considered as methodologically safe (providing internal validity), the generalizability of the results (external validity) is highly controversial. The debates focus on the critical question of whether the evidence at hand can be applied any place at any time.

2.2.2 Criticism

Evidence-based practice has been criticized on many grounds (Cartwright, et al., 2007; Charlton & Miles, 1998; Montuschi, 2009). Here, the review of those critics only covers three aspects; (1) in-built assumptions of the notion of evidence, (2) context relevancy and (3) limitation in the range of methods through which evidence comes into being.

First, the hierarchies of the evidence-based approach come with a set of in-built assumptions about the notion of evidence. As Cartwright et al. (2007) suggest, the findings emerging from what is considered to be the most scientific enterprise (randomized control trials) provide accounts of "genuine evidence" with high probabilistic relations between evidence and hypotheses. Once established, it is acceptable to discard whatever other evidence there may be. The high probabilistic relationship suddenly makes all candidates for evidence disappear before having them "on the table for consideration" (Cartwright, et al., 2007: p. 6). Eventually, the evidence emerging from randomized control trials leaves no room for negotiation to compare or combine with other findings of different research methods.

A second issue is the tendency to accept evidence from randomized control trials as being universal and thus applicable independent of contextual variability. Montuschi (2009) criticizes the one-size-fits-all notion of evidence by asking the critical question of "how do we know that the randomized control trials are the best providers of evidence in any and every context?" (Montuschi, 2009: p. 429). Proponents of evidence-based practice counter this argument by emphasizing the "conscientious, explicit and judicious use of evidence" (Sackett et al., 1996: p. 71). According to the evidence-based framework, practitioners are required to think critically within the process of evaluating the evidence at hand. However, this is a paradoxical situation that, in theory, evidence-based approach is initially set to limit the clinical intuition while, practically requiring clinical expertise in order to use evidence judiciously.

Thirdly, the evidence hierarchies, in fact, value certain methods other than the evidence claim itself. Within the current ranking schemes, the top-ranked methods provide ground for sound evidence validated by certain protocols. Only a limited range of research techniques and methods are represented in rankings. Ethnography, for example, is never listed since it does not have the self-validating virtues of the methods deemed available to be adopted by the evidence-based practitioner (Cartwright & Efstathiou, 2008). In other words, considering the set of methods, the cultural variables can only be represented, at most, in expert opinion and case studies. Ethnography might not be appropriate within most parts of the field of medicine; however, qualitative methods should be considered for potential application in other evidence-based practices such as policy-making, education or design and not ruled out *a priori*.

Within all the disciplines where evidence-based practice has become the dominant paradigm, the "practicable and applicable" theory of evidence is still thinly supported, if not absent (Cartwright, 2009; Cartwright, et al., 2007; Solomon, 2009). Considering the array of evidence emerging from different resources in a given practice, according to Cartwright, the evidence-based approach still lacks "a reasonable and practicable account of what different pieces of evidence say about a hypothesis and with what strength they speak" alongside with "a reasonable and practicable account of how to evaluate a hypothesis in the light of all the candidate evidence" (Cartwright, et al., 2007: p. 8). The evidence-based approach in design is not an exception in that sense. Similarly, in design, the criticisms summarized above manifest themselves in practice as the evidence-based framework guides the interventions on the design of physical environments.

2.2.3 EBD Practice

The healthcare design industry has provided fertile ground for evidence-based practice, and the approach has drawn enormous attention in the field since the late 1990s. Kirk Hamilton was one of the first to formally frame the approach in the field of design.

According to Hamilton, EBD is "the natural parallel and analog to evidence-based medicine", and "it is the deliberate attempt to base design decisions on the best available research evidence" (Hamilton, 2003: p. 18). The approach has been constantly evolving since its inception, and rather than being limited to actual design processes, EBD is now being perceived as the entire set of activities around evidence, including research, design and business cases aiming at best possible outcomes within the field of healthcare (Zimring, DuBose, et al., 2008). The intent behind these evidence-oriented activities is "to contribute to process and organizational outcomes through the optimization of physical environment" (Pati, 2011: p. 53).

Despite clear reference to the framework and practices in medicine (Hamilton, 2003; Zimring & Bosch, 2008), EBD has no evidence rating (evaluation) scheme. It has been repeated in the literature that the challenge of evaluation has been a significant theoretical weakness and a barrier for broader adoption (Pati, 2011; Stankos & Schwarz, 2007). However, there are three major literature reviews (Rubin et al., 1998; Ulrich, et al., 2004; Ulrich, et al., 2008) covering the existing research findings (evidence) in order to aid designers in practice. The agenda behind these efforts is to demonstrate that design of healthcare environments is part of a complex relationship with outcomes such as hospital acquired infection rates, patient fall occurrences, medication error frequencies, and staff satisfaction and/or stress levels. The major argument is that EBD can "genuinely contribute to the wide range of complex decisions involved with health care design" (Zimring & Bosch, 2008: p. 148) in order to achieve the critical goals such as safety, efficiency, and satisfaction.

The EBD approach introduces several procedural steps across the project delivery process. These include defining project goals and objectives, finding resources for relevant evidence, critical interpretation of relevant evidence, and creating EBD concepts (Kent et al., 2009). Obviously, this is a complex activity requiring tight collaboration and the cooperation of an interdisciplinary healthcare design team including owner representatives, healthcare planners, designers and consultants. The three EBD guide books published by the main institution advocating EBD, the Center for Health Design (Kent, et al., 2009; Malone et al., 2008; Quan et al., 2009), systematize the evidence-oriented healthcare design process by integrating the typical architectural design phases (conceptual design, schematic design, design development, and construction documents) with proposed EBD activities, namely goal definition, finding necessary resources, interpreting evidence, creating concepts, building hypotheses, collecting baseline measures, and monitoring design implementation. However, the critical question still remains unexplored: is EBD just an add-on to typical design process or is it an inherently different approach to the practice of architectural design?

In a recent article, Pati (2011) underscored the problems surrounding assessment and utilization of evidence in design practice which are argued to be the steps going beyond traditional design approaches. Proposing a framework for evaluating evidence, Pati suggests that the key issue in practice is “the separation of the evaluation of the strength and quality of evidence from the evaluation of appropriateness and feasibility in a specific application context” (Pati, 2011: p. 50). The crucial component of Pati’s proposal is that, in addition to rigorous assessment of scientific strength and quality of evidence, the fit between evidence and the application context should be studied in collaboration with client organizations and end users. The evidence, emerging from the appropriateness and the feasibility studies in context, “may not necessarily be evidence of high scientific strength” (Pati, 2011: p. 65). Therefore, multi-disciplinary teams in industry are faced with a mix of scientific and non-scientific evidence throughout actual design processes. Pati’s framework, in theory, provides a basis for teams to assess and utilize a variety of evidence emerging from different sources. However, the practical aspects of EBD frameworks are yet to be studied. The literature lacks “thick descriptions” (Geertz, 1973) of how multi-disciplinary teams accomplish EBD. The case pursued in this present study is one of the first attempts to provide an analysis of an actual EBD process *in situ*.

2.3 Studying Design *in Situ*

There is a relatively recent, but entrenched literature providing insights into life and everyday practices within workplaces that has long been amenable to qualitative analysis (Fine et al., 2008). Anthropologists and sociologists have provided frameworks and methods to study everyday patterns of interaction or, more broadly, the culture of work in action. The methodological toolkit, developed mainly in anthropology, has also been utilized in the study of the profession of architecture.

Architectural design, as it has been described in the literature, is a sophisticated activity involving people, systems, artifacts and representations. There have been several paradigms, with a variety of methods ranging from protocol studies to real-life observations utilized to study and understand various aspects of this complex activity. Influenced by Simon's problem solving framework (Simon, 1969), there have been a large number of protocol studies focusing on designers' behavior, including verbalization and sketching, while performing a task assigned by researchers. Results emerging from these empirical studies, mostly quantified, have enhanced our understanding of particular aspects of design activity (Cross, 2001). On the other hand, qualitative data-oriented researchers, equipped with social science methods, provide rich social data depicting designers' daily routines, activity patterns, languages and communications, and everyday tools used to accomplish their tasks in workplace settings. However, it has been a challenge in the study of design to account for social, cultural, and material aspects of work in an integrated manner.

The following sections provide a brief account of relevant ethnographic works, the emerging approach of distributed cognition framework, and the opportunities that the distributed cognition may present in analyzing problem solving activities of interdisciplinary design teams.

2.3.1 Precedent Work in Architecture

There has been an array of research utilizing ethnographic methods for the study of the work processes employed by architects. From different vantage points, these studies provide accounts of design work in which practitioners on a daily basis confront design- or organization-related problems. Systematic field observations, interviews and other ethnographic tools allowed researchers to describe social, cultural and material aspects of work culture in architecture. Several researchers with different disciplinary backgrounds have pursued questions such as how particular practices are maintained (Robbins, 1997; Yaneva, 2009a), how design problems are solved (Yaneva, 2005, 2009b), and how issues are negotiated between designers, consultants and clients (Cuff, 1991, 2000; Gutman, 1988). Following research traditions emerging from sociology and anthropology, scholars have rendered a culture of architectural practice involving a network of people, tools and artifacts.

Though having different agendas for their writings, Robert Gutman (1977, 1988) and Magali Sarfatti Larson (1977, 1993) were the earliest to study the culture and profession of architecture. The studies were not ethnographies, but were based on observations and interviews combined with historical and quantitative data. Both authors, with a sociological perspective, accounted for the profession's cultural patterns and trends on a larger scale. The work of Gutman and Larson provided a foundation for subsequent, detailed analyses, including ethnographies, which provide insights into the practice of architecture.

Judith Blau, another prominent sociologist studying the profession of architecture, also utilized ethnographic field methods, including interviews and observations, to pursue her research questions concerning "ingredients for success" in a competitive market

(Blau, 1984). Backed up with quantitative analysis, Blau's argument elaborates the organizational aspects of the culture of architecture involving firm structure and size (Blau, 1984; Blau & Lieben, 1983).

Edward Robbins, an anthropologist, has focused on a different level concerning a material culture, drawing, within the broader culture of architectural practice (Robbins, 1997). Having a completely different level of analysis than the studies mentioned above, Robbins presents his discussion on the shifting roles of drawing (e.g. drawing as an instrument of social practice, and as social act) based on his observations and extended interviews with nine architects (Robbins, 1997).

Some of the most significant works on the ethnography of profession of architecture are Dana Cuff's (1980, 1981, 1982, 1989, 1991) writings from the 1980s. Her "anthropological activity of hanging out" in firms resulted in thick descriptions of collective actions taking place in a "coherent yet invisible system governing its behavior" (Cuff, 1991: p. 1). In addition to other cultural phenomena that Cuff discusses, her narrative depicts "others" who are actively engaged in the process of design. Cuff states that "architectural practice emerges through complex interactions among interested parties, from which documents for a future building emerge" (Cuff, 1991: p. 4). Cuff's extended account sharpens, to some extent, our understanding on the complex nature of design problem solving within interdisciplinary real-world design practices.

Yaneva (2005, 2009a, 2009b), another ethnography oriented researcher, defines her approach to architecture as pragmatic, meaning that it is free from debates over style or broader socio-economic and political interpretations. She asks "how does a building emerge from mundane activities such as model making?" Employing the actor-network theory, Yaneva's research provides a thick description of activities taking place in "project bubbles" using a prominent design office for her case study (Yaneva, 2009b). The non-human elements in the network, mainly foam physical models, were pivotal in her research (Yaneva, 2009b: p. 189) :

> *What architects do in a presentation is add: the circulation model is added to the structural model, which sits on the table along with many other models, samples and options… To show the building over and over again, designers have to re-collect it – to displace several models from the working table to the presentation table and back again, from New York to Rotterdam.*

Yaneva's episodic accounts cover the full trajectory of numerous models (and their modes of existence) in which the building becomes "real and known" to actors within the network. In her study, Yaneva makes her methods and analysis very transparent which is rare in ethnographies of design (Yaneva, 2009b).

Yaneva's narrative also displays the "situatedness" and "distributedness" of architectural design practice between people and tools, and across space and time. Yaneva's unit of analysis, which includes interactive networks of human and non-human actors, allows her to provide insights into daily problem solving activities of designers within a social, cultural and material network.

As evidenced in the work of researchers, fragmentary explanations with a particular focus on social (Cuff, 1981) or material aspects (Yaneva, 2009a), are insufficient to integrate cultural, contextual, cognitive and historical dimensions in design problem solving. The next section introduces an integrative framework, the distributed cognition approach, to extend the existing analyses to another level where social, cognitive and material aspects can be meaningfully linked in the study of everyday design practices.

2.3.2 Distributed Cognition Framework

The distributed cognition framework provides a basis for the study of cognition from an integrated perspective that includes organizational, social, cognitive and material aspects. It can be considered a departure from the traditional cognitive science approach. In the introduction of his book, *Cognition in the Wild*, Edwin Hutchins (1995a) writes about a "troubled legacy" left from the developments that took place during the emergence of the discipline of cognitive science. In the early years of cognitive science, according to Hutchins, the study of cognition, seen as a solitary mental activity used mostly for analytical purposes, reinforced the perception that what is cognitive is an isolated domain to be studied apart from cultural and social dimensions.

Nersessian (2005) also clearly presents the divide between cognitive, social, and cultural in Science and Technology Studies (STS) arguing that differing definitions of cognition give rise to the divide between the cognitive and the socio-cultural. According to Nersessian, there is a perceived divide in science and technology oriented studies having implications for the way the two approaches construct accounts of how scientific knowledge is produced. On one side, there is the anti-cognitive position that treats the scientist's or practitioner's reasoning as a "black box," while on the other side there is the cognition-oriented position associated with early artificial intelligence and cognitive science studies that characterizes human cognition as symbol processing, free from socio-cultural and material environment:

> *On the traditional view, the cognitive system comprises the representations to an individual mind and the internal computational processes that operate on these. On the functionalist assumption of that view, thinking is "disembodied" in that it is independent of the medium in which it is implemented. Also although the environment is represented in the content of thinking through being represented in memory, cognitive processing is independent of the social, cultural, and material environment, and thus cognition is not "embedded."* (Nersessian, 2005: pp. 21-22)

The cognition-oriented approach that de-emphasizes the social, cultural, and material environments, works well, experimentally, in accounting for the problem-solving activities of individuals given specific tasks. However, on the other hand, establishing strict boundaries to cognition, which was in effect confined to the insides of people's skulls, overshadowed the importance of socio-cultural factors that are critical ingredients in real-life problem-solving situations. Along a similar line of thought, Hutchins refers to the problem of overlooking the cultural nature of cognition and states that "if we fail to bound the system properly, then we may attribute the right properties to the wrong system or (worse) invent the wrong properties and attribute them to the wrong system" (Hutchins, 1995a: p. 356).

On the other side of the controversy, within science and technology studies, there is the position that emphasizes the social aspects over the cognitive. Rather than focusing on an individual's operation in isolation, the unit of analysis is extended to include the socio-cultural and material environments which are considered to be essential ingredients of individual and collective actions. Nersessian also elaborates on this theoretical position:

> *Reductionism is, thus, taken in the other direction. Socio-cultural studies replace cognitive reductionism with socio-cultural reductionism. Banishing cognitive explanatory factors amounts to "throwing out the baby with the bath water"* (Nersessian, 2005: p. 23).

The socio-cultural approach, which categorizes the study of cognition as insufficient to interpret experiences in the real world, argues that practices, such as the construction of knowledge, emerge out of a rich network of actors involving human and non-human members. Having the social explanations dominant over the cognitive explanations contributes to the divide by creating the perception that the cognitive and the socio-cultural accounts are incompatible.

Nersessian (2005) mentions Latour and Woolgar's work (1986), *Laboratory Life*, as an example of the sociology oriented studies of practice that treat knowledge-construction as something that emerges from "the social." Latour and Woolgar (1986) try to explain the construction of scientific facts by observing and describing the routine activities of working scientists. Their argument holds that a richly detailed account of the scientists' complex social web (Actor-Network) is sufficient in explaining the production of knowledge as it occurs in the social landscape.

The boundary established between the social and the cognitive, which was an outcome of different notions of cognition within different theoretical approaches, is questionable in the light of studies on situated practices. The body of work conducted so far (Hutchins, 1995a, 1995b; Lave, 1988; Shore, 1996) has established a more firm basis to provide accounts of the social-cognitive-cultural nexus, one that is adequate for interpreting real-world practices as they are being enacted (Nersessian, 2005).

Hutchins' distributed cognition framework (Hutchins, 1991, 1995a, 2004) is one of those environmental perspectives, as Nersessian calls them, that bring a new understanding to account for the activities in-the-world. These studies characterize the social, cultural, and material environment as active elements of distributed cognitive systems. In brief, distributed cognitive framing introduces two distinct theoretical principles with different methodological implications. First, it rearranges the boundaries of the units of analysis in the study of cognition. The unit of analysis is the distributed cognitive system consisting of situated individuals, artifacts, representations, and the environment. Second, distributed cognition framing seeks a broader set of "mechanisms that may be assumed to participate in cognitive processes" (Hutchins, 2004). In that sense, generation, manipulation, and propagation of representations within distributed cognitive systems become critical mechanisms to be tracked in real-world activities, since:

> *…cognitive processes may be distributed across the members of a social group, cognitive processes may be distributed in the sense that the operation of the cognitive system involves coordination between internal and external (material or environmental) structure, and processes may be distributed through time in such a way that the products of earlier events can transform the nature of later events* (Hutchins, 2004: p. 2068).

As quotation suggests, cognition is extended beyond a single individual, a single activity, and beyond a limited period of time. Hutchins mainly presents compartmentalized activities that are already complex interactions, (e.g. a memory task for the pilot of a commercial airliner (Hutchins, 1995b) or a position fix cycle on the bridge of a naval vessel (Hutchins, 1995a)) and through those cases, involving human and non-human members of the socio-technical systems, provides in-depth analyses. Hutchins' perspective reconstructs activities in the real world with emphasis on the social and material organization of cognitive activity, going beyond the traditional formulations of problem solving in cognitive studies.

Distributed cognition framing provides the opportunity to account for real-life practices at various levels, involving individuals, systems, and the wider socio-cultural context, in an integrative manner. The approach, originating from Hutchins' work, is now being applied to more complex environments where contemporary interdisciplinary practices are being carried out (Nersessian et al., 2002). The distributed cognition framework, therefore, might provide new insights into the study of interdisciplinary architectural design practice taking place in rich socio-cognitive and material environments.

2.3.3 Distributed Cognition and Interdisciplinary Design

Research in cognitive science and in science and technology studies has already influenced the work being carried out in design studies. Although the body of research applying the distributed cognition perspective and terminology is very limited, there are a number of important contributions to the study of interdisciplinary design collaborations. Researchers including Bendixen and Koch (2007), and Perry and Sanderson (1998) make explicit reference to developments in science and technology studies, and adopt a terminology similar to that of Hutchins (1995a), Knorr-Cetina (1999), and Star and Griesemer (1989). The influence of science and technology studies is visible in the way researchers formulate their research questions (framed by the distributed cognition approach), and make use of similar terminology such as "inscription devices" (Latour & Woolgar, 1986), "epistemic objects" (Knorr-Cetina, 1999), or "boundary objects" (Star & Griesemer, 1989) in describing the tools or objects of daily practices. Another pattern apparent in both research fields is that, based on the philosophical position that science and design are both situated in time and space, the tools or objects within a system are treated as critical nodes of the networks in which they are situated. In other words, the systems, labs or studios are treated as socio-technical systems involving not only human actors, but also non-human elements. The following section briefly describes how these researchers treat a particular concept, in this case "representations," which is transferred from the domain of science and technology studies and cognitive science.

Bendixen and Koch's ethnography (2007) dives into the visual culture of architecture and engineering design practices. Their study emphasizes two theoretical concerns involving the role of representations and the nature of "the process as an ordered set of sequential activities" (Bendixen & Koch, 2007: p. 52). The researchers emphasize the role of visualizations as network-organizing devices in chains of interactions occurring between different actors in the web of practice. The significant feature of this research is that the unit of analysis is extended beyond designers and engineers to include the client as an actor in the network, allowing the researchers to show that visualizations are "inscribed with particular interests, making them political instruments" (Bendixen & Koch, 2007: p. 42). The shortcoming in Bendixen and Koch's work is that while they provide an account of how representations are employed within a social (interdisciplinary) context, they do not provide a substantial analysis of the processes involving generation, manipulation and propagation of those representations within the socio-technical system being studied.

Perry and Sanderson's work, on the other hand, goes deep within the issue of team communication in two engineering design companies (Perry & Sanderson, 1998).

They make explicit reference to distributed cognition framing and use its associated terminology. By tracking the day-to-day activities of design teams in two different settings (cases), Perry and Sanderson strive to account for “the ongoing nature of the knowledge representation and transformation work that takes place through the use of design artefacts” (Perry & Sanderson, 1998: p. 274). Having two cases at hand allows Perry and Sanderson to compare phenomena emerging from two different sites. The researchers contrast and compared “transferable” particularities such as authorization and control structures, the range of design organizations involved, inter-group and extra-organizational communication, and design process artifacts that they have observed on-site. Making use of distributed cognition framing, Perry and Sanderson seek to provide an in-depth analysis of interactive situations between humans and their material environments in order to account for the key role of artifacts and representations in the organization of work (Perry & Sanderson, 1998).

The research utilizing distributed cognition framework to study design practice is in its infancy. The use of key concepts, particularly analyses of cognitive processes around representations seems to be maturing; however there is much left to accomplish in the study of interdisciplinary design problem-solving in architecture. The distributed cognition framework has the potential to enhance our understanding of contemporary architectural design practices where more and more cooperation (e.g. the integrated project delivery approach) is required among an array of participants, each bringing their expertise, tools and representations from their respective disciplines. The approach and research questions formulated for this dissertation accommodate the distributed cognition approach by analyzing the problem solving practices of interdisciplinary teams in context. A specific focus on *the representations of evidence* carries the potential to provide an enhanced account of mechanisms concerning communication, reasoning, and learning in real-world situations.

CHAPTER 3

METHODS

This chapter introduces the details of research methods utilized and the case studied in this dissertation. Following a brief overview of the methodological approach, the chapter presents the details of data collection procedures, analysis protocols, and strategies to achieve higher levels of reliability and validity. An extended description of the case and the context is then presented to include the architectural firm, the client organization, the project and the key participants.

3.1 Approach

This study posits that problem solving practices in the domain of design are distributed across sets of people, tools, and representations. The nature of the research questions asked here, and the application of the distributed cognition framework to the study of architectural design practice, requires the use of a long-term observational study of the socio-cognitive context in which interdisciplinary interactions occur. This study uses ethnographic field strategies, observations, and open- and semi-structured interviews as methods to capture interdisciplinary problem solving *in situ*.

Ethnography as a methodology is part of the larger tradition of qualitative research. Weick defines ethnography as “sustained, explicit, methodical observation and paraphrasing of social situations in relation to their naturally occurring contexts” (Weick, 1985: p. 568). As Weick’s definition suggests, ethnography relies mainly on systematic field observations to study groups and people “as they go about their everyday lives” (Emerson et al., 1995: p. 1).

Ethnography has its roots in anthropology, where field researchers seek to understand the beliefs, practices, values, and technologies of cultures across the world. In order to acquire an emic perspective of a particular culture, social anthropologists have engaged in the lives, concerns and practices of their subjects (Emerson et al., 1995). Ethnographic methods were adopted by sociologists for the study of people and organizations. Organizational ethnographies, in particular, provided insight into the formal and informal relations that form systems in the (sub-) cultures of work environments (Fine, et al., 2008). Ethnography has also been employed in the study of cognitive processes, with particular emphasis on the material environment (Hutchins, 1995a, 1995b).

Researchers have even employed ethnographic methods to study the culture of architectural practice. Cuff, for example, points out the usefulness of ethnographic methods for gaining a better understanding of architectural practice (Cuff, 1991). Cuff provided one of the most substantial narratives on the nature of architecture, which, according to her, "emerges through complex interactions among interested parties, from which the documents for a future building emerge" (Cuff, 1991: p. 4). Recently, Yaneva also emphasized how ethnographic observation of practitioners allowed her to "access to the actor's own definitions of the social, of the way they are given identity as a group, of the variety of agents that partake in their actions" (Yaneva, 2009b: p. 25).

This research adopts ethnographic inquiry techniques in order to provide a "thick description" (Geertz, 1973) of the practices of an interdisciplinary healthcare design team that occur in situated contexts. Rather than starting with a theory or a preconception, this research aims at observing emergent phenomena related to our research questions. The goal is not to test a hypothesis, but to better understand webs of significance in studied practice.

The distributed cognition framework was adopted for this study because of its descriptive power to explain the "evolving systems" and sub-systems (Knorr-Cetina, 1999; Nersessian et al., 2003) of design work. Thus, rather than taking an individual person as the unit of analysis, this study focuses on a larger system, involving people, tools, and representations.

The research design document associated with this study was presented to the Georgia Institute of Technology Institutional Review Board (IRB) for research compliance review prior to site visits. Although the project was determined to be exempt from IRB regulations (Appendix A: IRB Approval), I have collected signed consent forms prior to recorded interviews with participants.

3.2 Overview of the Study

A preliminary survey of major healthcare design firms around Atlanta was conducted, which led to the selection of two firms who were at the time designing suitable projects. The process of selecting candidate firms involved a number of criteria including location, size and structure, types of services, scale, complexity, and availability of the projects delivered. A local architecture firm, ***Firm A***, emerged as the best candidate based on availability and accessibility of locations to conduct basic data collection procedures. In addition, the criteria included a secondary set of features including project size and complexity, and stated design goals (e.g. achieving EBD, LEED, or implementing innovation), which provided opportunities for further ethnographic examination of the transferability of findings of this dissertation.

Firm A is a local company with considerable healthcare design experience. The firm's healthcare studio, along with its separate religious and educational groups, has been involved in a variety of projects over the last three decades ranging from healthcare campuses to medical office buildings. The firm provides services including master planning, architecture, interiors, civil engineering, electrical engineering, mechanical engineering, and structural engineering. In addition to the group in-house experts to execute the variety of services mentioned above, ***Firm A*** also makes use of external consultants for projects depending on various factors related to projects and clients.

This research studied a single healthcare design project commissioned by ***Firm A***. Traditionally, ethnographies entail long-term observations spanning months or years. Although, according to Fetterman, classical ethnography requires at least six months in the field (Fetterman, 1998), there is no standard length of time to conduct observations. Within the scope of this research, I aimed at observing one project during the design development and construction documentation phases spanning a period of ten months. I finalized my field work by July, 2012 as the design team issued the construction drawing set package for owner review (Figure 1). The data set does not include observations of design team meetings, which continued even after the delivery of construction documentation, and the set of changes in design work that occurred after July, 2012.

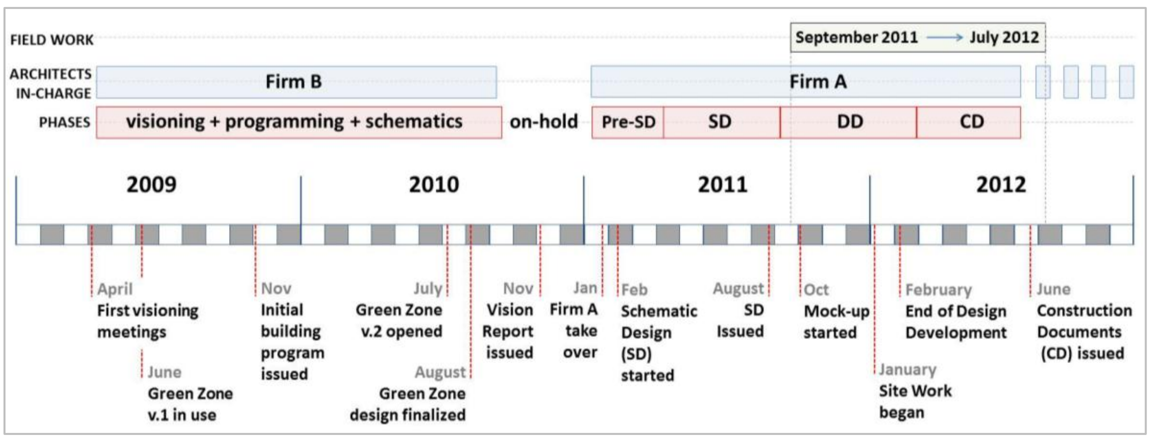

Figure 1. The project timeline for the ***PHSP*** replacement hospital

An important goal here was to observe design development (DD) and construction document (CD) phases of the project, where the experts from an array of disciplines work in close collaboration to finalize the design task. The rationale behind emphasizing these two phases is that DD and CD, traditionally, are the phases where intense interdisciplinary interaction is required to meet project goals. The schematic design phase, the objective of which is “to arrive at a clearly defined, feasible concept and to present it in a form that results in client understanding and acceptance” (Demkin & American Institute of Architects, 2001: p. 568), also entails a level of interdisciplinary interaction. In this study, the analysis was extended to include the visioning and schematic design efforts during which a set of guiding principles were established and developed. A retrospective inquiry, which was necessary to provide a substantial background, was conducted as part of the field work in the form of informal and formal interviews, and during the post-field work period when project related documents were studied to determine the history of certain design decisions.

Site visits revealed four main types of interactions occurring between participants; those between designers and consultants, between designers and the client organization, between designers and user groups, and finally, interactions within the design team. Designer-consultant interaction is an area of concern, particularly in the healthcare design field, since there is a growing body of research involving a variety of issues relevant to architecture, engineering, and management. Interaction involving the client organization is also relevant, since healthcare organizations today are one of the main drivers of innovations in the field. It is a trend within healthcare organizations to look at innovative ideas and research in order to make positive changes, to fix existing problems, and to improve clinical and organizational outcomes. Thus, we observed administrative staff and user groups as they engaged in design development sessions with designers and client representatives. Finally, field observations included observations of brainstorming sessions, and formal and informal meetings and discussions as they occurred among ***Firm A***'s design team members.

Data collection for this research occurred between September, 2011 and July, 2012 (Figure 1), and involved visits to multiple locations including the offices of designers and other consultants, the hospital where the meetings were held, and the mock-up studio. The total time spent in these locations amounts to about 145 hours, excluding the interviews which were separately scheduled and conducted. Out of 33 audio-recorded interviews, 25 were fully transcribed (Figure 2).

Type	Format	Recorded at	Quantity	Content
Interviews	Audio	Firm A Office, the PHSP Hospital, Consultants' Offices	33	Participant interviews (20 to 70 minutes)
Steering Committee meetings	Audio + Video	Firm A Office, the PHSP Hospital	16	Weekly meetings (70 to 150 minutes)
Design Coordination meetings	Audio	Firm A Office	15	Consultant meetings (20 to 80 minutes)
User Group meetings	Audio +Video	the PHSP Hospital, Mock-up Studio	22	60-minute sessions with hospital staff
Field observations / Notes	Logbook	Firm A Office, the PHSP Hospital, Mock-up Studio	145 hours	Field notes from observations
Online Communication	Mails, Online messaging	NA	NA	Exchanges between participants
Drawings, photos, pdfs, spreadsheets	Paper copy, digital file	Firm A Office, the PHSP Hospital, Mock-up Studio	NA	Drawings, images, etc…

Figure 2. Research data set

In the analysis of the qualitative data, this study adopted grounded theory coding as a basis for analytic induction (Strauss & Corbin, 1990). The transcribed data were analyzed following the standard steps in grounded theory, namely open, axial, and selective coding, through which developed codes and categories were related to observed phenomena. Of the interviews, seventy-five percent were coded. Additional coding was done on selected meeting and field notes. The details of the analysis protocol are described in later sections.

3.3 Data Collection

The data collection process relied on ethnographic observations, semi-structured interviews, and access to project documents including drawings, meeting notes, memos, and online exchanges between participants.

3.3.1 Field Observations

Through correspondence with representatives of the architectural firm (***Firm A***) and the client organization (the ***PHS***: stands for the ***Private Health System***), this research was proposed to stakeholders in the ***PHSP*** project. In September, 2011, ***D10***, the president of ***Firm A***, and ***O4,*** the president of the hospital to be replaced, granted access to locations for field observations. In the first meetings there were opportunities to introduce the research to participants following a pre-determined script.

Project schedules and the availability of participants determined the frequency of visits to field locations. Site visits were conducted at least twice a week, and one visit included an observation of the steering committee meeting that brought all senior people together, including representatives of client organization, consulting firms, the construction firm, designers, and users on some occasions. During these visits, observations were captured in the form of field notes. The field notes aimed at "transforming witnessed events, persons, and places into words on paper" (Emerson, et al., 1995: p. 9) and included diagrams to describe settings and locations of participants in meeting spaces.

Audio and video recordings were also utilized in order to capture the rich socio-cognitive environments comprising people, tools, and representations. The participants allowed the recording of 16 steering committee meetings, seven of which were both audio- and video-recorded. Video recordings were also made of two user group meetings during the design development phase.

Field studies included observations of four basic types of activities:

- The steering committee meetings. These occurred every Tuesday afternoon, usually in a meeting room in the old hospital. Occasionally the meetings were held in ***Firm A***'s office or in the studio in the county building where the team was given the space to build their physical mock-ups. Over a period of nine months, 22 steering committee meetings were observed, 16 of which were audio- and/or video-recorded. Field notes were also taken during the observations where regular participants could be observed in these meeting, including client representatives (***O1***, ***O2***, ***O3***, ***O4***, ***O7***, ***O8***, ***O9***), design team members (***P1***, ***D1***, ***D2***, ***D3***, ***D6***), consultants (***Ct1***, ***M7***, ***Ce1***, ***Ec1***), and construction firm representatives (***Co1***, ***Co2***), engaged in processes of discussing, negotiating, and decision making.

- Observations of user-group meetings. In these meetings, the staff from each department of the old hospital was invited to provide feedback for the design of their future work environments. In the four such meetings attended, the project team and the users engaged in communication, and designers, who mainly facilitated these conversations in the meetings, had the opportunity to present their developing ideas to users and solicit their feedback, and, more importantly, to learn about the everyday practices in the old hospital. A typical meeting with representatives from a single department (i.e., pharmacy, inpatient unit, surgery, etc.) included at least two staff members and lasted for an hour. There were some user-group meetings that were scheduled and organized by the client organization (the ***PHS***). Side-meetings that occurred between designers and individual users from specific departments were not attended. Only the two, two-day long meetings during the design development phase were video-recorded.
- Design reviews sessions, included regular meetings and other, unscheduled meetings. All were held with consultant teams that might include mechanical, electrical, and structural engineers. Since the unscheduled design sessions were impromptu and internal within ***Firm A***, it was only possible to attend the four of them that coincided with a field visit. Two of them were audio-recorded. The three attended coordination meetings, on the other hand, were scheduled for Tuesday mornings before the steering committee meetings at the hospital occurred. None of them were audio or video-recorded. Typically, in steering committee meetings, the participants from each

discipline provided a status update and a summary for the rest of the team, including the ***PHS*** representatives.

- Work sessions of designers at ***Firm A***. After being granted access to workspaces, it was possible to observe the everyday practices within ***Firm A*** for a period of four weeks. The intense observation sessions allowed us to develop an initial understanding of the people, the project, and the nature of interactions occurring in situated contexts. The observations included individual and collective work sessions where designers developed, exchanged and negotiated ideas to solve problems. The observations *in situ* helped identify developing tasks, individual responsibilities within the team, and levels of engagement in the project. Five to ten minute interviews were conducted with participants, before and after internal meetings, to understand emerging issues or, for example, to clarify the acronyms that were heavily used in the ordinary communication of the office.[2] The brief exchanges of the internal design review sessions were not audio-recorded. Visits after the first four weeks were not on a regular basis, but depended on meeting schedules and availability.

3.3.2 Interviews

The techniques of ethnographic interviewing in which, according to Spradley, "both questions and answers must be discovered from informants" (Spradley, 2003: p. 48) was the model for this project. Two kinds of interviews were employed: open and semi-structured. Initially, open-ended interviews were conducted where the interviewer largely followed the participant's lead. The average duration of these interviews was approximately 40 minutes.

[2] In addition to acronym-laden language within the world of healthcare (e.g. PE for protective environments, or HAI for healthcare-associated infections), the architects were observed to be developing other project-specific acronyms indicating individual buildings or relevant technical documentation.

The semi-structured interviews, on the other hand, were guided by issues and themes that the field researcher wanted to address, depending on field observations, and on-going analysis of the data. Semi-structured ethnographic interviews in involve asking descriptive questions without leading participants along a particular line of thinking. Aimed at exploring the subjective worlds of the interviewees, semi-structured interviews might require revising initial plans "in order to fit the person and the situation as it actually arises" (Wengraf, 2001: p. 109). In that sense, semi-structured interviews differ from structured interviews where a strict set of questions are prepared in advance. The location of these interviews depended on the availability and flexibility of participants. The interviews with client representatives or consulting firm employees took place at their own work environments. Open and semi-structured interviews were audio-recorded.

A large number of actors, including designers, consultants, clients, and users, were present in the environments under study. Exchanges among all participants were recorded in field observations. However, not all participants participated in interview rounds due to several factors. A purposive sampling strategy was followed in scheduling interviews (Patton, 1999).

It was a challenge to schedule interviews with the participants from the ***PHSP*** hospital due to the hectic nature of their work environments and their busy schedules. Even the steering committee meetings were interrupted when ***O3***, the chief nursing officer, had to leave the room on several occasions. We have conducted two interviews with each participant from the ***PHSP*** hospital (***O2***, ***O3***, ***O4***, ***O9***), whereas ***O1***, the project manager from the ***PHS***, was interviewed once. The shortest interview was 25 minutes while the longest was 60 minutes. The design team was relatively more flexible. In addition to the scheduled interviews with designers, many small conversations were audio-recorded in the workspace. The interviews were transcribed, labeled, and stored. For convenient retrieval and access, the labels for each transcript included date and aliases for the interviewer and interviewee, whereas the cover pages for each transcript had additional information to include duration and location (Figure 3).

		Transcript_D2_04_18_2012
		Interviewee: D2 – Interviewer: I1- Location: Firm A office – Duration: 43:55 – I(3)
01:40	I	So, let's start with this thing, I asked you like 2 weeks ago, if, whether other HS projects are evidence based design, and you said they are kind of EBD principled. Right?
01:49	D2	Yes.

Figure 3. Cover page from an interview transcript

An extract from an interview transcript is also provided in (APPENDIX B: Sample Transcript). For all firms (e.g. ***Firm A***, ***Firm B***), organizations (e.g. ***PHS***), and individuals (e.g. ***D1***, ***O1***) I assigned aliases, "sanitized" transcripts to remove identifying information, and kept taped interviews and meetings secure to protect the confidentiality of participants. All recordings and transcripts were kept in a database which can be accessed only by researchers of this study. Regarding the presentation of interview segments appearing in this research, a marked change in direction or pauses in speech are indicated by a dash (–), whereas the authors' condensation of interview text is indicated by ellipses (…).

3.3.3 Access to Project Documents and Archives

In addition to interviews and observations, the study utilized the data collection procedures below:

- Accessing online communications including e-mails and memos. The online communication exchanges initiated by the members of the design team were captured. This particular data set was not extensive since we were not allowed to access all of the exchanges occurring between design team members, consultants and client representatives. We have labeled the captured segments of communication and included in the qualitative data set.

- Accessing online and offline documentation. As part of their practice, ***Firm A*** made use of an online management software (called Basecamp) to organize the digital documents exchanged between people and firms. Maintained on ***Firm A***'s Web server, this management tool allowed participants, including designers, consulting firms, and client representatives to access all project related documentation, including official design briefs, schedules and drawings. At the end of the field work stage of this research, there were 84 individuals listed on the Basecamp project directory and 126 documents, including drawings, spreadsheets, and reports. Paper-based documentation was also reviewed, including sketches, diagrams, schematic drawings, and scaled printouts, in order to capture design development at various levels. We were granted access to the project archive where the designers labeled and kept the entire set of hard-copy production in the office. These drawings were particularly helpful in understanding the progress and design decisions made prior to our field work.

3.4 Analysis

In the analysis phase, this research adhered to grounded theory procedures that depended on inductively developing a theory that was grounded directly in empirical data. Developed by Glaser and Strauss, grounded theory is a way to develop a theory from data with a bottom-up perspective, rather than to gather data to test a hypothesis (Glaser & Strauss, 1967; Strauss & Corbin, 1990). The purpose is to "build theory that is faithful to and illuminates the area under study" (Strauss & Corbin, 1990: p. 24).

A grounded theory, according to Strauss and Corbin, "is discovered, developed, and provisionally verified through systematic data collection and analysis" (Strauss & Corbin, 1990: p. 23). Therefore, I have adopted a strategy to allow data collection and analyses to occur concurrently. The coding and examination of qualitative data informed subsequent interviews and other types of data collection that occurred in situated contexts. As data about observed phenomenon emerged, the procedures of grounded theory (Strauss & Corbin, 1990) were utilized to discover the set of concepts, categories, and their interrelationships.

As the study progressed through data collection and analysis, a set of concepts was developed that was considered theoretically relevant to the theory being developed. In order to enhance the richness and depth of focus in emerging concepts, I have followed methods of sampling described by Strauss and Corbin (1990). Throughout the process of developing codes, which is described in length in a following section, I carried out a sampling strategy across the qualitative data, including field notes and transcripts from meetings and interviews, to identify emerging practices that were relevant to the research questions of this study. In the samples with theoretical relevance, then, I focused on sites, people, issues, interactions, representations, and tools to develop a deeper understanding of situated practices. As I identified emerging patterns of practices, I simultaneously attempted to validate those observations and to uncover additional instances of events through further observations across sites. The concern was to study the "representativeness of concepts in their varying forms" (Strauss & Corbin, 1990: p. 190).

3.4.1 Coding Qualitative Data

Concerning data analysis, this research followed the three main grounded theory procedures, namely open coding, axial coding, and selective coding. In all coding processes, I utilized qualitative data analysis software (MaxQDA) that allowed the effective management of a large amount of qualitative data including interview and meeting transcripts, field notes, and e-mails. The software also assisted in the management of the taxonomy of emerging categories, sub-categories, and super-ordinate categories. The image below (Figure 4) demonstrates the software interface having the left column with the coding structure whereas the associated documents with codes marked in it is on the right.

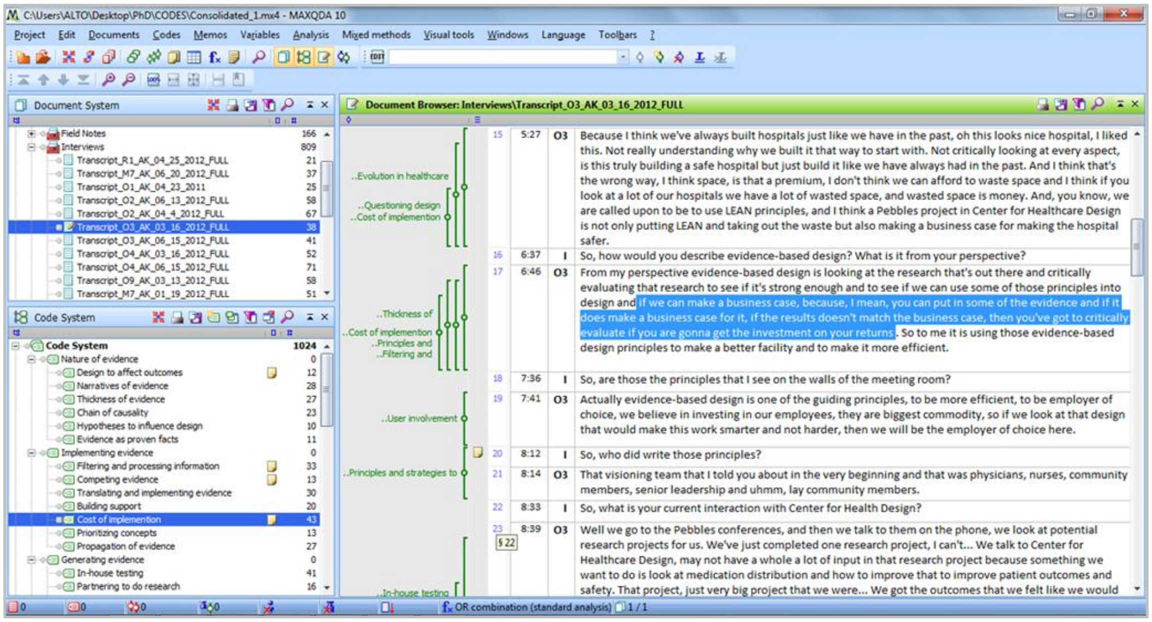

Figure 4. A screenshot from the qualitative data analysis software utilized for this study

Using the software mentioned above, three systematic coding procedures were developed to describe, conceptualize and assemble the data set. Below is a brief summary for open, axial and selective coding procedures that were followed in this study.

Open coding is the first step in analysis "that pertains specifically to the naming and categorizing of phenomena through close examination of data" (Strauss & Corbin, 1990: p. 62). The first step is dividing the data into discrete parts for further examination and comparison. The categories, their properties, and their dimensions emerge from these discrete units of analysis. Open coding was used for the set of transcribed interviews and group meeting sessions, and for observational notes. The data set was repeatedly re-examined and re-categorized through open coding in order to identify additional categories, their properties, and dimensions related to the phenomena observed at the field. "Properties" in this context means the set of characteristics pertaining to a category. "Dimensions," on the other hand, indicates location of these properties along a continuum (Strauss & Corbin, 1990). The table below demonstrates some of the categories and super ordinate categories initially established in the open coding stage (Figure 5).

Consultant involvement	Interacting with researchers
	Expert influence
	Engaging with consultants
Evidence in healthcare design	Forms of evidence
	Community of evidence-based design
	Expectations
	Organizing knowledge
Owner involvement	Owner preferences
	Senior level involvement
	Budget issues
	Longtime business relationship
	Principles and strategies to guide design
	Early commitments
Challenges in design	Cost-driven design
	Compromises in design process
	Exploratory design process
	Roles and responsibilities in design
	Arbitrariness in healthcare design
	Evolution in healthcare design

Generating evidence	Testing ideas in hospital
	Partnering to do research
Nature and role of evidence	Causal argument
	Design affecting outcomes
	Elements of evidence
	Evidence base
	Role of evidence
	Evidence as proven facts
Sources of evidence	Evidence in magazines
	Guidelines
	Expert judgment as evidence
	Research evidence
	Anecdotal evidence
	Learning from precedents
	Learning from industry
Implementing evidence	Implementing evidence
	Cost of implementation
Interacting users	Educating users

Figure 5. Categories and super ordinate categories established in the open coding stage

Axial coding is the next step of analysis in grounded theory. Based on a set of existing categories, axial coding involves "a set of procedures whereby data are put back together in new ways after open coding, by making connections between categories" (Strauss & Corbin, 1990: p. 96). The procedure followed involved evaluating categories and sub-categories based on the causal conditions that give rise to them, the context, the action/interactional strategies by which categories were managed, and the consequences of those strategies. In order to seek out the additional properties and dimensions of categories, or enhance existing ones, the raw data, such as transcripts and observation notes, was repeatedly revisited. Axial coding procedures facilitated a level of verification and refinement through a combination of inductive and deductive thinking, until a level of "saturation" was reached when no new information appeared about categories, their properties and dimensions (Strauss & Corbin, 1990).

Selective coding is the final stage of coding, where substantive themes and a theory are created from core categories. According to Strauss and Corbin, selective coding is about selecting the core category, which is "the central phenomenon around which all the other categories are integrated" (Strauss & Corbin, 1990: p. 116), validating the links between categories, and filling in categories that fall short in properties and dimensions. An in-depth analysis of selected themes will provide a detailed account of our field studies, which is a "thick description" according to Geertz (1973).

3.4.2 Super Ordinate Categories

The coding guide which was created and used for this research is presented in APPENDIX C: Coding Guide. The guide provides definitions for the set of 49 categories developed through the analysis procedures described above. The guide also uses segments from the qualitative data to exemplify each category.

In this section, I list the nine super-ordinate categories with their sub-categories;

1. *Generating evidence with the sub*-categories testing and deciding with mock-ups, partnering to do research, and in-house research or testing.
2. *Consultant involvement* with the sub-categories engaging consultants in design process, and interacting with researchers.
3. *Community of evidence* with the sub-categories sharing evidence, community and culture around evidence, the role of evidence, and engaging with vendors.
4. *Sources and forms of evidence*, with the sub-categories informal search methods, published resources, codes, guidelines, and regulations to inform design, anecdotal evidence, expert knowledge and judgment, utilizing a checklist, evidence from rigorous research, and learning from precedents.
5. *Nature of evidence in design*, with the sub-categories evidence as proven facts, hypotheses to influence design, chain of causality, thickness of evidence, narratives of evidence, and design to affect outcomes.
6. *Implementing evidence*, with the sub-categories propagation of evidence within the team, prioritizing concepts, cost of implementation, building support,

translating and implementing evidence, competing evidence, and filtering and processing information.

7. *Interacting with users*, with the sub-categories educating users, user involvement, user reaction or resistance, and extracting information.
8. *Interacting with owner*, with the sub-categories owner preferences, designing within budget and schedule, principles and strategies to guide design, and owner involvement.
9. *Challenges in design*, with the sub-categories evolution or alteration in design, questioning design, coordination in design, sequencing in design, arbitrariness in healthcare design, exploratory design process, roles and responsibilities in design, decision making in design, evolution in healthcare design, negotiation in design, and multiplicity of variables and complexity in healthcare design.

3.5 Validity

There are several strategies to achieve higher levels of reliability and validity with qualitative methods. This research followed two strategies, namely inter-rater reliability and triangulation.

Inter-rater reliability evaluation, which requires at least two independent coders to follow coding and interpretation methods and to establish a level of concurrence, is a method for ensuring rigor in qualitative research (Armstrong et al., 1997; Creswell, 2003). The level of concurrence, meaning the degree to which codings by multiple coders are similar, is one of the indicators of reliability. There are several epistemological positions for inter-rater reliability and for validity in general. Guba and Lincoln, for example, are critical of the concept of “reliability” which is, according to them, derived from the positivist tradition (Guba & Lincoln, 1994). Miles and Huberman, on the other hand, suggest that intercoder reliability should approach 90% (Miles & Huberman, 1994).

The inter-rater reliability protocol was initiated after the initial categories and super-ordinate categories were generated. A coding guide book was generated (APPENDIX C: Coding Guide) to include categories, descriptions, and samples from existing transcripts. Then, a graduate student with ethnography and qualitative data analysis experience was assigned a sample of transcripts to run the analysis following same coding protocol. The coding guide included instructions for the rater to facilitate following the protocol.

Inter-rater reliability analysis was conducted for a single transcript of a thirty minute interview with one of the key participants of this study. The coders, then, participated in a session for discussing and negotiating categories that emerged from the analyzed data set. A desired level of concurrence between the coders, based on initial and negotiated codes, was achieved in the first meeting. However, a second meeting was conducted to re-evaluate concurrence on the negotiated codes. Rather than generating codes, the task for inter-rater coder was to concur with existing codes in order to achieve a level of reproducibility.

Given the complexity and scope of the material, 80% level of concurrence was considered sufficient. No further meetings were held concerning inter-rater reliability, and the lead researcher carried on the analysis processes based on the negotiated categories of inter-rater reliability analysis.

Triangulation is another strategy that was followed in this research study. According to Patton (1999: p. 1192);

> *The logic of triangulation is based on the premise that no single method ever adequately solves the problem of rival explanations. Because each method reveals different aspects of empirical reality, multiple methods of data collection and analysis provide more grist for the research mill.*

Triangulation is a procedure in qualitative research where researchers pursue convergence among multiple sources of information. Although there are other types of triangulation that are employed for qualitative analysis, and this study followed two of them; methods triangulation and triangulation of data sources (Patton, 1999). Methods triangulation helped to ensure the consistency of findings from the different data collection procedures of the study, including interviews and field observations. Data sources were also triangulated to compare and cross-check “the consistency of information derived at different times and by different means within qualitative methods” (Patton, 1999: p. 1195). Field notes taken during each visit to also played a role in the triangulation; however the notes were not used as part of the development of codes.

3.6 Description of the Case

The following section provides descriptions of the firm and the project that was observed for this study. The characteristics of the design firm are discussed in order to provide a background for later chapters that provide a detailed description of design processes.

3.6.1 The Firm

Firm A was founded in 1977 by three partners, all of whom had an architecture background and one of whom is the current president. All three have maintained their employment with the firm since its inception. Over the years, the firm has built a significant portfolio of healthcare, religious and educational facilities within the regional market of Georgia and neighboring states.

Involvement in the design of certain building types has determined the client profile of the firm. The firm’s extensive list of clientele reveals that the firm has provided services for most of these organizations on more than one occasion. ***Firm A*** has thus been able to keep its clients over the years. In an interview with the president, he corroborated this fact and emphasized that the firm had grown together with its clients. The analogy he used was vividly realized when the firm added a new wing of office space, reflecting the way that the neighboring healthcare campus, owned by one of the client organizations, has expanded over the last 20 years. The "growing-together" statement holds true for the Private Health System (***PHS***) which is the pseudonym of the client organization for the case study project.

There are no branch or satellite offices for ***Firm A***. Since 1987, the firm has been operating in its current location which is in the Atlanta suburbs. It was a conscious decision made by the founding partners to stay away from the downtown area where many similar-size design firms have their offices. The woods surrounding the firm's headquarters, the creek running through the property, and the office building itself provide a distinctive workplace environment for the employees. The architects, who designed their own workspaces, let the qualities of the surrounding environment infuse the design of interiors. Recently, the interior design of the building, which is basically a continuum of open office spaces with wood finishes, has been awarded the "Interior Beauty of Wood Design Award."

The current building is a 250 feet-long linear structure with two floors on the new wing but three floors on the older one. These two wings with their different functional areas are linked through an entrance lobby where people have access to the exterior wood deck and the administrative spaces. The old wing houses the workspaces for the interior designers and in-house engineers, the president's suite, the meeting rooms and printing services, while in the new wing there is a grand open space on the second floor where designers from all three studios (healthcare, religious and educational) work together. The first floor of the new wing houses administrative areas, the kitchen and the dining hall where employees take their lunch breaks. Also in this dining hall, the firm hosts occasional lunch-and-learn events where employees have the chance to interact with visiting vendor firm representatives or experts in particular areas of interest. These meetings occur approximately twice a month, and attract most designers in the firm.

Firm A, since its early years, has adopted a multi-disciplinary practice approach. Other than architecture, the firm provides services in planning, interior design, civil, electrical, mechanical and structural engineering, and project management and leadership. All these services are carried out by personnel with relevant background and expertise. The project management among these services is a different business within the firm. The founding partners decided to establish another firm under ***Firm A*** to provide project management and leadership services for virtually the same set of clients for whom they are already designing. Although this secondary firm is a different entity under the same roof, the separation in terms of personnel and resources is not apparent. Human capital is fluid within the firm, and is reorganized and reallocated as new commissions come in. For example, the flexibility allows in-house engineers, architects or planning experts to join an ongoing healthcare project as needed. This feature of the firm was noted appreciatively by some members who were initially interviewed for this project. The interns in particular mentioned the value of “being exposed to different projects” and “engaging in portfolio-building projects” in informal discussions.

Nevertheless, in principle, the design department of the firm is organized around three typology-based domains; the educational, the religious, and the healthcare studios. Each studio has its separate directors to oversee the projects that range from quick renovations to the master planning of new campuses. Although the senior designers within the firm keep an affiliation with their respective studios, it is common to observe junior employees shifting between projects and studios as needed. Specifically, the interns or entry level architects who developed skills in digital modeling and building information modeling (BIM) capability are highly mobile across projects.

There are no physical boundaries in the firm between the designers from the three studios. The open-office configuration in the new wing accommodates side-by-side workstations for designers at all levels of expertise. The proximity between employees seems to facilitate a high level of awareness between people and projects within the firm. The workstations, providing limited audio and visual barriers, allow people overhear each other's phone conversations or see renderings, for example, on others' computer monitors.

The engineers and interior designers, who collaborate with the architects on project basis, have their work spaces in the older wing of the facility. Not every project at ***Firm A*** requires formal involvement of every group within the firm. Occasionally, the clients bring their own consultants into projects, which eliminates the need for the service of in-house engineers. However, evidence of ***Firm A***'s commitment to integrated project delivery approach is that it is not unusual for the firm to search for in-house consultants' opinions.

D10, the president of the firm, mentioned in the first interview that there were 55 employees in the firm including the administrative personnel, architects, designers, engineers, construction specialists, information technology and other support staff. In January 2012, however, the ***Firm A*** absorbed another small design firm, bringing in six of their staff members to join ***Firm A***'s work force. The director of the acquired firm was appointed director of the healthcare studio, a position which was previously occupied by ***D10***, the president of the ***Firm A***. Neither the new director of the healthcare studio nor the incoming staff actively engaged in the project observed in this research. In a press release after the merger, the new director expressed his position concerning the emerging research-based approaches, which was observed to be aligned with the intentions of the design team studied in this research:

> *This merger strengthens our professional expertise and artistry in ways that serve the growing complexities of today's healthcare. We understand that the physical environment impacts patient stress, resident/patient and staff safety, physician and staff effectiveness, quality of care, and quality of life**. We are positioning our clients and patrons to take advantage of environments built on credible research to achieve the best possible outcomes for clients and patients alike.*** *(Emphasis added by the author)*

There is no separate research and development unit or staff. The healthcare studio, with its twenty one members, is the largest group in the firm. The directors assign project managers to the commissions received. It is then the project manager's job to assemble the team to work on individual projects based on employee availability, workload, and expertise in building typology, construction, and design tools. The formation of teams depends on the size and scope of the commission being pursued. Besides project managers, a team at ***Firm A*** typically includes an architect having experience in construction details, an intern architect to create computer models and be in charge of drafting processes, and an individual with BIM expertise. The BIM specialist's work is critical in coordinating input from other engaging disciplines, and in the production of construction documents.

The digital infrastructure of the firm is maintained by an in-house information technology expert who solves all hardware- and software-related problems for employees. He also maintains the firm's data communication network for email and instant messaging. The firm also utilizes a popular web-based project management and collaboration software package that has the ability to serve internal and external collaborators. This online tool is used to pool all project-related materials for the participants' convenience. As a routine practice, a designated member within each project takes the responsibility of managing online folders, and uploading files, such as the plan drawings that are critical in terms of coordination across disciplines.

Some of the recent trends in the design community, including LEED (Leadership in Energy and Environmental Design), BIM, and EDAC (Evidence-based Design Accreditation and Certification) are evident in the professional profiles of ***Firm A***'s employees. For instance, the firm has LEED accredited engineers, interior designers, and architects working across projects. However, based on the scope and budget of individual projects, the firm does not pursue LEED accreditation for all projects commissioned.

Firm A has also adopted the BIM process. The recent projects undertaken by the firm include contractual obligations that require building information models to be submitted to clients together with other necessary documentation. During the field observation period for this study, there were two individuals in the firm who provide BIM support for projects. Both individuals had engaged in the ***PHS*** project in various levels and at different project phases.

Evidence-based design accreditation (EDAC) is another recent industry trend in healthcare design in the United States. It is a mechanism for proving commitment to certain research-related practices in design processes. The Center for Health Design, an advocate institution for evidence-based practice in the field of design, accredits professionals who have direct responsibility for planning and designing healthcare facilities. The purpose of the program is to enhance the utilization of credible evidence in design decision-making processes in order to improve the overall quality of care across the industry. During our observations, there were three EDAC accredited designers who were all assigned to the project. ***D1***, the lead designer for the project, and ***D6***, the interior designer, received their EDAC certifications a month before the firm officially received the commission for the ***PHSP*** replacement hospital project. ***D2***, on the other hand, who was hired during the schematic design phase, but attained his certification earlier, during his graduate studies, completed before the project began. When field work was completed at the end of the construction documentation phase, an entry level architect with EDAC certification was asked to join the project team to work on changes in the imaging suite.

3.6.2 Overview of Practices

In order to provide a more vivid picture of the context of this study, it is helpful to describe daily work life in ***Firm A***. Although observations of the firm include a wide variety of people and practices in different locations, the majority of the field work for this study took place in the offices of ***Firm A***. Until work stations were reorganized to accommodate new staff members in February 2012, field work was partly conducted from a work desk located in the center of the design studio. This immersive situation was extremely helpful in becoming familiar with the daily practices of the employees of the firm. After new workers were brought in, this was no longer possible, and the remaining in-house work was conducted on the periphery of the studio space on the second floor of the new wing.

The open-office configuration in the new wing offers a space for the designers with various backgrounds and specialties work side-by-side. The workstations where individual and collective design work is done, and the meeting room where collaborative work sessions, presentations, and other kinds of meetings occur are the main places of daily life at ***Firm A***. The scheduled or impromptu sessions in the meeting room bring participants together around the 12-seat table, the largest working surface on the floor. The meetings with external consultants, clients, and other collaborators also occur in this room. The second-floor meeting room is close to designers' work space and was observed to be the busiest location throughout the day. At any given moment, one can find designers with clients or consultants talking over stacks of print-outs lying on desks.

The use of physical models is very limited in ***Firm A***'s typical projects, whereas digital models and other types of digital representations for projects are constantly visible on individual screens at work stations. Although there are two types of physical models in the studio, during the field work for this study, no interaction involving these models was observed.

However, the first kind of physical model is the topographic site model, a representation of the plots where future buildings will emerge. Without any reference to building masses or nearby roads, these models visualize the physical terrain around building sites (Figure 6, left). The second type of physical model is the highly detailed exhibit model that clearly communicates the features of end-products. These exhibit models, which are produced outside of the firm, are used as show pieces, and they are kept in transparent boxes in the office (Figure 6, right).

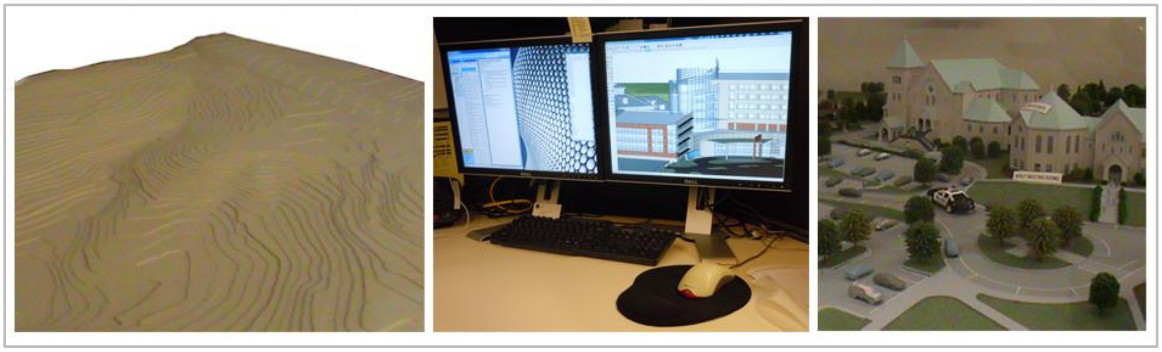

Figure 6. From left to right, a topographical site model (physical), a computer model (digital), and an exhibit model (physical)

Despite the existence of these physical models, the models that are actually used for a typical project within ***Firm A*** are the computer models through which designers study their ideas including, for example, spatial features, functional relationships, or materials to be used. At their individual work stations, the designers develop, transform and update these digital representations frequently. When needed, the representations are printed as white papers to allow employees to share "the latest and the greatest" drawings with each other or with their collaborators, such as consultants and client representatives.

It is common for particular individuals with considerable experience in certain aspects of design work to come forward to offer their expertise. Although the projects are carried out by teams in the studios, if help is needed on a BIM-related issue for example, it is a commonplace practice to borrow labor from other project groups. The membership of project groups is not very strict; transfers occur across teams and studios. For instance, two team managers from different studios might share the labor of an intern architect who has computer modeling experience to cover the needs of individual projects.

It is common to observe several people working on different issues within a single design project. A senior designer might be responsible for the facade design work, for example, while another designer takes on the responsibility for the space planning work of a commission. In terms of design, the tasks might be distributed across members of a team for a given project. This is the case for the design team observed for this research. The design of the facades (***D3***, ***D11***), the architectural detailing (***D2***, ***D7***), the space planning (***D1***, ***D2***, ***P1***), the computer modeling work (***D2***, ***D3***, ***D4***), and the interior design (***D6***) are all compartmentalized tasks run by different members of the team. All members with reduced responsibilities come together during the design meetings, update each other, exchange ideas, and try to come up with alternative solutions for design-related or other kinds of emerging problems.

3.6.3 The Project

The replacement hospital project is part of a larger expansion project initiated by the Private Health System (***PHS***), one of the largest healthcare provider organizations in the state.[3] The ***PHS*** was formed in 1993 from existing community-based facilities. With its five hospitals and five urgent care centers, 48 medical practice locations, and 14 imaging centers, the ***PHS*** is one of a group of mid-sized, integrated healthcare organizations in the United States. In 2010, the board of directors of the ***PHS*** has decided to allocate approximately 140 million dollars to replace one of the hospitals (the ***PHSP***) within the system. The hospital to be replaced is a 34-bed facility which has been in service for more than 50 years. The new campus, by contrast, will include a 112-bed, state-of-the-art hospital with enhanced services and programs to be developed around specialty lines. According to the plan, the first 56 beds will be in use by 2014, while two extra floors with another 56 beds will be added by 2016. The 265,000-square-foot hospital will serve a county that was ranked in top ten in population growth rate

[3] The names for the organization and the project have been masked at the organization's request. The abbreviations ***PHSP***, ***PHSK***, ***PHSC*** indicate different facilities of the Private Health System (***PHS***).

according to the U.S. 2007 census. The local press has paid considerable attention to ***PHS***'s significant investment, which is expected to create more than 300 jobs.

The architectural design commission for the ***PHSP*** was initially awarded to another architecture firm, ***Firm B***, in 2010. For less than a year, the ***PHS*** and ***Firm B*** collaborated to create a vision, a program, and an initial schematic design for the future healthcare facility. Eventually, due to undisclosed reasons, the ***PHS*** decided to terminate the contract, and announced ***Firm A*** as the new designers. The ***PHSP*** representatives and the new architects from ***Firm A*** officially initiated weekly steering committee meetings in January, 2011.

The ***PHS*** has done business with ***Firm A*** on several occasions in the past. However, the ***PHSP*** project is the most comprehensive collaboration yet between the two organizations. Furthermore, the ***PHSP*** project is the first ground-up hospital construction project for the ***PHS***, which has previously grown through acquisitions and facility expansions. After the land for the new campus was purchased in 2008, the organization started taking concrete steps to replace the old community-based hospital.

After receiving the commission, the president of ***Firm A*** has assigned ***D15*** to lead the firm's efforts. Rather than building on what had been produced by the previous design firm, ***D15*** and the design team started the project anew. However, program of the building, which was prepared by the previous firm, provided a basis for the design team to build upon. ***P1***, who was assigned full-time to work on building planning and programming, held discussions with ***PHS*** representatives to edit and refine the program for the new facility.

In March, 2011, the third month after receiving the commission, the design team needed to reorganize due to ***D15***'s leave of absence. ***D1***, who has previously managed other projects for the ***PHS***, was assigned as the design lead for the architecture team. ***D16***, one of the senior architects in ***Firm A***, was assigned to be the project manager for the ***PHSP*** project to orchestrate efforts with both the client and consultants inside and outside of the firm. However, in November, 2011, ***D16*** was replaced with ***D5*** who became the third project manager for the ***PHSP*** project in less than a year's time.

The land for the new hospital is owned by the ***PHS*** and is approximately five miles from the existing hospital. Initially on the plot there was a 76,000-square-foot medical office building which was also owned by the ***PHS***. The proposed program included another medical office building in addition to the existing one, and a 112-bed hospital which was approved by the local authority through a certificate of need (CON) process. The proposed site plan, created by ***Firm A***, combined the existing medical office building into a complex including the main hospital and a new medical office building, all linked together by a central atrium (Figure 7).

Figure 7. Site plan during schematic design phase

The existing three-story building housing leased medical office spaces has been in use since 2007. The facility offers services including cardiology, dermatology, gastroenterology, imaging, laboratory, neurology, oncology, orthopedics, otolaryngology, podiatry, urology, and vascular surgery. Before the replacement hospital opens in 2014, the organization intends to expand the scope of services currently offered in the existing building. The radiation therapy unit with a full cancer treatment service, for instance, has recently started admitting patients from the county and neighboring regions.

The second medical office building, with 80,000 square feet of space, is to be constructed concurrent with the main hospital. As with the existing building, it will offer leased medical spaces for healthcare professionals. Additional specialty services in this building will include women's imaging and therapeutic services, ear-nose-throat care for pediatric, sleep and cancer patients, cardiac diagnostics and treatment, and a cancer center with a full range of physician, diagnostic, treatment, education, and support services. According to the plan, a retail pharmacy will also be available.

The main hospital building, on the other hand, will be a 265,000-square-foot facility accommodating 112 patient rooms on four floors. In total, there will be eight floors which will make the hospital tallest building in the county. All patient rooms will be same-handed, meaning each will have identical layouts, and will provide a space to accommodate visitors staying overnight. As stated in the plan for the new hospital, there are two other significant features to be adopted; distributed nursing stations and extensive IT support to increase bedside time for nurses. The replacement hospital will be the first within the ***PHS*** to have bedside computers. The hospital will also include 30 adult and 10 pediatric emergency exam rooms and six surgery suites as opposed to 15 exam spaces and two operation rooms in the old facility.

The ***PHS*** has established a partnership with the Center for Health Design to have the hospital project become one of the 43 Pebble Projects across the U.S. The Pebble initiative, sponsored by the Center for Health Design since 2000, is an effort to "create change in the healthcare industry by providing researched and documented examples of healthcare facilities whose design has made a difference in improving patient and staff outcomes, as well as operating efficiency."[4] In other words, the Pebble Project formally offers knowledge support in various forms to promote the evidence-based approach spanning from planning to post-occupancy phases. A Pebble Project partner, the ***PHS*** in this case, is committed to run an evidence-based design process, to document rigorously the results and to share them with the larger network to advance the state-of-knowledge within the industry. As part of this commitment, ***PHSP*** seniors have assigned a business manager, ***O2***, to oversee the evidence-based design process and fulfill the requirements for the Pebble Project. The ***PHSP*** will be the first Pebble Project for the ***PHS*** and for the state.

During the planning phases, the direction pursued by the ***PHSP*** leadership was to achieve LEED Silver status for the replacement hospital. The steering committee, which included representatives of all participating parties, maintained the decision throughout the visioning and schematic design phases. In the early design development phase, however, the pursuit for LEED accreditation has been suspended due to budget constraints. The final decision was postponed until the end of the construction documentation phases. Meanwhile, the ***PHS*** leadership asked architects and consultants to build flexibility into their designs to accommodate LEED features in case the budget later allowed for it. When field work for this project was completed in July, 2012, LEED certification was still not on the agenda.

3.6.4 Key Participants

This section describes the project's key participants. Based on initial observations during the first two months of field study, it was clear that the ***PHSP*** project steering committee was the venue where new ideas were brought to the table, options were evaluated and design decisions made for the new facility. Capturing the Tuesday afternoon steering committee meetings was evidently critical to account for the

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[4] Retrieved from http://www.healthdesign.org/pebble/about on December, 26th, 2011.

interdisciplinary exchange between participants. In tandem with observations in the design firm were observations of the steering committee meetings. These higher level discussions were important because they influenced the direction of design work. Also, in terms of logistics, attending steering committee meetings allowed the observation of the project leaders from each discipline at the same time and place that immediate reactions of participants could be recorded.

This section provides brief descriptions of eight participants. Three individuals from the design firm (***P1***, ***D1***, and ***D2***), four from the ***PHSP*** hospital (***O1***, ***O2***, ***O3***, ***O4***), and two external consultants (***Ct1*** and ***M7***), were identified as the key participants based on field observations, interviews, and informal conversations during site visits.

P1 was one of the most experienced individuals working on this project, and was in charge of building programming and space planning for the replacement hospital. With a background in architecture, ***P1*** had over 30 years of experience exclusively in healthcare facility design projects, including programming, planning, and master planning. She has occupied top positions within significant organizations including prominent firms and the American Institute of Architect's Academy of Architecture for Health. ***P1***'s engagement with the design firm is relatively new. Previously, she was the consultant on several of ***Firm A***'s healthcare projects. For this project, however, she worked full-time for the firm. Assisted by ***D2***, an intern architect, she held planning-related discussions with the client and users and laid out the plans for the hospital floors. Together with ***D1***, she participated in all project meetings including the weekly steering committee meetings for the ***PHSP***.

D1 is one of the project managers for the healthcare studio. Based on the success of previous projects she had participated in with the ***PHS***, the president of ***Firm A*** has assigned her to this project after ***D16***'s departure. Although there were two other projects assigned one after another, ***D1*** remained as the design lead and functioned as "the face of the design firm," in ***D2***'s words, while other project managers remained in the background keeping busy with coordination and management issues. ***D1***'s background is in architecture and her experience in healthcare spans over fifteen years. At the outset, ***D1*** was one of the three individuals in the firm having EDAC accreditation. As part of her duties, she coordinated the relationship with ***O1***, the project manager on the client's side, providing updates and reports. ***D1*** participated in steering committee meetings, kept the official meeting minutes that included progress issues, decisions, and action lists, and made this material available to the design team.

D2 is one of the intern architects within ***Firm A***. He was hired recently after graduating from a master's degree program with special focus on healthcare design. ***D2*** has his background in architecture, and before graduate school, he had worked at a prominent healthcare design firm for 14 months. When he was hired in June, 2011, the project was already in the design development phase. ***D2*** was the other person in the firm, after ***D1***, to hold EDAC accreditation. He occasionally participated in the weekly steering committee meetings. Although he was tasked with several other duties, ***D2***'s main assignment was to develop space planning with ***P1***. As part of his duties, he was one of the design team members to interact with external consultants involving progress updates, information exchanges, and coordination with regards to project documentation.

O1 is one of the project managers in the larger ***PHS*** organization. Although he was assigned to the ***PHSP*** project, the largest construction project being undertaken by the organization, ***O1*** simultaneously managed other projects of various sizes. His educational background was in engineering, and he has been in charge of the most significant projects for the organization. He actively engaged in a variety of activities with collaborating parties across disciplines. ***O1*** himself administered the ***PHSP*** master budget to include the set of design, process, and equipment-related features to be accommodated in the future hospital. Accordingly, given his gatekeeper role, he had been the center of attention in meetings. ***O1*** also created and ensured adherence to the agenda for the weekly steering committee meetings. He occasionally participated in design group meetings that took place at the design firm.

O2 is the junior business manager at the ***PHS***. She holds a master's degree in health systems in addition to her degree in industrial and systems engineering. As part of her duties, ***O2*** had run the documentation for the Pebble Project and coordinated meetings on the client side. She participated in the steering committee meetings and constantly updated the group about progress on issues of her responsibility including the Pebble Project. ***O2*** also coordinated the collaborative research efforts with external parties. She was the point of contact, for example, for the Center for Health Design, and the flooring company involved in research on carpets in the old facility. As the design work progressed, her major focus shifted to the surgery suite where she actively engaged in preparing the business plans and related details in utilization of operating rooms.

O3 is the chief nursing officer and the vice president at ***PHSP*** hospital. She was working at other ***PHS*** facilities prior to her arrival to ***PHSP*** to work on this new hospital, develop a nursing process and nursing team, and on the design of the facility. She occupied a dual role throughout the design efforts. With more than twenty-five years of nursing experience, she vividly pronounced the user needs to be accommodated in the new facility. Given her position as the vice president of the ***PHSP*** hospital, ***O3*** was also one of the two senior representatives for the client organization which required her to oversee the overall progress and the direction of design.

O4 is president of the ***PHSP*** hospital. Holding the position of Senior Vice President of Real Estate and Construction for the larger ***PHS*** organization, he was the one who makes the executive decisions for the replacement hospital project. ***O4*** holds master's degrees in both business and healthcare administration. Besides his administrative position at the ***PHS***, ***O4*** is also involved in the Center for Health Design, the organization that promotes the evidence-based approach in healthcare industry. He participated in the weekly steering committee meetings where he actively engaged in the discussions with collaborators including designers and consultants. Occasionally, he participated in the user group meetings where the designers had the opportunity to interact with the staff of the existing hospital to meet their needs in the replacement facility.

There is also a set of external consultants hired by the ***PHS***. These consultants are expected to provide services involving a range of domains including care processes, engineering, information technologies, and equipment planning. For the purposes of this research, at the outset, we tried to observe the engagement of each and every consultant involved with the project. Due to logistical and time constraints, attention was focused on a smaller set of participants. The paragraphs below briefly introduce two of the consultants.

From the very beginning, the owner's intention was to pursue "an integrated project delivery" model that required all set of consultants present in the process starting from the visioning phases. Except for two areas that lacked a strong presence earlier in the process, information technologies and equipment planning, the steering team had managed to maintain the interdisciplinary conversation in the process. The interaction among representatives of different domains (the owner, engineering, design, construction), despite occasional communication breakdowns, helped the team to advance the design work, and to maintain the budget within limits. As details of the future facility became clearer, the steering committee sought support to resolve IT related issues related to the new space and practices that needed to be resolved. At the end of the schematic design phase, the ***PHS*** leaders decided to bring in an IT consultant to work on the technology plan for the replacement facility. In July, 2011, a representative (***Ct1***) from a prominent consultancy firm was invited to steering committee meetings to work on the IT-related challenges that had been considered peripheral during the schematic design phase.

Ct1 was the information technologies consultant for the ***PHSP*** project. He held the position of the senior advisor in the firm that had been hired by the ***PHS*** to plan and implement necessary information technologies. ***Ct1***'s background was in business, and had worked in the healthcare industry since 2001. His main task was to create the technology plan for the new facility in coordination with the designers developing the layouts and physical features of the future hospital. He was also responsible for developing the business case for the implementation of the information technologies that he specified. Due to budget constraints, it was anticipated earlier in the process that it would be impossible to adopt the entire list of desired technologies in the replacement hospital. Eventually, the report that ***Ct1*** actually prepared recommended a different set of technologies to the steering committee. In order to catch up with the latest technologies, the plan offered to develop a strategy for purchases and implementation which could happen later in the process. When field work ended in July, 2012, there were still undecided items in the technology plan to be implemented.

Ct1 participated in the weekly steering committee meetings and the user group meetings where he investigated the use of existing information technologies in the old hospital. Among the consultants, he was one of the most active participants in meetings, since information technologies needed to be considered in the context of decisions about the design of the facility and the processes to be adopted in the ***PHSP*** hospital. ***Ct1*** also involved another technology implementation project for a facility in the ***PHS***.

M7 is the president of the mechanical-electrical-plumbing (MEP) engineering firm that was hired by the client organization. He preferred to participate in the steering committee meetings himself, although there were other project leaders in the MEP firm working on this project. ***M7***'s background is in mechanical engineering, and he has more than twenty years of industry experience. Besides his certifications, including LEED and Healthcare Facility Design Professional (HFPD), ***M7*** is actively engaged in the Health Guidelines Revision Committee of the Facilities Guidelines Institute which is the major resource for healthcare design industry. Similar to ***Ct1***, the information technologies consultant, ***M7*** was one of the most active participants in the observed meetings. The steering committee sought his advice concerning critical issues such as indoor air quality, ventilation, and filtration, which are important with regard to occupant safety. On several occasions during the observed meetings, he was given the chance to extensively explain the current research about existing technologies, the scientific evidence at hand, and the alternative mechanical systems that could be adopted in the new hospital facility.

3.7 Summary

The nature of the research questions and the use of the distributed cognition framework to explain architectural design practice clearly required performing a long-term observational study of the rich socio-cognitive context where interdisciplinary interactions occur on a daily basis. For this reason, this study adopted ethnographic field strategies, observations, and open- and semi-structured interviews as methods to capture interdisciplinary problem solving *in situ*.

In the analysis phase, the research adhered to "grounded theory" procedures involving inductively developing a theory that was based directly in the empirical data collected. The typical stages of development for the grounded theory method, namely open, axial and selective coding, was employed in analysis. To achieve higher levels of reliability and validity, the research followed two strategies including triangulation and inter-rater reliability exercises.

A description of the firm, the client organization, and the project was also presented in this chapter to provide a background for the following chapters.

CHAPTER 4

INTRODUCTORY CONCEPTUALIZATION and DEFINITION OF TERMS

A number of special terms and concepts are frequently used in this study. This section defines this terminology in order to avoid misconceptions or issues associated with polysemic nature of certain concepts.[5] Rather than relying on existing terms with pre-defined meanings, this study employs a lexicon that is informed in part by data from field observations and interviews. Notably, in interviews with key individuals, participants communicated their own concepts. Unless otherwise noted, these terms are used consistently throughout this document.

The term ***users*** appears frequently in this dissertation to refer to professionals who contribute to the delivery of care in healthcare environments. The term is used interchangeably with ***staff*** and includes physicians, nurses at all levels, and some housekeeping personnel.

In this study, ***information*** refers to facts provided or learned about something or someone, whether or not it is used to support or challenge a theory or a design decision. In that sense, information is an encompassing term, and includes evidence as a subset. During the user group meetings observed for this study, for example, the designers gathered information about staff, spaces, devices, and process within existing facilities, and a sub-set of this information was utilized and presented as evidence in subsequent

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[5] It is not unusual that even major concepts were scrutinized by authors to provide further resolution in their respective domains. For example, see Margaret Masterman (1970) on the concept of paradigm, or Adrian Forty's (2000) article on "form" in Words and buildings: a vocabulary of modern architecture.

interactions. Thus, through a social process, segments of available information becomes evidence to be considered in design decision making.

The term ***evidence*** refers to information in various representational forms (i.e. documented or anecdotal) that provides a basis for belief about a phenomenon, which, in turn, affects design decisions. Evidence encompasses information drawn from scientific research, expert opinion, or even the statements of individuals, for example users who actively engage with a healthcare situation on daily basis. Furthermore, evidence can be embodied in publications, physical mock-up exercises, current or precedent practices, anecdotes, or regulatory documents. Following the example from the previous paragraph, for instance, a sub-set of information which emerged from the user group meetings was considered as evidence in designing the environments of the new facility.

Anecdote refers to a representational form in which evidence is introduced within incidents involving people and places. Below is an excerpt from a meeting that provides a clear example of anecdotal evidence that eventually challenged design decisions about a section (the green zone) of the emergency services area;

00:13:01 ***O3*** *I would prefer not to have a fast track… but… because I'm telling you, pediatrics, parents are gonna get irritated with that. We know that pediatric patients hate the green zone…*

It is not always easy, however, to identify the sources of evidence that constitute anecdotes. Many instances have been observed where participants, in their anecdotes, included evidence that they had taken from a variety of sources. With regards to patient satisfaction, for example, participants referred to "hard data" such as satisfaction scores, but also to their own experiences with actual patients who were either satisfied or dissatisfied with the services provided. Unless the participants mentioned the source of their evidence, we have considered such accounts as anecdotal evidence.

Causal argument or ***chains of arguments*** are phrases frequently used in this study to refer to constructs that provide a conclusion based on their premises. In the cases observed, we have recorded a set of the arguments that contained a clear demonstration of a cause and effect, and, occasionally, specific mechanisms with regards to causes (interventions) and effects (outcome). Below is an example of a causal argument taken from an interview with ***D1***, the lead designer on the project;

00:35:22 ***D1*** *…They know that day lighting and use of nature improve patient outcomes, reduces length of stays…*

The argument above includes two causal statements (provide day light, provide views to nature) which lead to a chain of effects (improved outcomes and reduced length of stays). These constructs became one of the qualitative categories of analysis for this study, and will be discussed at length in the final chapters.

Story refers to representations, created by users or staff, consisting of joined segments of accounts regarding a phenomenon; mostly physical environment features or healthcare processes. Briefly, stories are verbal structures where a set of evidence-pieces is sequentially integrated, then modified or maintained over the course of the project. In this study, users were observed invoking stories that combined precedents, anecdotes, or academic research to explain the reasoning behind a particular design strategy or decision. Pieces of evidence, in that sense, become critical elements that are integrated into emerging stories. Below is a lengthy example of a story that combines distinct items, including the Institute of Medicine (IOM) report, reference to incidents with regard to patient safety, past experiences, and a set of causal arguments, into a single account:

00:12:32 ***O3*** *… Because if you look at the IOM report that patients are being harmed every day within healthcare and one of those largely harms from the medications that we give them. That's why joint commission came out that we need do a medication reconciliation at every hospital visit, well part of those errors happen in hospital, I mean patients are harmed every day from giving the wrong dose, the wrong time, the wrong medication and we've experienced some of those medication errors ourselves. We have medication errors all the time, so we need reduce those errors to make a safer environment. So that* *was one reason and another reason is nurse fatigue, nurses travel up and down units all the time. And if we can decrease those steps, decrease the time that gives the medication then we can put more time back at the bed side, and that's the reason nurses got into nursing, it's to spend time with patients, not doing task.*

The scope and content of stories varied considerably in this research. However, a number of the observed stories were durable in terms of structure or individual items of evidence, even between people from different disciplines. As the description unfolds in the following chapters, additional stories will be introduced and analyzed in relation to the contexts in which they were observed or recorded.

A ***rule-of-thumb*** is a practical technique that designers or project personnel utilized for approximately calculating or recalling necessary values in design decisions. One rule-of-thumb, for example, was applied for determining the number of parking spaces for the future facility, where the team provided one space for every 2.0 to 2.5 people in attendance on campus at one time.

Depending on the context in which it is used, the term ***precedent*** either refers to precedent design examples, previous practices, past incidents (usually first hand-experience), or anecdotes from third parties. As this research progressed, the term ***precedent*** unexpectedly became be one of the key categories for qualitative analysis. The quote below is an excerpt from an interview that exemplifies “reference to precedents.”

00:19:26 ***O4*** *… We saw at one of the projects in Victoria, Canada, where they have two benches on the nursing unit. And what they found out was that the patients walking down the hallway stop their rest and they walk some more, families would congregate there…*

In the excerpt, ***O4*** refers to both a design feature (two benches on the nursing unit) and a practice (stop their rest and they walk some more), and communicates them with reference to both his first-hand experience (we saw) and to an anecdote from third parties (what they found out was).

As in all healthcare design projects, the steering committee for the ***PHSP*** project operated under budget constraints. Cost-related issues were always present in multidisciplinary group meetings where certain design features or care processes were subject to cost-benefit analyses. The purpose of these analyses was to evaluate the impact of those desired features on the overall budget. This study pays particular attention to the set of discussions and negotiations on the cost of implementation of certain evidence-based features that were considered during the design process. The discussions around "business cases"[6] for individual design features such as same-handed rooms were of great value. Thus, ***cost of implementation*** refers to the cost or cost-related consequences of implementing evidence in design work.

The ***visioning*** phase refers to the pre-design stage where project teams or others conducted meetings to "launch the project and clarify the project message, image, brand, or theme, as well as identify desired features or amenities and services to be included in the project" (Malone, et al., 2008: p. 78). Paralleling their interest in an evidence-based approach, the steering committee and other project leaders established a distinct visioning phase during which they formally launched the project (see Figure 1 for project schedule), clarified the project message and theme (world's safest hospital) and identified the set of services and amenities to be included in the project (initial building program). The visioning phase was the stage at which the entire team was exposed to the larger idea of evidence-based design and related approaches (e.g. integrated project delivery) and design features (e.g. same-handed rooms). ***Firm B***, the lead architecture firm during the visioning phase, published a booklet, ***the visioning document***, that reported the outcomes of the initial meetings and presented the vision for the new ***PHSP*** hospital, as well as the building program and a set of schematic drawings of the future facility.

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[6] Business case refers to particular documentation that evaluates the cost-effectiveness of features under consideration. A typical business case reports exercises with regards to first costs, cost-benefit ratios, and life-cycle costing.

CHAPTER 5

DESIGNING FOR EMERGENCIES

Time pressured work in an environment of uncertainty
creates a cognitive environment that has been described as
a natural laboratory for error. *The Nature of Emergency
Medicine* (Croskerry & Cosby, 2009: p. 6)

This chapter provides a "thick description" of the events that surrounded the design process for the emergency department (ED hereafter) of the new ***PHSP*** hospital during the design development and construction documentation phases (Figure 8). However the events that are included in this description necessarily go beyond those phases, since it is difficult to present a truly substantive account in isolation from other related events.

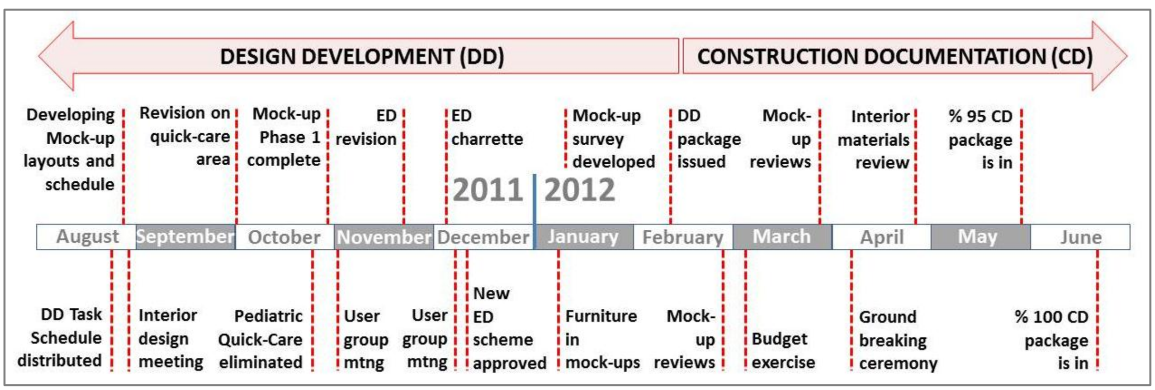

Figure 8. Project timeline with ED-related milestones.

The main body of the data set used in this study includes documents from the design development and construction documentation phases, which span over a period of ten months. However, whenever necessary, the data set was extended to include earlier phases by accessing the project archive of the architecture firm and by interviewing participants about emerging issues that occurred before the study began. Some of the design ideas that shaped the new ED and its sub-systems (e.g. waiting areas, fast-track care areas, pediatric section, etc.) were inextricably rooted in the ***PHSP*** hospital's history. For example, in order to understand the inception and the development of fast-track care spaces within the ED, it was necessary to extend the data set to include some of the activities that occurred prior to visioning meetings.

The sub-sections of this chapter follow a chronological order to account for the events as they unfolded during the design process. Initially, the facts, intentions, and ideas that were influential in the design of the ED for the new hospital will be described. Following this background material, the visioning phase, where an interdisciplinary group of professionals discussed and documented the vision for the new ***PHSP*** hospital, will be elaborated. As the participants of this study consistently acknowledged, the visioning phase was the venue where the seniors of the ***PHSP***, in conjunction with a group of designers, consultants, department leads, and community members, created the vision to be followed through the subsequent phases of design (Figure 9).

Client (PHSP) representatives	**O1**	Project manager for the PHS.
	O2	Project coordinator in the PHSP hospital.
	O3	Assistant vice president and chief nursing officer.
	O4	President of the PHSP hospital.
Project consultants	**M7**	President of the MEP firm.
	Ct1	Information technologies consultant.
	Ec1	Medical equipment planner.
Firm A: design team	**P1**	Space planning and programming consultant.
	D1	Lead design architect.
	D2	Intern architect.
PHSP staff	**U5**	Nurse. Participated in user group meetings.
	U6	Nurse. Participated in user group meetings.

Figure 9. Key participants in ED design

The following sub-section provides an account of a set of practices involving translation of initial ideas into schematic design. Following a set of previously expressed intentions involving various types of evidence, plus a set of strategies developed in earlier meetings, the schematic design and design development phases provided a shared environment for participants to solve problems, translate evidence, and further develop design work by utilizing an extended set of representations including physical mock-up spaces. As opposed to exchanges in visioning meetings in which participants discussed and elaborated on precedents or emerging ideas within healthcare, in subsequent phases the participants utilized various media to represent spaces in the future hospital in order to facilitate communication between individuals with different backgrounds. In other words, the earlier meetings involved the question of what was available that could be adopted for the new facility, while the subsequent efforts were oriented towards translating a series of desired processes and physical environment features into a developing design.

Using descriptions of distinct design episodes spanning from pre-design to construction documentation (sections 5.1 to 5.4), subsequent sections will present two events in the process where particular design decisions were challenged by staff members and subject-matter experts. These challenges, which eventually led to significant changes in design, are depicted with specific emphasis on their argumentative sources, evidential support, engaging actors, and negotiation processes. This chapter concludes with brief summary of the decisions during the design for the ED of the new ***PHSP*** hospital. The design changes which were made during the post construction documentation phase are beyond the scope of this study.

5.1 A Fast-track Experiment

ED design has emerged as a hot topic in healthcare design circles, in part because politically loaded debates around the future of reimbursement have become the center of attention across the community. In the light of these debates, healthcare designers increasingly engage with the problems of how to provide effective, efficient, and safe medical care at a lower cost. These questions lead to further inquiries concerning economy, productivity, and financial sustainability. Within the dynamic context of healthcare, ED design has become something of a sub-specialty of healthcare design and research, one in which specialists from a range of disciplines including architecture, engineering, business administration, medicine, and nursing, try to achieve optimized solutions for the industry (Huddy & Rapp, 2002; Zilm, 2007, 2010). The main expectation from design is to respond well to increasing demand for efficient, effective, and safe care processes (Zilm & Roche, 2010).

In many hospitals, the ED is the "front door" where patients with a wide variety of critical, urgent and semi-urgent conditions are admitted, triaged, and treated. Concerning architectural design, there are several established layout types that can be utilized in ED design (Zilm, 2007). These schematic templates (e.g. ballroom or pod-based layouts) provide designers with packages of solutions based on distinct basic organizational models. These distinct layout schemas and emerging alternatives, which demonstrate certain strengths and weaknesses concerning management and care models, have been made available to the community through various channels including articles, research reports, and guidelines (Harrell & Mazzi, 2012; Huddy & Rapp, 2002; Zilm, 2007).

Within the range of typical layout types, there is a host of sub-spaces in emergency services that are common in many hospitals. Each of these sub-spaces, such as waiting areas, examination rooms, or trauma rooms, has its own unique requirements, such as adjacency, privacy, and visibility. The growing ED design literature cited above provides recommendations and partial solutions to typical and developing issues associated with these sub-spaces.

This sub-section provides an account of the design process of the fast-track care area which is a key component within the ***PHSP*** hospital emergency services. Discussions among participants about the physical attributes of the area, in and out of steering committee meetings, emerged as one of the important topics throughout the design process. Here, the fast-track rooms are not treated as a unit of analysis, but as an extended event which exemplifies that evidence had been gathered or created, maintained or manipulated and represented across disciplines and over time.

Some of the ideas that shape the fast-track area of the new ED can be traced back to the activities which took place in the old facility, prior to the formation of the steering committee which was observed in this research. In 2009, the old ***PHSP*** hospital administration recognized the need to have a separate area to treat minor emergencies quickly and efficiently. Excessive wait times in the unit and a shortage of space, as evidenced by the necessity to share six of their beds with the surgery department during day hours, forced hospital administrators to consider seriously the future of the emergency services for the facility, which was expected to serve one of the fastest growing communities in the country according to the U.S. Census Bureau. The agreed-upon idea was to enhance the existing operational model to include fast-track rooms, which in turn could help to improve patient turn-around times and satisfaction scores within emergency services. As ***O3*** -the chief nursing executive of the hospital- put it in an interview:

00:23:27 ***O3*** *It's, it was demand. We cannot see the volume of patients in nine rooms, when you move to see forty thousand patients a year out of nine rooms, there is no way you can turn over patients fast enough to make it work…*

Led by the ED director, an interdisciplinary team was formed to manage the efforts to improve the existing care processes and spaces. The team included representatives from hospital administration, nurses, technicians, architects, engineers, and finance professionals to develop ideas for creating an efficient and effective treatment plan. For this relatively small but critical remodeling practice, the ***PHSP*** hospital administration contracted ***Firm A***, which had previously provided architectural services to the ***PHS***, to assist them in redesigning the space.

The initial task for the interdisciplinary team was to specify the characteristics of the fast-track area that they wanted to implement within the ED. The team initially established four criteria to guide design, which were not necessarily space-related, but rather a mix of administrative, process-oriented, and physical environment-related goals. The goals that were established by the interdisciplinary team included (1) creating a separate area with separate staff, (2) establishment of new criteria for the triage of patients, (3) the use of committed hours and staff, and (4) the implementation of a process that enables as many patients as possible to "stay vertical."

The interdisciplinary team, working from a list of desired attributes to guide them throughout design, then quickly identified a location adjacent to the existing ED to implement their ideas. In a month, the fast-track area was in place, including four curtain-separated bays with patient recliners and a more private patient care area for sensitive cases. This "successful" implementation was the subject of a later article authored by ***O2*** and ***O3***:

> *The space opened in June 2009, and ED customer service scores increased 5% immediately, while overall emergency department door-to-door times decreased for the hospital.*

However, it was hardly the end of the story for the design process of which was called as *the green zone*, after the green tiles used on the floors of the area. While the process-related metrics (customer scores) mentioned above had been improved, some concerns about the new fast-track area had immediately emerged after occupancy. In their article, ***O2*** and ***O3*** reported these post-occupancy issues that were documented through in-house measurements and anecdotes;

> *Due to the curtain separators between the treatment chairs, patients had minimal privacy and were privy to conversations in other areas. There was limited accommodation for family members in the treatment area, and many family members were forced to remain outside in the waiting room while treatment was in progress. Also, because the nurse supply cart was unattended in the middle of the space, there were instances of stolen or depleted supplies.*

… Finally, extended periods of waiting for test results sometimes bottlenecked each treatment space and prevented a quick turnaround time.

The initial design was regarded as successful in terms of the criteria established by the interdisciplinary team. However, the new facility and its associated spatial configuration required an additional modification to cover the emerging needs of patients, visitors, and staff. In order to overcome the new set of challenges within the fast-track area, ***PHSP*** hospital administration decided to facilitate a second design exercise which led to a partnership with NS, a firm which is known for its interior design solutions and furniture for healthcare facilities. It took less than a month for the interdisciplinary team to arrive at a new set of goals, and, accordingly, retrofit the existing space to provide solutions for the emerging problems identified during post-occupancy.

Through discussions with the medical director and staff, the team provided a schema to provide architectural solutions to the three major concerns, including lack of privacy, lack of space to accommodate family, staff and equipment, and bottlenecks due to patients who were waiting tests or results from other departments. In their article, ***O2*** and ***O3*** summarized the translation of emerging ideas into design solutions as follows:

The overall consensus was to change the space from curtains to a cubicle-type layout with accommodations in each treatment area for supplies, visitors, and staff.

There are now four cubicle-type patient treatment spaces, each outfitted with an oversized, comfortable patient chair; a family bench; a caregiver stool; and a supply station. The walls of each space were high enough to afford seated privacy and visibility from the nearby nurses' station. A nearby family consult room was also converted into a sub-waiting area using chairs from the previous Green Zone space, and it was finished to be spacious enough for three waiting patients. The installation was completed in less than a day, and the space was open for patient treatment in July 2010. After three months of seeing patients in the new space, customer service scores were maintained, while privacy and accommodations were both improved.

The design solutions in this phase, including replacement of curtain bays with cubicles to provide better privacy, placing a bench for accompanying family members, and providing an extra area for waiting to eliminate bottlenecks for care areas, helped the ED managers to further improve the new fast-track care process and maintain the high satisfaction scores which were already rising after the initial implementation of the model.

There was, however, one more design-related intervention to implement following anecdotal evidence concerning a lack of audio-visual privacy within the new four care cubicles. The complaints were persuasive enough for the ***PHSP*** hospital administration to contract NS, for a second time, to install 20-inch clouded glass “stackers” (dividers) on top of the existing care cubicle structures. This second post-occupancy intervention, which gave standing privacy to each care cubicle, was the final touch made by the interdisciplinary team in implementing the new care model and space within the old ***PHSP*** hospital.

In interviews the participants consistently referred to the design-related changes as the predominant factor in improving various outcomes (e.g. better throughput and satisfaction) within the department, although the design was only a single piece within the larger package of interventions that introduced a whole new care model within emergency services in the old ***PHSP*** hospital. In participants’ accounts, mentions of the specifics of the implemented model (e.g. nurse-patient ratio, new care protocol, etc.) were overshadowed by repeated references to physical environment features of the new fast-track area.

Although small in scale, this interdisciplinary exercise was treated specially within the extended history of the ***PHSP*** hospital which, unlike the larger ***PHS***, had limited organizational memory in collectively envisioning, designing and creating spaces for new care processes. The article published by ***O2***, the business manager, and ***O3***, the chief nursing officer, which summarized the creation of the fast-track care idea, was the first of its kind for ***PHSP*** hospital in that the design experience of the hospital was shared with the larger community by means of a journal publication. The concept, which synthesized a fast-track care model with associated sub-spaces throughout a number of iterations and modifications, was later transferred to the ED of the brand new ***PHSP*** hospital.

5.2 Beginnings: Visioning for the New Hospital

The envisioning and programming phase for the new ***PHSP*** hospital (Figure 1: Project Timeline) was roughly coincident with the implementation of the fast-track care area in the old facility on its way. Starting in April 2009, an extended interdisciplinary team including architects, the ***PHS*** representatives, and subject matter consultants, initiated a series of meetings to depict a detailed road map for the future facility. ***Firm B***, which was selected through a request-for-proposal process, supplied architects who were the primary actors in visioning efforts including a series of activities and the use of several techniques to gather necessary information to guide the design process. Over the period of a year, the interdisciplinary team conducted meetings to develop and detail the ideas that would shape the new hospital. As mentioned in an earlier section to introduce the case (Section 3.6), the visioning phase was the period during which the team was exposed to many ideas and approaches (e.g. evidence-based design ideas and implementations) that were in circulation within the healthcare design community around the country.

Designers from ***Firm B*** published the result of the visioning activities in a booklet before the ***PHSP*** hospital seniors decided to hire another firm as their architectural consultants. The purpose of publishing a visioning document was to have information readily available so that the owner and the design team could review past decisions that were the drivers of the project at a later date.[7] Following a period during which the

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[7] Statement is taken from the visioning booklet published by ***Firm B*** in November 2010.

project was held idle, ***Firm A*** was awarded the commission to design the new ***PHSP*** hospital.

One of the major outcomes of the visioning meetings was a set of guiding principles which was seen as means to identify and implement desired features in the new ***PHSP*** hospital. Reflecting the interdisciplinary nature of the team, the nine guiding principles (Figure 10) were a compilation of statements that cover a variety of issues including design, community and staff well-being, care processes, and sustainability. The intention here was to keep the project on track throughout the design phases by continuously testing available design options against these guiding principles.

9 Guiding Principles		
Leading with evidence-based design concepts and innovation	Designed efficiency through LEAN principles and processes	Wellness and prevention focus
Holistic environment that is the heart of the community	Integrative patient and family experience	Environments that enable success
Sustainability	Flexibility in design	Employer of choice

Figure 10. The guiding principles established during visioning meetings

The visioning document also included a series of diagrams that laid out several options for the master plan and individual departments to be included in the new facility. For each design alternative, the architects provided a rationale and a quick evaluation based on the design drivers that were established earlier. The visioning document provided clear connections to the initial building program, the set of available research paths to be pursued[8], and a schedule for the mock-up exercises that would help the steering committee and staff to experience some of the spaces of the new facility.

[8] The hospital administration's intention was to conduct original research in both old and new facilities to demonstrate the outcomes of process and space-related interventions.

The series of visioning meetings, outcomes of which were summarized in the above-mentioned booklet, was diverse in content and scope. There were five main visioning meetings in addition to seven side meetings where participants refined some of the crucial topics including Lean approaches[9] and the "big ideas", such as "creating the safest hospital in the world" that the participants wanted to be translated into design work. One of the five main visioning meetings was dedicated to the elaboration of design and operation concepts to shape emergency, diagnostic and invasive services of the future hospital. This particular meeting was later summarized in the resulting visioning document, in which architects reported several operation-related statistics and initial space-related solutions that might improve processes within emergency services:

> *While the majority of patients is treated and then released (88%), the ED accounts for 40-50% of all inpatient admissions. Access and flow can be improved with internal actions and process, such as dedicated fast-track area, limited triage, establishing turn-around-time goals and no waiting room.*

Combined with facts that emerged regarding the larger context of the project, such as a growing need for emergency services within surrounding community, the visioning report provided an array of "internal" solutions to problems at several different scales aimed at improving access, flow and efficiency within the ED. The report, with its design-related interventions included as part of the bundle of solutions, presented a set of initial approaches and concepts concerning goals (reducing turn-around time), processes (limited triage) and design (fast-track solution).

Occasionally, the alternatives for related problems were presented as a menu that the team could pick from. For example, the report included four alternative diagrams, each providing a schema to organize clusters of examination rooms within the ED. In a

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[9] Originated in manufacturing industry, Lean approach offers incremental process innovations to increase efficiency while decreasing waste. Organizations in healthcare organizations adopts this approach to achieve substantial improvements in the quality and efficiency of health care (C. S. Kim et al., 2006).

similar fashion, three different examination room layouts with varying dimensions were presented as available options to be pursued. In addition to these alternatives, there were also stand-alone, design- or process-related recommendations to increase efficiency, quality and satisfaction within emergency services. However, these recommended features were supported by causal arguments leading to desired outcomes within the new ED without reference to any kind of source (e.g. scientific study, expertise, or precedents). For example, it was stated in the document that installing electronic dashboards in examination rooms would be beneficial to achieve increased patient experience and satisfaction by means of “increased transparency, enhanced awareness, self-control and involvement,” but no evidence, anecdotal or scientific, was cited to support these statements.

Either in the form of a menu or stand-alone recommendations to enhance the quality of care, the team was provided with a range of alternatives, each of which had a different degree of evidential support. Throughout the visioning phase, however, the ***PHSP*** representatives, in particular ***O3*** and ***O4***, adopted several strategies to scrutinize the strength of evidence supporting emerging design features. These strategies included participating in conferences to discuss the features with individuals, groups or organizations in the healthcare design community, making themselves familiar with publications on related topics, and conducting site visits to locations where certain design features were operational. Furthermore, with regard to testing emerging ideas and recommendations, there were several projects conducted within the old hospital. Implementation of the fast-track area, which was introduced earlier in this chapter, was among these efforts to test the emerging ideas. According to ***O3***, this experiment allowed the team to test a new care model “fairly and cheaply.” However, for the remaining pieces of the ED, including examination rooms, trauma units, and waiting areas, such rapid implementations and performance evaluations were not possible. Most of the ideas represented in the visioning document, by means of propositions or diagrams, had to be set aside for months before they were translated into the architectural drawings, computer renderings, or physical mock-ups that allowed staff members to experience these patient care areas.

Fueled by the success of the fast-track experiment, the visioning team showed further interest in the design of emergency services. In order to flesh out the details of the future ED, a group of participants, including the managers, clinicians, and designers who would extract design-related information out of these conversations, was asked to imagine the "ideal" department and evaluate possible scenarios and emerging design solutions for the entire unit and the sub-systems within. As reported in the visioning document, the interdisciplinary team agreed on nine components which were expected to contribute to better emergency care within the new ***PHSP*** hospital. These components included: (1) eliminating waiting, (2) fewer transfers, (3) throughput efficiency, (4) flexible expansion and contraction, (5) standardized rooms, (6) no grouping of patients, (7) online registration and appointment capability, (8) having airborne infection isolation (AII) rooms, and (9) having private care coordinator. Like the nine guiding principles for the entire hospital (Figure 10), this nine-item list for the ED reflected a set of emerging operational and design-related concepts that attempted to optimize safety (e.g. standardized rooms), efficiency (e.g. throughput efficiency), and satisfaction (e.g. online registration and appointment or private care coordinators) which were features known by participants, either through rigorous studies or anecdotes, to contribute to quality of care.

While not presenting an extended analysis, the visioning document had included a brief "rationale" for some of the recommendations, reporting evidence for each that drew on a variety of sources including best practices, healthcare research, design standards, and a set of rule-of-thumb ratios that were widely acknowledged in industry. Concerning the component to eliminate waiting in emergency services, for example, the document mentioned a range of healthcare institutions which successfully implemented quick triage systems where nurses were stationed on the front desk to perform a rapid assessment. For items linking operations to programmatic elements or spatial configurations, on the other hand, the recommendations were supported by some approximations to lay out an efficient ED:

> 1. *8-10 beds per block/pod is good size for 40,000 ED visits.*
> 2. *Once the ED has exceeded 14-18 beds in size, the ballroom design inevitably becomes a large, single-loaded corridor and any advantages of the ballroom layout have been lost.*

The architects who put together the entire visioning report did not refer to any research studies or any precedents from industry to validate implicit and explicit arguments within these statements (e.g. *X is good size for Y*). However, particular statements clearly conveyed expert judgment involving how various configurations affect several operational properties. The second item above, for example, communicates how an elongated configuration of examination room blocks negatively affects one of the most critical organizational goals in emergency services, namely visual access to patients.

Included in the visioning report were other recommendations that synthesized operational and space-related considerations to recommend ways to achieve better outcomes in the new ED. These recommendations were presented in the form of causal arguments, and characterized a well-choreographed care model involving processes, space, equipment and materials, to be translated into architectural design. For example, the report stated:

> *Decentralized full triage to be completed in exam rooms.*
> *Reduce medical errors with fewer transfers.*
> *Decentralized supply close to exam rooms.*

In short, this recommendation involved bringing in necessary supplies and processes (full triage) into examination rooms, which would reduce transfers of patients within the unit or hospital, and which would eventually eliminate adverse transfer-related events throughout the care process. Specific segments within this chain of causal argument (e.g. decentralization, or fewer patient transfers) have been the subject of rigorous research in healthcare design and research community (e.g. see (Hendrich et al., 2004) on patient transfers and medication errors). Rarely, however, was the entire chain of complex arguments leading to achievement of safe care environments verified by empirical studies to account for all variables and confounding factors involving actual patients, staff, processes, and spaces. Rather than providing a recipe for safe environments, these complex arguments, which were readily available within the healthcare design community, made a set of concepts, practices, and associated facts available for the entire visioning team to start an internal discussion to provide a substantial background for subsequent design decisions.

Closely linked to the established principles (e.g. safety), the interdisciplinary team also considered some diagrams layout configurations that were proposed by the architects. The team was exposed a range of alternatives at various levels, namely unit level, sub-system level, and room level. In addition to diagrams and layouts represented on paper, a series of site visits, which occurred concurrently with visioning efforts, helped client representatives to see and informally evaluate these layout configurations and associated physical environment features in action. Throughout these site visits, the team members gathered anecdotal evidence from people who worked in the areas with the physical attributes (e.g. decentralized nursing stations, nurse servers, same handed or acuity adaptable patient rooms) that were being considered for the new ***PHSP*** hospital.

At the unit level, the diagrams presented in the visioning document, which had depicted the functional flow within emergency services, were paired with a description that included a set of numbers concerning operations and efficiency. Combined with the extensive expertise of the architectural firm in healthcare design, these numbers provided (e.g. 42,000 visits/year to run an efficient fast-track setting) some conventional approximations utilized within the healthcare design community. Generally, the diagrams were not fully prescriptive in the way they represented topological relationships or adjacencies across sub-systems within the unit, but communicated patterns of flows in designated areas. However, some early decisions, including having a fast-track setting or laying out distinct compartments (e.g. adults, pediatrics, psychiatric, and observation) within the unit, were made evident in particular diagrams (Figure 11) to inform or guide future design efforts.

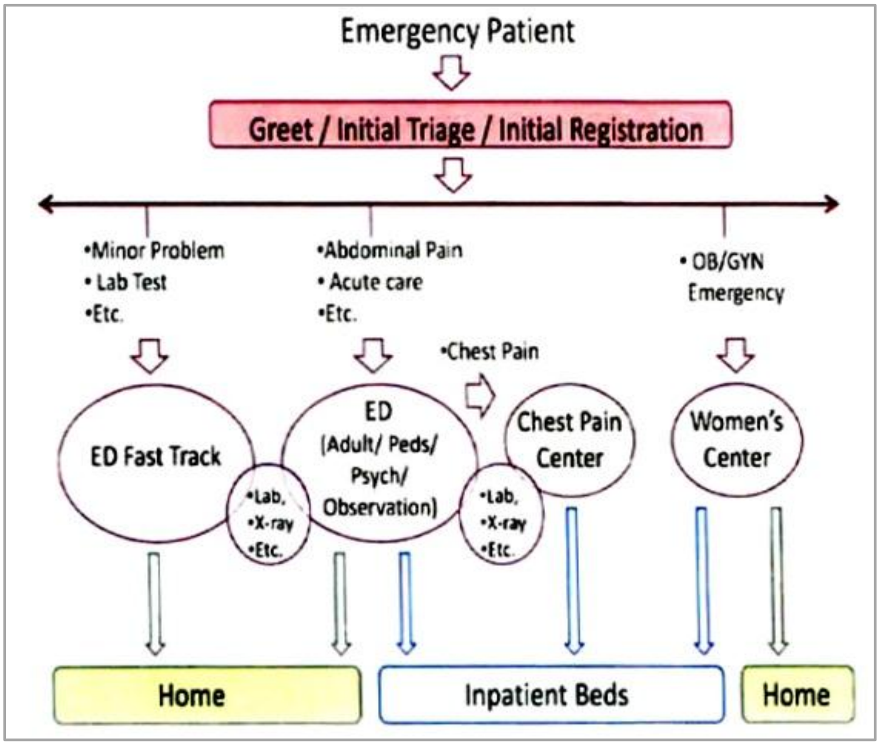

Figure 11. Unit-level diagram

At sub-system level, on the other hand, there were four configurations presented in the document that were to be considered as alternatives to lay out the examination rooms. The diagrams had a particular focus on linear pod configurations (Figure 12). As stated by ***O3***, the team was initially biased towards the pod model to be implemented as "2 blocks/pods for 40,000 ED visits." A ballroom type of configuration, on the other hand, was rejected based on its shortcomings with regards to economy and efficiency: "Linear (pod) design will potentially achieve an overall unit size of 610 DGSF/bed while a similar ballroom design would require 700-750 SF/Bed."

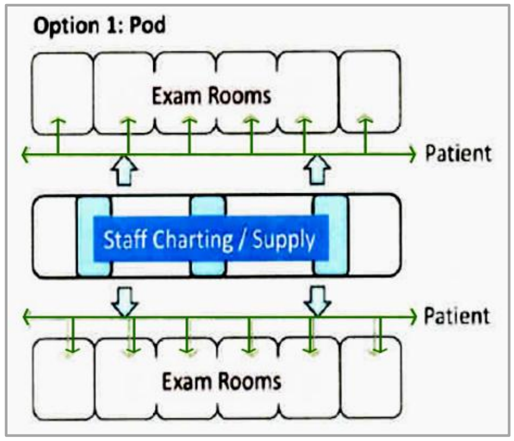

Figure 12. Sub-system level (exam room cluster) diagram.

The visioning document also included a set of recommendations for room-scale configurations to inform subsequent decision making in laying out examination rooms within the ED. Based on the information listed, and the diagrams included in the document (Figure 13), the two most important emerging considerations at room level were size, standardization, and surge or overflow capacity.

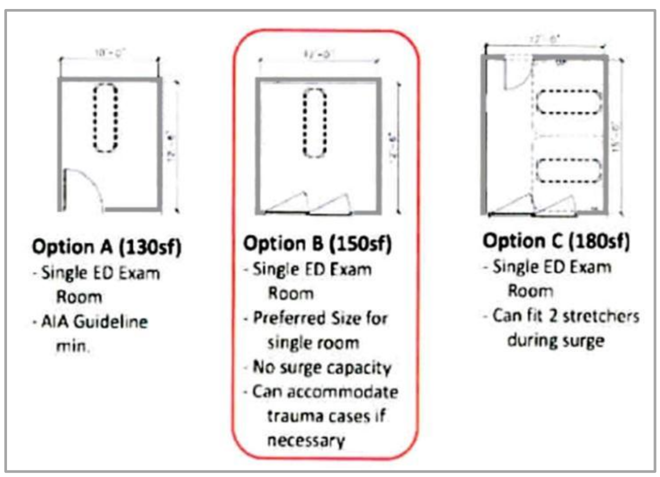

Figure 13. Room-level diagrams.

Linked to the diagram above, the narrative in the visioning document emphasized the concept of standardization to drive the decisions on examination rooms. The particular recommendation was to have a common size for exam rooms and to "have the capability of providing support for virtually all non-trauma patient care needs." Three options were considered for this recommendation (Figure 13). Option A represented the minimum square footage that was required by the guidelines for healthcare facilities (AIA Academy of Architecture for Health & Facilities Guidelines Institute, 2008), whereas Option B and Option C had modified the base model (Option A) to allow different scenarios involving trauma cases or surge capabilities. In the document, Option B was favored as the alternative with “preferred size.” However, in subsequent pages, the visioning document included two more-detailed layout configurations following the dimensions of Option A. The dimensions of Option B (12' by 12' 6"), which recommended a larger examination room than what was offered in the standards, were never observed to be utilized during the design phase. Other than the existing guidelines, the three options did not refer to any other source to inform recommended sizes and configurations for alternative examination rooms.

For the four services, including cardiology, the interventional platform, the emergency room, and inpatient services, a series of tables were created to compare the process- and design-related ideas across some critical variables such as area, operations, technology, and cost (Figure 14). The presentation, again, lacked any kind of references or sources to bolster such comparisons. Although there was no opportunity to question the participants about these comparisons, it is likely that the statements within the tables (e.g. standardized ED rooms increase square footage, Figure 14) relied on architects’ extended expertise in healthcare design.

	Decentralized Supply Close to Exam Rooms	Standardized ED rooms	Point of Contact (Personal Care Coordinator)
Square Footage	⊕	◗	⊕
Operational	◖	⊕	◗
Technology	⊕	⊕	⊕
Miscellaneous Cost	⊕	◗	⊕

major decrease (○), minor decrease (◖), neutral (⊕), minor increase (◗), major decrease (●)

Figure 14. A segment from the evaluation table

The architects strategically translated emerging design and process-related ideas into a type of representation that allowed cross-comparisons with regard to size, operation or cost on five levels (major decrease, minor decrease, neutral, minor increase, major increase). These cross-comparisons provided hints about how particular elements within the initial vision for the ED (e.g. linear configuration, standardization of rooms, personal care coordinator) would affect staffing and overall size of the unit. These tables specified the consequences of each decision (e.g. decrease in cost, increase in technology implementation) in a way that was intelligible for other members of the steering committee.

5.2.1 Summary

Throughout the visioning meetings, the interdisciplinary team including representatives from one of the largest healthcare architecture firms in the United States, ***Firm B***, discussed and evaluated a broad array of options for the new ***PHSP*** hospital. Documented in a report prepared and published by ***Firm B***, the team had considered a set of overarching principles, ideas and concepts, a variety of schematics and diagrams to guide the subsequent design efforts on various levels, namely unit-system level, sub-system level, and individual room level. Following the visioning phase, there was a series of master plan and schematic design sessions which were also held with ***Firm B***, before the owner organization decided to switch to ***Firm A*** as their architectural design consultants. The outcomes of the master and schematic design exercises were also included in the visioning report. The ***PHS*** needed this early design work alongside the program matrix of the new hospital to apply for a Certificate of Need (CON)[10] from the local authority.

[10] Initiated by the state, the CON is a program to overview healthcare projects. The intention is to measure and define the need to control costs, and to guarantee access to healthcare services in the state.

The documented vision provided a rich background for architects from ***Firm A*** who quickly processed the requirements and preferences needed to guide subsequent design efforts. However the new design team needed to revise the master building program while entirely abandoning the schematic design provided by their predecessors.

The visioning sessions involved many individuals, including healthcare administrators, clinical practitioners, architects, planners, engineers, and relevant thought leaders from the community, to discuss, evaluate and filter the information to shape the future ***PHSP*** hospital. As mentioned by the participants in later interviews, these meetings helped them to see "what's out there" in the world of healthcare design. In the case of the ED, many ideas involving technology, process, and design were brought forward with evidential support in the form of documented precedents and emerging practices in industry, individual expertise, site visits, and anecdotes. Rather than depending solely on a single form of evidential support (e.g. expertise or precedent implementation), the features considered in the visioning phase were circulated through developing stories combining multiple forms of evidence. While the field work for this study did not include firsthand observations of visioning meetings, many of the stories that were introduced, processed, and extended during early meetings, surfaced during observations and interviews undertaken during design development sessions. "Further processing" and "extending stories" refer to instances where participants provided evidential support to enhance stories by means of;

1. Adding their own experiences, in the form of anecdotes, regarding a particular design feature, or operation,
2. Referring to design features and practices that they witnessed in other facilities during site visits,
3. Referring to research studies that they learned about in an article or in a conference they attended.

The visioning document included limited reference to scientific studies that provided evidential support for certain design features. When asked in interviews, the participants had loosely incorporated research findings, from healthcare design or other domains, into their statements. While the participants' references to research studies lacked specificity (e.g. specific outcomes, methods, contexts), their accounts involving utilization and issues of particular design features within other facilities were vivid, clear, and detailed. Exposed to the ideas and rhetoric of research on evidence-based practice, the steering committee members, particularly the representatives of the client organization, were observed to consistently mention other evidence-based design facilities in the country, publications introducing successful practices, or anecdotes supporting or refuting particular design features or practices.

5.3 Re-programming and Schematics: Crafting Spaces

The ***PHSP*** hospital project was stopped for over a period of three months until the owner decided to resume the design work with a different architectural firm. ***Firm A***, a local firm which had provided services for the ***PHS*** in the past, was invited to the steering committee meetings as architecture and interior design consultants beginning in January 2011 (Figure 1: Project Timeline). The two high-priority tasks for ***Firm A*** were to overhaul the existing building program which significantly exceeded the initial project budget, and to rapidly develop a schematic design which was required to initiate the Certificate of Need (CON) procedures with the local authority. The ***PHSP*** leaders decided to abandon the partially-developed schematic design, and asked architects and planners from Firm A to put together a new master plan, a building program, a "low resolution schematic design", and a strategy to differentiate the three components of the new facility. These components included the existing medical office building, the new medical office building, and the hospital building (Figure 7), and the new plan would allow, if necessary, a multi-phase development. Essentially, the particular request was to devise a solution that would keep the project within its budget and on time.

In January 2011, three representatives from ***Firm A***, ***D10*** (one the three founding partners), ***D15*** (initial project manager for the ***PHSP*** project), and ***D1*** (project architect), were present for the steering committee meeting to join the client representatives and the pre-selected consultants including ***Ce1*** (Civil engineering) and ***Co1*** (Construction) who were already familiar with the project. While the client representatives introduced a set of challenges throughout these meetings, it was a particular request by ***O4***, the ***PHSP*** hospital president, to bring in a fresh look at what had been developed so far. ***O4***'s comments were clearly reflected in the meeting minutes which were kept by ***D1***:

> (Meeting minutes, 01_25_2011)
>
> *Regarding the current program not much is sacred/off limits and nothing is finalized. The only room size that has been sufficiently reviewed determined is the Operating Room size which is to be 650 sqf which was mutually agreed to by* ***PHSP*** *Administration and* ***U3****.*
> *Per* ***O4*** *nothing is a given nor have any decisions been made for things like same handedness.*

Given the authorization to manipulate the existing building program, except the operating room area, the core design team immediately initiated the two interrelated tasks of re-programming and master planning the new hospital. ***P1***, who was brought into the project as the programming and planning consultant for ***Firm A***, was given the initial building program to be reviewed and revised, whereas the rest of the design team led by ***D15*** began working on the design problem at different scales.

On the programming level, the approach was to build upon existing building program which was prepared by the previous design firm. ***P1***'s task was to review the entire program and further define and quantify each space for the new facility. Although she was given the freedom to reconsider and manipulate the numbers in the existing building program, ***P1*** was introduced two constraints to work with: the total square footage should not exceed the initial program, and the scope of services should remain the same. In her own words, ***P1***’s task was to enhance, edit and expand the program in coordination with the rest of the design team who mainly focused on an alternative design scheme for the new hospital:

00:06:32	***I***	*Going back to the visioning phase, are these* [programming work] *all coming from the previous work?*
00:06:34	***P1***	*No. A lot of did, but a lot of it has been enhanced, edited, expanded…*
00:06:44	***I***	*By?*
00:06:45	***P1***	*The [Firm A] team.*
00:06:46	***I***	*All right. So what is your role in this project?*
00:06:49	***P1***	*My role. That's a little interesting. Uhm, I was originally retained by Firm A to do program, to update the program. Firm B stopped it at a particular point. They had a room-by-room listing of all the spaces. They had a very preliminary scheme that was intended to support a Certificate of Need application. For whatever reason, we got an opportunity to sort of revisit all that. So very quickly we, kind of, redid the program, updated it, conformed various parts of it, made some changes to it. And then, redid a scheme in order to submit a CON application. That was intended to go in on the first of April. It didn't actually go in, I think, until July. Lost track of the dates. But we had a very, we had a first cut at a, well, fully defined, well it wasn't fully defined, that's going to make it sound more advanced than it was. We had a massing and blocking scheme and we had placed all the departments, uhmm more or less adequate for a certificate of need, not quite; close. We had that by middle of March. Then we later refined it and submitted the CON application which is under review right now. So my original role, really, was to focus on the programming but then as we got into it, I really started working a lot on the planning. And that's continued to be my role.*

As described by ***P1***, the previous architecture firm had initiated the task of translating the vision of the hospital into a list of spaces and associated square footages which were then revisited by ***P1*** to make it fit with both the budget and the vision which was codified in a set of guiding principles. The entire building program was represented in an excel worksheet, maintained by ***P1***, which allowed engaged parties, including the design team members and the representatives of the ***PHSP*** hospital, to track changes over time. In order to make these alterations and additions fairly accessible to the steering committee, ***P1*** was asked "to add another column to the program spreadsheet showing the "delta" of current programmatic square foot compared to last ***Firm B*** program.

As mentioned earlier in the project overview (Section 3.6), the team pursued a design solution, which gathered two medical office buildings and the hospital structure around a central atrium . The strategy was to remain within the constraints concerning the budget and schedule by means of a compact facility, as opposed to the earlier scheme which employed a relatively expansive scheme employing multiple courtyards. The design team utilized a set of massing and blocking diagrams to test their ideas on the master planning scale and on the building scale by placing all the departments represented in the building program into these "low resolution" diagrams which conveyed limited information with regards to interior configurations and interrelations of individual departments.

Besides being helpful in rapidly advancing design work, the massing representations helped other members of the steering committee, ***O1***, ***O2***, ***O3***, ***O4***, to visualize and comment on design decisions concerning particular visioning statements including flow, adjacency, flexibility, and efficiency. After ***Firm A*** took over the commission, it was the first attempt to translate the text and numbers (the building program) into visuals (rough digital or hand-drawn sketches) by shaping the overall mass and carving out individual departments within stacking diagrams. Allowing instant input by the steering committee members, the diagrams had initiated and facilitated a focused discussion around certain departments. During meetings in late February 2011, the team had agreed upon the maturity of these interrelationships represented in diagrams, and initiated "single line plans" which were required for the CON application which was scheduled for April, 2011.

P1 was key person within the team to lay out the departments as design work progressed from programming documents to stacking diagrams to single line plans, and then to schematic drawings with more resolution. Following the list of priorities established during visioning, the ED was identified as one of the four anchor departments within the schematic design phase. Starting from the very first meetings, the representatives from the ***PHSP*** hospital, including ***O1***, ***O2***, ***O3***, and ***O4***, were generous in providing comments, descriptions, and direction concerning features of emergency services that they had envisioned. The steering committee meetings were the venue for designers to extract design related information and capture them in the form of meeting minutes (kept by ***D1***) or annotations on drawings (recorded by ***P1***) to be considered during design sessions back in the office.

With regard to the design of ED, the design team had interacted mainly with three types input to be translated into segments within the building program, and then into schematic design. The first type involved quantitative statements that were surfaced during visioning meetings. The past and projected annual visit volumes for the ED, for example, were critical items to be considered in shaping the unit. The constantly growing number of emergency visits (36,755 visits in 2011, 47,655 projected visits in 2014) was used in determining the details of the building program including waiting areas, fast-track capacity, and the number of examination rooms that the department required to meet demand. However, research did not reveal how the exact numbers or areas were determined and issued in the initial building program in 2009.

During the first meeting that ***P1*** participated in, which occurred in the first month after ***Firm A***'s involvement, the pre-determined numbers (e.g. 40 exam rooms) to shape the program and the design of the ED were questioned and challenged. As evidenced in meeting minutes, the initial decision to have 40 exam rooms, for example, was not necessarily based on a specific calculation involving workloads in the ED. There was no indication of any kind of a study to determine whether or not these 40 rooms would meet the demand of the emergency services which was expected to receive 36,000 patient visits per year.

Rather, it was the result of the use of a rule-of thumb about the overall size of the facility and its bed numbers. The number that ***P1*** was given this meeting was 36,000 emergency visits per year. However, rather than merely using this number plus the specified 40 exam rooms, the team decided to have separate meetings with users, including nurses, physicians, and directors, to gather insight into the emergency department practices in order to safely determine the elements of the program. The insights provided by the users, combined with the actual visit records, led to the decision of keeping the number of exam rooms and ten fast-track bays as listed in the initial building program.

The other type of input that designers had extracted and recorded in the steering committee meetings involved a set of owner preferences on particular physical environment features or attributes to support care processes that the organization wanted to implement in the future facility. Rather than generating brand new ideas, the team referred back to discussions held within visioning meetings or to site visits where core team members had observed particular implementations in other facilities. ***O3***, who had participated in all site visits earlier, was the one to communicate the ideas to be integrated into design work. ***D1***, on the other hand, was the one to translate these comments into meeting minutes, which would eventually be integrated into developing design work. In the case of ED, for example, ***D1*** recorded ***O3***'s comments in meeting minutes where the design team had received a clear direction about how to handle the distinction between spaces for pediatric and adult patients:

(Meeting minutes, March 1st, 2011)

*Per **O3**: Pediatric ED really needs to look/feel like two separate areas. Would like distinctly separate entries. (adjacent to each other is ok)*
Pediatric ED/Adult ED are separate but entry point details not resolved yet.

Since these meetings predated our observations, the data set is limited to the official meeting minutes which were the responsibility assigned to architects from ***Firm A***. ***D1***'s meeting transcriptions, which had filtered the conversations in this particular instance, had provided a well-formulated problem for the rest of the design team to work on. ***D1*** had indicated, for example, the constraints with which to work (*need to look/feel like two separate areas*), and what might be a satisfactory solution (*adjacent to each other is ok*). Within the context of a schematic design phase, these statements contained a level of ambiguity that needed to be clarified (*entry point details not resolved yet),* but were considered sufficient to finalize the drawing package before advancing to the next phase. In that next phase, the interdisciplinary team had planned to conduct a series of user group meetings to elaborate on the details to be integrated into drawings. Until further feedback, ***O3***'s statements, which were based on her experience and practices that she observed during site visits, remained influential in shaping the ED.

The third type of feedback the architects considered in advancing the design work comprised workday stories transmitted by front line staff members. As acknowledged in meeting minutes kept by the design team, ***O3*** was the key person earlier in the process to communicate the needs of emergency services to the architects. ***O3*** occasionally provided anecdotes depicting the anxiety of patients and staff members under pressure to perform critical protocols, often in urgent or adverse situations. The specific interactions with staff from the ED in the old ***PHSP*** hospital, on the other hand, extended and enhanced the stories communicated to the architects who already possessed substantial expertise in healthcare design. The anecdotes introduced by staff were detailed ***functional*** descriptions of events occurring in these spaces. Although the statements of users were limited in providing a vivid glimpse into nature of the urgency and drama occurring in these spaces, their accounts painted a practical picture –centered around who is in those spaces and what resources they need- which helped the architects and consultants better contextualize the set of issues at hand. These practical anecdotes were structural pieces of larger stories that informed the decisions shaping the care environments in the future facility.

The design team, in conjunction with the representatives of the ***PHSP*** hospital and a set of consultants, had carried out the schematic design phase for over a period of seven months. In August 2011, the design team produced schematic design work alongside the master building program refurbished by ***P1***. Also included in the package was a set of renderings of the building, produced by a sub-team led by ***D11***, which allowed the steering committee members to get a better sense of the future building. These renderings, depicting interior and exterior views, were used by the ***PHS*** seniors to publicize the new hospital through various local and national media channels.

The schematic design of the ED (Figure 15) reflected several design directions that were set during the visioning phase. For example, the pod-type configuration, which was one of the prominent concepts mentioned repeatedly during visioning stage, was utilized in organizing sub-areas for distinct patient groups, namely pediatrics, adult and behavioral health. The pods, however, lacked standardization and consistency across the unit. Pods with different sizes and shapes were attached to a main corridor that also had the ambulance entrance on the east side. During steering committee meetings during schematic design phase, no oppositions were recorded to challenge the initial configuration of the ED.

Figure 15. The ED layout at the end of schematic design phase

The idea of decentralization, one of the concepts that emerged and gained support during the visioning phase, was also considered in the layouts. The designers had "teaming areas" (marked in blue dashed lines) centrally located to provide increased visibility to the examination rooms within each pod. In an interview, ***P1*** explained how the team strategically decided to utilize the term "teaming areas" which would help steering committee members introduce and communicate the set of new processes to hospital staff. Having the term "teaming areas" on schematic design drawings was the initial effort to translate the decentralized model that was intended for the new hospital.

O3's comments, quoted previously, illuminate how the architects provided separate, but adjacent entrances for pediatric and adult patients (see the two arrows on upper left in Figure 15). Although it was not explicitly listed as a key feature in the visioning documents, the idea of separating adult and pediatric patients, which was primarily supported and maintained by ***O3***, was adopted early in the schematic design phase. The two gates on the east façade would open up to two equal-sized waiting areas for two distinct patient populations. Unique insights and anecdotes about the daily life in

ED waiting areas were influential in locating side-by-side entrances and waiting areas. When asked, ***O3*** explained the reasoning behind the idea of separation:

00:24:49	***O3***	*Okay. Let me tell you why we did that. And yes, if you look at other facilities, they have divided up their pediatric and adult entrances. And reason being is because parents do not want their pediatric patients sitting in the same waiting rooms with adult patients. Uhm, you know emergency rooms are for emergencies, and what you can see in adults is patients that are intoxicated, they have... They can be bleeding, they can be throwing up you know... Protection of their child from adult body fluids. Parents just do not want to be sitting there; they want a true pediatric experience.*
00:25:57	***I***	*Mm-hmm.*
00:26:00	***O3***	*So, to give them a true pediatric experience, we separated the adult and the pediatric entrance. I can tell you it's all about that patient experience, when we separated that. The reason I know that is I came from PHSC where they opened up the entrance, when they built their new ER, to both pediatric and adult. They all come in the same way, they all triage the very same way. I can tell you that was the number one dissatisfier for pediatric patients, having to come in and sit with adults. They tried separating the waiting room, it didn't work. They still got lots of complaints. So they had to make a very small waiting room in the back close to the pediatric unit in order to make those patients happier. They still come in the same, but they immediately take the pediatric patients to the back into their waiting room.*

Combined in ***O3***'s extended response are three emerging themes regarding translation of evidence into design work. First is the role that precedents play as distinct elements in the story, in providing a justification for a particular design decision. ***O3***, as she usually did in steering committee meetings, invoked precedent cases to reinforce her statements, which also communicated her personal point of view concerning particular design features. ***O3*** initially stated that there were other facilities that utilized the idea of separate entrances, before she brought in a vivid case study in which she was personally involved prior to her engagement with the project. By relating the case of ***PHSC***, a large-scale hospital within the ***PHS*** organization, ***O3*** presented a clear formulation for planning the space to achieve “a true pediatric experience” involving providing separate entrances and separate waiting areas for pediatric patients. The formulation, as described by ***O3***, was translated into a schematic design and was maintained throughout subsequent phases.

The second theme in ***O3***’s account is the use of anecdotes to support the developing story around waiting rooms. In a hypothetical emergency room, ***O3*** described the close proximity of children that needed care and adult patients behaving in objectionable ways (*bleeding, throwing up*). The imaginary scene that ***O3*** painted was supported by a real world story from the emergency services department of another hospital (***PHSC***) where similar situations had led to complaints that eventually forced managers to separate the waiting areas for pediatrics and adults. An imaginary situation and an actual anecdote were combined in ***O3***’s story to reach the necessary consequence (inference) that had actual design implications.

The third theme is the existence of initial transfer and translation of evidence across domains. Traditionally, in the world of healthcare, patient satisfaction scores (e.g. Press Ganey Associates’ satisfaction surveys) are continuously being gathered in key departments across hospitals to provide information to determine and improve care quality. As a way of measuring or quantifying experience, these scores are constantly monitored by hospital managers, especially before and after the implementation of new practices or changes in physical environments, ranging from the individual room level to the overall facility. In her response, ***O3*** implicitly referred to this type of information by recalling complaints of visitors of emergency services who were “dissatisfied” due to the waiting areas with mixed patient populations.[11] As a reinforcement for the argument for separation, ***O3*** integrated documented evidence (satisfaction scores) into her narrative.

[11] Similarly, in the case of green zone, the satisfaction scores were influential in making further design-related interventions.

The architectural layouts produced at the end of schematic design phase did not reflect several of the major design decisions discussed in earlier documents and meetings. The concept of standardization, for example, which was repeatedly emphasized in the visioning document, was seemingly lost. Although the area for each examination room was maintained within a range of 120 to 130 square feet throughout the unit, the planning team, led by ***P1***, utilized three different shapes (rectangle, elongated rectangle, and square) to make the program fit in allocated department area. In the drawing set, the examination rooms, which were the most repeated elements within the unit, were not drawn in enough detail to communicate features such as openings, equipment, and furniture.

The fast-track care idea was another example that was not fully translated into the schematic design. There were mere hints of a quick care setting adjacent to the waiting areas (Figure 15), however the area was labeled as “triage” which was to be eliminated in the new care model, according to the visioning report. The intention was to implement an improved version of the green zone of the old facility, which had already been operational for over a year when the design team issued the schematic design package. The idea was not revisited, refined or translated during schematic design phase.

The urgent need for a final building program and schematics to be submitted to local authorities (for the CON application), and the tight schedule led the design team to operate in a very intense way during the start-up period. The proposed “integrated project delivery” model required that all consultants coordinate and integrate their work from very beginning. However, not all consultants were fully engaged. The consultancy in information technologies (IT) and equipment planning were considered to be critical elements in the design of ED, but they lacked a strong presence early in the process. ***Ct1***, who was the IT consultant, and ***Ec1*** and ***Ec2*** who were the equipment planning consultants, had limited interaction with the design team through the schematic design phase.

In addition to ***O3's*** introduction to existing and desired care processes for the new facility, the design team had a number of meetings with individuals representing key departments including the ED. These extended user group meetings were scheduled to occur later in the process, soon after the pressing issues involving schedule, budget, and official building permissions were settled. The steering committee also discussed other plans to be realized in later phases, including conducting original research and building mock-up rooms. With regard to full scale mock-ups, for example, immediately before the schematic designs were finalized, the design team members were asked to provide the very first layouts of the examination rooms in emergency services. As the architects prepared detailed layouts for selected rooms, ***O1***, the project manager on the ***PHS*** side and the gate keeper for the main project budget, informed the steering committee that $50,000 had been allocated for the mock-up exercise.

Another developing idea within schematic design phase was the desire to design and conduct a research project which would take place in existing and future hospital facilities. The ***PHSP*** hospital representatives, mostly ***O2*** and ***O3*** who had published the green zone case previously, were trying to clarify and refine several ideas for original research that they were pursuing as part of the Pebble Project. Following the research ideas mentioned in the visioning document, the team concentrated their focus on several areas of inquiry, including medical distribution models and hospital flooring, before they had the opportunity to host ***R1*** who was the representative of the organization to lead and manage Pebble-related efforts.

R1 was regularly in touch with ***O2*** via e-mail or phone to provide assistance in introducing emerging topics in healthcare, in linking them team with prominent partners in the Pebble Project, and in developing particular questions and research design. Her visit did not particularly affect the emergency room design which was on its way; rather the visit involved a series of meetings to refine and develop ideas concerning the research contribution of the ***PHSP*** hospital to the Pebble knowledge base. During her visit ***R1*** had seen the schematic design; however she had limited interaction with the design team members who were struggling to finalize the schematic design package.

5.4 Developing the Design

The architects from ***Firm A*** submitted a schematic design package in August 2011 for owner review and for further budgeting exercises to be conducted by construction consultants (***Co1*** and ***Co2***) in tandem with the project manager representing the client, ***O1***. Except for the minor comments on the entrances, there were no significant challenges recorded to make designers reconsider their approaches and current decisions. Thus when the steering committee began the design development phase during late August 2011, the design team already had a clear schema for the department to be further processed. The intent was to arrange meetings with hospital staff and develop physical mock-ups for designated spaces, including examination rooms, which would provide designers with critical feedback from actual users.

As design development and construction documentation phases progressed, a new set of challenges concerning new care models, information technologies, and interior material selection, was introduced, joining the existing issues of limited square footage, budget and schedule. Hence, each decision required close coordination between participants, and occasionally beyond the members of the steering committee. The architectural changes proposed for the fast-track area, for example, required the involvement of other individuals (e.g. department managers, nurses, information technologies, operations staff, etc.) to evaluate the impact across all engaged disciplines. Two distinct strategies, involving physical mock-ups and user group meetings, were utilized to manage, process, and translate input emerging from various resources. The nature of the evidence that the designers had to deal with was varied in terms of source, scope, and form. The following sub-sections will provide an outline of this interplay across people, tools, and representations.

5.4.1 User and Consultant Engagement

Throughout meetings held with ED staff from the soon-to-be-replaced-hospital, the architects were introduced a variety local practices, processes, flows, space, and equipment utilization. This first-hand input was translated into schematics; however certain developing issues required more intense coordination through subsequent phases, during which architects continuously interacted with project consultants and users.

In addition to holding several side meetings, the design team, together with some members of the larger steering committee including ***O1***, ***O2***, ***O3***, ***O9***, ***Ct1***, and ***Ec1***, had two sets of user-group meetings, one in November 2011, and the other in December 2011 (Figure 1: Project Timeline). These meetings, which were held at the existing hospital campus, included an extended set of staff members from the old hospital to meet with architects and consultants to collectively review updated drawings. Each meeting with a designated group lasted approximately an hour and included two to three staff representatives interacting with ***D1***, the design lead, and ***P1***, the planner and programmer for the ***PHSP*** project. The visiting groups included representatives from security, respiratory service, materials management, patient administration service, chapel service, surgery, emergency department, inpatient unit, physical therapy, care coordination, laboratory, human resources, pharmacy, volunteer and gift shop services, administration, biomedical, environmental services, and education.

A month after the interdisciplinary team officially initiated the design development efforts, the designers at last felt comfortable enough with the drawing set to take it to users to solicit their feedback. Two key consultants, equipment planner, ***Ec1***, and information technologies (IT) consultant, ***Ct1***, were present in the first series of user group meetings that took place in early October 2011. Following space planning related discussions, the conversations that ***Ec1*** and ***Ct1*** had with users involved asking questions of users, having them describe current processes and equipment, recording their responses on paper, and introducing potential solutions to existing problems. ***Ec1***, whose primary task was to determine the equipment inventory, and **Ct1**, who was struggling to prepare an IT plan for the new facility, did not rely on drawings or any other types of visual representations during their initial conversations with users and architects. Conversations took place in a pre-determined order (i.e. architecture-IT-equipment) and were repeated each hour with different user groups, providing architects (***P1***, ***D1, D2***) and consultants (***Ec1***, ***Ct1***) insight into the daily practices of different categories of workers.

In a typical user group session, ***P1*** initiated the conversation by introducing overall hospital design, and getting into the details within relevant layouts. ***P1*** delicately handled design-related conversations by means of providing substantial explanation, and giving users time to understand and absorb developments and changes in layouts. She clearly articulated emerging concerns from the architects' perspective while asking carefully formulated questions in order to gather necessary data that would assist in the ongoing design work. In each meeting, in the presence of visiting users, she cautiously summarized and clarified issues which were discussed during the meeting. In addition to ***D1***'s official meeting minutes, ***P1*** recorded user responses by annotating plans which eventually guided her and ***D2*** in making necessary updates on layouts.

On many occasions, the initial set of design statements (e.g. the visioning document), or fragments of information –emerging from the organization's own history (e.g. the green zone case) or from industry– remained insufficient to advance the design work. For the ED design, a considerable set of information, eventually treated as evidence, mostly in forms of anecdotes, had emerged during the user meetings, which in turn challenged the initial assumptions and led to substantial changes in the design work. The following exchange was recorded in a meeting with staff from the ED of the old hospital, and provides a typical example of those interactions among participants where the exchanges led to changes to the existing layouts. In this instance, three members of the steering committee, ***P1***, the planner, ***D1***, the lead designer, ***O3***, the chief executive nurse, had interacted with three individuals, ***U4*** and ***U5***, to review the layout of the ED:

00:12:54	***O3***	*I'm not so sure you need fast-track for pediatrics.*
00:12:57	***U4***	*Well, that's what I was wondering.*
00:13:01	***O3***	*I would prefer not to have a fast-track… But… because I'm telling you, pediatrics, parents are gonna get irritated with that. We know that pediatric patients hate the green zone. So if we could… I hope the pediatric unit, for the most, is part gonna be a fast-track, don't you think?*
00:13:20	***U5***	*Yeah.*
00:13:20	***U4***	*Yeah.*
00:13:24	***O3***	*So, I would increase that area to be the adult area, and not have pediatric.*
00:13:36	***P1***	*Let me back up and ask another question. I think what I'm hearing is one fast-track area, basically all adults, but we don't know how many spaces. I heard eight is a good number.*
00:13:52	***U4***	*Yeah.*
00:13:54	***P1***	*You want eight chairs, two assessment rooms?*
00:13:56	***D1***	*You wanna max it to eight?*
00:14:01	***P1***	*Or you wanna max it to ten?*
00:14:04	***O3***	*I would max it ten.*
00:14:05	***U4***	*Yeah.*
		…
00:16:10	***U4***	*So we want to have it easily accessible, not having to go obviously around the…*
00:16:12	***P1***	*No, no. I think what I would do, make it all, sort of, one larger consolidated area, but clustered such a way that you have the… You're like you're on display to the whole other nine folk.*

The emerging issue that the group discussed involved determining the size and scope of the fast-track care area, which was initially divided into two clusters in the layouts, for pediatric and adult patients. In response to ***P1***'s initial statements that introduced individual areas and physical attributes, ***O3***, who had a working knowledge with the existing fast-track area in the old hospital, challenged the idea of having a separate zone for pediatric patients. ***O3***'s initial comment was oriented towards ***U4*** and

U5 in the form of an invitation (*don't you think?)* to reconsider the configuration within drawings. To support her argument, ***O3*** employed an anecdote (*pediatric patients hate the green zone*) which asserted claims against mixing pediatric with adult patient populations. ***O3*** then proposed a new schema in which the pediatric zone was absorbed into the adult fast-track area. The new configuration offered a different model where pediatric patients requiring a relatively quick care were taken away from the main fast-track area which was reserved for adults only.

The designers, on the other hand, were observed to be paying close attention to ongoing exchanges among participants while taking intermittent notes as the conversation unfolded. As evidenced in the excerpt above, the designers' intention was to stabilize the flow of comments to reach a shared understanding among the participants (*I think what I'm hearing is…)*, and quantify elements to be translated design (*one consolidated area, eight chairs*). At this point in conversation, the designers in tandem with the user group attempted to re-formulate the fast-track zone by means of re-organizing sub-zones (fast-track areas) and associated quantities (number of chairs) to provide care. After a quick negotiation, the revised building program was modified to have ten, instead of six or eight, care bays in one larger area. The intended changes in the fast-track area were recorded in meeting minutes as items 3 and 4:

3. Pediatric does not need a green zone (pediatric parents don't like green zone)
4. Make adult 8 chair centric + 2 assessment areas = 10 total

The next iteration of the drawing set included a single larger area accommodating all the fast-track areas to provide care for low-acuity adult patients. The new configuration for this particular sub-area, a version of which was tested years ago in the old hospital, was maintained throughout the design development and construction documentation phases. In subsequent user group meetings, the programmatic definition of the fast-track area was no longer under consideration as the team shifted attention to other sub-areas within the ED.

The discussions throughout meetings between designers and user groups made a crucial set of evidence available that needed to be translated into design work. The initial presentations by designers, which involved communicating processes and spaces to users through layout drawings, provided *entry points* for participants to describe their own understanding and react to what was proposed. Given a fair amount of time to *get into* spaces represented in drawings, the participants were observed to provide detailed descriptions of how they currently operated in space, and what their ideal spaces would look like. The drawings, combined with anecdotes involving other practices and spaces known to participants, helped designers sustain a fruitful exchange with users who provided information, some of which was quantified by architects. The evidence was, then, translated into drawings by the background team (***D2, D3***, ***D6***, and ***D7***) before the project leads, ***D1*** and ***P1***, presented revised layouts back to the user groups.

5.4.2 Mocking up Examination

Within the context of emergency room design, mock-ups facilitated another way to process or generate evidence concerning particular physical environment features. The nature of the process, however, was different when compared to the conversations among architects and user groups through layouts. This section provides two quick cases of how designers and users interacted through physical mock-ups concerning two spaces within the ED; an examination room and a fast-track care bay.

From the very first day, the interdisciplinary team had promoted the idea of experimenting with physical mock-ups to make decisions or to simulate and test processes for the replacement facility. However, the specifics of such exercises were not determined until the design development phase. The team knew that there would be mock-ups for a set of most-repeated care spaces in the hospital. But the tight schedule allowed only a very limited preparation period for the team to devise a detailed and comprehensive plan for a structured "learning process"[12] pursued through realistic simulations to examine proposed care processes.

The walls of the mock-up spaces were erected in the County Building, located three miles away from the old ***PHSP*** hospital. Once these were finished, the steering committee decided to initiate user group visits which involved bringing in the staff from the existing hospital. During the visits, attention was mostly on the two inpatient unit rooms, one being a regular medical/surgical room and the other an intensive care unit room. In a typical visit, the designers had relatively short meetings with groups in the mock-ups for the ED spaces, including examination rooms and a fast-track bay, which were significantly less studied compared to the patient rooms.

Two main strategies were observed to be significant during the mock-up exercises for the examination room and the fast-track bays, and each helped designers learn from users and make informed design decisions based on experiences in actual physical spaces, rather than on paper. The next sub-sections provide descriptions of these two strategies in detail.

5.4.3 Representation and Manipulation

The first strategy used by the designers involved questioning users about their daily activities in their work environments and, accordingly, about their reflections on the features of the mock-ups which, admittedly, were initially far from realistic. Rather than pursuing verbatim translations of the users' responses, the architects hoped to facilitate fruitful conversations and then to record and process information gathered from users. The examination room mock-up therefore provided a platform for designers to extract

[12] Participants constantly used phrases "learning exercise" or "learning process", indicating both design-experiments and the use of mock-ups for educating hospital staff about modified care processes.

information -later treated as evidence- concerning room configurations (e.g. the location of seats versus patient beds) or positions of critical elements on headwalls (e.g. med-gases, supplies, etc.) which were beyond the scope of regular user group meetings.

By placing notes on the mock-up room walls, and even on the floors, the architects recorded a set of the initial comments of visiting staff members. The information, which was extracted and externalized in the first place, was then reorganized (manipulated) to be useful within the constraints set by users. For instance, an additional set for the oxygen-air-vacuum outlets was to be included in a number of examination rooms in order to expand surge capacity when needed (see blue boxes in Figure 16a). To indicate this, a note to that effect was placed on the headwall.

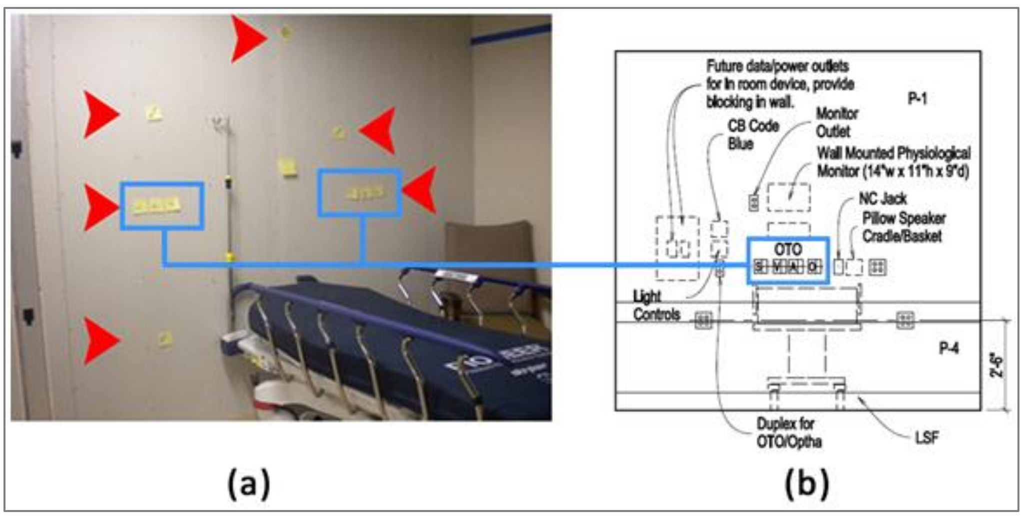

Figure 16. (a) Paper notes that represent features to be integrated into exam room headwall, and (b) the end product in the construction documentation package

A brief, impromptu exercise to determine how to accommodate two stretchers in a standard exam room was also conducted. At first, a smaller group including ***O1***, the project manager, ***D1***, the lead architect, ***P1***, the planning-programming consultant, and ***O3***, the chief nursing manager was involved. Initially, ***O1*** had a secondary set of sticky notes, representing outlets, on the same wall with the first set (see Figure 16a, and alternative configuration 1 in Figure 17). The team soon recognized a problem in accessing patients lying on stretchers on the far side. The next alternative considered was to have the longer wall as the headwall with outlets for both stretchers (see alternative configuration 2 in Figure 17). Without actually measuring the clear spaces around stretchers, the conclusion reached by the team was that there was not enough space for staff to work around the upper bodies of hypothetical patients in the room. The clearance around key body parts, namely chest, neck and head, were evaluated as insufficient for standard protocols to be followed within given room dimensions. Enlarging the rooms to accommodate the protocols was one solution, but the team invested more time and effort in solving the problem at hand without changing room dimensions.

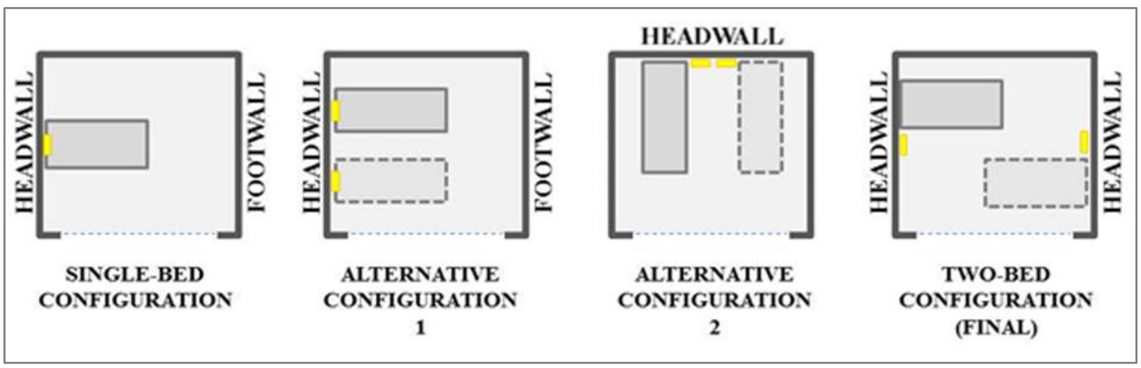

Figure 17. Configurations for the examination room (Diagrams created by the author)

Additional trials run by ***P1***, involving angular placement of stretchers, did not improve or satisfy necessary clearances for two stretchers. Remaining alternative was to have two short walls as headwalls with outlets that were represented by sticky notes (see final configuration in Figure 17). This final alternative provided easy access to both patient heads and was deemed satisfactory for the engaging by the team members before it was communicated to a wider group of participants. No significant challenges were recorded during subsequent conversations involving the final configuration of the exam room mock-up. The layout decision, which was initially reached through a series of simulations within a three dimensional space, was then translated into final drawings which included ten examination rooms with two sets of outlets (oxygen-air-vacuum) to be utilized in case of mass-casualty emergencies.

By simulating the situation through objects, representations, and embodied activities in space (e.g. reaching out to an imaginary patient on the far end of a stretcher), the team negotiated the locations for additional sets of gas outlets. Rather than having two sets of outlets on the same wall (Figure 17, alternative configuration 1), which proved to be insufficient in providing enough work space for care givers around a hypothetical patient head, the team collectively decided not to have them on the same wall. Through evaluating alternative solutions during a short period of time, the team decided to have two outlets across each other, one set on headwall and one set on footwall, which allowed better accessibility to both beds. The initial evaluation and negotiation, involving ***D1***, ***P1***, and ***O3***, took less than ten minutes. The options, as they were simulated and tested, were presented to users during visits. The final state was not challenged by users and emerged as the satisficing[13] solution for the examination room configuration, in terms of both layout and wall elevations (Figure 16b).

Once externalized in the form of sticky notes, representations of certain elements within an experimental environment (the mock-up room), allowed all parties to contribute to the generation of alternatives, evaluation, and further processing. For instance, location of an in-room computer, which was introduced by a visiting staff member, was also represented in the form of a sticky note on the mock-up room floor. Having all critical elements available simultaneously, the task for the team, then, was to re-consider the set of physical items (patient bed, seat, hand-washing sink, etc.) and test different configurations within the room. By utilizing mobile representations which were

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[13] Here I borrow the term "satisficing" from Herbert Simon who argued that humans do not act as ideal rational agents when faced with choices, but rather adopt those that meet an acceptable threshold level. He advocated for a notion of "bounded rationality": most humans were "satisficers" who end their deliberations and make choices once they had reach a satisfactory solution - such solutions are rarely "ideal." Simon, H. A. (1956). Rational Choice and the Structure of the Environment, *Psychological Review,* 63(2), 129–138.

occasionally manually moved around the mock-up spaces, the team was able to find an agreed-upon solution for layouts rapidly and cheaply.

Over time, there were multiple representational states of configurations for the exam room, as the team facilitated discussions to evaluate developing alternatives on the spot. Unlike the fixed representations on paper, the mock-ups allowed instant manipulation which, in turn, allowed the interdisciplinary team to reach a negotiated representational state. Multiple states of the exam room mock-up, which emerged from a series of activities involving people, objects, and representations, remained accessible for further manipulation over a period of two months, before the negotiated configuration (final representational state) was translated into paper form.

5.4.4 Experimentation

The patient bays in the fast-track care area, were also mocked up by the team to allow them to evaluate various features concerning dimensions, equipment, and layout. The plan developed in various visioning meetings was to provide chair-centric care bays to implement an expedited process for patients with urgent conditions that can be treated quickly.

Conceptually, the fast-track idea, which was also known as "treat-and-street"[14] among the team, was known to be growing in popularity in healthcare facilities to manage wait times and delays in emergency services. The interdisciplinary team had been exposed to the operational details of the idea when they had visited other healthcare facilities and interacted with subject-matter experts earlier in the process. The site visits, exchanges with actual users, and previous experience with the green zone –the fast-track

[14] The term "treat-and-street" indicated a process where a patient admitted to a treat-and-street bay was to be quickly treated without having him or her deeper in the hospital where more serious cases were handled, and returning the patient back to "the street" with a reduced the overall length of stay in the ED.

area in the old hospital– generated a degree of awareness of a set of distinct physical features and relevant concepts (accessibility, visibility, privacy) to be carefully considered in the design.

Throughout the design development phase, three distinct configurations of the fast-track area were observed to be tested out in layout drawings (Figure 18). Individual hexagonal units (Figure 18a), manufactured by a firm that the group interacted with, were initially utilized in laying out the first version for a consolidated fast-track space to simultaneously serve ten patients, two being accommodated in an enclosed space. This alternative, which was translated into drawings during early design development, was abandoned due to several factors including budget constraints and other layout-related problems that immediately forced designers to reconsider the overall footprint of the fast-track area. Necessary reconfigurations in the adjacent units (e.g. the front concourse, the dining area), required project architects to work with a smaller area in the next iterations of the fast-track area.

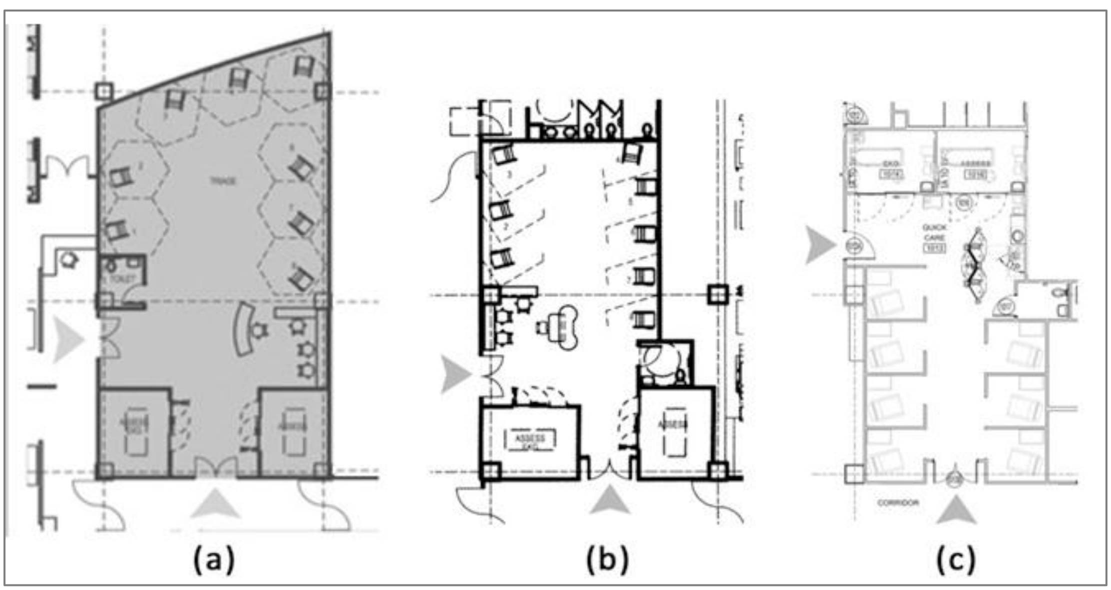

Figure 18. Three configurations of the fast-track area: (a) with hexagonal bays, (b) with angular walls, (c) with rectilinear walls.

Following user review meetings held in November 2011, the design team introduced another configuration (Figure 18b) for the area which utilized angular walls that were intended to provide visual privacy for patients. Acoustical and visual privacy, particularly in an area where patients generally divulge their health-related information, was an important concern in shaping this alternative. ***D1***, ***D2***, and ***P1*** were well aware of the privacy requirements which were repeatedly brought to table by ***O2***, and ***O3*** who referred back to their experiences with the green zone in the old facility. Although there were several functional problems with this second configuration, the angular walls were considered to be a good solution to the problem of visual privacy. The use of the walls also helped the designers to reduce overall size of the area while maintaining eight care bays and two assessment rooms as required by the master building program.

As the design team proposed the angular wall alternative, the mock-up rooms with fast-track bays with rectilinear walls were already under construction. The construction consultants, who were in charge of building these rooms, were given their drawings earlier in the process, so that that the entire team would be able to review alternatives before design decisions were translated and finalized in design development drawings which would be due February, 2012.

In December 2011-approximately three months before the deadline for design development work- the mock-up with rectilinear walls (Figure 19a) was ready when it was decided to have the weekly meeting in the mock-up studio, instead of the regular meeting room at the old hospital. The group had the chance to collectively experience the “square-ish” fast-track bay which was significantly larger than the angular wall option. However, the eight fast-track bays with angular walls were kept unchanged on paper until March 2012.

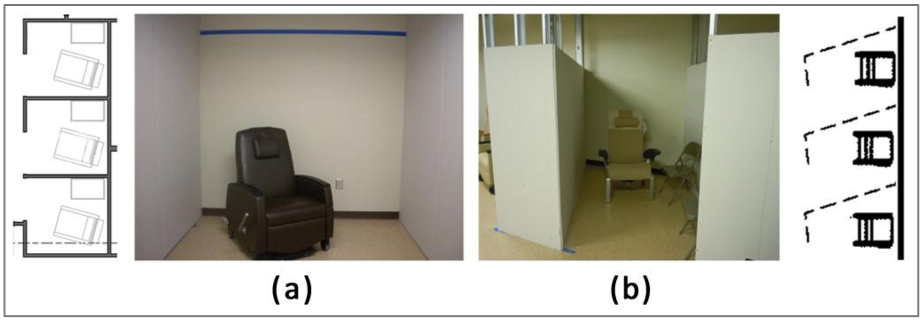

Figure 19. The two mock-ups for fast-track bays; (a) rectilinear walls, (b) angled walls

No decision was made about the fast-track bay design until the midpoint for the construction documentation phase had passed. Soon after the design development phase was concluded in February 2012, the design team decided to mock-up the angular-wall option (Figure 18b) which initially seemed to be the most efficient for the overall layout of the area. The mock-up was ready in March 2012 (Figure 19b) when the group hosted multiple visits by users, community members, and other local executives for various purposes. Unlike the first version with rectilinear walls, the new version did not have full-height walls, which, in a way, reflected the partitions of the existing fast-track cubicles in the old hospital. As mentioned by ***P1***, the design team was well aware of the limitations of short walls which provided little audio privacy across bays.

Based on the comparison between the two mock-up spaces, the team decided to have bays with floor-to-ceiling walls, a decision which gained support after the presentation of anecdotal counter evidence suggesting that the short walls were detrimental to providing audio privacy across bays. There was no effort to conduct any kind of acoustical measurements, or to simulate the situation with actual people in mock-ups to test speech intelligibility across bays. But as ***P1*** or other design team members presented the space to users or other guests, the mock-up with angular short walls (Figure 19b) was utilized to support the developing idea of how the team eliminated alternatives and favored the provision of audio privacy.

Eventually, the members of the team turned their attention back to the earlier option (Figure 19a) built prior to the angular version, and which, to some extent, represented the formal properties of the fast-track area in the old hospital's green zone, Slightly larger in size, the design with rectilinear full-height walls became the option that the group decided to pursue. The rectilinear wall configuration was studied and finalized through revisions on paper. The fast-track area, in the construction documents, had seven instead of eight chair-centric care bays. Post mock-up work on paper also introduced arrangements in wall openings that provided a level of visual privacy across bays. Although the area did not meet the requirements of the building program (seven bays instead of eight), the configuration was considered as a satisfactory solution and was supported and approved by users and the owner representatives including ***O3*** and ***O4***.

The use of mock-ups for the fast-track areas was different than the way they were utilized in the design of exam rooms. Two versions of a single-chair bay were mocked up to test the effect of the configuration of an individual bay on the overall layout of the fast-track area. The option with angled walls embodied some design considerations concerning visibility, and it helped designers demonstrate that the short-walls between units were detrimental to acoustical privacy. Without conducting actual measurements or simulations, designers utilized mock-ups as part of their demonstration of the shortcomings of the walls, combined with anecdotal evidence, and precedents (the green zone) building persuasive stories.

5.5 Detour One: An Adverse Event in the ED

The interaction process among the interdisciplinary team and the user groups was not always flawless. Types and forms of evidence communicated to designers occasionally led to dead ends where it was necessary to revisit the process with regard to particular areas of the design. Following the mock-up exercises where the flow of information among team members and users was relatively unhampered, this section focuses on costly negotiations where the team needed a series of additional meetings to resolve particular issues. Eventually, the layout configuration, which had reflected a set of initial assumptions, was challenged by user groups and external participants. The strategy, then, was to step back, reprioritize concepts and attributes, and try to re-integrate them back into the design work in an incremental fashion.

Despite minor setbacks, the design process for the new ED was on track as the interdisciplinary team was preparing to show the layouts to users for the second time during design development process. The first user group meeting, which was held in early November, 2011 (Figure 8: ED Timeline), was productive in the sense that major layout decisions were well-received by visiting staff members, and these staff members provided several new instructions for the architects to follow. While a set of minor problems identified on print-outs were regarded as solvable, the overall design of the ED was satisfying to all parties including the design team, the users, and the steering committee. The next struggle for the design team, led by ***P1*** and ***D1***, was to integrate new comments from users who were vacillating between favoring the existing care models and the new ones which were introduced over the course of the project.

The strongest attribute related to care processes and architecture that was carried out during the visioning and early design development phases for the new ED was to consider pods as an operational cluster for patient care. The idea was strongly supported by ***O3***, the chief nursing officer, and the initial concern in laying out the entire ED in the schematic design phase was to create pods where the desired nursing model could be implemented and maintained. Following recommendations of major organizations (e.g. Emergency Nursing Association) and evidence from field studies, the team's intention was to keep the four-to-one patient to nurse ratio by forming clusters and pods which could serve various populations including adults and behavioral health patients. Treating the four patients per nurse as an industry standard, the ***PHSP*** hospital representatives, mainly ***O2*** and ***O3***, tried to implement the model following a pod configuration in combination with a distributed nursing system where staff and other resources were to be kept close to clusters of examination rooms. Although no reference to any particular research study was in evidence that specified the ratio, among the team the four-to-one ratio was treated as an evidence-based feature derived from healthcare research.

During the schematic design phase, ***P1***, the planner, introduced four pods that consistently utilized basic nursing clusters with four or five examination rooms (Figure 20). The idea of a four-to-one ratio and the distributed nursing stations, as opposed to central nurses' station, was transferred into a pattern of four or five single-bed exam rooms surrounding a small-scale station which was labeled a "teaming area" on layouts, which, then, formed four distinct pods within the department. It was the architects' interpretation and design expertise that produced such configurations within the given floor plate-to accommodate the desired care model.

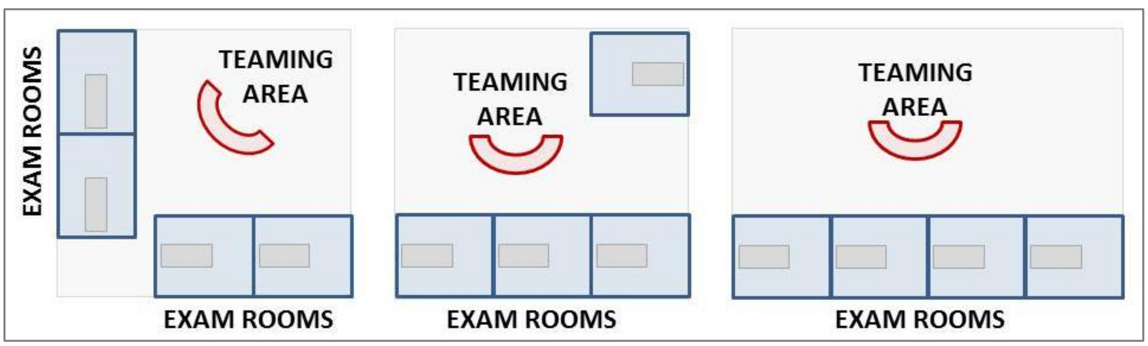

Figure 20. Basic clusters to maintain (4 to 1) patient to nurse ratio and to build 8-10 room pods utilized within ER layout (Diagrams created by the author)

The ED design in the schematic design package consisted of various configurations of eight to ten bed pods –combining two clusters illustrated above- to fulfill the need for a 40-bed department including the beds in the trauma rooms (Figure 21). During the initial user group meeting in the design development phase, the group mostly focused on the fast-track spaces, supplies and equipment management. No opposition was raised to this configuration of the overall unit. Some minor comments with regard to adjacencies within the unit, however, were taken seriously by designers and recorded in meeting minutes for further processing. The need for the separation of the behavioral health section from the pediatric care section, for example, was included in ***D1***'s meeting notes which, then, guided ***P1*** and ***D2*** in modifying floor plans.

Figure 21. The layout of the ED based on 4 pods (in blue continuous line) consisted of clusters with four to five exam rooms (Markings by the author)

Prior to the second round of reviews with users, the interdisciplinary team had a special meeting with a group of representatives from a healthcare furniture manufacturer who was one of the candidates to provide furniture and relevant services for the replacement hospital. The meetings were scheduled for two days, and were organized as work sessions to review key department designs that were being created during the design development phase. Several other reviewers from the ***PHS***, who had not participated previously, were also invited to provide their feedback.

As the extended team went deep into the review of minor details concerning the "life in the ED," major issues emerged with the overall configuration of the unit. As evidenced by the meeting notes, the partially completed design of the ED raised a set of concerns including additional needs (e.g. *Need family room back in ED for visitors not going into room*), accessibility (e.g. *Access family area at trauma from corridor*), standardization (e.g. *Need to look at opportunities to standardize the support cores and* *nurse/Phys work areas*), and privacy (e.g. *HIPAA -The Health Insurance Portability and Accountability Act- concerns about screen visibility at workstations*). By the end of day one, the level of criticism was enough for ***O4***, the president of the existing ***PHSP*** hospital, to call for immediate action. In an e-mail following the meeting, ***O4*** invited the hospital staff to join the design team to re-consider the layout of the ED:

> *The opportunity to design an all new ER does not come too often. Therefore, we need to be sure we have considered all options. In designing space we have a tendency to get going down one road and not taking the opportunity to step back and question the path. Although we have a proposed design that may be the final product, I would like to give the team the opportunity to imagine other possibilities.*

The plan was to have a charrette session to better understand objections to the current design and provide solutions accordingly. Empowered by ***O4***, the participants of the day-long ED charrette challenged the pod-based schema of the unit which was created based on clusters of four to maintain desired nurse-to-patient ratio (Figure 21). In order to understand the nature of the discomfort with the existing layout and better respond to the emerging challenges, the strategy adopted by the architects was to facilitate a conversation where desired attributes and features were re-prioritized. Based on user feedback, the team was able to identify a set of design imperatives that could be translated into subsequent versions of the ED design. While maintaining the basic element of pod clusters, the design team was asked to modify the layout for better visibility and accessibility for care givers, reconsider adjacencies, include additional spaces (e.g. areas for staff and family), and provide a way to accommodate operational flexibility to match the fluctuations in emergency department load.

Some features prioritized by the users initially seemed to be in conflict with the pod configuration. Visibility and accessibility, for example, was partially limited in the pod configuration where some clusters (3, 6, and 9 in Figure 21) were observed to be detached from the main corridor with the ambulance bay. However the anecdotes providing insights into daily operations within emergency services were persuasive enough that the designers broke down some of the clusters to provide improved accessibility and visibility:

00:02:01	***O3***	*U5, this is what I said yesterday. I'm little concerned with behavior health being in the center twenty four seven, and we have two trauma rooms down there. So when you are… At two AM, you have behavioral health and few other rooms open, two trauma rooms at the end...*
00:02:19	***U5***	*Right.*
00:02:20	***O3***	*Where does the staff go?*
00:02:22	***U5***	*And that was one of the concerns I brought in.*
00:02:25	***O3***	*And then, another concern is the visual thing. Even if you are here, the visual down here is still very difficult for me to be able to yell and call some help. I just can't do it.*

In this excerpt taken from a meeting with staff from the existing ED, ***O3*** raised two critical issues, key elements that contributed to a larger story that forced changes in the layout. In introducing her objections, ***O3***, strategically embedded her arguments in imaginary situations in the ED (e.g. at two AM, yell and call some help, etc.). The first issue was related to the operational processes and adjacencies within the unit. According to ***O3***, spreading out the three sub-systems, including behavioral health, trauma rooms, and adult exam rooms was a challenge in terms of staffing during periods of low occupancy. It was not an easy problem that could be solved simply by switching pods, but a more complex concern which was eventually resolved by reorganizing the circulation schema and adding a secondary ambulance entrance on the southern wall. The second concern raised in the excerpt was the visibility issue. Visibility was initially limited due to the fact that the configuration of pods created niches (Figure 20 and Figure 21) of isolated work spaces for nurses. By reorganizing the circulation and breaking down some of the four-bed clusters, the design team provided a satisfactory solution that alleviated criticism concerning visibility, accessibility, and isolation (Figure 22). The new layout, compared to the old one, introduced uninterrupted corridors where, in ***O3***'s words, one could "*yell and call some help"* from one end to the other.

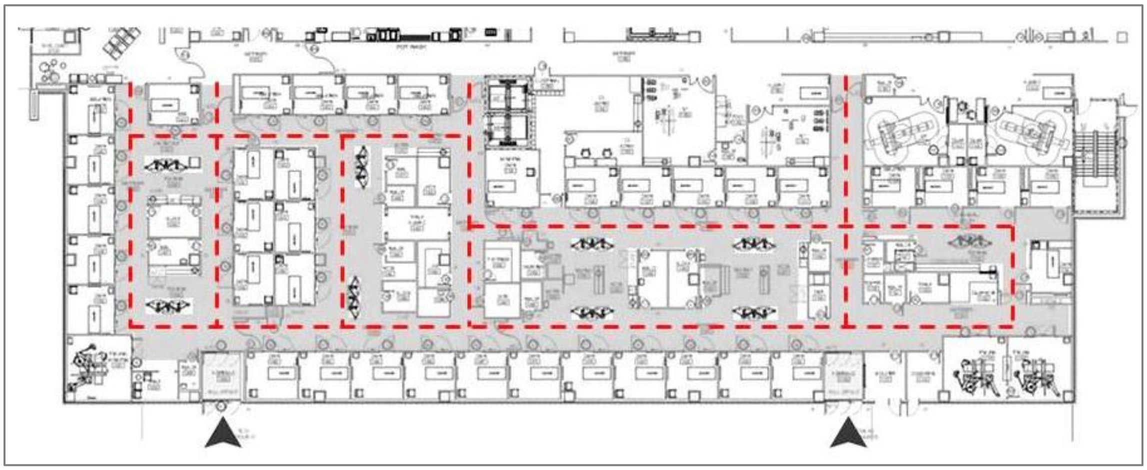

Figure 22. The revised ED layout with continuous corridors to enhance visibility and accessibility

P1, the lead person processing and translating anecdotes from staff, moved the project away from a layout dominated by pods and gave it a new configuration based on "a linear ballroom type;" a design schema which is frequently used in emergency services. The new layout, which was approved by all individuals participating in the earlier charrette, was also compatible with the flexible process model. The segments of anecdotes used to support this model, which came from user group meetings, were also utilized by other participants in their narratives during post-process interviews where they explained the rationale behind the configuration. The interview with ***O2***, for example, offered a clear instantiation of how anecdotes emerging from user group meetings propagated and were integrated into stories and, then, into design. In her interview, ***O2*** resorted to similar examples when providing the background story for the ED design:

00:17:16 **O2** *It is, it is… But as far as the design drivers for the ER, we really wanted to make it a phasing model, so you don't open any more than you have to of your emergency room. We don't have to have all 30 adult rooms open in one time, we don't have to have all 10 pediatric rooms. Because at 3 o'clock in the morning you are not gonna have that many patients,* *you don't need to... So we designed it so that we flex really easily and keep all the patients in one central area when our census low or when our census high, so our staff can be focus and they don't have to travel as far as all the different patients. We also wanted to make it as close as possible to the imaging modalities. So X-ray, MRI, CT, and I think we achieved that as well. And another focus will be behavioral health patients, we wanted to make sure that they were separated from the general population in emergency room, and in a way keep our staff safe...*

00:29:46 **O2** *I mean, we have a users challenge, I mean I keep going back to ED is the biggest example, because we originally have the rooms and pods, so groups of four, because you know the clinical evidence show most nurses have four patients, and so we thought, as design team, four rooms together, and make the nurses travel a lot easier. And the nurses didn't like it at all, you know they want... They didn't want to be isolated, they want it to be able to flex up and down, so if a room you know was emptied, you are gonna have one nurse over here with two rooms and one nurse over here four, it wouldn't be balanced. So we blew up that model completely because they did challenge and it made sense. And so that's why we went and redesigned it.*

The chain of events initiated during a visit by external parties led to a new layout for the ED. The charrette, a considerable time commitment for participants, gave the team the opportunity to run an extended conversation with users where the priorities for the new ED were clarified. The new set of priorities, which was mostly based on anecdotes emerging from day-to-day operations within the unit, challenged the pod type arrangement which was formulated around the idea of four-to-one patient nurse ratio. Eventually, the pod configuration was partially modified, and the team introduced a new layout with better visibility, accessibility, and flexibility. While still recognizable in the revised layout, the emphasis on pods was significantly diminished.

Frequently throughout the design development meetings the concepts or desired attributes were reprioritized due to various factors, including budget constraints or changes in care processes. The intensive process of re-assessing and revising priorities to drive ED design was repeatedly revisited until the team collectively reached a level of comfort with the layout. As it propagated through the team, the story, which was a synthetic construction based on scientific evidence, precedents, and anecdotes, was observed to be contributing to the level of comfort with the design. This was shown by the way participants provided accounts explaining reasons for particular design decisions in interviews. As concepts and attributes were clarified, elaborated, and prioritized (e.g. the need for visibility to access help), the stories became more detailed, which made it easier for designers to translate them into drawings.

5.6 Detour Two: Changing Hands

I have observed hospital staff members periodically challenging decisions at various design scales, even very late in the construction documentation phase during which architects finalized the requirements for construction of the project. Most of the time, when there are such challenges, the design team members were on the front lines to evaluate the nature of the concern and, if possible, quickly provide solutions without slowing the overall design progress. Especially after the schematic design phase, changes in layouts had to go through several channels before they were translated into drawings. The emerging challenges had to be persuasive enough for ***O1***, the project manager on the owner side, and ***O4***, the ***PHSP*** hospital president and the leader of the steering committee, who made decisions after checking in with designers that the issue can be resolved in time without causing any ripple effects.

One final episode to consider in this chapter exemplifies those quick but important changes that did not require additional meetings or charrettes. In this case, the design decision-making was less complicated because designers immediately processed and translated user feedback into design. Very late in the project, a reorganization of the behavioral health section of the ED occurred, demonstrating the nature of interactions between pre-established and evidence-driven design commitments and the segments of evidence emerging from daily practices of actual users.

One of the most fashionable topics in the healthcare design community is whether or not same-handed patient rooms contribute to safety goals in environments of care. The idea is based on a type of physical environment standardization which is claimed to prevent error or confusion in emergencies and, thus, improve safety. Pati and colleagues define same-handedness as "a type of room standardization where attributes of the physical elements (chiefly location, assuming that the design of individual elements—headwall, supply cabinet, and so forth—are already standardized at lower scales) in the patient room are standardized in relation to three axial plains: the midsagittal, the coronal, and the transverse planes of a patient lying in bed" (Pati, Harvey, et al., 2010: pp. 74-75). In another words, all same-handed rooms are identical with the patient always in the same orientation to the door.

Although the concept was favored by rigorous studies in the aviation industry, where researchers investigated standardized cockpit configurations, in healthcare the evidence base for such standardization is insufficient (Pati, Cason, et al., 2010; Pati, Harvey, et al., 2010). However, implementing same-handed patient rooms is an accepted strategy to support process and workflow standardization to improve performance and safety measures.

The idea of same-handedness was introduced to the steering committee in the visioning phase when the team had the opportunity to visit other facilities that had implemented the concept. The idea was well received by the ***PHSP*** seniors. Despite cost implications, ***O4***, who was aware of the fact that the concept was not empirically proven in the context of healthcare, made the executive decision to have same-handed rooms in the replacement hospital. Although the architects entertained other ideas, including mirrored configurations, the idea of same-handed rooms was always an option. The idea gained support through ongoing communication and propagation across the team. ***O3***'s anecdote was part of the larger story to communicate the idea to engaging parties. ***D1***, for example, referred back to the same segment of ***O3***'s anecdote while explaining the concept in an interview:

00:41:51 ***D1*** *There're some positive reasons why you might wanna do that. But one of the things she came up, uhmm, to the table with was her… Basically her assertion that... She said you know when I was a young nurse, and I was learning, and gaining my experience, and becoming an ICU nurse, she said it occurred to me that the visual... She said I was understanding that, I was really using visual cues to do my job. She said cause you're always multitasking, you're having to assess things really quickly, and she said when you really watching over a patient, it's not unlike a monitor that has stats on it where you're just spot checking certain critical criteria, she said, visual cues were huge for her. If a patient had a catheter or didn't, or if a patient had a wound care pack, or if a patient had a... You know certain things. And all the patients were different, she said, I walked in a room, you wanted to quickly do your five-point check on, do I need to change a catheter, do I need to do this, do I need to do that...*

The design of the new ***PHSP*** hospital, throughout schematic design, design development and construction documentation phases, had maintained the early commitment to same-handed standardization in patient rooms. Days before the design team had issued the construction drawings, however, a group of users who were concerned with staffing and operations in the behavioral health area of the ED proposed to change the design to a mirrored configuration for that particular area (Figure 23). The argument was that the mirrored configuration would increase visibility into the room, a primary concern for this type of patient population. Furthermore, the users wanted to have special work-stations with additional safety features with regard to adverse events involving violent patients.

Figure 23. Behavioral health section, (a) with standardized same-handed rooms, (b) mirrored configuration with a modified nurse station

Both abandoning same-handed configuration and "beefing up" the work station were in conflict with the commitment to standardization favored by a developing story that relied mainly on claims of greater safety and efficiency. The counter arguments raised by the users also involved claims supported by anecdotes. The staff members argued that with mirrored configuration, the ability to supervise multiple patients would be improved, which, in turn, would facilitate safety for both patients and staff. Similarly, reinforcement of the workstation was expected to provide a level of safety for staff confronting violent patients. In a post-project interview, ***O3*** briefly mentioned the nature of the challenge and the people involved:

00:18:23 **I** *So one thing emerging from my conversation with* ***O4*** *is that there is a recent change in the behavioral section of the ER, where you're kind of not doing same-handed rooms anymore.*

00:18:39 **O3** *For four rooms.*

00:18:40 **I** *Yeah.*

00:18:42 **O3** *We mirrored them, and the reason being is because if the patient is violent, they really have to be secured into their room. Uhmm, it's most important, to keep a visual on those patient rooms. The way the ED is laid out, you cannot get that visual on that patient in same handed rooms, if you have one staff person that needs to watch two patients. So we mirrored those beds to be able to promote safety. That was* *challenged by the behavioral health experts...*

00:19:36 ***I*** *In house?*

00:19:37 ***O3*** *Not here in house but that works in our behavioral health unit at over PHSC hospital. They came to look at our final plans, and they challenged the feature same handed in the behavioral health unit.*

Just before the team was set to finalize the construction documentation package that would be the basis for the construction process, the design team members were asked to integrate the comments raised by experts from a sister facility, namely the ***PHSC*** hospital. The concerns of experts were communicated to ***O1***, the project manager on the owner side, and ***O4***, the president of the ***PHSP***, who quickly authorized the changes. Unlike the earlier ED charrette which was costly in terms of time and labor, the team was able to decide these issues quickly without additional work sessions or further reviews (Figure 23b).

The challenge of changes in design work was local and limited. However, the set of recommendations based on day-to-day practices of experts went against the global strategy of same-handedness. Following the opinions of experts, standardization in both room configuration and workstations was immediately modified by the architects:

00:03:08 ***D2*** *The users are... Great wealth of knowledge of how the room works, should work, you know, what they do and how they use these rooms.*

00:03:18 ***I*** *They have rooms like this in the existing hospital?*

00:03:20 ***D2*** *They have rooms that they use as behavioral health rooms in hospital.*

00:03:23 ***I*** *Okay.*

00:03:24 ***D2*** *Yeah. So what we changed is, they want to be able to station a security guard at this spot here [station in the center in Figure 23b], and at this spot here. They want to have, when the door shuts, visibility from security guard to the patient head. So when you do that for one location, we need to flip this room. So that's exactly what happened, rotated this room, flipped it, flipped the door swing, put the hand wash sink on a roll, and this becomes a... One and a half, two foot partition, with the TV and bed embedded in the wall for each room.*

...

00:05:03	***D2***	*The other change was, uhmm, we have this [furniture] unit.*
00:05:10	***I***	*Is that a perching station?*
00:05:11	***D2***	*It's a perching station. But they wanted to go with, instead, with a built in millwork that was extra tall, uhm, to give the impression which is the psychological impression, that it's built into the floor and you cannot knock it over. The perching stations, even though they're built into the floor, you can knock them over if you can run into the hard enough, and do that. This will be a big chunky piece of millwork, will be a little extra tall, so if someone does try to jump it, it gives the staff, you know, extra half a second to move. Uhm, you know, it's not typical thirty six inch counter height, so you can... I believe it's forty eight inches which is pretty tall.*

Both parties, design team and the staff, were observed to be in agreement when it came to the desire for enhanced visibility and improved safety for patients and healthcare workers. A global strategy of standardization to be applied across patient rooms had been proposed initially in the layouts. In terms of safety, however, the local needs within the behavioral health section required a different configuration that deviated from the idea of standardization. Based on a chain of causal arguments (better visibility, better supervision, safer environments), the proposals of behavioral health experts, accompanied again by an emerging story (e.g. *so if someone does try to jump it, it gives the staff, you know, extra half a second to move)* were accepted by the team. Without any recorded resistance, the new set of proposals introduced by experts was translated into the layout.

5.7 Emerging Evidence

The series of events presented in this chapter provide insight into the significant events where an interdisciplinary team interacted and processed various types and forms of evidence. To some extent, the characteristics of the larger hospital design were partially exemplified in this limited set of collective efforts in the design of the new ED. The description provided in this chapter relied on archival data, interviews, and field observations, to reveal the salient issues in representation, propagation, and translation of evidence into architectural design.

The case study of the design of the fast-track care area demonstrates both asynchronous and simultaneous generation of evidence to support design decisions. The green zone experiment provided an array of evidence, in the form anecdotes and recorded measurements (e.g. satisfaction scores), for the interdisciplinary design team to rely on in shaping the fast-track area of the future ED. The initial inclusion of fast-track areas into the building program (*individual 3-sided spaces with recliners*) by ***P1***, the planner, relied on a straightforward and ready-to-use formula to be further processed on subsequent design phases. In fleshing out the area during the design development phase, on the other hand, the design team utilized mock-up spaces that provided evidence in the form of anecdotes. The embodied evidence generated or activated by mock-ups, which highlighted what attributes to adopt and what to abandon, had enriched a developing story that provided a basis for design decision making for the fast-track area.

Design team members and the other engaged parties did not fully simulate work protocols that typically took place in fast-track bays, but loosely evaluated the two mock-up environments with different physical attributes. Consensus was achieved as the steering committee members and other participants experienced and reviewed the options while physically in the mock-ups. Ultimately, a set of design alternatives (e.g. rectangular configuration, floor-to-ceiling walls) that were evaluated (Figure 19), led to design decisions by the steering committee members to be implemented in the future ED.

The ideas that drove the design for the new ED were introduced in the visioning phase during which the steering committee members had the opportunity to engage with the broader community of healthcare designers. By means of focused meetings and field trips, the steering committee was exposed to a variety of ideas and applications that could be employed on different scales. Through visioning efforts, the team was able to gather a mix of anecdotes and research-based evidence to support certain concepts. The range of physical environment attributes and processes were then translated into the visioning document in the form of narratives, diagrams, pictures, and tables, and into a master building program which included brief descriptions for individual rooms.

The visioning document also provided several comparison tables that communicated the impact of selected attributes on square footage, operations, technologies and costs (Figure 14). Anecdotes from meetings and visits, and the expertise of designers, managers and clinical practitioners on the steering committee, were the source for these comparisons. When asked, the participants were observed to provide a coherent story, referring to similar implementations and outcomes in other facilities, for physical environment attributes mentioned in the visioning document. The participants were also observed to loosely refer to research evidence to support their stories. However, without referring to specific studies (contexts, methods, limitations, etc.), the participants accounted for broader causal arguments on principle level (e.g. *reduce medical errors with fewer transfers)*.

As the team later developed the schematics, the evolving building program and a set of (stacking) diagrams were utilized as intermediary representations. Based on comments by the steering committee members and other hospital staff, the architects manipulated and modified the representations (e.g. *redid the program, updated it, conformed various parts of it, made some changes to it.*) in an incremental manner and at different scales, before they were re-represented in the form of architectural layouts. Early in the process, the master building program was the primary medium utilized as an interface between designers and non-designers to accommodate descriptions of desired attributes that that had been introduced by various sources and in different forms. During the initial phases, before the ideas were represented by architectural drawings on paper, the building program was the main representation to enable interaction among the steering committee members as they made decisions involving spaces and processes in the future facility.

Through design development meetings, the steering committee actively engaged with users to collect more detailed and first-hand information so that they could design spaces at a higher "resolution." In addition to the building program and actual layouts on paper, the design team utilized physical mock-ups to solicit useful feedback to be considered in the design. Based on negotiations within the team during meetings, there were changes made to the building program (e.g. *you want eight chairs, two assessment rooms?),* the layout drawings (e.g. the configuration of the fast-track area), and the mock-ups (e.g. the exam room configuration) to accommodate evidence from user-based anecdotes. While each was different in nature, all three representations were observed to be critical in accommodating project-specific evidence in various representational forms.

The user feedback was closely tied to the staff's day-to-day experiences within the ED, but was not always reflected in what was translated into drawings or mock-up spaces. The engaged parties, including staff from the existing facility, experts from other facilities, and other consultants, challenged the design work at different scales. Practice-based anecdotes and particular causal arguments regarding principles of visibility, accessibility, and safety, led to significant changes in layout configurations.

A growing dissatisfaction with the overall layout of the ED the emerged late in the design development phase hampered progress of the work. Since there was no immediate solution to the perceived problems, the team decided to hold multi-disciplinary meetings to discuss these issues. The design team used a charrette to quickly and creatively process design ideas in a limited period of time, and as a result was able to access, understand and translate the new priorities. The developing stories of users were, again, influential in unpacking the staff's everyday practices in the unit, and in re-organizing the layout with enhanced accessibility and visibility to accommodate emerging needs.

In the last case, the experts and users came up with a problem that was closely tied to their daily work practices, as well as a solution that challenged the concept of the same-handed design strategy. The challenge was persuasive enough for the steering committee to alter the layout without much resistance. Propagated in the form of anecdotes, the argument against same-handedness was translated into design work by means of abandoning same-handedness in a specialized area, the behavioral health section within emergency services.

Throughout field observations, participants were observed interacting with four main sources of evidence: anecdotes, precedents, scientific research, and local experiments conducted internally. These pieces of evidence were usually delivered, received, and maintained orally among the team, and informed design decisions at various scales from the visioning phase onward.

The structured user group meetings and mock-up exercises allowed the team to benefit from timely input to advance their design work. However, there were exceptions where the architects were challenged by delayed feedback, and they needed to revisit earlier design decisions and revise several of the layout configurations. In the two cases discussed in this chapter, problems involving conflicts between initial strategies and associated physical environment features developed; namely creating pods versus accessibility and utilizing same-handed rooms versus visibility. As these conflicts were independently discussed under the overarching principle of safety, the engaging parties challenged design decisions that relied on relevant research evidence conducted in other domains.[15] Faced with a complex set of design problems, the architects were expected to provide synthetic solutions by processing the entire set of inputs while taking into account the constraints of a tight schedule and budget. These constraints required locally developed, unique solutions that were not addressed by available research studies conducted in healthcare settings. In laying out the emergency department, for example,

[15] Nursing research provided a particular nurse-to-patient ratio (one-to-four) which was kept by the laying out clusters and pods, and research in the aviation industry provided supporting evidence to implement same-handed standardization for patient rooms.

P1, the space planner, was guided by her individual expertise and knowledge of typical design configurations at various scales, rather than particular segments of research evidence. When challenged by other experts and users, the design team's strategy was to reprioritize first principles, by means of an interdisciplinary charrette, which provided them with a guide for the immediate needs (visibility and accessibility) that needed to be satisfied. Through a process of collectively creating and evaluating alternative configurations, the architects were able to provide local solutions (e.g. breaking down pod configurations to facilitate visibility and accessibility, adding an extra ambulance entrance) for these new problems. In re-configuring layouts, the architects drew upon convincing anecdotes, eventually combining them into stories, and these supported the reasons for making particular changes in existing layouts.

S*tory* refers to representations gathered from field observations or interviews that introduce connected pieces of accounts with regard to a phenomenon. In this study, participants were observed to invoke stories that combined precedents, anecdotes, intuition, and scientific academic research to explain reasons behind particular design strategies and decisions. These stories were maintained orally among the group; additionally, several pieces were recorded in meeting minutes as they were introduced during weekly steering committee meetings.

The segments of larger stories I observed included experimantal situations within research projects, particular features from hospitals that were regarded as best practices, and previous successful implementations (as participants called them) that were experienced first hand form the segments of larger stories that I have observed. Thus, while some segments, including in-house experiments conducted by participants themselves (e.g. the green zone), were closely tied to actual healthcare environments, others were allegoric in nature (e.g. the idea of same-handed cockpits in aviation industry), which added another layer of complexity to these stories by expanding the arguments beyond the domain of healthcare. In any case, the causal arguments in these stories were well communicated, sometimes through bodily gestures in addition to oral narratives, even though not all specifics were brought to the table to be further investigated. Over time and across individuals, the segments of these stories were observed to be durable in terms of structure or individual items of evidence.

The pieces of evidence surrounding the design of emergency services, for example, were utilized by participants to form stories to guide and explain design work. The diagram below illustrates the storyline employed by participants, the supporting evidence, the program evolution, and the final layout configurations that were framed by various types of evidence.

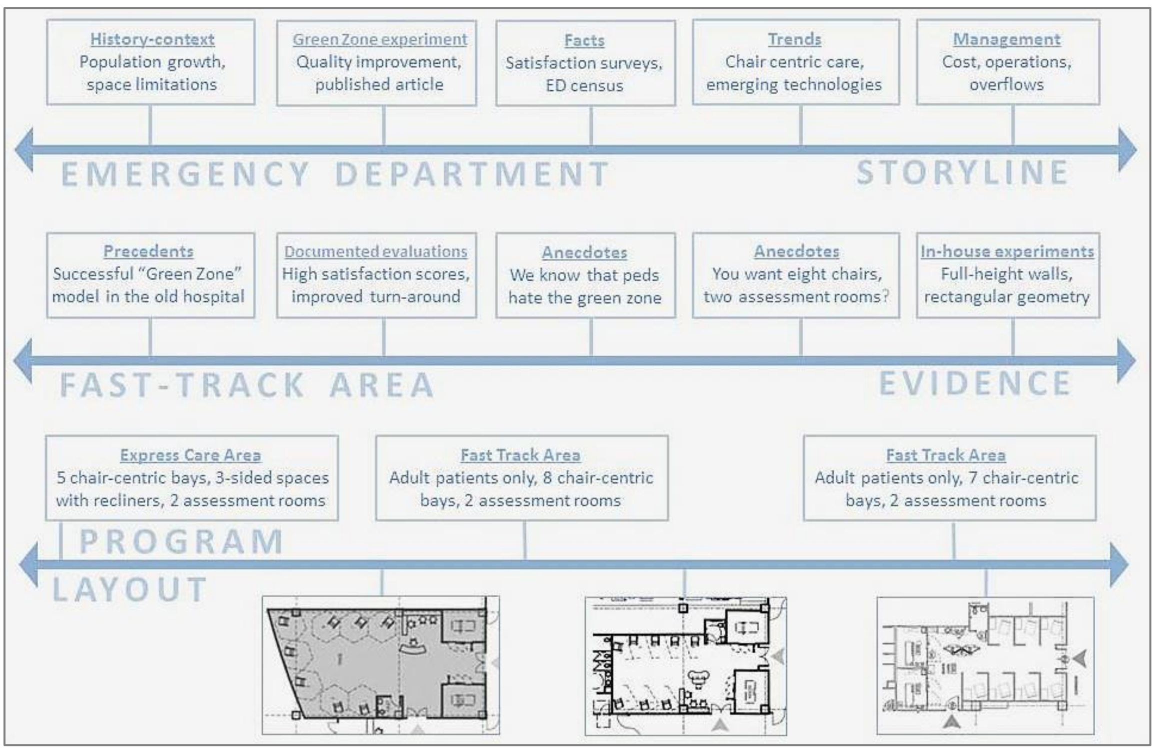

Figure 24. Developing story, evidence, and evolving design work for fast-track care area

During field visits, architects were observed developing stories, processing evidence of various types, making programmatic changes and creating new layout configurations to achieve architectural solutions that could be endorsed by all the other participating parties. The architects' ability (interactive expertise) to engage in focused conversations involving complex care processes in emergency services allowed them to capture and translate critical feedback (anecdotes) into initial programmatic segments, and later, into spatial configurations that corresponded to their stories, even as they developed and changed over time. Also observed in field studies, were architects acting as agents in generating evidence through local experiments involving mock-ups (Figure 17: developing exam room configuration, Figure 19: determining room perimeter and wall heights). When scientific evidence failed to provide enough specificity and applicability, architects resorted to concentrated interdisciplinary activities such as charrettes and mock-up exercises in order to better understand their problem space (prioritization) and to generate local evidence to support design decisions.

5.8 Distributed expertise

During the design of the ED, two distinct kinds of external representations, layout drawings and mock-ups, were generated, propagated, and manipulated within a cognitive system in which design was undertaken in a distributed fashion. In order to benefit from the distributed expertise of the team, the architects strategically utilized representations that addressed design issues at different scales. Both scaled-down layouts and mock-ups initially acted as the key representations generated or built by architects, and later they were made available to others for collective processing. Following these multi-disciplinary exercises, it was again the architects –who possessed a form of meta-expertise to process what had been proposed by engaging parties– to ***put it together*** and translate it back into representations of future spaces. Through various practices, the architects, as meta-experts, pooled the set of emerging evidence (e.g. user group meetings, mock-up exercises), recognized the set of programmatic needs (e.g. evolution of the fast-track area), incorporated specific needs concerning spatial configuration (e.g. visibility), and processed available solutions (e.g. examination room layout) without, as frequently mentioned by ***P1*** hampering "the integrity of design." As brokers among multiple domains of technical expertise, architects were ones to possess a level of awareness of ***all segments*** of the developing stories around particular physical environment features.

Following the creation of the floor plate for the master plan and the blocking diagrams that established interrelationships between departments, the project architects developed a layout configuration for the ED that accommodated the building program for emergency services. The layout representation was built up from distributed fragments of available care models (reflecting various levels of evidence) and through exchanges with participants who possessed expertise with regard to planned care activities.

Distributed fragments of care models, in this case, refer to three clusters of input that were processed by architects. The first of these was the desired model of care, offering a basic nursing unit that was translated into patterns (Figure 20) to be utilized in laying out the unit. In other words, architects employed their particular skills and expertise to represent a piece of information (evidence) drawn from nursing research in another medium, and this information was further manipulated using additional input from other agents (e.g. consultants, nurses, managers). This complex translation process from words to patterns to be employed in drawings involved utilizing pre-established layout models (stereotypes) for ED configurations, such as ballroom, linear and pod types. ***P1***, who was the lead person in space planning, frequently referred to these types in explaining the overall configuration (e.g. *the rest of it is bit more like a ballroom…*). Since ***P1***'s initial layout exercises preceded the observation phase of this project, the available data set does not provide details as to how these pre-established layout types influenced the selection of pods for the eventual design of the ED.

The second type of input was the master building program, which imposed a specific set of requirements to be accommodated in the floor plate. The number of examination rooms, for example, was a mandate in the program. The architects laid out pods consisting of basic nursing units of four or five rooms, and the layout eventually met the requirement that the unit have forty beds in addition other programmatic requirements including waiting areas, restrooms, and storage areas.

The third type of input involved established guidelines from the American Institute of Architect's Guidelines for Design and Construction of Healthcare Facilities. This guide offered specific dimensions to be used in establishing relationships between elements in the other two clusters of input. The guidelines document circulated among users in the design group and was instrumental in defining the solution space by means of imposing constraints and offering acceptable models. The designers observed in this process might have possessed the knowledge of most of the segments within the guidelines (e.g. dimensions for corridors, adjacencies), but I observed only the architects resorting to these mandated guidelines to make sure that there would not be any problems with compliance.

The layouts, which were built up by architects using a distributed process, were central in discussions during user-group meetings (Figure 25) during which these representations were open to further manipulation based on input from knowledgeable hospital staff members. However, field studies and participant interviews revealed that the visiting staff members who were "not trained to read architectural plans" were not always adept at understanding this particular type of representation, although the architects provided considerable assistance to the staff in "reading" the layouts. Limitations in the effectiveness of interactions between architects, consultants, staff members and the available representations caused both minor and major delays in feedback, eventually delaying the integration of all the input to arrive at a design solution. A major delay in feedback, for example, significantly hampered the rate of progress in the design of emergency services (Section 5.5. re-considering overall unit configuration). The evolving cognitive system, however, was adaptable enough to accommodate the delays, major or minor, and maintain progress by means of charrettes or other focused meetings that assured a level of feedback clarity and scope sufficient to support the ongoing design work.

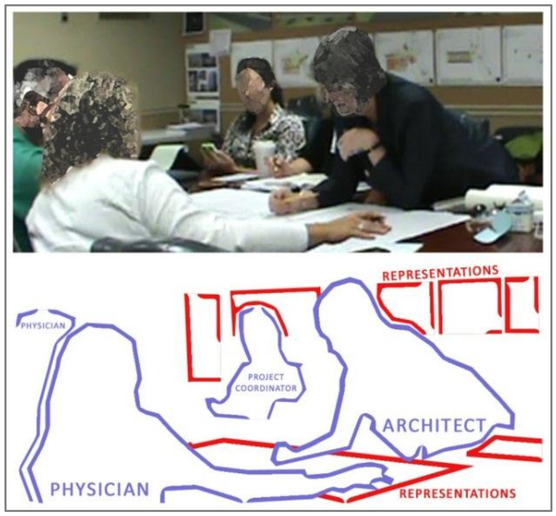

Figure 25. User-group discussions over layouts

The mock-ups, on the other hand, were both tools and representations employed by the team to achieve progress. By representing the examination rooms in a different way than the layouts, the mock-ups acted as cognitive tools to incorporate the distributed expertise of the group. By means of externalizing input (Figure 16: sticky notes), the architects were able to record and process user feedback.

The key feature of the mock-ups as cognitive tools, however, was their ability to facilitate real-time simulation within a space that more accurately represented the constraints and affordances of care environments. By providing an instantaneous mechanism for manipulation and feedback that simultaneously involved space, equipment, and people, the examination room mock-up room was instrumental in "discovering" a satisfying configuration that could be utilized during overflows (Figure 17). As opposed to two-dimensional representations of examination rooms on paper, the mock-up allowed the distributed expertise of the various team members to be collectively processed to determine certain design considerations (e.g. position with regard to bed, height, etc.) in a realistically simulated environment.

CHAPTER 6

SITUATING EVIDENCE

A design based on evidence must be able to display the chain of logic that connects specific research findings or credible data to a planned outcome associated with the completed project. (Hamilton, 2012: p. 141)

This chapter reviews how the design team gathered and interpreted new evidence to support design decisions related to the inpatient rooms of the future ***PHSP*** hospital. The design of individual patient rooms evolved significantly over the course of the project from the initial visioning phase through the schematic design, design development, and construction documentation phases (APPENDIX E: Patient Room Evolution). The main focus in this section is on particular episodes related to certain important design decisions that characterize the overall room design process. One important feature of this chapter is that, when possible, it incorporates instances of decision making processes that occurred before field studies. Additionally, it examines the design process broadly, showing how it extends across many people and over a considerable length of time.

Following early field observations, early analysis identified in the resulting data set the fact that patient room design was one of the key issues that participants repeatedly discussed in project meetings. Early on, their expressed goal was to develop an entirely new patient room, different than the rooms in the old facility, to support a set of new care practices that could be adopted in the new ***PHSP*** hospital. The stated intention was to implement as many "evidence-based features" as possible, because they believed this would create a safe environment of care for patients, families, and staff members. The term "evidence-based features" is used by participants to refer to features that have been discussed in visioning meetings. These physical environment features, including same-handed rooms and distributed nursing stations, are not necessarily supported by scientific research, but continuously being discussed in EBD community.

Beginning with the visioning phase, the interdisciplinary steering committee engaged in activities, including site visits, participating in major conferences, and meeting with a variety of experts, to develop a sense of what was available in terms of novel ideas and available evidence to be translated into the room design. Throughout the field studies, numerous participants were observed referring frequently to this period of concentrated and intense activity where team members learned about the current trends in healthcare industry. Therefore, it made sense to pay increased attention to discussions involving patient rooms because they linked multiple participants, fashionable ideas, various sources of evidence, and various types of representations. As in the earlier inquiry into the ED design, questions were included in semi-structured interviews explicitly to elicit information about particular design features in patient rooms in order to understand how the team members interpreted and utilized evidence about these features.

Initially, this chapter provides a chronologically ordered account to establish the background for the events surrounding the design process of patient rooms. Then, the following sub-sections will introduce three design attributes linked to the categories grounded in the qualitative analysis. These three sub-sections will describe interdisciplinary processes to develop features including same-handed standardization, ventilation systems, and patient room corridor walls. Based on analysis of the data set, these three case studies in combination form a distinct layer to the analysis because of the particular evidence utilized and the individuals (Figure 26) and tools involved.

Client (PHSP) representatives	**O2**	Project coordinator in the PHSP hospital.
	O3	Assistant vice president and chief nursing officer.
	O4	President of the PHSP hospital.
	O9	Transformation consultant for the PHSP hospital
Project consultants	**M7**	President of the MEP firm.
	Ct1	Information technologies consultant.
	Ec1	Medical equipment planner.
Firm A: design team	**P1**	Space planning and programming consultant.
	D1	Lead design architect.
	D2	Intern architect.
PHSP staff	**U8**	Nurse. Participated in user group meetings.
	U9	Nurse. Participated in user group meetings.

Figure 26. Key individuals in this chapter

6.1. A Room to Shape

As the design of the patient rooms of the new ***PHSP*** hospital consumed considerable amount of time and efforts throughout the project, the field studies in this research paid particular attention to exchanges occurring around the rooms. A quick review of literature suggests that in almost every hospital design project, patient rooms are typically the most repetitive spaces in hospitals, and they are regarded as a key element of a hospital. Probably the most compelling justification for this increased level of interest is that the design of these spaces is argued to have a direct effect on patient-related outcomes (Chaudhury et al., 2005; Hendrich, et al., 2004; Maze, 2009; Pati, Cason, et al., 2010; Ulrich, 1984). There are in fact a number of studies that demonstrate that the design of patient rooms or wards has traditionally been a serious issue in the healthcare community (see for example Thompson and Goldin (1975) or Verderber (2010) on evolving patient rooms). In addition to publications coming from design domain, there is more recently a body of literature produced primarily by individuals in the healthcare field such as physicians, nurses, managers, and infection prevention specialists. Further, many articles in academic or popular publications (e.g. Lorenz and Dreher (2011) on room design), or book-sections (e.g. chapters in Hughes (2008); an evidence-based handbook for nurses) have been written by non-designers who elaborate on physical environment features in patient care areas.

As the number of publications on patient room design has grown over the past several years, more fine-grained concerns were introduced, adding to sustained interest on the overall configurations of rooms or units. Paralleling the variety of backgrounds of their authors, these articles discuss a diverse set of issues, for example materials, ventilation installations, or alternative locations for care equipment. Reinforced by recently developed patient-centered frameworks, researchers and practitioners from a variety of fields have proposed a set of design features supported by different forms of evidence, and which, in turn, have added another level of complexity to design decision making in healthcare projects.

Working with a vast array of constraints, healthcare design teams are responsible for creating an optimum solution for patient rooms, one that takes into account a set of interdependent factors involving architecture and engineering design, care processes, and technologies alongside local parameters such as budget and schedule constraints. Because circumstances differ from one care provider organization to another (i.e. market share, care model, budget, schedules), or from one patient population to another, patient rooms display significant differences across hospitals in industry. Local constraints, regulations and codes, and the desire to "introduce innovation," lead to the creation of different patient rooms in each and every hospital project. In that sense, the case observed in this research was no exception.

The set of potential design features to be included in patient rooms were repeatedly discussed over the course of the ***PHSP*** project, as design work evolved from visioning to construction documentation phases. The steering committee meetings, where a group of representatives from a variety of disciplines participated, were the venue for evaluating new design-related alternatives. All participants, including managers, architects, engineers, and nurses, had the opportunity to reflect on issues that were brought to table by consultants or by the ***PHSP*** hospital representatives. Throughout the design development and construction documentation phases (Figure 27), I paid close attention to these steering committee meetings, along with other side meetings and evaluation sessions, in which a set of evidence was processed from literature, precedents, or a series of events (including user-group meetings, mock-up evaluations, and focus-group meetings).

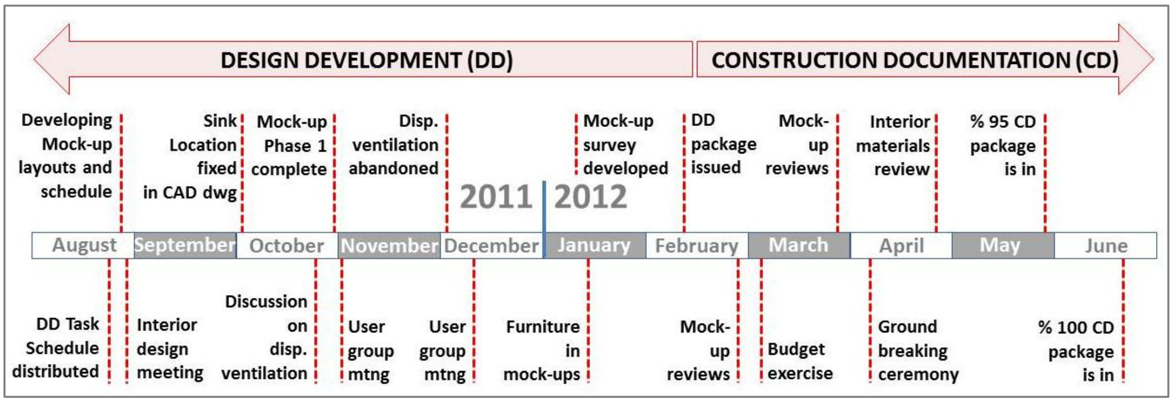

Figure 27. Project timeline with patient room related milestones

The steering committee members negotiated over many alternatives for room designs. All the participating parties in these meetings contributed to some extent to the design of the rooms, and the design significantly evolved over time. The next section is a brief history of the design processes of the ***PHSP*** hospital patient room as it was incrementally developed over a period of two years. Following this chronological description, sub-sections will discuss events surrounding three key case studies, including the design of corridor wall, the decision to design with same handedness, and the issue of room ventilation.

6.1.1 Vision

Similar to the focused meetings on the ED, the interdisciplinary team, in collaboration with several external consultants, also discussed the trends, options, and precedents concerning the design of the inpatient units. One of the major problems addressed in these meetings involved determining the basic specifications for physical environment features or attributes that could be included in the design of a patient room in "the world's safest hospital."[16] As summarized earlier, facilitated mostly by the project architects, ***PHSP*** representatives experienced an intense introduction to the concepts and rhetoric of evidence-based design through focused meetings and presentations, site visits, and precedent examples from the healthcare industry.

As the interdisciplinary team dived deeply into issues concerning particular spaces of care, a set of emergent issues, concepts and associated design features were brought into focus. Many of these concepts involved the idea of standardizing the design of the physical environment, decentralized nursing stations, or increased bed-side support. These issues were emphasized in the visioning document prepared by the architectural consultants. The recommendations of the external consultants, combined with first hand anecdotes obtained during site visits, increased the persuasiveness of stories surrounding these concepts, as the client representatives gradually adopted these new ideas. Although the ***PHSP*** administration replaced its architects soon after the visioning phase, the senior managers, mainly ***O3*** and ***O4***, made sure that these initial ideas were clearly communicated to all members of the committee, including the new architects, and that they were kept alive for the rest of the project period.

Presenting options

Concerning the inpatient unit, the visioning document reflected a distinct presentation strategy created by the project architects that explained the available design alternatives for the rest of the team to review. At room scale, the architects presented alternative spatial configurations and design features to reflect various modes available in

[16] The lofty aspirational statement made at the outset was "to create the safest hospital in the world." As it was recorded in the visioning document, the pursuit was providing safety for patients, families, the individuals working in the hospital, the community and the environment.

healthcare design; the traditional approach, current standard practice and innovative concepts. Associated with each of these modes, the project architects provided a brief analysis and discussed advantages and disadvantages.

For example, based on their extensive healthcare design experience, the architects presented three patient room layout diagrams that characterized existing room typologies utilized in the industry. In the “traditional family-centered care” mode, for example, the room diagram portrayed separate zones for caregivers, patients and families (Figure 28a). The traditional rooms were arranged in a mirrored configuration with an outboard toilet next to a family area and a window with an exterior view.[17] Compared to the others, this traditional room had the smallest area (265 square feet). The room in the second diagram also had a toilet, a family area, and a space for caregiver supplies, and was presented as the “current standard practice” (Figure 28b). Slightly larger than the traditional room (340 square feet), the standard room design was based on a same-handed standardization as opposed to a mirrored configuration. The largest of the three was the “innovative patient room concept” (370 sqf) which integrated a substantial patient activity area, in addition to areas for caregivers and families. This concept was further explained through a more detailed layout drawing with a so-called “technical cocoon” which integrated a medicine and supply closet. The innovative concept was also designed to accommodate a same-handed configuration which was argued to contribute to safer care processes.

[17] Known to participants, Maze’s (2009) article provides an account on “the great toilet room debate” for inpatient rooms. As Maze summarizes, the three most common patient rooms includes inboard toilet rooms, outboard toilet rooms, and nested toilet rooms. In inboard model, the toilet room is placed next to the corridor, as in a typical hotel room, whereas in outboard configurations, the toilet is located along the exterior wall. The nested model, on the other hand, suggests two toilet rooms located between every two rooms resulting in one inboard and one outboard configuration for patient rooms (Maze, 2009).

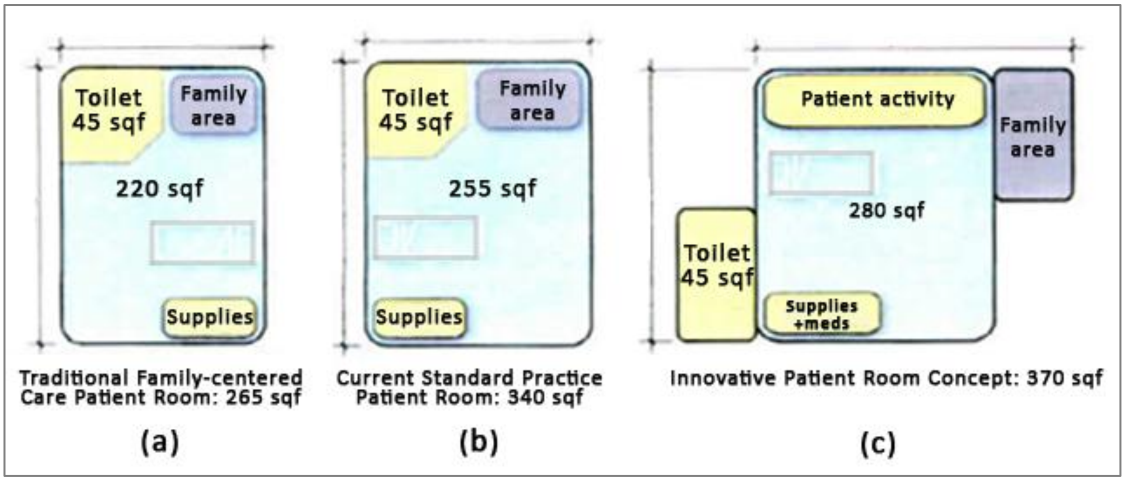

Figure 28. Patient room types introduced in the visioning phase" (a) the traditional room, (b) the standard room, (c) the innovative room

The extra attention paid to the innovative room schema during the presentation apparently reinforced the expectations of the ***PHSP*** representatives, who were already moving away from the traditional models of care and their associated physical environments. The presentation of novel design ideas for patient care, such as creating zones for patients to get out of bed as much as possible, or locating a supply closet in rooms to reduce walking distances for care givers, initiated a fruitful conversation which, according to participants interviewed, was sustained and enhanced throughout the visioning, schematic, and design development phases. Later in the design process, for example, the idea of "moving patients out of beds" was developed and situated through contributions of visiting staff members who brought in anecdotes from practice:

00:14:58	***P1***	*We're also setting up what we call front porches. Little seating areas sprinkled all over these surfaces here. They're not necessarily organized as the way they will be. Just trying to give some ideas what they could look like.*
00:15:22	***U8***	*We would like to have areas where if one patient… One younger patient told me that they wanna talk to other patients… That's one thing they want to do with their disease process. So we can have areas on the floor where patients can meet.*
00:15:42	***P1***	*Yes, could be anywhere. These are not designated spaces. I mean*

whoever wants to go out there….

In this exchange from a meeting during the design development phase, ***P1*** starts the conversation by introducing the space, rather than the bigger idea of providing opportunities to get patients out of their beds. Then ***U8***, from a functional point of view, adds a quick anecdote involving particular spots on floors (i.e., porches) that ***P1*** points out. Eventually, the two participants in this conversation realize the natural fit between what they both propose; the seating areas outside rooms offered by ***P1*** and the particular need of patients characterized by ***U8***. This is how the participants collectively initiated local stories developing around design features as staff members provided anecdotes to situate design intentions which were represented verbally or through drawings.

In the visioning documentation, the strategy of contrasting standard practice versus innovative approaches was also used for the unit-level configuration of the inpatient department. The idea of the decentralization of caregivers, supplies, and equipment, which was recommended by the project architects, was contrasted with traditional unit configurations where inpatient support spaces were centralized. In line with the concept of decentralization, "the six second rule" was also introduced during discussions of the inpatient rooms of the future ***PHSP*** hospital.

Introducing new care processes

The visioning document briefly mentioned concepts such as "the six second rule" or the "80-20 rule" that did not originate in the field of healthcare, but were translated into the discussion of care processes to facilitate safety, efficiency, and effectiveness. The 80-20 rule is an engineering concept aimed at identifying and eliminating, if possible, all causes of variation or problems in a process. The idea was transferred and further developed in various forms in nursing research. Another concept, the six second rule, mainly involved getting necessary supplies into the hands of a physician in six seconds. It was also included in the visioning document (see below excerpt) after participants became familiar with the concept through meetings, site visits, and occasionally through reading relevant articles:

> *Hunting and gathering minimized with 80% of supplies and equipment within 6 seconds (20 ft) of bedside.*
> *Decentralization of nursing units, supplies, and medication improves (increases) nursing time at the patient bedside and supports efficient, effective, equitable, safe, timely, and patient-centered care.*

Through conversations with internal and external consultants, or site visits to facilities that incorporated similar concepts, the steering committee members were exposed, to some extent, to the design- and cost-related implications of these novel ideas. Some of these concepts, which were expected to initiate a significant "shift in ***PHSP*** hospital care culture," were deeply embraced by the ***PHSP*** representatives, who then began introducing and disseminating these process- and space-related concepts to staff members at all levels. The ideas, however, were primarily communicated through anecdotes, without reference to any particular research evidence generated inside or outside the healthcare field.

Though many of the concepts were not initially listed in the master hospital budget, the developing stories[18] that introduced them were persuasive enough for ***PHSP*** managers to pursue and incorporate these features into the patient rooms of the future facility. In particular, same-handed layout standardization, distributed nursing stations, in-room supply closets, and distinct zones for caregivers, families, and patients –each furnished with necessary physical environment features– emerged as the outstanding key design features that the team decided to implement in the replacement hospital.

Firm B was hired initially to design the replacement hospital and was the regional branch of a major international architecture firm headquartered in the United States. The architects from ***Firm B*** had previously engaged in several hospital projects touted as

[18] How "stories" are conceptualized in this study was introduced and exemplified earlier in Chapter 4.

“evidence-based design” and had demonstrated their expertise and experience early in the process. Their actions generated a substantial level of awareness among participants with regard to recent developments in the world of healthcare design. The client representatives, ***O3*** and ***O4*** in particular, had frequently referred back to earlier efforts in the project as a learning process:

00:02:20 **O3** *…But I think ultimately you have to look at the evidence out there. Is it evidence based? I think we have educated ourselves tremendously. I learned more about the total package than I ever would have if I had not been on this journey. Uhmm, I did not know a lot about areas such as operating room. But over the last couple of years I have educated myself, I have talked with experts, I have read a tremendous amount. And then, I've gone site visits as well. And I worked with vendors. So I have, uhmm, really become an expert in short amount of time…*

Due to undisclosed reasons, however, the ***PHSP*** administration had parted ways with ***Firm B***, and hired a local firm, ***Firm A***, to lead design efforts for the rest of the project. As replacement architects took over the design tasks, they maintained the attention given earlier to certain key areas, including patient rooms, other departments, and their interrelationships. Although ***Firm A*** had never engaged in an evidence-based design process[19], the architects that the firm supplied possessed substantial expertise in the field, and this allowed them to engage immediately in ongoing discussions with steering committee members, including client representatives, consultants, and staff members.

A collection of ideas about the design options for key areas (e.g. emergency room, inpatient unit, patient room), a set of principles to guide design efforts (e.g. safety for all), and a building program were provided to the new architects. They were then expected to

[19] Evidence-based design hospitals are those that became members of the network, known as the Pebble initiative, which was initiated to create a “ripple effect” in the healthcare industry by providing documented examples of hospitals that have used an evidence-based design process to document outcomes and share their up-to-date knowledge.

finalize the design work, to stay within the budget, and finish on time, while also satisfying the initial aspirations of the client, such as creating the safest hospital in the world. In the very first steering committee meeting, however, it was ***O4***'s request from architects not to take anything as given, that there might still be room for negotiation around the concepts included in the visioning document. A specific example that ***O4*** mentioned, as recorded in the meeting minutes, was the utilization of same-handed rooms versus mirrored rooms which was still pending for a final decision.

To sum up, the steering committee for the new ***PHSP*** hospital experienced a very rich visioning phase where a range of consultants introduced them to fashionable concepts in the healthcare design industry. Shortly after beginning the schematic design phase, however, the ***PHSP*** executives decided to switch to another architecture company, ***Firm A***, to lead the design efforts. The task for the new architects was to engage with informed client representatives in order to execute a design job under strict budget and time constraints. Following the pre-established principles to guide design work, the architects were expected to incorporate evidence-based design features, each of which had considerable cost- and space-related implications.

In early 2011, the architects from ***Firm A*** began participating in weekly steering committee meetings where the client representatives recapitulated information about processes and physical environments of the hospital that they wanted to create. The leaders of the architecture team, who possessed a wealth of expertise in healthcare design, revised the building program quickly, and produced layout diagrams visually depicting the departments in the hospital and their interrelationships. As the steering meetings progressed, the diagrams and the building program co-evolved following feedback provided by client representatives and other consultants.

6.1.2 Schematics

During the schematic design phase, the designs of patient rooms were continuously reshaped by ***Firm A*** architects at all levels. Blocking diagrams created earlier in the process by senior members of the design team aimed at solidifying the overall floor plate for the inpatient unit, whereas on a different scale, an extended group of designers struggled to provide the required number of rooms in these rectangular department blocks (Figure 29). In terms of floor areas, the individual rooms introduced in these drawings were aligned with the "innovative room concept" that was discussed earlier in the visioning phase (Figure 28c). Accordingly, the architects were able to decide on a floor plate for inpatient units before the team reached the mid-point of the schematic design phase.

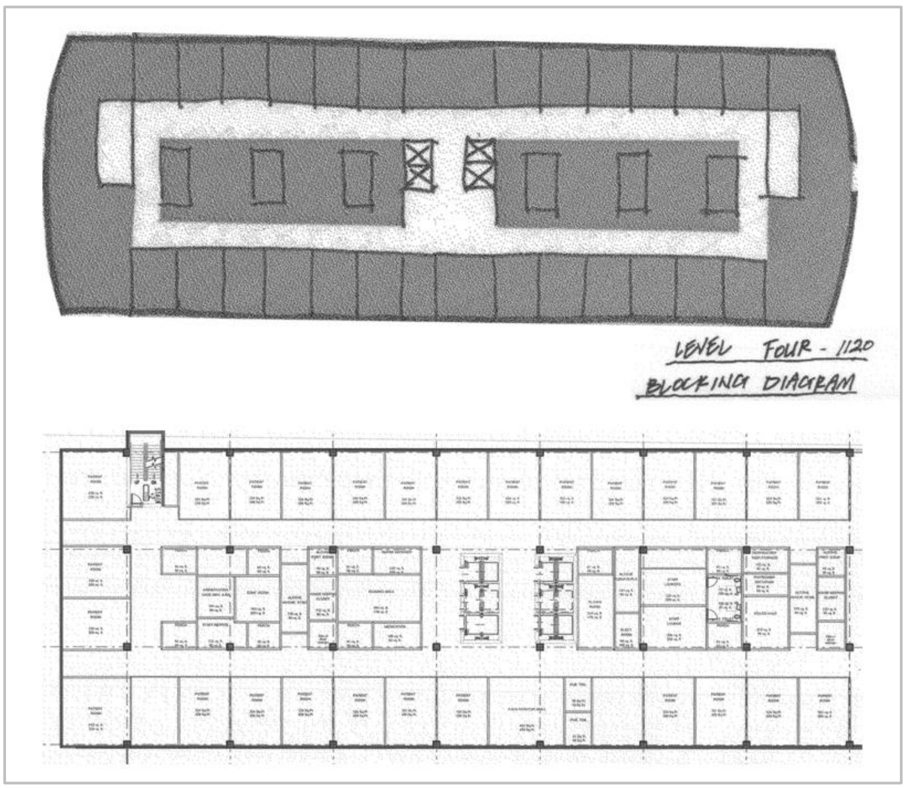

Figure 29. An initial diagram and a scaled drawing for the inpatient floor plate

It is enlightening to review these diagrams together with the building program which was re-evaluated and completed by the architects during the schematic design phase. In the modified ***PHSP*** hospital program, after being reviewed by the planning and programming consultant, ***P1***, patient rooms were listed as follows:

	Room or space	no of spaces	NSF	Total	Comments
13	Patient Room, Private Acute Care	16	320	5,120	includes toilet/shower, external charting alcove, in-room supplies and meds, family-patient interaction space, family sleep provision. Size may be reduced during mock-up.
14	Patient Room, Private ICU	8	320	2,560	
15	Patient Room, Bariatric Isolation	2	320	640	
16	Patient Room, Isolation	2	320	640	

Figure 30. Building program section for patient rooms

The drawings and the building program segment presented in Figure 30 permit a quick analysis of what was initially recommended and envisioned earlier versus what was planned and developed during the schematic design phase. The program and initial drawings reveal that patient rooms in the future hospital (320 sqf) would be close in size to what was presented as the standard-practice patient room (340 sqf) in the visioning document. However on the other hand, based on the comments provided in the building program (Figure 30), designers introduced participants to the attributes of innovative rooms in industry by specifying particular features (i.e., supplies and medications or family-patient interaction space). Therefore, the challenge for the designers was to incorporate several design features without exceeding the numbers in the building program.[20] The architects also noted that, based on subsequent experiments with mock-ups, there was the possibility to reduce the overall size for a single-patient room (Figure 30). As this fact suggests, from the beginning the mock-up exercise was already on the

[20] The challenge is to provide a solution without "super-sizing" the facility. The term is transferred to the context of healthcare by Latimer and colleagues who studied the excessive growth in healthcare facilities in the last three decades (Latimer et al., 2008).

agenda of the steering committee, and it was expected to contribute to design decision making, rather than just being a showroom or a fund-raiser for the replacement facility.

Key decisions

However, some critical design decisions were not made during the early programming and design phases. Drawings produced during the schematic design phase, for example, lacked information about the same-handed room layout standardization, toilet location (inboard, outboard or nested), and amenities for family members (Figure 29). Such decisions, and many more, were discussed later during site visits as the team collectively developed an understanding of design, process, and cost implications of desired features.

In the second half of the schematic design phase, the emphasis was on the details of the inpatient unit. In addition to specifying the floor plates of departments in the overall footprint of the hospital, and solving accessibility problems across and in those units, a long series of sketches were produced to explore various configurations for individual patient rooms (Figure 31). The sketches demonstrated the effort to integrate particular elements, such as hand-washing sinks, nurse servers, and charting alcoves, each of which offered a distinct care process to be adopted in the replacement hospital.

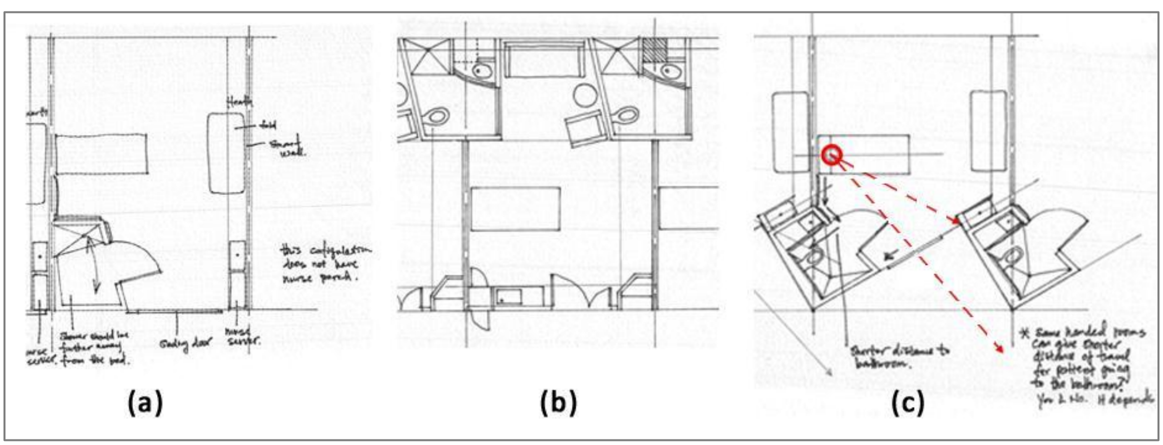

Figure 31. Three sketch studies on patient room layout: (a) inboard toilet configuration, (b) outboard configuration, (c) Visibility studies on an inboard configuration (red dashed lines highlight added by the author to highlight architects concern on visibility).

All following a fixed boundary which was determined by the structural grid governing the entire facility, patient room alternatives varied significantly with regard to the locations of several design features including toilets, hand washing sinks, and the nurse stations holding supplies and equipment. Toilet locations and configurations, for example, were different in the three sketches in Figure 31, all of which were drawn within a period of two weeks. In Figure 31a, the toilet was located on the corridor side, and was connected to the patient bed by a continuous handrail. In Figure 31b, however, the sink and the supply storage were moved to the bed-side while an outboard toilet space was provided next to the family area by the window. The advantage there was to have supply cabinets close to patient beds, and to have sinks on the path from room entrance to patient bed. Later in meetings with user staff, the participants collectively situated these features as the architects communicated the intention to the future users of those spaces.[21]

A different concern was manifested in the third drawing (Figure 31c) Here, the design team conducted a study to determine whether or not patients' heads would be visible from a nearby corridor or from charting alcoves.[22] These sketches (to be analyzed later in this chapter), attempted to resolving visibility issues if rooms were to have an inboard toilet configuration.

In all the sketches, the design team studied a set of concepts (i.e. zoning in patient rooms), configurations (i.e. inboard and outboard toilets) and features (i.e. nurse servers, sinks) which were informed by trends in healthcare industry. The architects considered

[21] In the case of hand-washing sinks, for example, ***P1*** was the one to explain how they strategically incorporated a sink which gave the opportunity to wash hands without turning the caregiver's back to patients or visitors. I have observed participants who, then, offered quick anecdotes to support the decision behind specific location and configuration of hand-washing sink (***O3***: *It is very rude to turn your back to patients*).

[22] The study involved an on-the-spot examination by sketching line of sights on paper, rather than software-based visibility computations which were conducted on computer-aided drawings.

various configurations until they received a clear direction in a steering committee meeting in May 2011:

> (Meeting minutes, May 24, 2011)
> *Per **O4** the patient toilet/showers will be outboard.*
> *Per **O3** the patient rooms will be same handed unless budget forces a mirrored configuration. At the line item cost current.*

As explained by participants in interviews, the steering committee decided to implement outboard toilets, since it would give them the opportunity to increase their options for configuring the corridor wall which was already crowded with decentralized nursing stations and nurse servers. The consensus was that outboard toilets on headwalls provided an easier path from patient bed to in-room toilet.

Decisions concerning other design elements in patient rooms such as nurse servers remained pending, because the committee required time to gather further evidence. In the same steering committee meeting mentioned above (May 24, 2011), ***O2***, who was the lead manager of the Pebble Project[23] efforts at the time, informed the group that an in-house experiment, "meds at bedside," would be initiated in two months in existing ***PHSP*** facilities to determine the efficiency and effectiveness of bringing necessary medicine closer to patients. The idea for this experiment had been developing since the time of the visioning meetings, as the ***PHSP*** representatives engaged with several consultants from various local and nation-wide organizations to plan and initiate original research to be conducted in existing and future ***PHSP*** facilities. The purpose was to examine *in situ* evidence from the ***PHSP*** hospital's own staff, resources, and practices, as opposed to available research evidence from other settings which might not necessarily be applicable to the ***PHSP*** care culture. The intention was to make the decision on

[23] Pebble project efforts involved both managing original research efforts in existing hospital facility, and interacting with Pebble database where healthcare environments research was pooled.

whether or not to utilize nurse servers in patient rooms based on results of this particular research.[24]

At the end of schematic design phase in August 2011 (Figure 27), the architects presented a patient room design that incorporated only a few of the recommendations made during visioning meetings. However, they were receptive to further modifications, and an extended group of users were expected to provide feedback, or evidence, during design development meetings and physical mock-up exercises (Figure 32). Physical environment features such as distributed nursing stations, sink locations and toilet spaces and their locations that were negotiated among the interdisciplinary team were already integrated into CAD drawings. However, there was still the possibility of cost- and design-related discussions and negotiations. For example, the decision to include nurse servers in rooms was not finalized, although these closets were already indicated in the architectural drawings. The master budget kept by ***O1*** did not include nurse servers as separate line items until later design development meetings. The strategy that designers followed with nurse servers was to introduce a level of flexibility by reserving a space in room drawings that could either be utilized as nurse servers or a simple millwork closet that could be used for other purposes. The expectation was that design decisions for such issues would be informed through mock-ups, and team members would have the opportunity to study their features in a physical setting with actual users.

[24] The nurse servers were already integrated into layout drawings before the research was officially initiated.

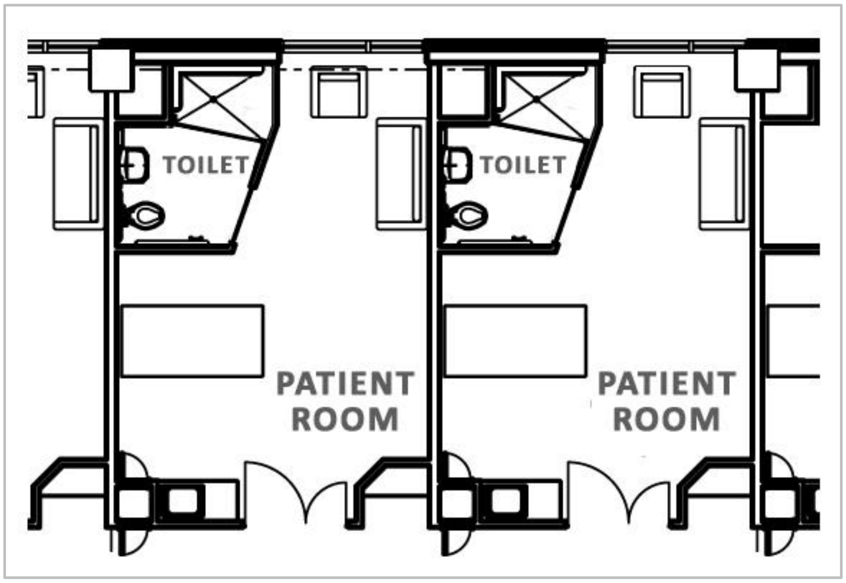

Figure 32. The ***PHSP*** hospital patient room at the end of schematic design phase

6.1.3 Finalizing the Design

From August 2011 to June 2012 –that is during the phases of design development and construction documentation– the architects had introduced significant changes to what was proposed at the end of schematic design phase (Figure 32) as the extended team interacted with information from various sources. The inception of some of the ideas that shaped the patient rooms, however, can be traced back to studies and discussions which took place earlier in the process. For example, the evidence-based idea of providing easy access to patient toilets, which was argued to be reducing patient falls, was discussed during visioning phases. As the architects developed the details of the design, they revisited the idea of accessibility and provided, after a series of layout studies, a solution for a toilet space that was closer to patient beds, with hand rails added to support patients. Concerning visibility, on the other hand, the sketches produced during the schematic design phase, which involved adding an angled entrance to rooms (Figure 31c), was again revisited and integrated into the drawings.

Many fine-grained details, on the other hand, were discussed for the first time and developed as project architects engaged in conversations with users, consultants, and other designers in ***Firm A***. For example, ***D17***, a mid-level architect in ***Firm A*** who was not officially assigned to the ***PHSP*** project, had developed a sliding toilet door in another hospital, and was consulted on the design of a similar door for this project. During exchanges with users, several nurses had expressed their concerns about the way that the sliding doors installed in mock-ups could trap users' fingers. ***D17*** provided support to develop a solution for the sliding doors which was eventually implemented in the mock-up.

The architects developed details and finishes for patient rooms as they approached the deadline for construction documentation. Details of headwalls, footwalls, locations for certain devices, and flooring were translated into drawings based on new evidence. Each and every comment raised during meetings were addressed by the architects, and, if agreed, integrated into the room design in a piecemeal fashion (Figure 33).

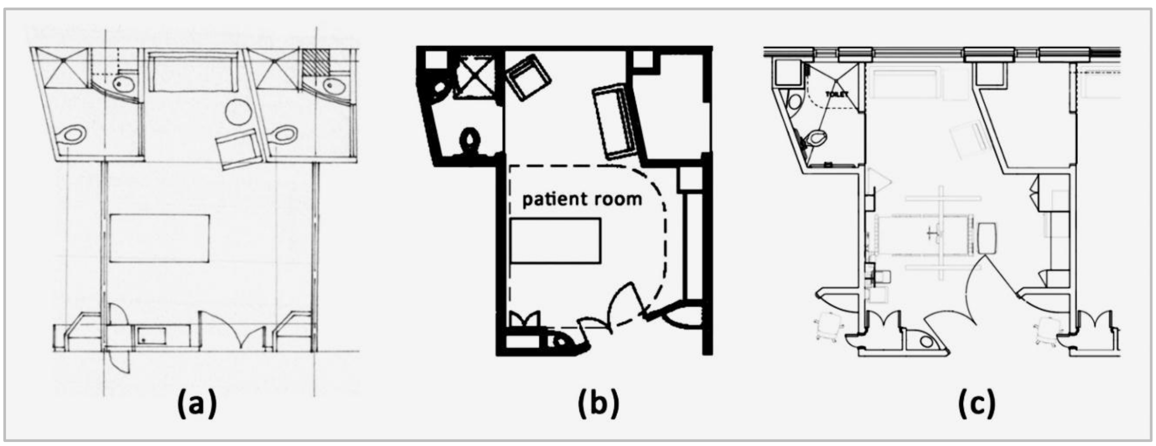

Figure 33. The single-bed patient room through design development and construction documentation phases

In order to finalize details, the user group meetings were extremely helpful in providing information about the day-to-day activities of hospital staff, and they gave them opportunities to evaluate these pieces of information for use in shaping physical environments. Two, two-day user group meetings were scheduled during Fall 2011 for soliciting feedback from users for what was developed, and for gaining further insights into care processes in every department. As in the case for the ED design, the users, in addition to several steering committee members, provided insight into the everyday practices as well as the urgency and drama taking place in these spaces. The focused exchanges with users and many other individually scheduled and conducted meetings provided architects with anecdotal evidence which they translated into drawings.

The user group visits to mock-up rooms were also informative for the design team. In contrast to users' oral descriptions of their typical care activities, in mock-up rooms segments of actual care processes were enacted in order to communicate what was appropriate to support provisional care practices involving protocols, devices, and space. The mock-up rooms were based on a layout produced earlier in the schematic design phase, and altered throughout the process as visitors, including staff members, the ***PHSP*** executives, and community members, provided input for architects and the steering committee members to process.

In addition to the patient rooms, the entire inpatient unit floor with its support core elements and internal circulation paths was also finalized in the design development and construction documentation phases (Figure 34). The distributed nursing model was integrated into the unit layout by adding the physical environment features used in place of the traditional central nurses' stations: charting alcoves, perching stations, and teaming areas. By using stories, drawings, and mock-ups, the idea of decentralization was communicated to future users of those spaces. Although some of the nurses serving in the old facility were not quite familiar with the intended care processes, no significant resistance was observed on users' side to challenge the idea of omitting traditional nurses' stations.

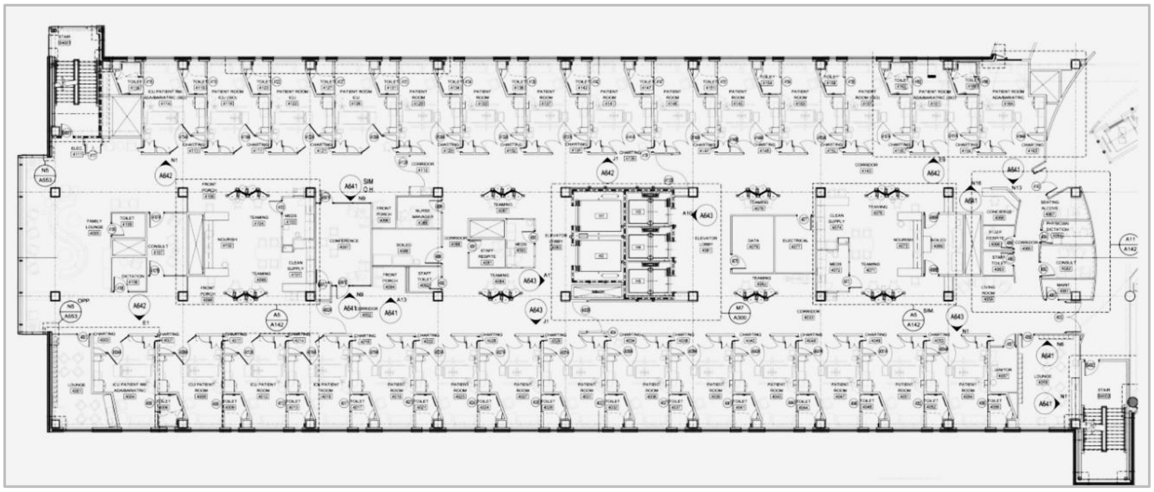

Figure 34. Inpatient floor layout at the end of construction documentation

Further elaborated later in this chapter, the issues related to engineering solutions were also introduced and their cost and architectural design implications were discussed. The lead mechanical engineer in the process, ***M7***, was a regular member of the steering committee meetings, and was occasionally consulted concerning particular ventilation, filtration and air-conditioning solutions for patient rooms. ***M7***, who was a member of the committee to develop and revise the guidelines for design and construction of healthcare facilities in the U.S., demonstrated his extended knowledge by introducing important precedents in industry and recent research results published in academic and popular journals. One of the few participants who frequently used the word *evidence*, ***M7*** always made his line of reasoning transparent and accessible to other members of the steering committee. For particular recommendations for unconventional implementations (e.g. the ground-source heat pump system), ***M7*** provided extensive stories which collated evidence from various sources including scientific research. Section 6.2.2 in this chapter introduces a case involving one of ***M7***'s earlier recommendations for a ventilation system that could be adopted for the patient rooms of the replacement hospital.

6.1.4 Mock-ups

The intention to build mock-up rooms was present since the very first visioning meetings. The budget, scope and number of these rooms, however, were settled during the schematic design phase after ***Firm A*** was commissioned as to be the architectural consultants. In steering committee meetings late in the schematic design phase, the team discussed how to handle the mock-up exercises, as project architects developed the first sketches for mock-up spaces. The construction, however, was delayed until October 2011 when a drawing describing how to build five rooms in a studio was sent to the construction consultants who were assigned to erect the walls of patient rooms. The diagram below (Figure 35) was the initial configuration for patient rooms to be adopted in mock-up exercises.

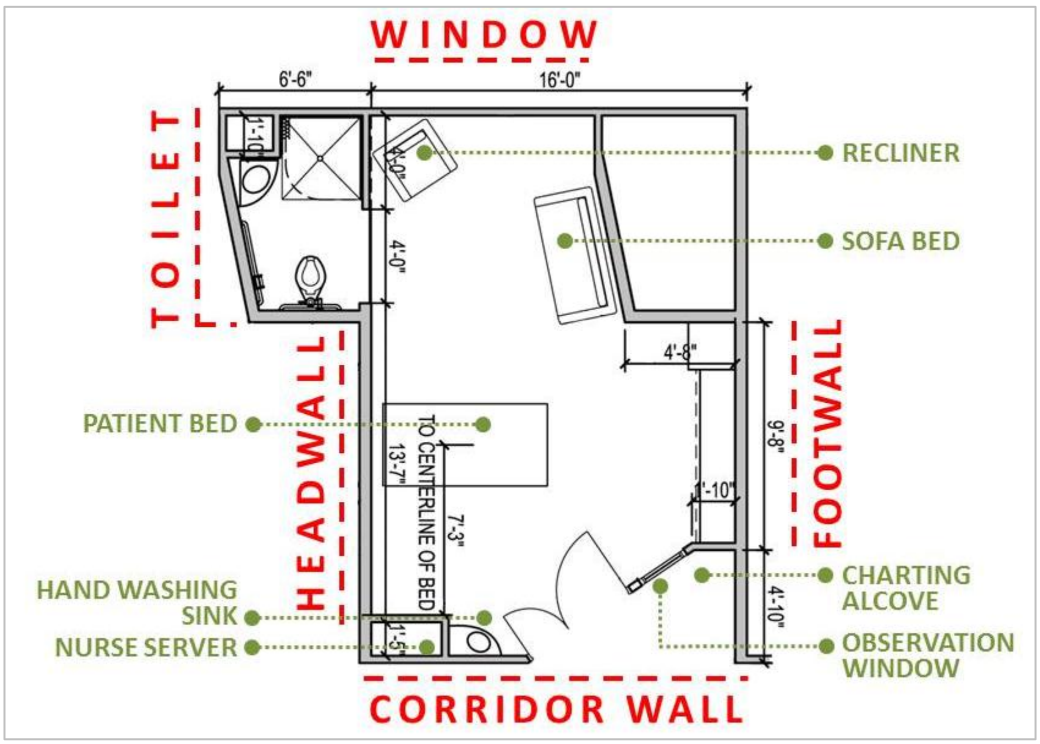

Figure 35. The layout for patient room mock-up[25]

[25] Labels in color were added by the author to guide readers about locations of in-room features discussed in the text.

The steering committee, led by ***O4***, decided to build five of the most repetitive rooms from three departments. In addition to two fast-track rooms and an examination room from emergency services, the plan was to have an inpatient room and an intensive care unit room sized for a bariatric patient. Worked out by the programming and planning consultant for the ***PHSP*** project, ***P1***, a distinct strategy was considered throughout the mock-up exercise. ***P1*** created a four-phase construction plan introducing step-by-step changes to mock-up spaces as the design work progressed. To some extent, this plan was followed for patient room mock-ups, whereas it was almost abandoned for examination rooms which were left without adding further details and finishing work.

According to the initial plan, the first phase involved evaluating the patient room perimeter by utilizing movable walls. Since the width of the room, from headwall to footwall, was fixed based on the facility structural grid, only the toilet room space and corridor walls were left as the elements to experiment with (Figure 35). The first phase did not include any small-scale details or finishing materials. The second and third phases, after fixing the locations of patient room walls, involved introducing details such as doors, headwall and footwall design, hand rails, millwork, and nurse servers, in order to make decisions based on feedback received. According to the plan, locations for in-room furniture, including a reclining chair and a sofa, was to be determined before proceeding to the final phase of mock-up exercise.

The final phase, on the other hand, involved specifying finishes on all surfaces as well as lighting fixtures, cabinetry, wall and door colors and floor tiles. It was discussed during earlier steering committee meetings that the final phase mock-up would be utilized for publicity as well as for nurse education. It was planned that the mock up rooms, during the transition period, would serve as a venue to refine patient room care processes. In June, 2012, at the end of the data collection phase for this research, the mock-up rooms were observed to be missing many of the details which were initially intended to be included. The nursing staff, however, had already started reviewing protocols, simulating clinical scenarios, and testing in-room workflows in mock-up spaces.

The design team members who created this four-phased mock-up plan had envisioned a build-review-rebuild model that would allow them to proceed with design decisions from larger scale (e.g. room perimeter, wall angles) to smaller scale (e.g. location of TV, or in-room computer). ***P1***, the planner and programmer, ***D1***, the lead designer, and ***O3***, the chief nursing officer for the ***PHSP*** hospital, were the ones to accompany visitors as they walked through to the mock-up spaces in each phase.

Obtaining feedback

P1 was the leader in introducing design features that were quite different from the ones in the old facility. By using simple language, ***P1*** communicated design ideas clearly, patiently, and confidently to visiting staff members. On most occasions, she physically acted out care activities that would take place around the room features and sub-areas while she was providing descriptions to account for and support reasoning processes behind design decisions. While introducing sink placement in a typical walkthrough, for example, ***P1*** always explained the strategic placement of the sink between the door and the bed which was thought to affect workers' hand washing compliance, and she mentioned how the angle of sink allowed healthcare workers to wash their hands and keep an eye on patients at the same time (Figure 35). These developing stories around particular design elements were occasionally reinforced by phrases such as "as research suggests," and were observed to be acknowledged quickly by users without any resistance. In the case of the sink placement, for instance, no challenge or opposition was raised by users who were observed to easily "buy in" to the idea by offering supportive anecdotes.[26] The sink location in mock-up rooms was resolved easily and quickly, and eventually translated into construction documentation without any changes.

Following these introductions to the features of the room, the team members invited visitors to comment on or criticize what was being proposed. The visitors, most of whom had seen the design earlier on paper during user-group meetings, were generally active in engaging in the conversations by asking questions, providing feedback, or endorsing what was proposed by the design team.

Figure 36. Evaluating physical environment features within patient room mock-up.

Capturing evidence

The architects, mostly ***D1*** and ***P1***, used four methods to capture user feedback from exchanges with individuals or groups visiting mock-up rooms. First, user input was captured in the form of meeting notes kept by ***D1,*** who recorded comments in her notebook. ***D1*** made these notes available to a sub-group that had engaged in planning and mock-up processes. The other method involved writing sticky notes on the spot. ***P1***, in most cases, was the one to stick notes on floors and walls to indicate locations of

[26] Remember for example ***O3***'s statement, mentioned earlier, to confirm the particular configuration of the sinks, which facilitated continuous interaction with patients and families (***O3***: *It is very rude to turn your back to patients).*

equipment or devices as requested by visiting staff members. Some of these notes were initially translated into mock-ups (e.g. features in headwalls, or outputs on walls), and then made their way to drawings. These sticky notes, which can be considered as memory aids for the design team, were kept on mock-ups until the group reached a final decision on these particular items.

The third method involved real-time manipulation of the elements in the mock-up spaces. The movable walls that were utilized during the first phase of the mock-up exercise, for example, allowed designers to arrive at a configuration that provided "perfect" visibility for nurses. When a desired solution was achieved through negotiations in the mock-up spaces, the architects then translated the approved configuration into layout drawings.

The fourth method to capture user was to conduct surveys with visiting staff members. Based on ***O3*** and ***O4***'s earlier request more structure in capturing user comments, ***P1*** devised a one-page survey consisting of nine questions (Figure 37). ***P1*** relied on her extended expertise in the field, and put together a set of focused questions to capture users' reactions to proposed spaes. The survey participants were asked whether they agreed or disagreed with a statement using a five-point scale. After each item on survey paper, ***P1*** deliberately left two blank rows for participants to fill in their comments with regard to design elements mentioned in questions.

PHSP HOSPITAL PATIENT ROOM SURVEY

PATIENT ZONE				
A. I would be very comfortable as a patient in this room.				
Strongly agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
B. I would feel close to my nurse if I were a patient in this room.				
Strongly agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
C. This patient room would be safe for me as a patient.				
Strongly agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*

BATHROOM				
A. I would be very comfortable as a patient using this bathroom.				
Strongly agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
B. I would feel very safe using this bathroom.				
Strongly agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
C. Everything I would need as a patient is in this room.				
Strongly agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*

FAMILY ZONE				
A. I would be very comfortable as a visitor in this room.				
Strongly agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*
B. This room would make it easy for me to stay overnight with the patient.				
Strongly agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*

OVERALL				
A. I would not change anything in this room.				
Strongly agree	*Agree*	*Neither agree nor disagree*	*Disagree*	*Strongly disagree*

Figure 37. The survey.

The design team strongly encouraged visitors to fill in these surveys immediately after their walk-throughs. During weekly steering committee meetings, ***O4***, the president of the ***PHSP*** hospital, showed interest in these surveys and repeatedly asked for a quick update on users' assessments. ***P1***, together with ***O9***, the transformation consultant for the ***PHSP*** hospital, reviewed the responses to the survey, and, when asked, informed other members about emerging issues. There were no quantitative analyses conducted to assess responses to surveys. The strategy adopted by ***P1*** and ***O9*** was to review each survey and follow up later on whether or not they were resolved in next iteration of layouts. In most cases, survey review and filtering process was purely based on ***P1***'s expertise:

00:05:39 ***I*** *Well, I remember you were mentioning comments on paper.*

00:05:43 ***P1*** *Mm-hmm.*

00:05:45 ***I*** *And you were using words like statistically significant. What does it require to take those comments seriously, is it just numbers, or…*

00:05:54 ***P1*** *Oh, well. Sometimes it's the nature of the comment. If you get, you might get only… I thought it was significant when one user said, you know, I almost hurt my hand in the sliding door on the patient room toilet. Uhmm, there was only one person mentioned it, but I thought that was significant enough, just by virtue, a potential risk. Uhmm, others, you know if you get more than twenty-five of the respondents, you need to* *take a look at what that comment is.*

In the case of sliding bathroom doors for example, ***P1*** thought that a single comment by a staff member "was significant enough" to be revisited by the whole larger group. The issue was further elaborated and resolved in subsequent meetings. The improved design for the sliding door was then reviewed, approved, and translated into construction documentation.

Developed incrementally throughout design development and construction documentation phases, the mock-ups were utilized as laboratories to test the layout and functionality of rooms of the future facility. The build-review-rebuild strategy was maintained until budget constraints held the team back. In a steering committee meeting in late April 2012, two months before the construction documentation deadline, it was officially decided to stop mock-up building activities and continue to use these spaces for training purposes.

Although there were individuals who were dissatisfied with the scope of the mock-up exercises, most participants mentioned the process as the most exciting segment of the entire project. The owner representatives, including ***O2***, ***O3*** and ***O4***, repeatedly appreciated the "community efforts" to shape these rooms, referring primarily to the use of mock-up spaces.

00:15:22 ***O2*** *… That room coming to life, and the fact that we have had monumental changes from that mock room, from things like angle of a wall to the headwalls to the footwall. And those things I don't think would come out have we not done the mock up room process. Because you can't make decisions like that without living in the space. So it's been very worthwhile exercise, and it's been great for our staff engagement. Because we have gotten almost all of our staff into that room, and everyone who has seen it got excited about it.*

6.2 Implementing Ideas

As a supplement to the brief narrative of the trajectory of patient room design, the remainder of this chapter presents three cases that enhance the account, based on data that emerged from observations and interviews. The three cases display a variety of actors, representations, and tools involved, each contributing to the richness of the interactions occurring during the design process of the new ***PHSP*** hospital. The first case, same-handed rooms, presents an account involving an idea that was not substantially supported by healthcare research evidence. The case illuminates how implementation costs came into play as the team progressed towards a decision on a type of standardization to be adopted for patient rooms. The second case introduces a particular episode involving one of the engineering consultants who introduced an innovative ventilation system. The case focuses on research-based recommendations of the mechanical-electrical-plumbing (MEP) consultant of the project, ***M7***, who had an innovation-driven agenda. The case also provides an introductory discussion of the scope of mock-up experiments, an issue that also emerged in the third case. Case three examines one of the in-house experiments conducted with mock-up patient rooms. The episode presents particular contributions of mock-up rooms in facilitating interdisciplinary collaboration and in enabling evidence from different sources to be visible to all participating parties.

6.2.1 Same-Handed Rooms

If you can't put the knowledge on the device, then develop a cultural constraint: standardize what has to be kept in the head. (D. A. Norman, 2002: p. 170)

During the visioning phase, the ***PHSP*** representatives were introduced to several design concepts that were increasingly being utilized in the healthcare industry. Most of these concepts were far newer than those employed in the construction of the old ***PHSP*** hospital. Since there was "no way to upgrade the fifty-year old facility," according to ***O3***, the senior executives decided to invest money in a brand new facility that could offer the type of services that the fast-growing community needed. In order to achieve "a patient experience with high quality and ultimate safety," the hospital representatives initiated conversations with internal and external consultants where they were exposed to a series of design interventions on various scales, which were developed inside and outside of healthcare design community. In visioning meetings, the architecture team introduced and further explained these new ideas through presentations and site visits during which the team had the chance to observe these features in working facilities. Some of these features were later included in the visioning document that was expected to guide subsequent design work.

Universal same-handed rooms, where patients are always in the same orientation relative to the door, was one of those ideas that the client organization intended to utilize for the new facility. Although the scientific research evidence behind the idea is not substantial, there are a growing number of new facilities, some of which are described as evidence-based design hospitals, that have already utilized same-handed standardization for their patient rooms. Because a common wall cannot be used for utilities for the headwalls of two rooms, it increases costs, but same-handed design is argued to reduce errors during emergencies because each room is identical.

Although the contribution of the same-handed type of standardization in healthcare is questionable, the evidence emerging from aviation industry, combined with stories from field, is enough to keep the topic alive in healthcare design circles, and in the group that was observed for this research. The participants had clearly displayed their awareness of limitations in the research evidence as they evoked similar stories involving studies in other industries. References to research on standardization in aviation industry, however, remained anecdotal since the participants did not name any particular research study to support same-handedness.

In addition to loose references to studies in aviation industry, which was treated as nearly canonical in explaining the reason behind same-handed rooms, the participants also incorporated a piece of locally created anecdotal evidence into this explanation by referring back to ***O3***'s stories from field. ***O3***, the chief nursing officer with more than twenty-five years of practical experience, was one of the steering committee members who favored same-handed rooms, and her first-hand stories were utilized by others in explaining the reasoning behind the design:

00:35:22 ***D1*** *…There's some interesting evidence that points towards things like same-handed rooms, might have some benefits.*
… Jury's still out, but there is some pervasive, you know, thoughts there that, you know, you go a little bit on faith but it's leaning towards looking like this might be beneficial or whatever, so there's some things in those categories that we'll scrutinize and review with the owner to see which ones look like they marry well with their own kind of culture and direction they are going.

00:41:50 ***I*** *Umm-hmm.*

00:41:51 ***D1*** *Just because it... well, why not? There're some positive reasons why you might wanna do that. But one of the things she* O3 *came up, uhmm, to the table with was her… Basically her assertion that... She said you know when I was a young nurse, and I was learning, and gaining my experience, and becoming an ICU nurse, she said it occurred to me that the visual... She said I was understanding that I was really using visual cues to do my job. She said cause you're always multitasking, you're having to assess things really quickly, and she said when you really watching over a patient, it's not unlike a monitor that has stats on it where you're just spot checking certain critical criteria, she said, visual cues were huge for her. If a patient had a catheter or didn't, or if a patient had a wound care pack, or if a patient had a... You know certain things. And all the patients were different, she said, I walked in a room, you wanted to quickly do your five-point check on, do I need to change a catheter, do I need to do this, do I need to do that...*

00:42:56 ***I*** *Mm-hmm.*

00:42:56 ***D1*** *And she said if the patient was always in a different position in every room, and sometimes the back was on the side, you could see, sometimes it wasn't. She said, then you make more mistakes or you could potentially make more mistakes, especially as a young nurse. So her*

> *hypothesis was that the more you can make the rooms the same, even if they're mirrored, but you still want them to be set-up the same, whether they're mirrored or same handed. She said those visual cues can be very critical, you know, to really understanding your patients especially since you have patients with lots of different conditions. And I thought, wow, that's really, that was a very, that's the strongest argument I've ever heard for same handed or same-configuration rooms. Because the visual cues, I can see how that would be huge.*

This lengthy quotation contains several key points that need further explanation. First is the immediate and consistent dissemination of the anecdote provided by ***O3*** (…*when I was a young nurse…*). The same anecdote permeated the accounts of other participants who were asked, in interviews, to explain the rationale behind same-handed rooms. This story, which also integrated external elements (e.g. research in aviation industry) was collectively created and utilized to support the decision for same-handed type of standardization.

A second point to emphasize is the awareness about the nature and strength of evidence surrounding same-handed standardization. ***D1***, the lead designer in the ***PHSP*** project, stressed the fact that the research on same-handed rooms was inconclusive (*…the jury's still out*), although the idea was pervasively favored in healthcare industry. All participants in the ***PHSP*** project knew that they were proceeding with a decision not supported by scientific evidence that was produced in healthcare environments research.

Following the second point above, the third item gained from participant interviews and observations was that although there was no research evidence to support this particular design feature, the argument, or "*the hypothesis*" in ***D1***'s words, was persuasive enough for the team to pursue same-handed rooms.

There are, however, other points that need to be recognized in the decision making process. Throughout the project, ***O3*** occupied a dual position; one being a senior client representative, the other as a consultant who constantly infused her clinical expertise during project review meetings. In a follow-up interview, ***D1***, the design lead, acknowledged the fact that ***O3*** was "the big voice in the room," however she emphasized that her suggestions were never meant to be "an edict." During meetings that I observed, ***O3*** frequently put forward her extensive background in ICU nursing in making suggestions or in challenging design decisions, so that it was difficult, if not impossible, for an observer to make an on-the-spot judgment on how she was received by other participants. Within the scope of this thesis, I acknowledge such influences, but do not attempt to provide an account for the complex power relations among participants.

Since it had significant cost implications, the decision to implement same-handed rooms was not taken lightly. For this type of standardization, the plumbing chases are not shared as in mirrored room configuration, results in increased construction costs. Besides the search for evidence that suggested same-handed rooms facilitated safer processes in standardized environments, the steering committee members were also trying to gather evidence to support the business case behind same-handed type standardization. Bounded by budget and schedule constraints, the team investigated the cost of implementing same-handed rooms in each inpatient unit. In that sense, the participants were able to retrieve evidence from different sources to influence the decision making process.

The steering committee members, as they visited several facilities around the country, engaged in conversations with their counterparts who, for the most part, had recently experienced the design or construction of a healthcare project. Referring back to those conversations, the participants always enriched their stories by mentioning cost-related anecdotes drawn primarily from interactions occurring during site visits:

00:11:27	***O4***	*We saw this, it costs five thousand dollars a room to go same handed. There were many gains by going same handed. One is there is a total standardization of rooms now. It's not a mirrored standardization, which, there is no evidence out there, but there is evidence that standardization decreases errors.*
00:11:50	***I***	*Okay.*

00:11:51 ***O4*** *So the most standardized we could be, five thousand dollars a room wasn't that much…*

The other source of evidence was the internal consultants who provided numbers specifying cost of implementation per patient room. The cost that plumbing and construction consultants suggested was three thousand dollars per room, which was lower than what participants heard during site visits. In addition to these conflicting numbers, the lack of credible cost-related investigations published in literature, and in industry, made it harder for the team to ground their decision on a reliable cost-benefit analysis for the implementation in the replacement hospital. Neither a strong business case nor rigorous studies pointing out positive outcomes were available to influence decision making. When asked about the topic during interviews, the "strong argument," or "the hypothesis," was the only grounds that they could explain their reasons:

00:10:36 ***O4*** *There might not be enough evidence there to totally say oh yeah, that's totally been proven. But the hypothesis makes sense. And if the hypothesis makes sense, and it doesn't cost you a significant increase in your budget, that's sort of what we feel why not have it. Because I think so many times in the years past, we really didn't question how and whys or anything other than what is new in the market. Now we're saying, okay, why are we doing this? And sometimes we run into things that they do not have enough evidence to say, yeah that's definitely gonna improve this element. But the hypothesis, probably not hypothesis, and we all believe in it. If it doesn't cost that much, do it. It's like the same handed rooms.*

Although the team spent time and effort to access scientific research evidence on same-handed rooms to support them in decision making, what they eventually gathered was weak with regard to both safety and cost implications. In ***D1***'s words, the team "went a little bit on faith" when faced with cost implications, and decided to have same-handed rooms in the new facility.

Summary

Until after the schematic design phase had begun, there was no final decision on whether or not same-handed patient rooms would be utilized. As steering committee members engaged in conversations with their counterparts in industry, they became aware of increasing interest in the concept, although there was no strong research evidence to support it in healthcare settings. Also, there was no definitive business case to illuminate related cost implications. Alongside the desire to catch up with a healthcare industry in which more and more hospitals utilized same-handed rooms, ***O3***'s anecdotes propagated quickly and were particularly influential in creating particular stories in favor of the concept. Possessing awareness that the evidence-base to support the concept was not strong, the steering committee eventually decided to invest the money and adopt same-handed rooms for patient rooms in the new ***PHSP*** hospital.

6.2.2 Ventilation

The steering committee also pursued innovative concepts in the engineering domain. On the relatively large scale, for example, the mechanical, electrical, and plumbing (MEP) consultant's (***M7***) recommendation for implementing a ground-source heat pump system was well-received by the client representatives, who wanted to build an environmentally sensitive building in order to achieve their safety goals for the community. The system was said to eliminate on-site emissions and acoustic pollution, and would be the first implementation of its type in the state.

One of the regular participants of the weekly steering committee meetings, ***M7*** is the president of the engineering firm which also provided services for the ***PHS*** on various other projects. Having an extensive background in healthcare design projects, ***M7***'s firm has a good reputation in local market. There are several ways that ***M7*** differed from other participants observed. First was the fluency and frequency with which he utilized cases of scientific research and associated terminology. The piles of academic journals and article print-outs in his office clearly suggested his high level of engagement with relevant scientific research. ***M7*** is actively engaged in the Health Guidelines Revision Committee of the Facilities Guidelines Institute which is the major resource for architects and engineers in the healthcare design community. This nationwide committee convened three times during the revision cycle, and, in ***M7***'s words, "writes whatever changes happened" in industry. This particular engagement with the larger professional community was observed to be limited for other participants in this study. Furthermore, because ***M7*** participated in the guidelines revision committee over the years, he had developed an understanding of how knowledge is produced in the field, and how research evidence, strong or weak, is translated into guidelines or regulations:

00:02:43	***M7***	*Yes, uhh, we're in the, we're about the start the second year of the current revision cycle that is for 2014 Guidelines. And this is my second cycle. So we met last year, as a group, in Chicago, I believe. And uhmm, it's a hundred, hundred and thirty people or something like that, maybe more. Uhmm, and talked about process, and what kind of things we're looking at, and then there's been a public proposal process to make proposal for changes. So we're about to meet in two weeks actually for... To start reviewing those proposals, and figure out how they want to respond each proposal. So, a very complex process.*
00:03:42	***I***	*It's another process, project but, you make changes according to what, based on what?*
00:03:48	***M7***	*Aaah [smiles]. Isn't that a question? Uhmm, basically it's consensus of what we think is appropriate. Uhmm, and off a lot of the decisions that we make, as engineers, as architects, as, I think, even physicians, are just, are based on our experiences, and what we have learned formally and informally. Uhmm sometimes with strong evidence, sometimes with just what we think as best, and there's a lot of judgment involved in every step of this profession.*

M7 certainly possessed a sense of the limitations of available scientific research in his particular field where "*there's a lot of judgment involved in every step.*" In interviews, ***M7*** made a clear distinction between the nature of evidence in architectural design and in engineering. According to him, engineers create models and conduct analyses "reliably," and eventually produce "pretty clear evidence," whereas architects "use the fact that they've been doing it for years, as evidence that they should do it now." Besides his crude characterization of evidence and its utilization in architecture, in interviews and in meetings observed, ***M7*** displayed confidence in the work that they were doing and in recommendations based on "reliable models" that they generated for the new ***PHSP*** hospital.

M7 participated in almost every weekly steering committee meeting, where he repeatedly engaged in conversations with the rest of the multi-disciplinary group of healthcare managers, architects, engineers, IT experts, and nurses. A particular recommendation raised by ***M7*** is the focus of this section. Although the idea he proposed had been circulating since the visioning phase, it was at one of the meetings during the design development phase where ***M7*** extensively introduced a non-conventional ventilation model, *displacement ventilation*, to other members of the steering committee.

Displacement ventilation is an in-room air distribution strategy, initially proposed for operating rooms, that is argued to improve safety, comfort, and energy performance by delivering supply air at very low velocity through diffusers at or near floor level and removing it at ceiling level. In order to improve the air quality, the system requires the strategic positioning of supply and return openings in rooms. Besides energy-related issues, the significance of the displacement ventilation system is in its potential to safely remove airborne pathogens that cause infections. This aspect is particularly important in healthcare environments where it is necessary to take precautions to protect immunocompromised patients.

In an early design development meeting, ***M7*** re-introduced the idea as a design feature that could be used in several departments. For patient rooms, according to ***M7***, except for the case of a single hospital, the system had not been implemented or extensively studied. The client representatives, who were keen to the idea of building "the world's safest hospital," showed interest in this ventilation system and its potential to reduce healthcare-associated infections. Having emphasized that there was no solid evidence to support the use of displacement ventilation in patient rooms, ***M7*** asked for more time to further investigate the idea. He also stressed that the decision on whether or not to pursue displacement ventilation should be made before the end of design development phase. In our interviews, I have questioned ***M7*** with regard to his research on displacement ventilation:

00:05:54	***M7***	*... We talked about early on in this project about, uhh, displacement ventilation. I've spent a lot of time, researching, just looking for the articles I could find, all the studies published. And it's amazing how many different perspectives there were. There were CFD[computational fluid dynamics] models done early on that indicated, this is where it [inaudible]. There were a lot of articles written by people who had designed systems using displacement ventilation. And there is some significant energy savings, but improvement in the environment was what I was after. I finally found a study that actually looked at two people in the same room, and then one breathes what happens to the air that comes out his mouth. And the conclusion of that analysis, the CFD analysis, the conclusion of that analysis for was that displacement ventilation environment is much more likely to transmit my breath to you.*
00:08:24	***I***	*Mm-hmm.*
00:08:25	***M7***	*Uhmm, and obviously in a healthcare environment, that could be fatal… And that was the study that made me say, we need to not do this. Uhmm, that was done by people who, I don't think have any gain. Not equipment manufacturer, not a designer engineer who's trying to justify what he's doing.*
00:08:55	***I***	*Mm-hmm.*
00:08:56	***M7***	*Uhmm, I can say it was academic research. Uhh, so, what I was looking for in there, why do it, why not do it, what's the evidence for doing it. I'd like to say proof but evidence is the best when it's hard, in general. All the studies I looked at for displacement ventilation, most of them are positive, and then there is this one that's negative. That*

one appeared to be the best research, and unbiased source. And it's evidently contrary what we were trying to do...

Even though there was a host of published research in favor of the displacement ventilation system, ***M7*** relied on one particular piece of research which suggested evidence against the system in healthcare settings. In interviews and conversations in steering committee meetings, two distinct attributes of research had emerged that ***M7*** and his team considered in making recommendations. First, ***M7*** looked for specificity, trying to match the circumstances of the research studies to the situation at hand. Rather than relying on research conducted in office environments, for example, ***M7*** found a particular research study that "looked very specifically at transmission." Although the global idea of displacement ventilation initially seemed promising, ***M7*** was persistent in investing time and energy to make sure that the system was safe to use in patient rooms where airborne infectious diseases can impose health risks to patients, healthcare workers, and visitors.

Second, ***M7*** looked for an "unbiased source" of evidence; research not conducted by an "equipment manufacturer, not a designer engineer who's trying to justify what he's doing." ***M7***'s rigor and attention to such details required him to be increasingly selective with the multitude of publications he had uncovered. When he located a single study that seemed to be written by an unbiased source that was applicable to the situation at hand, he did not hesitate to make his recommendation. He relayed the news to the steering committee in a meeting five weeks after he introduced the potential of the system:

01:41:44 ***M7*** *Displacement ventilation, just briefly. There's been very, very new research that's come out just in the last few months, where they looked very specifically at transmission of, uhmm, what one person breathes and what another person receives. Looking at some very specific arrangements that might occur, you know, in a hospital patient room. And it looks like, in some very specific cases, displacement ventilation makes the situation worse. And with that information, I'm, I'm not gonna*

		recommend that at all, in this present time.
01:42:32	***O4***	*Better or not [inaudible].*
01:42:34	***M7***	*It's a very complex dynamic. That was overlooked by all the…*
01:42:38	***O4***	*So basically you're going back to the traditional method of high volume air.*
01:42:42	***M7***	*Overhead air…*
01:42:44	***O4***	*Okay. I'm okay with that.*
01:42:51	***M7***	*What we all know, uhmm, but. And there may still be more research that says that displacement ventilation some time in future, but for right now, latest stuff we have says not such a good idea.*

O4, the president of the ***PHSP*** hospital, was not entirely convinced of this "untried" system, and did not challenge ***M7*** on his recommendation to abandon it for patient rooms. The reasoning provided by ***M7*** was strong enough for the team, and the issue was never revisited for the rest of the project. The final decision was to implement a rather conventional ventilation system.

Utilization of displacement ventilation system would have had consequences concerning the configuration of patient rooms. As mentioned earlier, in order to provide fresh air directly to the occupied zone the system requires air supply outlets that are close to floor level. Hence, placement of supply grills emerges as an important factor to be considered in room layouts. It would have required a new arrangement of elements in the room (e.g. couch, sofa bed) so as not to block the low-level air supply outlets.

When ***M7*** introduced the idea of displacement ventilation to the group, the patient room layouts had already reached at a level of maturity, and furthermore, the construction consultants were ready to erect the walls of first phase mock-ups. On the verge of initiating mock-up exercises with users, ***M7***'s introduction can be considered timely since his intention was to raise the opportunity to include engineering-related issues in mock-up experiments. As he explained in a later interview, however, the mock-ups were not utilized to test potential ventilation installations:

00:14:08	***M7***	*… I had hoped that the mock-ups we were doing for PHSP, we might be able to get in and do something more substantial. But those mock-ups were much more about the layout of the room and end-up material selection and stuff like that. All architectural.*
00:19:26	***I***	*What is your interaction with mock-up rooms?*
00:19:28	***M7***	*Almost none.*
00:19:29	***I***	*All right.*
00:19:32	***M7***	*I think we're missing opportunities, as a result. If you look at this process, it took them six months to build mock-up rooms. I was suggesting simple things like come into the toilet rooms figure out what's best place to put showers. Showers are constant problem within hospitals. Because of drainage issues. So let's look at it. Let's figure it out. They were more interested in what it looks like.*

M7 emphasized that he was not active in the mock-up exercises. The mock-up strategy, which was prepared by the architectural firm (***P1***), was oriented towards accommodating input from users in order to test the functionality of spaces and equipment, and this eventually precluded the potential to facilitate discussions concerning other disciplines. The idea of displacement ventilation, when it was first raised by ***M7***, was a challenge for the progressing patient room layout, and accordingly had caused concerns among the architects. Already operating in a tight schedule, the architects' intention was to finalize the room layout as soon as possible. A decision to test displacement ventilation would have required that the architects reconsider layout configurations in order to properly locate supply outlets, furniture, and equipment in the patient rooms. When ***M7*** made his final recommendation to not to pursue displacement ventilation, it was a relief for designers:

00:19:16	***I***	*Does that, displacement ventilation… What are the spatial implications of that idea? If there are any.*
00:19:22	***M7***	*Uhmm, in displacement ventilation air supplied down low and at low velocity which means you need diffusers that are in the wall, down low, and they are large.*

00:19:29	***I***	*All right.*
00:19:30	***M7***	*So there was a… There was going to be a need to coordinate that design with the architecture, and the millwork, and interior design, everything, to make that work. Uhmm, that was gonna be a challenge all by itself. Because that had not been integrated into the preliminary design of the room. As they were building the mock-up, we were trying to get to the bottom of whether that's what we're gonna do, so that we can work it into the mock-up, and see how that works.* *…There was a lot to deal with right there. So, as soon as we realized that it was probably not... That we couldn't recommend it, everyone said, oh, good, we can just keep moving.*

The idea of displacement ventilation was abandoned for the mock-up studies, which were progressing incrementally towards delivering a satisfying functionality and visual aesthetics for patient rooms. For ***M7***, the mock-up was "a missed opportunity" by being an exclusive tool for certain types of experiments.

Summary

The steering committee that ran the design and construction process of the new ***PHSP*** hospital included engineering consultants who occasionally made their presence felt throughout the project. In the case presented above, ***M7***, the lead MEP consultant, introduced a non-conventional system: displacement ventilation that had the potential to contribute to the project's overarching safety goals by improving indoor air quality. The system, which initially seemed promising and supported by a series of scientific research studies, was kept on the agenda for about a month until ***M7*** recommended abandoning the idea of implementing displacement ventilation. In his literature search, ***M7*** had located a single study that suggested evidence against the system. This particular study, despite two decades of academic research on the subject, was persuasive enough for ***M7*** who made his recommendation based on this recently published, *unbiased* and *applicable* evidence. As he felt confident with the piece of evidence at hand, ***M7*** made his judgment, which involved reviewing and interpreting available research. Displacement ventilation was taken entirely out of the project agenda as ***M7*** made his reasoning transparent to the other participants during a steering committee meeting. I have not recorded any challenge to ***M7***'s final word, but observed a level of relief on the part of both owners who were hesitant to implement this "untried" system and the architects who thought that making the idea work would take a considerable amount of labor and time for the team which was already operating in tight budget and schedule constraints.

Concerning the case presented in this section, there are three key points to be made. The first issue involves the potential of empirical research evidence to influence important decisions in design processes. In the case observed, even a single study, which was regarded as unbiased and applicable, was emphasized and elevated as the major evidence to be considered in design. Second, this particular event demonstrated the authority of individuals in command of technical issues. Aligned with the overarching goal of safety, ***M7*** made his recommendation in presence of reliable and applicable empirical research evidence which put an important issue to rest for the remainder of the design process. He was never challenged with this recommendation which carefully situated evidence emerging from a single research study. Third, the exclusion of particular disciplines from mock-up exercises demonstrated the strategic utilization of the tool throughout the process. The architects, in tandem with the owner representatives, were the ones to determine the scope and depth of mock-up exercises. Thus, the opportunity to generate evidence for decisions concerning engineering domain was compromised, although the team invested considerable time and efforts to finalize even the smallest detail to improve the design from an architectural point of view.

6.2.3 Designing a Wall

On many occasions, the concept of visibility had emerged as one of the major design considerations. At a range of scales, the steering committee members had revisited layouts in order to make sure that the design provided a sufficient level of visibility for spaces, equipment, and people. As evidenced in participants' statements, visibility was considered important in promoting safer practices for patients, staff members, and visitors. In countless exchanges involving designers, consultants, client representatives and staff members, the value of providing a better line of sight was repeatedly emphasized. Personal expertise, previous experiences, first- or second-hand stories, and precedent cases (e.g. observation windows or low benches that did not block the line of sight) constituted the sources evidence in design review meetings, whereas throughout my field observations, I have not observed any of the participants referring to a particular research study concerning visibility. Stories created to emphasize the need for better visibility, which were provided by all engaged parties, clearly suggested the value of the concept which was deeply embedded and prioritized in the culture of care:

00:15:25 ***O3*** *Uhmm, you can have as much technology that you can around the bedside, but observation, being able to see the patient is the best skill that a nurse can have, looking at their color, looking at their respirations, looking at how they are feeling to their overall environment. Many times we know that a patient is in pain by the expressions on their face, the movement, and their sleep, before they actually complain their pain…*

Providing visual access to patients was one of the major concerns in patient room design of the new ***PHSP*** hospital. Starting from the very early meetings, the steering committee had embraced, without any recorded resistance, several concepts to facilitate enhanced patient observation. Introduced as one of the principal features to bring nurses close to patients, the idea of distributed nursing stations, for example, was adopted by the committee during visioning, and maintained throughout the project.

The distributed (or decentralized) layout model is one of the most popular topics in healthcare design community (Hendrich, et al., 2004; Ulrich, 1984). Compared to traditional unit configurations with central nurses' stations, this relatively new concept proposes distributing resources, both human and material, across patient care units (see the charting alcove in Figure 35). Alongside novel care protocols to be adopted, the model introduces a set of design interventions to achieve an effective, efficient, and safe care process. One design implication is to incorporate individual work stations outside each patient room which "increases the time available for meeting patients' needs and decreases the time and distance nurses must travel to help patients" (Hendrich, et al., 2004: p. 41).

The steering committee members were exposed to the idea earlier in the process through formal and informal presentations and site visits that enabled them to see the distributed nursing model first hand. My interviews with both ***O3*** and ***O4*** revealed that the client representatives were aware of the benefits and shortcomings of this new model. They were also aware of the fact that the staff, at all levels, needed to be continuously informed and educated about the new model which meant a "shift in ***PHSP***'s care culture." Throughout field observations, both ***O3*** and ***P1*** were observed patiently and clearly explaining the set of new processes and design implications to staff members.

Neither in actual field observations nor in reviews of past meeting minutes were there any challenges recorded against the idea of distributed nursing. Even in early patient room schemas produced during the visioning phase, individual work spaces outside patient rooms were incorporated into the layout drawings. The team was able to consistently propagate and maintain this early commitment throughout the project.

Having all these initial principles and ideas at hand, and mindful of budget and schedule constraints, the task for the project architects was to come up with a satisficing design for patient rooms. In particular, the design for the corridor wall of the room (Figure 35) was expected to accommodate a nurse server, a hand-washing sink, a convenient entrance, and a work station for a nurse, and represented a design challenge that would consume many hours before designers arrived at a solution. When it was time to delve into the details of the patient room design, the project architects produced countless sketches to synthesize their initial ideas (Figure 38).

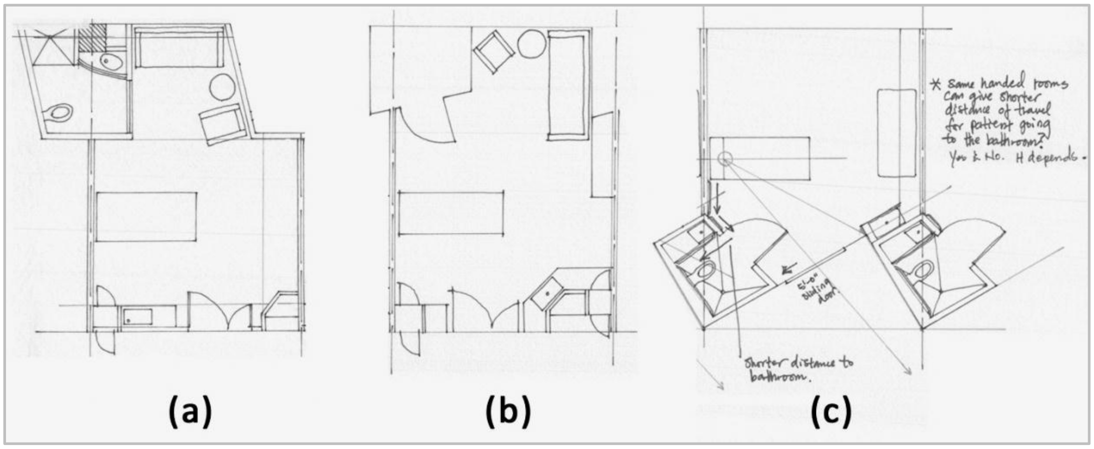

Figure 38. Developing corridor wall

Following comments made by client representatives late in the schematic design phase, the architects narrowed down their focus to room configurations with outboard patient toilets, which reduced the number of elements to be integrated into corridor walls. Another clear result of the meetings with client representatives was the utilization of same-handed rooms, which eliminated alternatives with a shared headwall.

One of the most striking attempts to shape the patient room corridor wall emerged during exchanges with client representatives, mainly involving ***O3***. I was able to identify several sketches dated May 2011 that portrayed an angled corridor wall (e.g. Figure 38c). In this series of sketches, the designers indicated lines of sights intersecting at a circle representing a patient’s head. These lines, through which the designers had studied visual access to patients, were generally extended to corridor space, and to nurse stations.

The designers had entertained the angled wall idea through many sketches, each providing another reconfiguration of elements, including doors, sinks, nurse servers, and nurse work stations. These studies were not immediately translated into CAD drawings in the schematic design phase, but were archived in the form of sketches, each with a name and a date on them. In order to interview the designer who introduced the angled wall idea to layouts, I have scanned the entire set of sketches by names. I was able to identify two names on these particular sketches, alongside countless anonymous drawings which were also kept in the archive. Unfortunately, both names had cut ties with Firm A four months before we initiated our field observations. In semi-structured interviews, on the other hand, the participants were not in consensus in naming the individual who first sketched out the angled corridor wall.

The angle of the corridor wall in these sketches displayed great variety (see for example Figure 33b and Figure 33c), ranging from very small angles (~5 degrees) to open ones (~30 degrees). The architects did not arrive at a final decision on the particular configuration of corridor walls, even as the team approached the deadline for schematic design. Discussed earlier in group meetings, the plan was to continue developing the room design in both layouts and in mock-ups until they were refined and deemed appropriate and acceptable by the steering committee. The angled wall option was suspended for a while until the team started developing plans for mock-ups during the design development phase. The earlier versions of patient rooms, which included designs created for the schematic design package, did not communicate any of the experiments with the corridor wall (Figure 32: Patient room design at the end of the schematic design phase).

As the team developed the strategy for mock-up rooms later in schematic design phase, the architects focused their attention back on the details of the patient room. ***D2***, who was given the task of developing the drawings for the mock-up exercises, returned a set of drawings which included certain features (e.g. outboard toilet, angled wall, charting alcove) integrated into the room design (Figure 35). These drawings were adopted by the construction consultants to develop Phase 1 mock-ups consisting of movable walls to define the room perimeter. The expectation was to engage in a discussion with a larger group, including nurses from the ***PHSP*** hospital, involving a collective exercise of utilizing movable walls, and, eventually, to finalize the geometry of the room.

Even though the staff members were presented with the computer renderings and the layouts of the rooms many times prior to their visits to mock-ups, they were amazed that the size of the room was significantly larger than the patient rooms of the old hospital. The staff members frequently expressed how “really big” the room was. For the first phase mock-up exercises, the staff members’ comments were limited, since there was very little to talk about other than the overall size, dimensions, and clearances around certain elements in the room perimeter as defined by the walls. During a later visit, however, a group expressed their concerns with regard to visibility to patient heads from work stations just outside the rooms. This comment, raised only once in a series of visits by staff members, had significant consequences involving dimensions and the angle of the corridor wall:

00:25:29	***I***	*How about the other two issues, the visibility issues?*
00:25:32	***D2***	*The visibility issue found the charting niche to the patient head, uhh, we have a very unique design at that door to the patient room and the angle of that wall was prohibiting a nurse from standing at the charting niche and seeing directly to the patient head. You can see the majority of the bed, but you couldn't see their face very well unless you lean down very awkwardly, so we increase the angle a little bit so they…*
00:26:01	***I***	*On the mock-up?*
00:26:02	***D2***	*Yes, on mock-up. They are working on it now actually.*
00:26:06	***I***	*All right. So how did you decide on the angle in the first place?*
00:26:11	***D2***	*We, uhhh. Just in the computer actually, and then sketch up, and in modeling programs, kind of taking some views from there. Looking at the floor plans and getting view angles, and looking at perspective views and so that's how we put the original. We knew there was gonna be some tweaking. And this is actually the third tweak of that particular angle that we are doing just, you know just to get it exactly perfect. So that no one is leaning or turning in an awkward way, we want to be as natural as possible.*

D2 emphasized that the architects “knew there was going to be some tweaking” following the mock-up exercises and they were expecting the mock-ups to generate staff input “to get it perfect.” By having actual staff members seated at charting alcoves and letting them check visual access to hypothetical patients lying on beds in mock-up rooms, the architects were able to test patient visibility instead of drawing sight lines on layout drawings (see for example Figure 31c and Figure 38c), or by three dimensional renderings.

As opposed to other media (e.g. layouts, renderings), which were collectively reviewed multiple times earlier in the process, the exercises in using mock-ups allowed generation of first-hand evidence involving actual staff members enacting practices that they would perform in the new ***PHSP*** hospital. The comments concerning the angle of the corridor wall were evaluated and re-evaluated by the architects ("*this is actually the third tweak of that particular angle"*) by using movable walls before the "right" angle was translated into layout drawings. Without updating computer drawings after each "tweak" on mock-ups, in this particular case, the architects' strategy was to wait until the group arrived at a satisficing solution which provided better visual access to patients. Until the angle of the corridor was re-reviewed and approved by staff members who communicated the issue earlier, the mock-up remained as the major representation to be manipulated.

00:29:28	***I***	*So, how about discussing issues with users on the paper and on the mockups? I mean is there a difference or not?*
00:29:40	***D2***	*Yes there is a huge difference. I don't... I personally think users have a hard time with visualizing what the space is going to be like in plan. You show them the plan, and they have very hard time understand it unless they have experiences with building design before. And not many nurses have ever done design exercises, spatial recognition, I mean nothing. So you are trying to explain something to them, the only thing they have ever seen is, you know, the architectural digest, a plan of a house. So you are trying to explain very complex space such as a hospital to them, and a lot of times you can show them perspectives, and that helps some. But the mock-up has been irreplaceable in terms of that…*

D1 and ***P1***, the senior architects of the team, negotiated the corridor wall angle with the users, whereas ***D2*** kept track of the progress on mock-ups and translated the "perfect" angle into layout drawings (Figure 39). What ***D2*** stressed in the quotation above with regard to the differences in utilizing drawings versus mock-ups during design review meetings exemplifies the design team's opinion. This view was repeated by ***D1***, ***D2***, ***D5***, and ***P1*** in multiple interviews. Mock-up space was an "irreplaceable" medium which enhanced the negotiations with users, which eventually allowed the architects to process and translate first-hand evidence emerging from the interaction between the mock-up and the hospital staff.

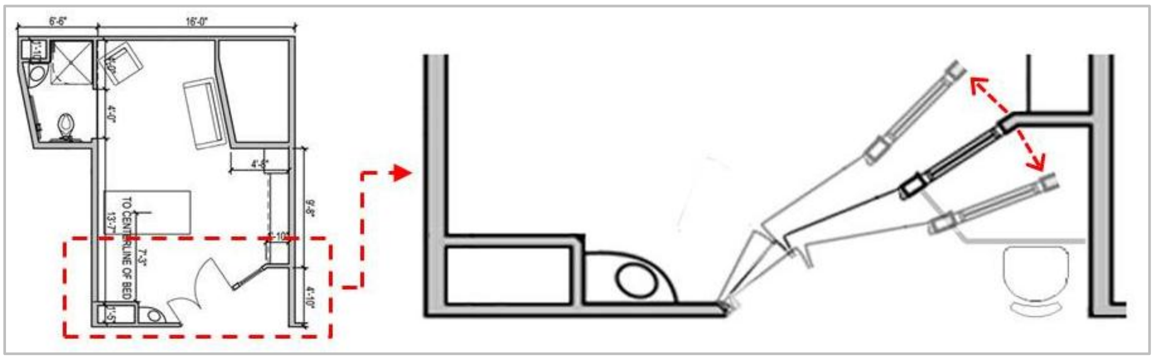

Figure 39. Finding the right angle for the corridor wall.

To recapitulate, the idea of introducing an angled corridor wall was maintained and developed in layout drawings before it was collectively reviewed in mock-ups. The anecdotal evidence from conversations with users of the mock-ups suggested a series of tweaks to improve visual access to patients. While plan representations were repeatedly reviewed with staff members earlier in the process, the mock-up rooms presented an environment that allowed participants to simulate their everyday practices, and test visual access to hypothetical patients. The evidence emerging from such exchanges involving individuals from various disciplines was captured within mock-up representations which allowed instant manipulation and feedback that then was crystallized within a particular corridor wall configuration. The mock-ups facilitated a scaled-up and embodied representation of the patient rooms, which, in turn, allowed the interdisciplinary team to focus on specific details of the developing design. These extended and focused discussions in mock-ups superseded other means of exploration (e.g. orthographic drawings) into the "proper fit" of the space to the end user of specific concepts, notably accessibility and visibility, and particular features, notably distributed stations or nurse-servers. As the angle for the corridor was decided alongside other features that were also incorporated into design (e.g. nurse servers, hand washing sink), the architects updated and fixed the set of plan drawings based on the interdisciplinary exchanges within mock-ups.

6.3 Distributed Problem Solving

… [Navigation] tools are useful precisely because the cognitive processes required to manipulate them are not the computational processes accomplished by their manipulation. (Hutchins, 1995a: pp. 170-171)

The final design configuration for patient rooms, or any other space in the hospital, was not determined by the cognitive processes of any single designer, but instead was achieved through the multidisciplinary interactions of participants engaging with each other and with representations and tools. Using a framework that views design as occurring within a distributed cognitive system consisting of situated individuals, representations and tools, this section examines various representational media and one new tool that became instrumental in advancing and completing the design task at hand. From the perspective of distributed cognition, the representational practice involving generating, manipulating, and propagating layouts was central to the evolving cognitive system where expertise was distributed, and necessary feedback was usually delayed. Mock-ups, on the other hand, were both representational media and a generative design tool to be collectively manipulated to accomplish tasks requiring complex computations. The following sections contribute to the larger account by signifying the properties of layouts and mock-ups as representations or tools allowing transition across representational states while facilitating an environment to blend the distributed expertise and knowledge of concepts in the system.

6.3.1 Layouts

Plan drawings, either digital or on paper, have traditionally been central to architectural design practice. There are some analyses on the significance of drawings (Henderson, 1999) or objects in general (Eckert & Boujut, 2003), in facilitating design collaboration and influencing outcomes. This study instead focuses on the features of particular practices of manipulation and propagation of various representational media in order to incorporate input (evidence).

The design team members had to deal with a range of representations and various types of feedback from engineering teams, consultants (e.g. information technologies), and hospital staff concerning care practices to be implemented in the new hospital. Over the course of the project, the plan drawings turned out to be the anchors for coordinating progress in separate domains. Incorporating feedback from engineers (structural, civil, mechanical), client representatives, and actual users, the layouts progressed through a pre-determined order of manipulation, sustained collaboration, and coordination across individuals and teams. The term “anchor” refers to Hutchins’ discussion of material anchors that facilitate associations between conceptual structure (care models and processes) and material structure (layouts) in order to perform complex cognitive tasks (Hutchins, 2005). Thus, layouts in this context were not mere external representations but key cognitive artifacts to provide ground for conceptual blending. For instance, the set of orthographic section drawings – another type of representation frequently used by architects – was also available to all participants. However, on the way to advancing the next representational state, the sections were never elevated to a status as anchors for conceptual and material structures.

As frequently mentioned by senior managers of the ***PHSP*** hospital, the intention was to achieve “a shift in care culture” by means of implementing new practices and environments in the replacement facility. Aside from how participants defined ‘culture’ during interviews, there was a consistent pattern throughout the project which involved contrasting what was being practiced in the old hospital (existing care model), and what was planned to be implemented in the new facility. The existence of two (conceptual) models of care with different design implications created a complex environment for designers who were struggling to design-in the basics of patient care (e.g. patient visibility) while also trying to find ways to incorporate new physical environment features into the spaces of the future hospital. Throughout these complex reasoning processes, the layout drawings emerged as primary cognitive artifacts to blend differing models of care and associated spaces, at least until the point where mock-ups were built.

By providing stable representations of constraints and affordances (e.g. topological relationships in and across units), the plan drawings were instrumental in both generating feedback (input) and allowing ongoing manipulation. It was the team's collective ability to project a set of desired care models and processes onto layouts, whereas it was designers' ability to progress from input space to a solution space where models under development were blended into a single representation. During meetings with users, the print-outs of plans (Figure 40) were utilized to generate feedback from users. They also served to record that feedback, as the annotated and marked layouts became a model of how staff would operate in space (care model). This information was then processed in a mixed representational practice involving computerized drawings and sketches aimed at solving existing problems or incorporating desired physical environment features. "Problems" in this context refers to particular mis-matches between desired care models and affordances of the evolving hospital spaces. Progress was made by means of processing user feedback, generating a solution through sketching exercises, and these had their own syntactic and semantic properties such as creating computerizing drawings, and bringing print-outs to user group meetings where participants were satisfied with the solution provided (Figure 40).

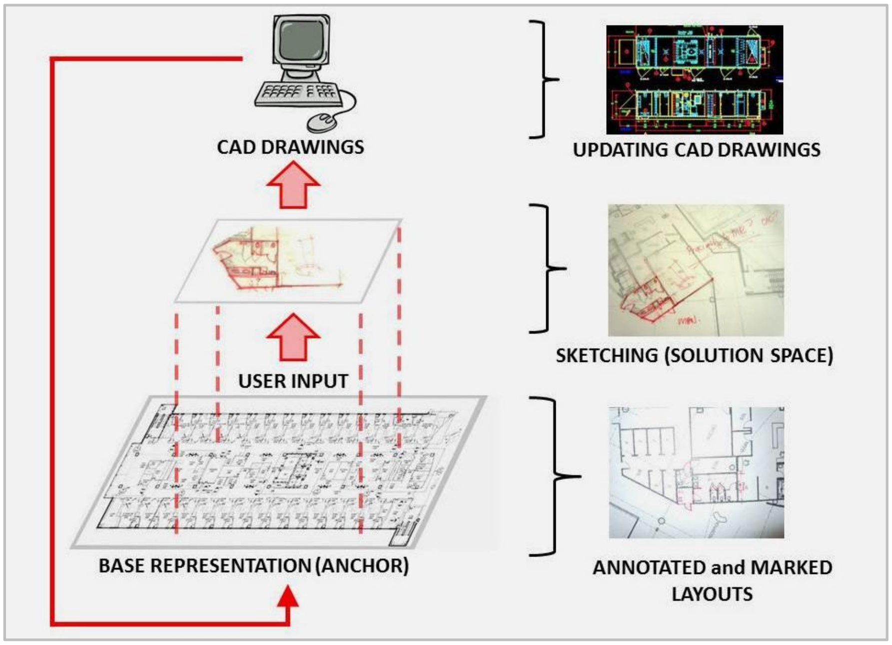

Figure 40. Representational system to generate, manipulate and propagate plan drawings

The assumption in labeling the print-out plans utilized in user group meetings as material anchors was that these representations were regarded as accessible by all participating parties, including nurses who were expected to process these layouts and provide instant feedback. While sketches and CAD drawings were generated on desktops back in the office, the print-outs were the media brought to meetings to facilitate fruitful exchanges during which participants put marks and annotations on paper for further processing. While the designers provided verbal descriptions of proposed care models and processes, users were also invited to analyze the layouts. This may have been a culturally coherent practice for architects, but that was not necessarily the case for hospital staff. Occasionally, the delays in receiving user feedback slowed the design development or construction documentation phases.[27]

Over eight months, the project architects developed plan drawings based on user feedback by projecting a multiplicity of complex care processes and models onto layouts and using the layouts for testing or analysis. Although in most cases the layouts were

[27] Detours in ED case instantiated such delays in design process.

both effective and instrumental in advancing design work, the team had to await the mock-ups to identify shortcomings in design that the extended group of participants had failed to identify in the layouts.

6.3.2 Cognitive Partnering

One interpretive notion to account for interactions in distributed cognitive systems is "cognitive partnering" which is specified as a form of "cooperative participation within an epistemic culture that enables or sustains particular cognitive cultural practices" (Osbeck & Nersessian, 2006: p. 147). Interviews and in field observations confirmed that mock-ups were one of the key tools in mediating or facilitating person-to-person cognitive partnering, a process that can be critical in interdisciplinary problem solving. The super-ordinate category *Generating Evidence* (APPENDIX C: Coding Guide) provided us the grounds to conduct our analysis.

The literature supports what was in evidence during this study, that healthcare design is an interdisciplinary practice where an array of actors with a variety of backgrounds are involved in design processes. Mock-ups, traditionally utilized in healthcare design, often are regarded as tools for providing multi-disciplinary evaluation and feedback in order to achieve the best possible spaces in hospitals. However, it is common in healthcare industry to use mock-ups only for marketing purposes (Watkins et al., 2008), rather than experimentation. In the project observed in this study, a variety of concerns, including experimentation, marketing, and education, had co-existed. With regard to interdisciplinary problem solving situations, mock-up utilization in the ***PHSP*** replacement hospital project emerged as a cooperation facilitating tool to blend the distributed expertise of individuals inside and outside of the project team.

Before presenting instances of "person-to-person" cognitive partnering, two important aspects should be emphasized. First, a discussion around tools initially suggests questions concerning the existence and agency of a tool designer and builder. In that sense, mock-ups observed in this study can be considered as exclusive and strategic tools designed by architects to efficiently test a designated set of features in patient rooms. The strategic choices of architects (e.g. focus on locations, configurations and functionality) were physically embedded in the tool. For example, the mock-up were not intended to affect the width of patient rooms, because that would have implied a change in the already-fixed structural grid of the entire hospital facility. Similarly, the mocked-up spaces did not allow testing available ventilation strategies that could have been adopted in the future facility. But they allowed participants to “toy” with equipment, partitions, and walls within the constraints of the structural grid. The mock-ups were created as an instrument with certain *limitations* initially set by the architects of the project.

Second, besides limitations mentioned above, there were several built-in features of the mock-up room that can be considered as *affordances* that could communicate a set of possible new care practices. Certain qualities, such as nurse servers that would introduce a new model for medicine preparation and distribution, or the inclusion of a recliner and sofa which suggested existence and participation of family members (Figure 35), were already in-place when groups from the old facility started visiting the mock-ups during design development meetings. ***O3*** and ***O4***, the senior managers of the ***PHSP*** hospital, repeatedly emphasized the critical role of mock-up rooms in making qualities and affordances of the new care culture available for healthcare workers years before they started practicing in actual spaces.

With such built-in limitations and affordances, the mock-ups were key tools in forming relations or cognitive partnering among individuals interdisciplinary and distributed problem solving situations. The ***PHSP*** management’s desire was to achieve a cultural shift by implementing several contemporary operational models alongside novel physical environment features such as distributed nursing stations. The plan was to introduce the distributed nursing model to staff members by having them experience mock-up rooms where individual charting alcoves were readily integrated into the corridor walls. The patient room mock-up embodied the affordances and limitations of the concept and the set of design intentions with regard to utilization even if the designers were not present. For example, the comment that gave rise to the issue of patient visibility from the charting alcove first emerged during a visit in which the architects "did not have any representation:"

00:39:27 ***D1*** *Uhmm, the comment actually came from, unfortunately from a visit where we did not have any representation there. But the process worked. The comments did, I mean they did record the comments, and they did notify us, you know, that it was discovered. So, of course we went back out and reconfirmed it and wanted to look at what we could do to change the conflict there. And physically of course, we moved the wall and that way they were able to come back and physically confirmed that the site line was fixed.*

In this particular case, the mock-up mediated partnering between architects, who did not always accompany visiting staff members, and nurses who themselves simulated the intended practice by locating themselves at the charting alcove and tried to observe hypothetical patients. The practice of patient observation was an expertise not known by the designers, but was enacted by nurses, and eventually led to a "discovery" that there were shortcomings in terms of visibility. Although the architects were well aware of visibility concerns and studied them through two dimensional sketches (Figure 31), it was nurses' practical expertise that introduced the improvement to the angle of the corridor wall. Earlier in the process, the architects acknowledged probable gaps in their knowledge base, and anticipated several "tweaks" to the design based on feedback from other domain experts.[28] The mock-up, in that sense, was a tool to mediate the partnership between individuals with different disciplinary backgrounds.

[28] This interpretation is in parallel with Hutchins' description of partially overlapping distributed expertise in navigation teams including a plotter, a bearing taker, and a bearing time-recorder.

In most cases, however, the architects accompanied visitors and other steering committee members as they visited the mock-up studio. During these visits, the participants collectively evaluated existing locations for items and projected locations for items to be added in the future. The options explored or decisions made based on these exchanges were recorded by architects in various forms.

While mock-ups were available during design development phase, the team held a number of meetings with staff members in these spaces to process locations for each item. The transcript below is from a mock-up review meeting where participants collectively discussed the locations of particular outlets (gas and electric outlets, care devices, etc.) which were not discussed on paper prior to mock-ups:

00:00:12	***O3***	*For dialysis, personally, I prefer the box being on that side, plus it's close to bathroom. Reason be... Because if nurse comes in, she's gonna work on this side. The dialysis nurse probably be just sitting over there.*
00:00:33	***U8***	*Yeah, if you've got two. That's right. That's good.*
00:00:37	***D1***	*Recessed in the wall, under the hand rail?*
00:00:39	***O3***	*Yes.*

Typically in these meetings, nurses were the ones to simulate their practices involving hypothetical patients and equipment, whereas the architects were the ones to observe, take notes, and further specify the locations of equipment or configurations of space by engaging in the conversation to ask specific questions. In the conversation above, ***O3*** and ***U8*** (a nurse from the ***PHSP*** hospital) described a projected practice including positions of staff members for a dialysis process (primary nurse on the right, dialysis nurse sitting on the next) and a location for related equipment (dialysis box) to be used in space. ***D1***, on the other hand, engaged in the conversation as ***O3***'s reasoning unfolded, and suggested a specific location for the dialysis box (recessed in the wall, under the hand rail), which was eventually approved by all participants in the room. Many decisions at this scale were made on the spot in the mock-up spaces following relatively short conversations spanning just minutes. Unlike the previous case, where the architects were not present when users questioned the position of the corridor wall, in this case all parties simultaneously processed new information as they made a series of decisions. Again the mock-up mediated the partnership in this situation where the multidisciplinary team collectively put together a configuration that was not represented on paper.

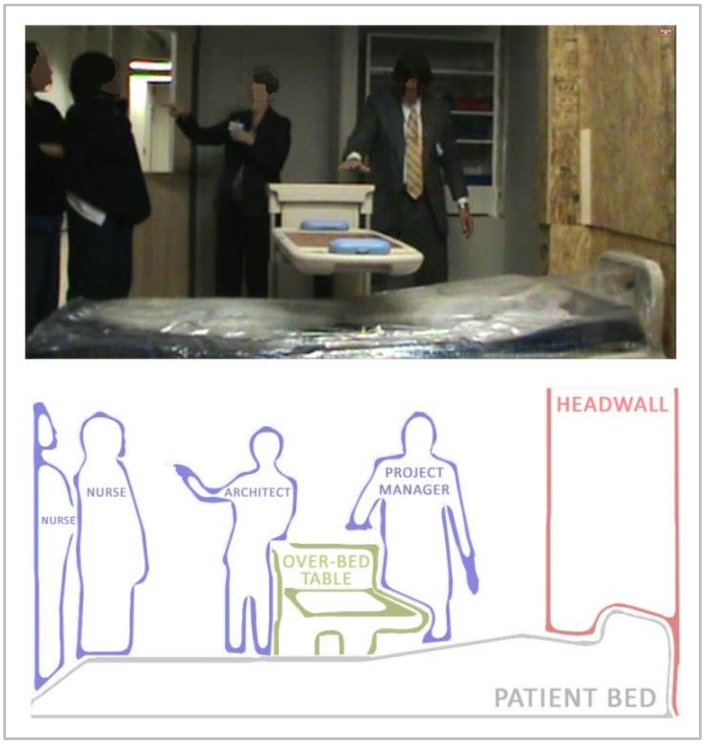

Figure 41. Interdisciplinary meetings in mock-up studio.

Explaining action through the notions and language of the distributed cognition framework demonstrates the central role of mock-ups in collective reasoning processes. As designers of this particular tool, architects strategically used its affordances and constraints in order to benefit from the distributed expertise of a multidisciplinary group.

6.4 Evidence in Design

The process of designing the patient rooms of the ***PHSP*** hospital instantiated, on a smaller scale, how the multi-disciplinary steering committee approached the overall design of the new facility. The intention was to catch-up with the latest developments in the rapidly evolving world of healthcare design, and to erect an up-to-date facility to bring services for the surrounding community. The senior managers of the hospital took every opportunity to initiate conversations with individuals and healthcare organizations in the industry to extend their awareness of new care processes and architecture. Designers accompanied the client representatives early in the process and helped them better understand physical environment features and the value that architecture could bring into care processes. The rhetoric of evidence-based design, which was communicated by architects, consultants, and other individuals from peer organizations, was highly persuasive for the ***PHSP*** senior leaders.

Long before the project architects produced the first layouts for the patient room, the ***PHSP*** representatives were already familiar with ideas involving both care processes and physical environment features that could be implemented in the new facility. Throughout the visioning phase, the team was exposed to a range of room layouts, physical environment features, and associated care process even when some of them were not sufficiently supported by research evidence. As steering committee members judged evidence from various sources including anecdotes, precedents, and scientific research, they collectively created stories around particular design features. These stories were eclectic in nature, but disseminated rapidly across people and over time as the design work progressed.

6.4.1 Creating Stories

Concerning individual design features, participants created particular stories which merged individual expertise, anecdotes, precedents, and research findings into a single structure which was then circulated in and outside the group. In interviews and in team meetings that were observed, these stories surfaced consistently repeatedly as participants accounted for the reasons behind design decisions. For example, the participants invoked the story created around same-handed type of standardization regardless of their disciplinary background. The story consisted of research findings about various work settings, the anecdotes of a seasoned nurse, and precedent examples, and was developed and sustained among the interdisciplinary team over the course of the project. Although some individual pieces of this story did not support the idea of the adoption of same-handed rooms, the story as a whole was persuasive for the team, including the client representatives who favored the idea despite its cost implications.

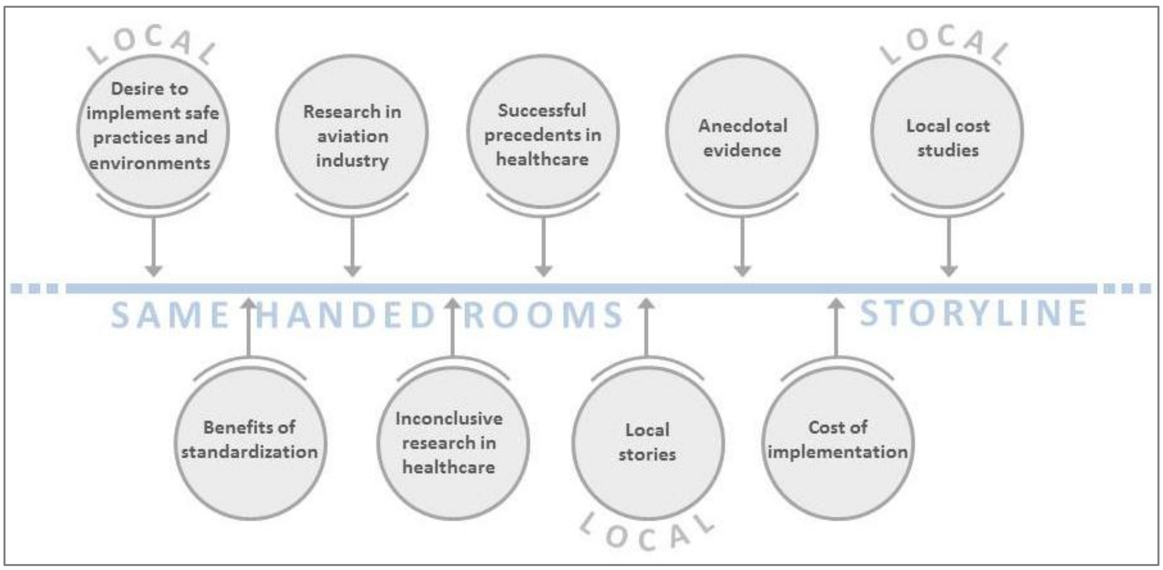

Figure 42. Constitutive pieces of the story around same-handed rooms

Participants further questioned and investigated specific segments of the story, an activity that had the effect of leading them to support same-handed rooms, whereas other pieces remained intact as they were incorporated into the larger structure. The steering committee members sought additional information on the specific costs of implementation, and accordingly updated relevant pieces in the story, while ***O3***'s anecdotes from practice were never challenged but were maintained as a segment of anecdotal evidence in support of same-handedness. As participants gathered reports and updated elements (e.g. cost, precedents) or maintained particular pieces of the larger structure (e.g. reference to research in aviation industry, anecdotes from practice, precedents), the story remained as the basic structure to explain the reasoning behind why the new ***PHSP*** hospital would have same-handed patient rooms.

The stories helped participants to deal with chunks of evidence gleaned from different sources, whether they were supportive, inconclusive, or against the adoption of same-handed rooms. While no single piece of evidence (e.g. research evidence, anecdote, precedent) was overwhelmingly convincing for team members, the story as a whole was effective in persuading the group of people involved in the project. I have not observed any attempt on the participants' side to dissect the complex story around same-handed rooms in order to judge individual pieces of evidence; rather the story was subject to an overall judgment concerning *reasonableness*. As the story, which was developed across people and over time, was regarded as "reasonable" and "making sense," the interdisciplinary team headed towards the direction of pursuing same-handed configuration.

In the absence of fully satisfying evidence, the participants' reasoning relied on the non-empirical criterion of judging the overall reasonableness of the story. Thus, the use of stories provided a basis to avoid an open comparison between inconclusive research evidence versus anecdotal evidence. While some pieces of evidence included in the story were incorrect or inapplicable, the overall story passed the criterion of *reasonableness* as the team progressed towards implementing same-handed patient rooms.

The anecdotes offered by ***O3***, the nurse executive of the hospital, were the key elements shaping the reasoning behind this design decision. As opposed to specific pieces of evidence taken from academic research, her anecdotes were flexible in nature and they fit well into project needs (e.g. desire to design safe environments). Flexibility was due to the fact that they were occasionally drawn from real or hypothetical (pseudo-real) experiences to fit the circumstances at hand. The "good fit" between such experiences and the desired features consolidated the role of anecdotes within stories, and contributed to the overall persuasiveness of the story.

The story, which was relatively stable by the late schematic design phase, was strong enough for the steering committee to make the decision on same-handed rooms before building mock-up spaces for the design development phase. Although there was room for “tweaking” in mock-up exercises, the decision on same-handed rooms was beyond the point of no return once it was translated into physical mock-ups which, eventually, added another segment to the overall story.

6.4.2 Generating Evidence

By contrast, the healthcare literature provided solid evidence in support of the distributed nursing model. Promising findings in favor of distributed nursing were published in the highly visible publications of the Institute of Medicine (2004). As the steering committee progressed towards implementing a distributed model, unique constraints of the ***PHSP*** project (e.g. budget or process-related) gave rise to complications in incorporating desired physical environment features on a fine-grained level. As designers introduced particular design elements into the project (e.g. proposed locations for elements, canted corridor wall), the room design began to deviate from the patient room layouts recommended in the literature. Thus, the interdisciplinary team was required to generate *in situ* evidence that the room configuration facilitated visibility and accessibility to patients.

With regard to visibility, the project architects had not studied the sightlines from nursing stations to patient heads, but strategically left the task open to be finalized during mock-up exercises. There they would have the opportunity to benefit from the nurses’ embodied experience in care spaces. Even though the architects briefly studied views to patients, the actual users (nurses) had limited interaction with these representations. These representations, including layouts, animated computer models, or print-out renderings, were generated by architects who possessed the authority to access the tools to produce such renderings. The initial design decisions, translated into layouts prior to mock-up exercises, were never externally evaluated in terms of visibility. When the layouts were translated into three dimensional space, however, the nurses' tacit expertise of patient care came into play. Through their interaction with the mock-ups, the nurses were able to identify a problem in the configuration of the corridor wall that required them to lean over to observe hypothetical patients. The structure of mock-ups, then, allowed the team to play with movable walls in real time in order to facilitate a design with better views. The team collectively conducted subsequent design operations to fix the angle of the corridor wall. Thus the mock-ups afforded both problem identification and problem solving in this particular design situation, and eventually they generated new evidence that patients are visible, accessible, and, thus, safer, in line with published findings.

In addition to the critical ability to merge evidence from various sources into design work, the mock-ups also facilitated a fruitful interdisciplinary exchange between architects and healthcare workers. The architects on the project, who certainly possessed a high enough level of interactive expertise to assess nurses' practices and languages, created mock-ups that facilitated an exchange in which distributed expertise emerged that was needed to shape the patient room. In this multidisciplinary environment, the mock-ups, utilized both as tools and representations, made nurses' everyday practices apparent to designers, while, on the other hand, they also made particular design ideas more accessible to non-designers than they were with other representational forms.

6.4.3 Judging Evidence

The third case presented in this chapter, selecting a ventilation system for patient rooms, depended on a particular strategy to deal with research evidence as part of the design process. While the participants occasionally followed a strategy of incorporating evidence from various sources into stories, which were then judged based on their reasonableness, there were also pieces of evidence, mainly from scientific publications, that were resistant to such treatment. The concept of displacement ventilation, for example, was not known or fully understood by all members of the steering committee. It was one of those ideas that was not collectively explored or judged. In the case observed, the MEP consultant (***M7***), who was familiar with how evidence, scientific or anecdotal, was created and disseminated in the healthcare design domain, was the only authority to process, judge, and make recommendations accordingly.

The consultant's was a two-step process in which the available scientific available evidence was analyzed, followed by a second search based on his judgment of the initial evidence. Unconvinced of the validity and applicability of the available research evidence, the consultant extended his individual research process, even as the creation of layouts for patient rooms progressed during the design development phase. Unlike the majority of research in the healthcare domain which aimed evaluating (or measuring) the effects of a package of interventions involving people, processes, equipment, and technology, the academic and scientific nature of evidence that ***M7*** interacted with allowed him to focus on particular parameters. A single research study was located that seemed unbiased in a commercial sense and appeared to be a good match with the situation at hand was persuasive to ***M7*** as he formulated his recommendation. Rather than combining multiple pieces of evidence from various sources (e.g. precedents, anecdotes), his strategy was to treat each piece of evidence individually and judge constitutive elements including validity and applicability. This approach enhanced the persuasiveness of a single item of research evidence against a body of research favoring displacement ventilation.

CHAPTER 7

EVIDENCE, MECHANISMS, AND DESIGN REASONING

This chapter develops and frames an argument about design based on an examination of the nature of evidence-based practices. The discussion of evidence-based practice is, in turn, based on the realities of evidence-based design (EBD) described in the chapters on the design process of emergency services and on inpatient units. First, I will review the claims of evidence-based medicine (EBM), which has served as a model for EBD, together with critiques emerging from a variety of domains. Although there are inherent differences in developmental trajectories, there is significant analogical transfer between EBM and other evidence-based practices, including EBD (Edelstein, 2008; Viets, 2009). The chapter first surveys philosophical literature on EBM as a whole, providing an overview of the numerous issues under consideration. For the purposes of this study, I will subsequently focus on three issues that have relevancy for EBD: 1) the theory of evidence in EBM, 2) causal mechanistic reasoning processes, and 3) the role of expertise. The goal of this chapter is to move beyond the rhetoric of EBD to develop an understanding of evidence that squares with the realities of practice.

7.1 EBM: Problems from Perspective of Practice

Promulgated as a way to teach and practise medicine,
EBM largely ignored the fundamental philosophical
assumptions and positions upon which it necessarily relied,
choosing instead to focus on teaching the skills deemed
necessary to become a bona fide EBM practitioner.
(Tonelli, 2011: p. 1013)

In two decades since the term was introduced with “a rhetorical *tour de force*” (Howick, 2011), the proponents of EBM still faces aggressive criticism of the foundations of their method. Tonelli (2011) notes that only in recent years has the EBM community attempted to provide comprehensive responses to practical and philosophical challenges. However, the body of publications in support of EBM practice has not reached a critical mass to secure EBM's position over persistent skeptical claims that have been consistently developed over the years (Naylor, 1995; Tonelli, 1998, 2011). As the term propagated across domains, including public policy, education, and design, an elaborate critique was mounted by individuals and groups who initially questioned the core assumptions within the source domain, namely medicine (G. R. Norman, 1999; Tonelli, 1998). For the most part, the core epistemic claims of EBM, built upon beliefs in the supremacy of clinical research and corollary evidence hierarchies, have been maintained over the years. This is in addition to concessions in the forms of minor modifications to the original definition of EBM.

Jeremy Howick, from the Centre for Evidence-Based Medicine at Oxford University, introduced a multi-layered argument aimed at clarifying issues surrounding the theory and practice of EBM (Howick, 2011) for the purposes of justifying its use. Briefly, he maintained the view that the best research evidence, whether randomized control trials or "upgraded" observational studies, should inform clinical decision making. From a progressive perspective, Howick also argues that practitioners should weigh high-quality evidence, and, drawing on their clinical expertise, integrate the best evidence that is congruent with patient values and circumstances. According to Howick, only "high-quality mechanistic reasoning," something not frequently called for in earlier evidence hierarchies, can be employed to bolster the strength of evidence in favor of effective treatments. Per Howick, incomplete mechanisms, which are not fully supported by scientific evidence, do not provide coherent inferential chains to link interventions to outcomes (Howick et al., 2010). Drawing on Howick, the following sections introduce issues that have emerged from the EBM debate that could have significant implications for design.

7.1.1 What EBM Offers

Basically, EBM offers a step-by-step protocol whereby practitioners initially determine the information need (that involves, for instance, diagnosis, causation, and therapy) to locate the best available evidence to answer questions at hand (Straus et al., 2010). A critical appraisal concerning validity, impact and applicability of evidence is then undertaken, according to the canonical description (Sackett et al., 2000), combined with clinical expertise and circumstantial parameters. This straightforward protocol has been accompanied by a theory of evidence hierarchy, which consistency places randomized trials at the top and which has remained constant across EBM textbooks over the years.

A theory of evidence

Do certain kinds of evidence carry more weight than others? And how exactly should medicine be based on evidence? When it comes to these details, the evidence-based medicine movement has got itself into a mess… (Worrall, 2010: p. 356)

The core claim that EBM introduces involve a particular view towards what counts as "good" evidence. According to Howick (2011), good evidence is that which introduces, beyond any doubt, patient-relevant benefits that outweigh negative side-effects, possesses external validity, and, ideally, provides information on available alternatives. All these attributes within the rhetoric of EBM converge onto randomized trials or systematic reviews of randomized trials, which are considered categorically superior to observational studies, clinical expertise, and mechanistic reasoning (Figure 43). Despite critics (Cartwright, 2007; Worrall, 2007), the proponents of EBM have persisted in arguing that the results of randomized trials imply the best causal conclusion.

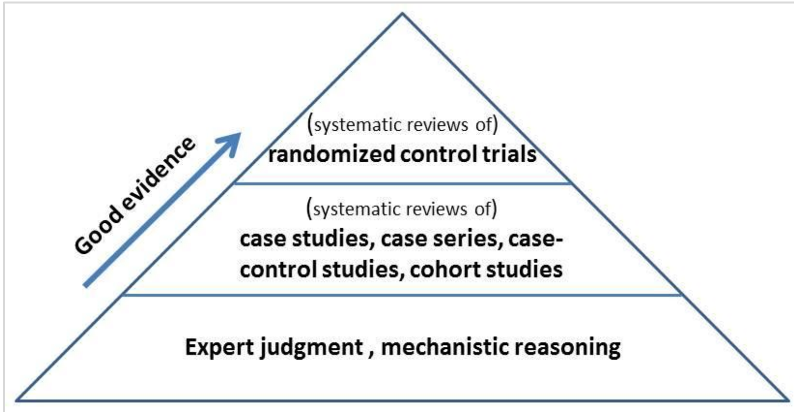

Figure 43. Simplified version of EBM evidence hierarchies (Adapted from Howick, 2011)

Unlike randomized trials, observational studies (including case studies, case control studies, and cohort studies) suffer from three kinds of bias: self-selection bias, allocation bias, and performance bias. Observational studies (middle step in Figure 43) lack random allocation and experimental administration, and therefore it is difficult, if not impossible, to control variables in the phenomena observed (Howick, 2011). Although it was recognized that observational studies have strengths in providing a certain level of external validity, the EBM textbooks clearly suggest that practitioners discontinue use of non-randomized studies and invest in finding articles based on randomized trials (Sackett, et al., 2000). Following this line of thought, EBM proponents go beyond devaluing observational cases to provide several cases drawn from the history of medicine that suggest the ineffectiveness of accepted treatments when re-investigated using randomized trials.

“More measured voices” within the EBM community, according to Worrall (2010), acknowledge the value in randomized control trials while suggesting that other kinds of trials also provide reliable evidence. Glasziou et al. (2007) and Howick (2011), for example, emphasized the potential of observational studies and systematic reviews of observational studies to provide sufficient evidence when putative effects outweigh plausible confounding factors. While committed to the methodological strengths of randomized trials, Howick (2011) suggested consideration of evidence emerging from rigorous high quality observational studies that were carefully adjusted to reduce confounding factors. Following Howick's formulation, case studies and case series[29] were immediately dismissed because they did not provide evidence involving comparative investigations. Hence, high-quality observational studies included only controlled investigations (e.g. case control, cohort studies) in which confounding factors were limited to maintain the strength of arguments presented.

Nancy Cartwright (2007) also points out other methods that have the ability to provide reliable evidence with a level of external validity, which is relatively limited in randomized trials. Referring to the notorious trade-off between internal and external validity, Cartwright puts forward "vouchers," one of them is the case study methodology, which provide an extended range of applications. Randomized trials, by contrast, deductively provide results that are "valid for the group enrolled in the study, but only for that group" (Cartwright, 2007: p. 12). Cartwright argues that such voucher methods introduce inductive weight to a conclusion without deductively assuring the conclusion. The main point Cartwright makes is that "there is no a priori reason to favor a method that is rigorous part of the way and very iffy thereafter over one that reverses the order or one that is less rigorous but fairly well reasoned throughout" (Cartwright, 2007: p. 19). Cartwright's argument openly challenges the hierarchies of evidence represented in pyramids where RCTs are on top, followed by observational studies, expert judgment and mechanistic reasoning. The next two sections briefly expand the issue around expert judgment and causal mechanistic reasoning in clinical decision making.

Causal mechanistic reasoning

As Howick notes (2011), mechanisms can be employed for various purposes, including providing an explanation (Machamer et al., 2000) or an account of the "secret

[29] How case studies are framed in EBM methodology is important since in architecture best practices are typically presented in the form of case studies.

connexion" (Hume, 1975) between phenomena observed. However, within the scope of this study, the main consideration is of mechanisms that are utilized as evidence for decision making. As Howick et al. state (2010: p. 434):

> *Mechanistic reasoning is the inference from mechanisms to claims that an intervention produced a patient-relevant outcome. Such reasoning will involve* ***an inferential chain*** *linking the intervention (such as antiarrhytmic drugs) with the outcome (such as mortality).* (Emphasis added by author)

In simple terms, mechanistic reasoning is characterized as a particular mode of cognitive operation linking inputs to an output, occasionally involving a step-by-step explanation of "the black box" between intervention and outcome. Howick et al. (2010) speak of high-quality mechanistic reasoning, which involves providing a causal argument that is supported by only high-quality evidence, preferably randomized trials, for each link within the chain. The authors provide an example that illustrates a complete[30] evidence-based mechanistic chain, where each step is well-understood and based on quality research evidence (Figure 44). The diagram depicts a rather progressive approach that also provides room for non-randomized studies (see second half of the "chain" in Figure 44) for a complete mechanism as reliable evidence. The critical feature of such a mechanistic reasoning model as evidence is that "it involves a coherent inferential chain linking the intervention with the patient-relevant outcome" (Howick, et al., 2010: p. 434).

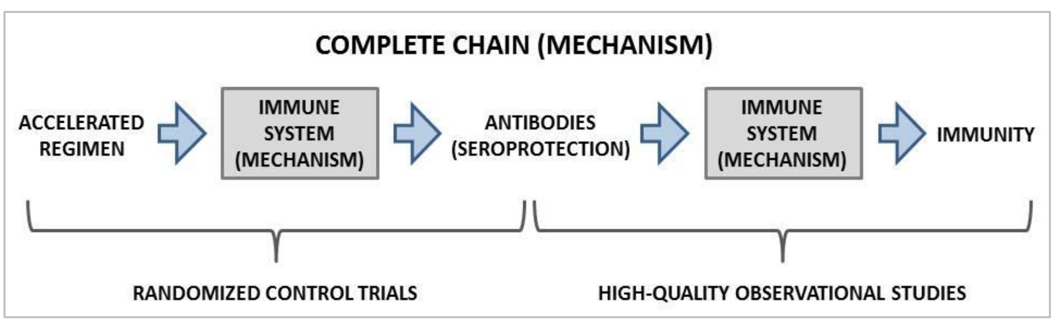

Figure 44. A complete chain of high quality evidence-based mechanistic reasoning (Adopted from Howick et al., 2010)

[30] The term "complete mechanism" is used here instead of Howick et al.'s term "not-incomplete mechanism" (Howick, et al., 2010).

Obviously, not all mechanistic causal arguments are as well-understood as the diagram presented above. Howick and colleagues recognize two prominent epistemological problems with mechanistic reasoning. First, the causal mechanistic arguments occasionally rely on incomplete chains with empty or partial mechanisms, which directly affect evidential strength. In such cases, the understanding of entities and activities within mechanisms is incomplete, and hence the inference is flawed. The second problem with mechanistic reasoning involves the complex and often probabilistic nature of mechanisms, which directly affects inference from causal chains. The complexity involving individual mechanisms or interactions between components within mechanisms “makes reasoning from knowledge of what happens via (some of the) mechanisms under intervention to a prediction of a clinically relevant outcome highly uncertain” (Howick, et al., 2010: p. 437). From this perspective, mechanistic reasoning can only play a supportive role in the context of high-quality evidence emerging from comparative clinical trials (Howick, 2011).

For both of the two problems described above, practitioner expertise comes into the picture for filling in gaps or completing links in causal mechanistic models. The role of expertise in evidence-oriented practice presents another controversial issue: the occasional utilization of anecdotal and observational evidence in making clinical decisions.

The role of expertise

As the definitions of EBM have been modified over time, there has been a visible shift in the understanding of clinical expertise in evidence-oriented practice (Figure 45). Haynes and colleagues (2002) provide a straightforward narrative of how the integration of clinical expertise into EBM models evolved over time. According to Haynes and colleagues the shift involves introducing a series of responses to emerging criticism and a new prescriptive model of practice to replace descriptive models (Figure 45b).

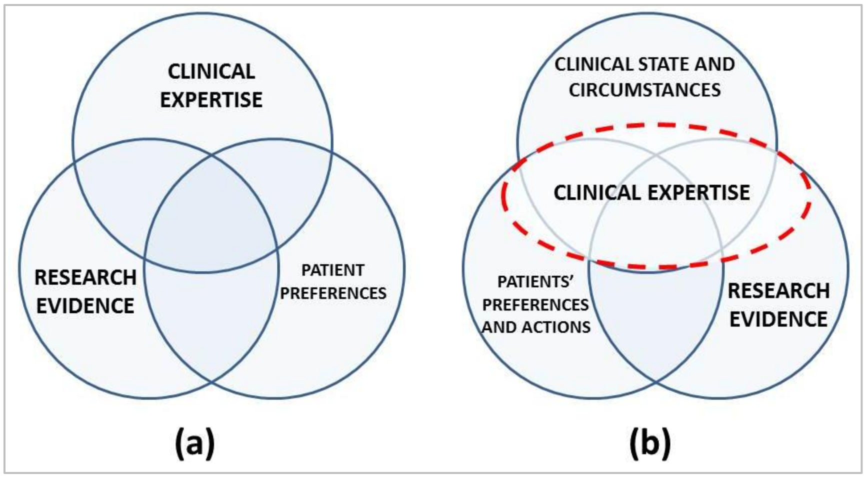

Figure 45. (a) Descriptive and (b) prescriptive models of EBM (Diagrams adapted from Haynes et al., 2002)

Early EBM models (Figure 45a) presented clinical expertise as one of the three key elements within practice, although the initial accounts of ideal EBM practice were unquestionably dominated by arguments in favor of high-quality research evidence instead of traditional determinants (Haynes, et al., 2002). Expertise was of secondary importance, and the main focus was on retrieving and utilizing the best research evidence available. The updated model (Figure 45b), by contrast, located clinical expertise in the center. Clinical expertise intersects clinical state and circumstances (varying best evidence within different clinical situations), patients' preferences and actions (considering patient particularities), and research evidence, preferably high-quality randomized trials and observational studies (Haynes, et al., 2002).

The updated EBM model underscores the role of clinical expertise as a tool to "encompass and balance" the three components surrounding the practice, rather than as a pure source of medical knowledge to be employed. In Haynes et al.'s account, expertise is characterized as a set of translational skills required for "doing the right things" for the care of individual patients:

> *Clinicians must be atop not only the research evidence, but they must also acquire and hone the skills needed to both interpret the evidence and apply it*

appropriately to the circumstances - doing the right things. (Haynes, et al., 2002: p. 38)

The model represented in Figure 45b connects us back to the issue of utilization of evidence emerging from various sources, including randomized trials and observational studies. As pointed out by Cartwright, in practice, it is not uncommon to call for 'non-rigorous' judgments in exporting particular claims manifested through rigorous test trials to a given target case.[31] The evidence at hand, whether emerging from randomized trials or from mere anecdotes, has to go through a practical meta-filter, which has been collectively created, before it is utilized in actual situated decisions.

7.1.2 Summary

I have considered, briefly, three major issues from the critical discussions of EBM that have substantial implications for evidence-oriented design in the healthcare design domain. The three issues involve questions of; 1) what is the theory of evidence in EBM, 2) the role of causal mechanistic reasoning processes, and 3) the role of expertise. Concerning the theory of evidence, it is clear that EBM conveys a theory through established hierarchies of evidence, mostly depicted in a pyramidal form where randomized control trials are on top. However, critical voices have emerged that highlight both the shortcomings of randomized trials and the value that observational studies can bring into practical relative to the EBM model. The challenges raised have not been totally ignored as the definition of EBM evolved over time and as high-quality observational studies are also included in complete causal mechanistic models that characterize the outcomes produced through certain interventions. However, on the other hand, the epistemological problems with causal mechanistic reasoning, involving empty

[31] Similar point made by **M7**, the mechanical engineer of the project who produced "reliable models" to support decision making, who also stated that: "There's a lot of judgment involved in every step of this profession".

or partially understood mechanisms and the complex and often probabilistic nature of mechanisms, are also acknowledged in the field. Howick et al. (2010) rightfully warns about weak mechanistic chains as unreliable evidence, while acknowledging the potential of high-quality mechanistic reasoning involving an evidentially justified chain, which does not have obvious missing links and does take potential complexities into account. Concerning the role of expertise, on the other hand, there is also a visible transformation in characterizing decision making in practice. Early narratives of evidence-oriented practice, presented in Figure 45a, were dominated by utilization of high-quality research evidence over traditional determinants, whereas recent models acknowledge the central role of expertise in interpreting circumstantial factors, patient preferences, and research evidence. Clinical expertise as a tool, in that sense, is seen as an inseparable component of practice, where practitioners draw on skills to interpret and apply evidence emerging from different sources. The unresolved issues that challenge the evolving model of EBM are important for our consideration of the way the concepts and methods from EBM are being exported to another domain, namely design.

7.2 Practice observed

The multidisciplinary team observed in this project was committed to pursuing an evidence-based design (EBD) project for a hospital that is to serve a rapidly growing community in the United States. As stated in the very first meetings, running an EBD process was the leading goal of the project. The intention was to follow the pre-established norms of EBD practice, which involve creating and sustaining an interdisciplinary team to drive an evidence-oriented design process. How established norms of the EBD approach influenced the process and design thinking in general is the focus of this study.

In his book *Design Thinking*, Peter Rowe provides an extended analysis of normative positions in architecture (Rowe, 1987). These positions, either in the form of categorical systems or strong doctrinaire positions, facilitate “frameworks necessary for answering what proper architecture is” (Rowe, 1987: p. 119). Rowe provides two examples of such normative positions in statements from the history of architecture; one from Hannes Meyer who addressed architecture by way of its function and another is from Le Corbusier who introduced five ingredients[32] of “proper” architecture. The overarching characteristic of such positions, as Rowe emphasizes, is that they provide “direction for action.”

According to Rowe, statements of normative positions in architecture, including the ones mentioned above, share common characteristics including “the location of a problem or of pertinent issues under contention, an unfavorable assessment of prevailing practice and an enumeration of untapped opportunities, and a counterproposal with its rationale”[33] (Rowe, 1987: p. 116). Rowe goes on to elaborate on functionalist, populist, conventionist, and formalist positions[34] as exemplary classes of theoretical positions in architecture, each representing concepts of “proper architecture” and, certainly, providing direction for action which, according to Rowe, brings together “design thinking, the artifacts from its practice, and theoretical pronouncements from the same or a nearby source” (Rowe, 1987: p. 149). A functionalist position, for example, formulates architecture as “a matter of accommodating the functions that are prescribed for it and of functioning in a manner that is consistent with its material composition and construction”

[32] Well known to students of architecture, the five points include supports, roof gardens, free plan, horizontal windows, and free design of the façade.

[33] These statements can be located in primary sources of EBM and EBD. The introductory article for EBM, for example, opens with the sentence: “A new paradigm for medical practice is emerging.” (Evidence-Based Medicine Working Group, 1992: p. 2420). Similarly, Cama’s (2009: p. xiv) first chapter opens with: “A new strategy has emerged for the design of our buildings and in particular the design of our healthcare facilities; it is called evidence-based design.”

[34] See Rowe (1987) for an extended analysis for these four positions.

(Rowe, 1987: p. 124). According to Rowe, the functionalist position is exemplified in "the spatial organization of urban and suburban areas, with their adherence to concepts of transportation efficiency and an economically determined distribution of land uses" (Rowe, 1987: p. 125).

Following Rowe's characterizations, I would argue that EBD maintains the potential to facilitate and propagate a normative position oriented towards achieving particular health and organizational goals, such as safety and efficiency, by means of introducing physical environment interventions. EBD was introduced as a call for designers, or interdisciplinary teams, to pay increased attention to scientific evidence in designing hospital facilities. However, the current rhetoric of EBD is observed to be evolving into a normative position, which is becoming *de rigor* in healthcare design domain as more practitioners and healthcare organizations engage in evidence-oriented practice. The case observed in this research presents a stage in EBD's evolution where not only a set of (norms for) physical environment features was circulated by means of a variety of representational forms[35], but also a certain model for collective and individual reasoning, namely mechanistic reasoning, was propagated and influenced the socio-cognitive landscape of architectural design. I will substantiate this argument by referring back to episodes within the case observed in this study. Initially, following the theory of evidence in the field of medicine, I will frame the notion and scope of evidence observed in practice. Then, I will consider the gaps in available evidence and refer to particular events in the process where team members, individually or collectively, attempted to fill in gaps by creating evidence that emerged through traditional practices in architecture (e.g., a charrette and mock-ups), which was employed in other socio-cognitive practices (i.e., mechanistic reasoning) imposed by evidence-oriented practice.

[35] In the case observed, the concentrated introduction to EBD in the visioning meetings employed diagrams, precedents, and stories from practice.

7.2.1 A Theory of Evidence

EBD promotes itself as following the medical model (Edelstein, 2008; Hamilton, 2003), although a deviating trajectory in design was acknowledged by several authors (Viets, 2009). Such deviation is visible even in the way primary resources of EBD frame the term “evidence,” as “information gleaned from published research studies, professional practice articles, and best practice reports” (Quan, et al., 2009: p. 36). The primacy of scientific research evidence, however, is strongly and repeatedly stressed in introductory texts on EBD (Cama, 2009; Kent, et al., 2009; Malone, et al., 2008; McCullough, 2010b; Quan, et al., 2009; Zimring & Bosch, 2008). One of the guidebooks of EBD -*Building the Evidence Base: Understanding Research in Healthcare Design*-, for instance, is dedicated to providing a general introduction to scientific research and related terminology, the utilization of which, according to authors, marks a departure from traditional design processes. Nowhere in this book can anecdotal evidence be found, even though there is recognition of experiential knowledge emerging from both experts and users. Rather than suggesting any novel theory of its own, the developing literature on EBD follows a framework of evidence that is similar to the one in medicine, where the dominant emphasis is on high-quality scientific research. There are, however, visible tweaks, including an increased interest in case studies, often introduced as “best practices” or “success stories” that possess the potential to inform design decision making.

Throughout the project meetings and work sessions observed in this research, the term ‘evidence’ was infrequently used. My analysis of the events over the course of the project, presented in the form of episodes in preceding chapters, has nonetheless provided hints about the varying notions of evidence that were embedded in participants’ actions and statements. In subsequent interviews, on the other hand, I explicitly asked participants to describe their understanding of evidence in the context of the ***PHSP*** hospital project. The participants presented a flexible notion of evidence, which was similar to what I observed in meetings. Although most team members[36] referred, to some extent, to the prevalent definition of EBD (i.e., "conscientious, explicit, and judicious use of current best evidence from research and practice in making decisions"), they typically went beyond scientific research and mentioned the set of user-based information that was considered as evidence in the project. For instance, ***D1***, the lead project architect, provided an extensive response to our question "what is evidence for you?"

00:27:47 ***D1*** *… What's, if there are, success stories, if there are things that can be gleaned from past projects that have come before your project. Why wouldn't you want to learn from them? Uhmm, and you might, could call that somewhat evidence-based, but I think there is a lot more rigor, a lot more expectation with true evidence-based design. I think it takes more of a cue from what has been practiced in medicine for a long time, which is evidence-based medicine. So, rather than just, you know, saying, oh I've read a mag... out there reading magazines, and I've kind of seen the trends, that's how I'm doing what I'm doing today, that's only a part of it. I think it goes a lot deeper into true, true evidence and research and that's a lot more factual based.*
…I guess evidence to me is anything I can, sort of, hang my hat on as far as, things that are just, definite items that just aren't negotiable. Things that really need to find a way into the project, you know, that are gonna help you navigate. When you could do A or B, you know, and you need to make a decision, I think, I think evidence to me is how much can we weed out all the arbitrary decisions, and make thoughtful decisions that matter…

Plurality in characterizing evidence, as it is developed by the larger team, is visible in a single interview excerpt with the lead architects of the project. More importantly, ***D1***'s statements reflect the tension between scientific evidence, which is emphasized in EBD, and other types of evidence (e.g. anecdotes, best practices) used among architects interacting with the ***PHSP*** project on daily basis. ***D1***, in her interview,

[36] There were individuals in this project, including ***O2***, ***O3***, ***D1***, ***D2***, to hold the evidence-based design accreditation and certification (EDAC) awarded by the Center for Health Design.

contrasts “somewhat evidence-based” to “true evidence-based”, which is something she defines as “what has been practiced in medicine.” While acknowledging the intention of “true evidence-based design” as relying on utilization of scientific research, ***D1***, as her answer unfolds, immediately develops a specific characterization of evidence as “anything I can hang my hat on,” which includes non-negotiable items, such as “things that really need to find a way into the project.” As mentioned earlier, ***D1***, was the person in meetings, including larger steering committee, mock-up and other side reviews, to keep official meeting minutes where participant statements and particular requirements were recorded; this helped architects to “weed out all the arbitrary decisions.” Obviously, not all statements were supported by scientific research, and many were anecdotes that helped architects to advance floor plans.

In his response, ***O4***, the president of the ***PHSP*** hospital, also acknowledged that scientific research evidence was not the only driver throughout the project, as the team explored several emerging ideas in the healthcare industry:

00:17:32 ***O4*** *So, to your question, to me evidence truly is that has… researched and proven. But in our thinking we also looked at what are some of those out there that aren't totally proven, but they make sense. and, uhmm, that's where the same-handed rooms came in.*

O4 indicated the limitations of available research evidence that the team could have utilized in making design decisions. As project progressed, the team considered design ideas at different scales that were not substantially supported by scientific research evidence in healthcare design. Same-handed rooms, for example, was one of those ideas that was not “totally proven” to be contributing to safety in healthcare, but it made sense for the participants, through supporting anecdotal accounts, to adopt it despite its premium cost.

In order to arrive at “a thoughtful decision” in the absence of confirmatory research findings, the team also considered emerging anecdotes and a generative tool, namely mock-ups, as sources of local evidence that eventually influenced the building program and layout. These segments of evidence, which were generated internally, helped participants to fill in the gaps within scientific evidence that was, according to the description propagated within the community, expected to guide practice instead of anecdotes and individual expertise.

7.2.2 Filling Gaps in Chains of Evidence

Concerning evidence and situated design decision making, three sources need further discussion concerning their ability to fill in the gaps in available scientific research: best practices, anecdotes (to represent both outstanding practices in industry and participants' own and observed activities) and local experiments. In the form in which they emerged in this study, neither anecdotes nor local experiments can be included within the boundaries of rigorous research. Mock-up exercises, however, to some extent, made use of environment and behavior research methods in that they utilized surveys or quick experiments to test functional capabilities. Anecdotes emerging from best practices or participants' own experiences and observations, on the other hand, continuously surfaced in interviews or in project meetings, and provided the interdisciplinary team with a set of reasons in which they grounded their design decisions.

Healthcare design projects traditionally employ physical mock-ups for a variety of purposes (King et al., 1982; Peavey et al., 2012). Peavey et al. (2012), for instance, mention the valuable contributions of mock-ups involving activities in which user immersion is facilitated. Although the mock-ups came relatively late in this process, the participants in the ***PHSP*** project exploited several strategies, including walk-throughs and surveys, to solicit user reactions, which then provided designers with reasons for modifying the design. ***O1***, the ***PHS*** project manager, recognized the ability of mock-ups to generate user-based evidence[37] that could be utilized in decision making at various scales:

00:06:56 ***O1*** *Evidence-based is your decision is based on facts or findings or evidence, on a test of a given similar design, or your design. Sort of why you do mock-up rooms.*

… We build the room, they walk in and say, well this won't work for these ten reasons, or for these two reasons. You're standing in there and say why won't it work, and then you kind of solve the problem. And they can do because they can touch it, feel it, point it say, no I need to do this. Or say, let me go and get this piece of equipment, and bring it in the room and watch how and what I have to do to hook it up. Now, we could do it in hospital, in any room, but, you know, this is sort of the, what's the designers work with the users in small groups. And then you start to sit there next to, now move that over here, I want to be able to reach it. They don't know that's four-eight inches off the floor, or something. They just know they want that height. When they do that, and we measure, then we modify what they're trying to say, we end up with a better product. It's just, you know, again it's a tool. And, uhh, it's expensive, but, uhh, whatever we spend on that we avoid ten times that in problems, or failures, or things of that nature.

O1's definition of evidence-based, in this interview, is, again, not bounded by research findings, but includes mock-up studies that are internally conducted experiments to investigate constraints and affordances of the design at hand. From this perspective, mock-ups provided a platform for experiencing two critical aspects of the design work. First, even though the interdisciplinary team possessed insights to how individual physical environment features might work, precedents and research studies fell short in providing reliable evidence about how the unique configuration of the patient room would work as a whole. The patient room had novel features including elements based on scientific research (e.g., hand rails from bed to bathrooms) and in-house experiments (e.g.

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[37] In this context, the term "user-based evidence" indicates evidence emerging from users' accounts that communicate particularities of their local practices.

an angled corridor wall). Second, as ***O1*** emphasized in the excerpt above, the interdisciplinary team's expectation was to benefit from the embodied affordances of mock-ups in generating situated evidence based on staff members' interactions with this "expensive tool." As mentioned earlier, the patient room, with its dimensions and features integrated within, was entirely new for the nurses, who were practicing in the fifty-year old ***PHSP*** hospital. By means of a physical mock-up, the interdisciplinary team explored the proper fit between the set of novel physical environment features, projected care processes, and everyday practices of nurses who were given the chance to "touch," "feel," and even manipulate their future work spaces.

In her interview, ***D1***, the lead architect, referred to another form of embodied and situated evidence, the green zone, which was presented earlier in Chapter 5 (on the design process of the emergency department, *Section 5.1*):

01:01:29 ***D1*** *They have already been running trials, they've been testing certain ideas that they have, they got a green zone they've done in their ED which is basically a quick care area to try, and decongest the ED so that they can, you know, take care of the less acute and less critical, so that they can sort of streamline the treat-and-street sort of concept, and they've been testing things like that.*

Even during pre-design phases, there were certain types of tests conducted in existing environments that provided evidence to influence the future building program and design decisions. Rather than searching, locating, and implementing a ready-made fast-track concept, the team's approach was to build upon lessons learned from the green zone experiment in order to create a model that fit local needs. Additionally, the developing model required certain modifications based on anecdotes emerging from practice. Anecdotes that were introduced by the intended users, in addition to the outcomes from tests described above, were incrementally developed into larger stories (Chapter 6) which eventually formed another source of evidence. These stories, over time, closed the gap where rigorous studies published in the healthcare design and research literature fell short in meeting particular needs of the project at hand. The stories, which were created through intense interactions with hospital staff, were the repositories of evidence to shape the physical environments in the future facility. As denoted by ***D2***, who assisted ***P1*** in space planning, there were certain episodes throughout the design process where users' propositions were not challenged, but were instead immediately translated into design:

00:05:56	***D2***	*So those are the, that's the only… The mirrored, the vision panel here for security to be able to see through, beefing up the teaming area. I think that's the only change that happened.*
00:06:18	***I***	*So you're not calling it nurse station?*
00:06:21	***D2***	*No. No nurse station, they're teaming areas.*
00:06:27	***I***	*Did you check any, kind of, research about this area? Or…*
00:06:30	***D2***	*Oh, we relied totally on the users.*

7.2.3 Summary

Two sources of evidence, local experiments and user anecdotes, suggest a practical model for activating, generating, and utilizing evidence in decision making. These types of evidence, however, are not always scientific or research-based; instead they are extracted from the actual hospital staff in the form of anecdotes from practice or are created internally by means of physical mock-ups that provide embodied and situated evidence. From a functional perspective, the local experiments and anecdotes provide the grounds to link the general to the specific circumstances. The variety in implementing distributed nursing stations in industry illustrates this particular function of anecdotes and local experiments in contextualizing ideas offered by research.

Although they recognize the potential contribution of mock-up exercises and user-group meetings, the major sources on EBD repeatedly underscore the primacy of scientific research and offer methods of accessing, evaluating, and translating particular outcomes of rigorous studies. Practice as observed, however, points to a model where practitioners pursue and, in some instances, give preference to evidence that surfaced within the system more than evidence that emerged from scientific research. Throughout this process, the architects' "meta-expertise" in capturing, interpreting, re-presenting, and communicating evidence in a variety of media (e.g. layouts in user-group meetings, or strategically planned mock-up exercises) provided a ground for manipulation, re-evaluation, and consensus-building among individuals with different disciplinary backgrounds. These instances, where participants interacted with re-presentations of evidence, facilitated situated decision making that was not always supported by scientific research evidence, but was supported by other types of evidence emerging from in-house experiments and anecdotes.

7.2.4 Mechanistic Reasoning

Starting from pre-design phases, the intention was to have a structured process that was oriented towards achieving the pre-established goals of the project, which were not all entirely architecture-based concepts[38]. Throughout the project, the members of the interdisciplinary team constantly questioned whether or not the decisions at hand were consistent with the goal of "creating the world's safest hospital." In their pursuit of this goal, I observed the participants employing segments of particular causal mechanistic arguments in both design meetings and interviews, where they introduced stories about particular design features.

In project meetings and interviews, mechanistic chain models (generally, testing an intervention against visibility, efficiency, or, ultimately, safety as an outcome) appeared in participants' statements (see Figure 44). An instance from an interview with

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[38] These principles, as they were listed in the visioning document, included "leading with EBD concepts and innovation, flexibility, creating a holistic environment, efficiency, sustainability, environments that enable success, wellness and prevention focus, integrative experience, being employer of choice."

M7 (MEP consultant) exemplified this type of mechanistic reasoning as he introduced particular interventions concerning his domain of practice. The chapter on inpatient room design presented an example of mechanistic reasoning that ***M7*** advanced concerning the displacement ventilation system. In the interview segment presented below, ***M7*** talks about another system, the ultraviolet germicidal irradiation system (UVGI), which has the potential to positively impact infection rates:

00:11:14	***M7***	*Most of what I do doesn't have that much research behind it. Uhmm, use of ultraviolet light in an air handling system to clean the air, there is evidence about what ultraviolet does to keep coolant coil clean, and I've actually been involved in shining ultraviolet on a dirty coil to see what happened, it is remarkable. The sales brochures are actually true. And there is evidence that ultraviolet kills what is in the air. What effect does that have when occupying a space? Can't find any research to tell me that.*
00:12:19	***I***	*Mm-hmm*
00:12:21	***M7***	*Uhmm, just killing the bugs in the air doesn't mean that you necessarily improve the air quality in the space. You can assume that was gonna get trapped by filtering light. So just measure downstream in filter and tell me the difference. I can't find that out. Let alone actual experiential data for what happens to humans in the space.*

M7, in this excerpt, introduces a chain of statements bound together to suggest that an intervention (i.e., use of ultraviolet light) could lead to an outcome concerning human occupants. However, the chain, according to ***M7***, is incomplete in that not all steps were supported by evidence, and that the effort to fill in the gaps within the chain was as yet unsuccessful (*I can't find that out*). Then, ***M7*** mentions how one can fill in the missing link by "assuming" benefits that lead to the desired outcome within healthcare environments. Being aware of the missing, un-studied, or less-understood link in this model, ***M7*** went ahead in a later steering committee meeting to propose utilization of UVGI in the new ***PHSP*** hospital, and his proposition was well-received by the client representatives.

D2 also introduces chains within a causal argument when asked about the evidence-base related to implementing a fast-track area for emergency services:

00:31:45 ***D2*** *Well, the… All we can say is that the reduced the lengths of stay and reduced wait times reduce stress. So uhmm, perceived wait times also going to that as well. If you spend time in a waiting room, your stress is increased. Umm, and the process here is that a patient is checked as soon as he or she walks in the door. They are observed by a physician. So that they know exactly where they're gonna go as they walk in the door, rather than, you know, sitting in a waiting room for thirty-five - forty minutes. So, uhm, we can... That's* **[reduced wait times reduce stress]** *where the evidence comes from. This is all about reducing wait times, reducing the stress on the patients, and getting them in and out in a more efficient process.* (emphasis added by the author)

The fast-track area under consideration was projected to eliminate the need for the traditional triage concept and its associated protocols and spaces by introducing a new process using chair-centric bays to reduce waiting times in emergency services. This was suggested as decreasing stress for both patients and hospital staff. Although the idea was initially introduced as a process model, the architects were required to engage in details of care protocols because the protocols would have significant implications for layout configurations. The ultimate aim was to achieve high levels of satisfaction and efficiency by implementing a fast, effective and efficient process in an environment that is inherently full of stress, tension and drama, a characterization partially introduced by hospital staff in the form of anecdotes.

The reasoning processes suggested by participant statements parallel the mechanistic models of EBM presented earlier in this chapter. Figure 46 below juxtaposes the three chains, one adapted from EBM literature (Howick, et al., 2010) and two grounded in our observations, which progress through segments linked by causality.

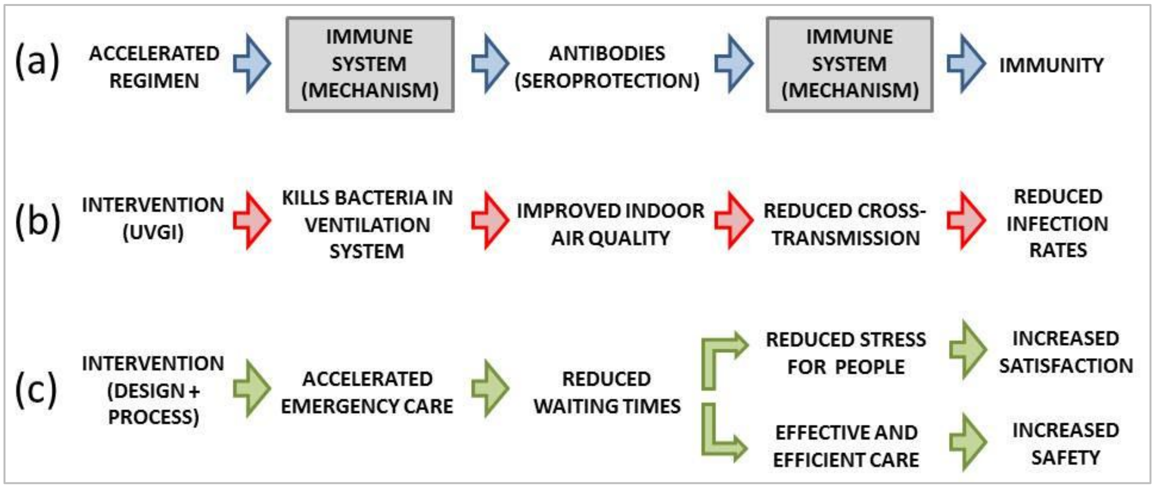

Figure 46. Simplified causal mechanistic arguments within three domains (a) medicine, (b) engineering, and (c) architecture

As Howick emphasizes, obviously not all mechanistic reasoning is created equal (Howick, 2011; Howick, et al., 2010), and these models suffer from partially understood or missing links. Accordingly, segments within causal chains in engineering and architecture (Figure 46b and c) were not fully supported by scientific research such that they do not strongly suggest a complete and reliable model of a mechanism. However, the overall structures of the two examples provided in the diagram were created, maintained, and propagated within the larger community of practice and were observed to permeate design thinking as designers or engineers introduced complex interventions (*treatments*) involving processes, space, and people. In the case of fast-track area design, for instance, the architects were observed to be engaging in reasoning processes concerning particular segments within longer chains having an extended scope (e.g. architecture, medicine, engineering, systems and process design), as they considered the potential effects of their design ideas on efficiency and satisfaction (Figure 46c).

Although other forms of reasoning can be found over the course of the project presented in this study, causal mechanistic reasoning was observed to be the dominant cognitive mode, both individually and collectively, across the members of the interdisciplinary team. In individual sketching exercises, the architects were the ones to test and develop their ideas, (e.g. introducing an angled wall to patient rooms) against these causal mechanisms before presenting their ideas to client representatives or users. The architects translated propositional forms of these mechanistic models, illustrated earlier in Figure 46, into architectural representations (e.g. layouts, mock-ups), which allowed other participants to provide feedback, sometimes by means of manipulation (e.g., moving the corridor wall), to improve the match between causal models and projected spaces of the future facility.

In collective discussions, on the other hand, the yard sticks for design ideas were again chains of causal mechanisms, segments of which seemed to attract individuals with different disciplinary backgrounds (e.g., developing the details of the fast-track area to achieve effective, efficient and safe protocols). These causal mechanisms, by their very nature, accommodated problems that occasionally forced participants to reason beyond their particular disciplines. As ideas or design solutions were externalized and represented through sketches, layouts, and mock-ups, the architects benefited from the distributed expertise of the team by means of interacting with client representatives, consultants, and users, all of whom provided anecdotes concerning their everyday practices, which helped to fill in gaps in designers' knowledge base. As mentioned earlier, within the EBM community, the status of mechanistic reasoning as a reliable form of evidence is questionable due to its incomplete and partially understood mechanisms. In the project presented in this study, however, causal mechanisms were the prominent structures that allowed practitioners to speculate, systematically or not, about design features within given conceptual constraints concerning productivity, satisfaction, visibility, accessibility, and safety. The way architects thought about the spaces that they were tasked to create and the way they explained these spaces to others contained forms of mechanistic reasoning that incorporated a bricolage of evidence drawn from scientific research, best practices in industry, anecdotes, and in-house experimentation.

7.3 EBD: In Principle versus in Practice

We must have complete transformation of the entire design process into an interdisciplinary approach, one that begins by asking a clinically relevant question, "What would be the outcome (safety, efficiency, satisfaction, healing, cost, culture) if we did this?" (Stichler, 2008: p. 127)

According to Hamilton (2003), in EBD practice, there are four stages of involvement, corresponding to four different levels of applications. Addressing practicing architects in the field of healthcare, Hamilton explicitly describes these stages where practitioners are required to engage in a variety of activities. As outlined in the article, Level 1 EBD practitioners (such as architects and various design professionals) fulfill minimum requirements of EBD practice by staying up to date with literature and extracting relevant evidence and applying it to ongoing projects. By the Level 4, the practitioner is expected to follow the literature, hypothesize the link between design interventions and health outcomes, measure the results and report them, and, if possible, "collaborate with social scientists in academic settings who contribute to the formal literature" (Hamilton, 2003: p. 24). Hamilton's scheme outlines a certain progression from a knowledgeable designer interacting with a specialized body of knowledge to a scientist publishing in peer-reviewed journals. Hamilton, one of the prominent figures within the industry in the U.S., is here making a striking proposal that points to the next generation of issues concerning specialized knowledge and architects' professional autonomy. The focus in this section is on the rhetoric of EBD insofar as it communicates a model of practice, like Hamilton's framework, and the influence of this rhetoric on the project observed in this dissertation.

Hamilton's four-tier proposal above (Hamilton, 2003), alongside other EBD frameworks offered in the literature (Cama, 2009; Malone, et al., 2008), projects an evidence-oriented practice that infuses design processes at various levels, spanning from project management activities to situations where individual and collective design thinking occur. At a process level, the proponents lay out a set of norms for conducting an EBD practice that promotes evidence-oriented interdisciplinary design teams to drive healthcare design processes (Cama, 2009; Hamilton, 2003; Malone, et al., 2008). In addition to the usual participants on integrated project delivery teams, the EBD-oriented interdisciplinary teams are required to include individuals with a level of expertise in scientific methods to maintain a continuous interaction with evidence emerging from literature and to help design research projects that will be conducted in settings where the teams have acces to (e.g., baseline investigation) and in future environments that will allow the teams to compare the impact of design interventions against baseline metrics. Furthermore, in this model, the task for the researcher is to mediate the integration or creation of evidence as an interdisciplinary team progresses from pre-design to post-occupancy phases. As teams attempt to base design decisions on the best available research evidence, the existence of such researchers, alongside other stakeholders, introduces another threshold in design decision-making processes, which involves processing available evidence on the effects of the environment on patients, staff, and visitors from a variety of perspectives. In other words, in a given EBD team, a "designerly"[39] way of thinking is continuously accompanied by a form of scientific reasoning in which space is considered as a variable, in tandem with projected care processes, that affects outcomes.

In the case observed in this research, the team had interacted with a researcher, ***R1***, who intermittently engaged with the team from a distance. Although ***R1***'s involvement was limited once the visioning meetings were complete, there were other members of the team –mainly ***O2***, ***D1*** and ***D2***– who, to some extent, maintained the stated norms of EBD practice (Cama, 2009; Kent, et al., 2009; Malone, et al., 2008) at an

[39] The term "designerly" refers to Nigel Cross's article –"designerly ways of knowing" (Cross, 1982)- wherein he questions what it means to be 'designerly' rather than to be 'scientific' or 'artistic'.

organizational level. By norms, I mean the documented set of key processes that characterize an EBD practice, including defining project goals and objectives, finding relevant evidence, developing hypotheses, monitoring implementation, and measuring outcomes (Malone, et al., 2008); sustaining engagement with other evidence-oriented communities in industry (e.g. the Pebble Project), and reviewing best practices and attending healthcare conferences (McCullough, 2010a). These key steps were being undertaken through the end of construction documentation, when I finalized my field observations. At that time, participants were initiating two research studies in the old hospital: one related to medicine distribution and the other to flooring materials. ***R1*** provided assistance in designing these research projects, which were expected to provide evidence for both the interdisciplinary team and the industry. The team's plan was to publish these research efforts in a journal. This is a step which fulfills the criteria of Level 4 EBD practice per Hamilton's description (Hamilton, 2003).

The transformation that the proponents of evidence-oriented practice calls for a departure from traditional ways of designing healthcare facilities which "[have] been driven by the last experience of the engaged architectural firm, the personal, clinical and administrative experience of the client, and changes in technology, rather than research findings" (Malone, et al., 2008: p. 2). The episodes of the EBD practice that were presented in previous chapters, however, rendered a practice in which anecdotes, precedents, and expertise were still heavily used. I did not observe any participants perusing a research paper or specifically mentioning a scientific study, although, during field studies, some participants loosely referred to research on a particular topic. However, a quick review of EBD-oriented literature and research studies that practitioners are expected to benefit from reveals the fact that the issues and the forms of reasoning modes parallel the processes observed in the ***PHSP*** hospital project team. I have observed participants characterizing design problems or situations through the causal models formulated in both introductory texts and EBD-oriented scientific research.

I located several original research articles published in prominent peer-reviewed journals wherein researchers studied the effects of particular design interventions on human behavior, and operational, health, and organizational outcomes through causal structures. Mechanistic models, which I briefly introduced earlier in this chapter, are largely in play in these articles. The *Environment and Behavior* special issue on EBD (2008, 40:2), for example, includes articles exemplifying this mode of research, where investigators explore the implications of design features (e.g., single-family rooms in Shepley et al. (2008) or emergency department design in Hall et al.(2008)) on specific outcome variables (e.g., satisfaction and stress levels in Shepley et al. or timeliness in Hall et al.).[40] The arguments and themes in these papers were also present in the case observed[41], even though none of the participants named the journal or similar academic publications during interviews.[42]

On the other hand, it is not surprising to see in these scholarly articles that statistical significance characterizes the notion of evidence. Even in their abstracts, these articles employ a set of statistical terms to report their findings (e.g., adjusted odds ratios and confidence intervals in Hall et al, 2008). When I searched for articles concerning the topics that were discussed in the practice observed, I came across a similar set of terms through which researchers explained the results of their studies. With regard to same-handed rooms for example, I was able to locate a single investigation, by Pati et al. (2010), which reported a study conducted in an experimental setting. Similarly, Pati et al. employed statistical methods to analyze the data which, eventually, did not suggest outcomes in favor of same-handed configurations. In other words, there is no "hard

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[40] In introductory publications, The Environment and Behavior journal is recognized as one of the prominent venues within the field of EBD.

[41] Remember ***D2***'s statements, quoted earlier in this chapter, where he speaks about fast track areas that facilitate an expedited care process which, eventually, reduces stress.

[42] One of the common question in interviews inquired publications that participants followed.

evidence" to suggest that same-handed rooms contribute to safety.[43] This result was communicated repeatedly by participants using somewhat more simplified, statistics-free terminology. However, they did not specifically refer to this particular paper, which is only study I was able to locate, despite a rigorous search, that empirically studied same-same handed room configurations.

How Pati et al. framed their approach to the study of same-handed rooms presents another issue (Pati, Cason, et al., 2010). The researchers graphically communicated a causal mechanistic model, similar to the ones represented earlier (Figure 46), wherein an intervention (i.e., physical environment standardization) leads to a desired outcome, namely operational efficiency and safety (Pati, Cason, et al., 2010: p. 13) This is precisely the model that was present in participants' descriptions of same-handed rooms. Although there is no indication that participants interacted with single piece of research, both the causal argument and the outcomes were readily circulated, with a notable level of fidelity, within the interdisciplinary team.

Introductory texts that explicitly communicate EBD's rhetoric, on the other hand, utilize visual narratives where causal models are embedded in diagrams or layouts to describe particular design features that have become norms of evidence-oriented healthcare design practice. The two recent books by McCullough (2010b) and Cama (2009) are examples of publications in which the authors illustrate ideas, some of them not yet supported by scientific research evidence, that are becoming accepted practice across projects in the United States. These ideas, again, in parallel with design features discussed in the case observed, include location and position of hand-washing sinks, nurse-servers, or like-handed (i.e., same-handed) rooms. Through presenting cases of these design features from real-world practice, Cama, for example, proposes a

[43] Just to remind readers, with regard to same-handed rooms, ***D2*** simply stated that; "the jury's still out there."

framework, similar to Hamilton's model, which requires EBD practitioners to "set strategic goals, hypothesize outcomes, implement translational design," and "measure and share outcomes" (Cama, 2009: p. 10). In addition to the research terminology employed, the structure of arguments presented in scholarly journals, as mentioned above, can also be found in publications addressing mainly designers, namely healthcare architects in industry. Nothing is surprising about leaning towards scientific terminology and associated models in a framework that suggests the primacy of evidence emerging from rigorous research studies. The issue is rather how architects adapt relative to invasive norms of evidence-oriented practice and associated model of design reasoning. The episodes presented in this dissertation suggest that architects, involved in their first project labeled "EBD", were able to quickly adapt to such positions, in both their theoretical and practical aspects, and actively engage in a process that displayed the developing norms of evidence-oriented practice.

7.4 From Science to Design Practice

As has been mentioned repeatedly throughout this study, there were very few instances in which I observed participants to interact with or refer to specific scientific research studies during interdisciplinary meetings or intra-team meetings in the office. Furthermore, whenever there were such moments, the participants' account did not include the context, methods, or other specifics concerning the scope and relevance of the scientific study. The question, then, is how was it possible for the participants to speak confidently about the body of research evidence and causal models that surrounded particular design interventions and associated outcomes. This section attempts to provide a brief answer which is grounded in my observations.

7.4.1 Community and culture of evidence

The set of qualitative data analyzed in this study suggests an existence and influence of a "community" which practices, develops, realizes, and disseminates an evidence-oriented praxis of architecture in healthcare design domain.[44] Frequently mentioned in participant interviews, the interdisciplinary team had gone through an extended pre-design phase over a period of fourteen months during which the team members, individually or collectively, engaged with external parties including consultants or colleagues from other facilities who had recently experienced an evidence-based design projects. The interaction with the larger field of healthcare design was often regarded as a learning process that facilitated an immersion into the concepts and the rhetoric of the evidence-oriented practice in architecture:

00:02:20 ***O3*** *… I think we have educated ourselves tremendously. I learned more about the total package than I ever would have if I had not been on this journey. Uhmm, I did not know a lot about areas such as operating room. But over the last couple of years I have educated myself, I have talked with experts, I have read a tremendous amount. And then, I've gone site visits as well. And I worked with vendors. So I have, uhmm, really become an expert in short amount of time… And we're gonna share our learnings with everybody that wants to see it. Everybody that wants to do it, evidence-based design…*

As ***O3*** notes in the interview excerpt above, the interaction with the larger community is not considered as a one-way transfer, but as a mutual benefit exchange as the team plans to share their "learnings with everybody that wants to see it." In fact, the community actually demands its participants to share the results by means of reporting and publishing the outcomes of the design interventions within hospital projects. The Pebble Project, which included the ***PHSP*** hospital as a partner, urged its members to design and conduct original research studies to be conducted in their facilities, and share the outcomes with other organizations in industry.

The Pebble Project, which is an industry-wide initiative with a number of partners including healthcare organizations, research institutions, and vendors, represents a

[44] "Community of evidence," one of the super-ordinate categories in the coding guide (Appendix C) provides the basis for this analysis.

significant portion of the "community of evidence," as I have called it. Marked with the publication of the green zone case in 2011, which was the first of its kind in ***PHSP*** history, the participants in this study were in continuous interaction with this community over the course of the project. In an interview, ***D1***, the lead designer in the project, expressed her understanding of the Pebble Project:

00:02:20 ***D1*** *… Well, Pebble… I don't. Well, they're different, but I mean they're… Pebble, I think, is more a, uhmm, conglomeration that allows people who want to practice and get educated on evidence-based design, and health. You know, cause, Pebble is really where the, the knowledge base is. I mean they're the ones who are trying to organize it, put it together, create it as a resource, build this community of professionals who tap into it, not unlike PlaneTree did, you know, as a fledgling organization, you know, twenty years ago. So Pebble is more, uhmm, I guess, the organizational structure that allows evidence-based design to grow and stay, you know, rigorous like, somebody wants to keep a watchful eye over it to control it, to make sure that it does not just dissipate, become something that isn't trustable, even trying to build solid knowledge-base. I think that's what Pebble is trying to do.*

While acknowledging the existence of other similar communities (e.g., PlaneTree), ***D1*** characterized Pebble as a "conglomeration" to allow propagation of EBD practice through a community of professionals and a knowledge base. The extended interaction with this conglomeration was influential in making design decisions over the course of the ***PHSP*** project. Engagement with this community and accessing the knowledge base that it offered, which involved visiting brand new hospitals, participating in conferences and colloquiums, talking to subject matter experts, and interacting with the research reports and white papers[45], was continuously transferred into design meetings in

[45] Compared to the giant databases in medicine, this collection is a limited resource which is only available to partners who are expected to contribute to the growing body of knowledge. The official website of the initiative states: "Pebble Partners have access to more than 40 free research reports and whitepapers that link the built environment to outcomes and searchable

the form of precedents in industry, anecdotes, and pieces of research evidence with limited reference to the source or the context of such studies (Figure 47).

Example	Context	Provided by	Sample
Precedent	Interview	***D1***	*And it's really building on chair-centric care that Florida hospital use…*
Anecdote	Interview	***O4***	*We noticed this thing in a lot of hospitals that have gone really good at decreasing the noise level in patient units. But because they have used a lot of solid walls, you couldn't, in the nursing core, when you walk onto the unit, you didn't see people, you didn't hear people, and what they... Most of them say is that sometimes that makes their patients nervous because they don't know anybody's there.*
Scientific Research	Steering committee meeting	***D1***	***O2*** *: The other one pops in my head is the pharmacy. Because it's one area where you definitely want to have direct light... Read prescriptions and read different things, picking medications. So that one can be direct light.*
			D1 *: [Taking notes of what O2's saying] There is studies, I mean the evidence is already out there that says that, [inaudible], the point is that task lighting is not optional, which... focus it where you need it, not just blasting it everywhere, uhmm.*

Figure 47. Bringing precedents, anecdotes, and scientific evidence into design

The "conglomeration" that the team members interacted with included all these elements (i.e., precedents, anecdotes, and scientific research) which allowed practitioners to become versed in developing ideas, concepts, trends, and design features that are continuously being informed by rigorous research conducted in a variety of domains including systems engineering, nursing, aviation, and architecture. Furthermore, the interaction with the larger community including researchers helped the participants to develop an understanding for each design intervention which provided a background for stories that were created and enhanced within the interdisciplinary team. Furnished with a level of knowledge of design interventions and their impact on outcomes, the

databases of relevant research and project examples" (Retrieved from http://www.healthdesign.org/pebble/about).

participants, then, were able to talk confidently about the evidence base without any reference to a specific scientific research.[46] The interdisciplinary team observed in this research was constantly in touch with several individuals from this larger community (e.g., researchers, vendors), and was exposed to the “conglomeration” of knowledge which was filtered and communicated to participants who did not necessarily need to interact with primary sources of evidence.

The body of evidence emerging from this conglomeration is part of the praxis which defines a layer between scientific research and individual projects where interdisciplinary teams struggle to utilize and translate empirical research into designs at hand (Figure 48). Here I deliberately use the term praxis to define an invasive process of developing, enacting, and propagating an evidence-oriented practice in architecture which infuses design thinking with its causal mechanistic models as basis of design decision making.

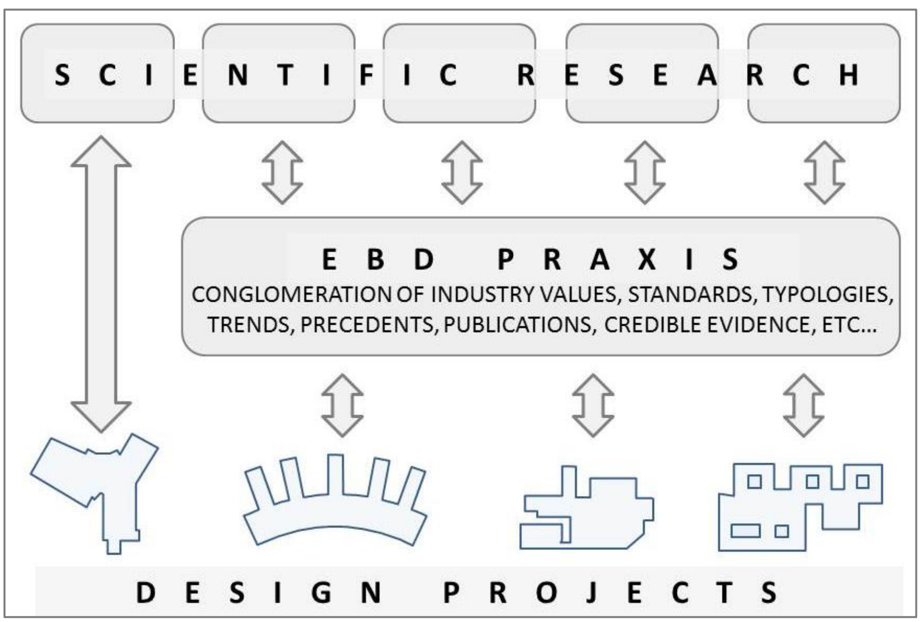

Figure 48. The praxis between scientific research and individual design projects

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[46] ***D1***’s earlier statement on same-handed rooms clearly exemplifies this confident and straightforward expression concerning the evidence base for a design feature: “The jury is still out.”

For analytical purposes, the diagram above presents three layers which were observed to be inextricably intertwined in the case observed in this dissertation. There are also, however, significant discrepancies across these domains which pose their own values and constraints. It is possible, for example, to distinguish individual design projects from the larger community in the way the situated project teams develop and impose their own local approaches, cultural values, and stories. Differences in established norms, on the other hand, can contribute to the distinction between these layers. "Reasonableness of a story," for example, can be considered as an acceptable basis of action at the level of individual design projects, while it is highly questionable at the level of scientific research.

The case observed in this dissertation provides several examples of the issues concerning the trade between these layers. As the project team became entwined with the larger community of EBD, the members were immersed into the praxis which propagated particular design features, trends, and modes of thinking that relied on chains of mechanisms involving people, processes, and physical environments. While absorbing the norms of this praxis, one key struggle for the members of the ***PHSP*** was to adapt the emerging concepts to local needs by using several strategies including, for example, the mock-up exercises. In introducing the developing norms, novel design features, and recent trends in industry into the design (Figure 48: the arrows linking EBD praxis to individual projects), the interdisciplinary team was also sensitive to local values, habits, and practices..

One other feature represented in the diagram was the direct link between scientific research and individual design projects that by-passed the influence of the community of EBD praxis. Exemplified in the case of displacement ventilation, the teams can have individuals who possess broad knowledge of the relevant scientific research, and who have access to the most recent publications in the field. Therefore, without going through the steps within the larger community of EBD where academic studies are being review, filtered, and translated, scientific evidence can immediately find its way into design decision making processes. In such cases, however, the teams rely solely on the interpretation provided by professionals who are in command of technical issues.

The purpose for employing two-way arrows in Figure 48 was to indicate the opportunity to enhance the trade between domains represented in the diagram. The arrows represent cases for architectural research that offer the potential to inform both theory and practice of architecture. This potential was already recognized by several researchers have who published articles that are sensitive to both developing issues in practice and methodological norms of scientific research (see for example see, Latimer et al., 2008,or Pati et al.,2010). Given decades of rigorous research on the architecture of healthcare facilities, including the seminal work by John Madge and Llewellyn Davis (studies in the functions and design of hospitals, (1955)), the two articles mentioned above do not provide an entirely novel venue of research, but point to the potential of EBD as a praxis to inform key areas of investigation that can provide a genuine response to the notorious "gap" between research and practice.

7.5 Summary

The case observed in this research demonstrated that architects formulated and explained their design ideas in terms of mechanistic arguments where scientific research, best practices, and anecdotal evidence were integrated into segments that formed causal links. Kim (2001) has suggested that client/user demands significantly influence the culture of healthcare design practice, and specialized knowledge and skills have had a positive impact on design-decision autonomy, phenomena that Kim observed in a qualitative study investigating the relationships between healthcare design complexity, specialized knowledge, and healthcare architects' professional autonomy. I agree with Kim's findings, but also propose a modification as follows. Design-decision autonomy relies on architects' meta-expertise (including the chunks of specialized knowledge that

Kim mentions) which allows them to represent evidence based on scientific research, anecdotes or causal mechanistic models, and, accordingly, negotiate regarding physical environment features in tandem with projected care models.

EBD outlines a framework that regulates and integrates the relevant knowledge base found within disciplines surrounding it. In other words, EBD, because it is inherently multidisciplinary, cross-fertilizes the knowledge within various disciplines with the aim of impacting design work in a positive manner by introducing recent and relevant scientific evidence to be adopted by teams involved in healthcare facilities design. The qualitative data analyzed in this study suggest a "community of evidence" which regulates the norms of evidence-oriented practice. The interdisciplinary team observed in this study was in constant interaction with this larger community which allowed the participants to talk confidently about the body of evidence to support the concepts, design features, and associated care processes considered in the project.

In the case observed, evidence made its way to design through different modalities, including user or consultant anecdotes, scientific studies, guidelines, and mock-ups, and these modalities generally entailed translations between various representational forms. Segments of chains of evidence, anecdotal or scientific, were utilized within causal mechanistic models that eventually influenced both the building program and the design features of physical environments. Further, I argued, rather than being mere structures within specialized healthcare design knowledge base, the mechanistic models infused the designers' reasoning processes at all scales of design, ranging from site planning strategies to the design of handles between patient beds and toilets.

These mechanistic models, as repositories of trans-disciplinary knowledge involving design, medicine, epidemiology, nursing, and engineering, expand the scope of traditional understanding of specialized knowledge in healthcare design. Architects are required not only to become knowledgeable in the available evidence on healthcare, but also in *interpretation, translation (re-presentation),* and *production of evidence* to meaningfully engage in interdisciplinary exchanges. By re-presenting causal models through layouts or mock-ups, architects create a platform to display shortcomings of available evidence and to show where evidence needs to be created *in situ*.

Given the use of mechanistic models as guiding reasoning processes, architects' skills in generating and manipulating representations, which facilitate translations of evidence into design, allow them to maintain their position as key players in the game. As evidenced in both the production of layouts and the mock-ups, the architects observed in this research had their own discursive space in which to maneuver and to introduce their skills in re-presenting ideas, and this space was instrumental to negotiation and consensus-building. For instance, the architects facilitated a series of mock-up exercises that aided the team in blending research-based evidence with the local needs of users emerging through anecdotes. The mock-up was an "irreplaceable" medium that enhanced crucial negotiations with users and eventually allowed architects to process and translate both a novel idea, namely distributed nursing stations, and user input that perfected the mechanism for patient surveillance. In another episode during ER design, by contrast, architects were the ones to initially translate evidence emerging from an outside discipline, namely nursing. Within a floor plate with strict boundaries, the examination room configurations (Figure 20) created by ***P1***, the space planner, accommodated a four-to-one (patient per nurse) ratio, which was recommended to achieve effective and efficient nursing processes. Even though the configuration was later challenged by users during the late design development phase, architects remained vital as the key players in advancing the plans, both in terms space and processes, to implement a new emergency unit.

CHAPTER 8

CONCLUSIONS

This dissertation presented an ethnographic study that was conducted with the aim of understanding: what is the nature of evidence in the context of healthcare design, and how are various forms of evidence being transferred or produced, negotiated, propagated and translated within interdisciplinary design teams? In order to characterize the context and clarify the particular research approach, this study first presented a background involving three domains. First, "the utilization gap" –which has been a topic concerning research and practice in architecture since 1960s– was introduced. Following issues within "the gap," the next section accounted for evidence-based design (EBD) which was put forward as a framework to infuse scientific research findings into design decision making. The third section in background, then, presented the approach in this study to characterize and investigate interdisciplinary problem solving in architectural design.

The dissertation adopted ethnographic research methods and observed a real-time hospital design project over a period of eleven months. Through field observations and interviews the study looked closely at two issues which were formulated as the research questions: (1) what are the forms of evidence in situated contexts of healthcare design, (2) how is evidence translated within the interdisciplinary team? The dissertation examined these two intertwined aspects with the purpose of developing an understanding of EBD practice in architecture.

In two core chapters, one on the design process of the ED, the other on the inpatient unit, the dissertation dissected episodes which presented interactions of participants with each other, particularly through representations and tools which were shown to be central in interdisciplinary exchange. Following the descriptive episodes on

ER and inpatient unit design, Chapter 7 then presented an analysis of the practice with the purpose of developing an argument concerning architectural design and evidence.

The section below presents the conclusions of this investigation with regard to the research questions posed at the outset. The last section, then, accounts for a set of recommendations and further venues of research.

8.1 How is Evidence Represented?

Although the emphasis in evidence-oriented practice is mainly on evidence emerging from scientific research, the cases presented in this study introduced an extended notion of evidence to also include anecdotes based on past experiences or observations, precedent cases, and what I called 'local evidence' emerging from in-house experimentation involving architects and frontline staff from the hospital to-be-replaced. It is hard, if not impossible, to make a clear classification among these various representations based on the case observed, since there was considerable overlap, or convergence, in evidence coming from different sources. The idea of distributed nursing stations, for example, has been studied by healthcare researchers who suggested evidence showing reduced walking distances and increased patient care time (Institute of Medicine (U.S.), 2004), but in the design process the notion was also supported by anecdotes from participants in this study who had had the chance to observe the practice in a prominent facility during a field visit. Therefore, in the case observed in this study, the idea of distributed nursing stations came along in a variety of evidential support including scientific studies, anecdotes, and precedents in industry. Apart from initial representational forms, assembling different types of evidence into oral structures that combined ***the textures of evidence*** was a prominent strategy observed within the case presented. These oral structures, which I called stories, were the major resource for participants. By their very nature, these stories were evolved, expanded, modified, and transmitted across people with different disciplinary backgrounds, while maintaining all relevant informational pieces around a particular topic, mostly the physical environment features which were discussed over the course of the project. It was the architects' task, then, to manage and blend these segments within stories into design representations through various tools including plan layouts and physical mock-ups, which inevitably added another layer to the developing stories.

8.1.1 Varieties of Evidence

In the practice observed, evidence was initially introduced, emerged, and re-presented in a variety of forms. Through interactions involving people, representations, and tools, the design progressed from pre-design phases to construction documentation, as the set of evidence was continuously translated and maintained in the system.

Diagrams as representations of evidence

Utilizing diagrams to represent ideas with varying levels of evidential support was one of the strategies adopted by the project architects. In both cases, involving the design processes of the ED and the inpatient unit, a series of diagrams were brought to the attention of the team. These diagrams, concerning layouts at different scales, communicated particular configurations which were tied to positive outcomes such as "reducing noise and congestion, reduced nurse walking distances, and improved hand-washing compliance." The architects of the project who introduced the diagrams did not specify any scientific research to support these claims. But as the interdisciplinary team engaged with external consultants, they were exposed to the body of available research evidence concerning the topics represented in these diagrams. Briefly, by means of *activating available evidence* concerning particular physical environment features and processes considered for the new hospital, these diagrams were instrumental for reaching an initial consensus among participants. The architects, who possessed a level of expertise in related fields, were the ones to strategically integrate evidence emerging from a variety of domains (e.g. design and nursing) which eventually aided the entire team in developing an understanding of local and industry-wide practices. As the design work progressed the team revisited their decisions in the light of new evidence which was introduced in other forms of representations.

Precedents

Almost every physical environment feature considered in the design process was accompanied by precedents which either had been observed by the participants or were communicated in the form of anecdotes, published case studies, or research conducted in these environments. As participants employed it in their exchanges, the term "precedent" referred to three different entities, each of which represented evidence to challenge design decision making. First, "precedent" referred to the site visit conducted throughout the early phases of the project during which the participants had observed *evidence-in-action*. Frequently revisited in later exchanges occurring in steering committee meetings, these site visits provided the participants with evidence to suggest whether or not particular design features work in situated healthcare environments. A faulty location of hand-washing sinks in a hospital visited by the participants, for example, was repeatedly mentioned during design development phases as the team developed the details within the inpatient unit. This particular counter evidence emerging from a precedent case eventually became a segment in stories developed around the design process of the corridor wall of the inpatient rooms.

Second, as shown in the case of the fast-track areas, the precedents included past experiences in existing facilities to suggest local evidence in decision making. The green zone which was developed in the old ***PHSP*** hospital facility served as a powerful precedent to be considered, modified, and transferred into the future hospital. My use of the word "powerful" indicates the availability of details concerning this particular type of evidence which was still fresh within the hospital's organizational memory as two of the participants had published the experience with the green zone in the form of a case study in a healthcare magazine. The case was also supported by developing anecdotes involving the staff members and formal or informal research studies (e.g. satisfaction scores or in-house process improvement efforts) which were eventually translated into design work. The green zone, being two doors away from the room where the group had the weekly steering committee meetings, was a vivid source of evidence as it was frequently recalled by the hospital staff.

Third, particularly during the visioning phase, the participants were exposed to precedents which were introduced in the form of individual cases that come to bear on issues at hand. The cases introduced in the conferences that participants attended, mostly regarded as best practices, or the precedents emerging from architects' own repertoire were referred as sources which served to either support or counter claims on individual physical environment features and associated processes. This type of precedent was not entirely accessible for all participants as in the case of green zone, but was maintained by individuals who introduced the specifics of such cases as needed.

Either in the form of best practices from industry or local cases, the precedents suggested a set of *evidence-in-action* to support or refute particular design ideas which were considered throughout the project. As the design progressed, the set of precedents was collectively assessed, contrasted with (e.g., facilities offering different locations for sinks in patient rooms), and represented in a variety of media (e.g. photographs, layouts, and mock-ups), and was eventually crystallized and translated into the architectural drawings as the team approached the deadline for project completion.

Scientific research

Although the evidence-oriented practices promote scientific evidence as the major support, compared to the other varieties of evidence, the set of rigorous research to influence or challenge design decisions was limited. As it was demonstrated in the visioning document to guide design phases, there were only few topics that were supported by scientific research, while others were "not examined, under study," or were supported by “anecdotal information.” Thus, the availability of solid research findings was made clear to the interdisciplinary team at the outset.

During my observations and participant interviews, I noticed claims about evidence from scientific researarch circulating in the form of loose statements without any specific reference to any kind of research study conducted in healthcare environments (e.g.: ***O4****: actually, there's been a lot of research on how you place the head of the bed to the bathroom door*). These statements, as they were employed in exchanges within the group, utilized particular design features at different scales, ranging from handrails in patient rooms to configuration of individual departments. There were, however, several topics which revolved around individual design features with or without evidential support coming from scientific research. As the participants repeatedly mentioned and discussed these issues in design meetings and interviews, the details around these particular topics had become clear.

The case of displacement ventilation (***M7***), for example, demonstrated how a single piece of research could impact design decision making. For ***M7***, who possessed autonomy and expertise in a particular technical domain, a single study that he considered to have produced convincing and applicable evidence was enough to formulate his recommendation on the ventilation system to be utilized in the new facility – even in the face of a substantial body of scientific research that supported the original design. In contrast with the patterns of dissemination and adoption of scientific research evidence in medicine, which mainly rely on systematic reviews and meta-analyses, the evidence-oriented practice observed in this study provided a case where a single scientific research study influenced design decision making. Although only one instance was observed, displacement ventilation case gives credence to the critics of EBD who maintain that there is currently no existing practicable theory of evidence and utilization in practice.

Another case, which was on utilization of same-handed rooms, illustrated the nature of scientific evidence considered in healthcare design. Although the idea was not supported by rigorous research conducted in healthcare environments, the participants decided to pursue and implement this controversial design feature. Despite the source publications on same-handed rooms, which did not provide *statistical significance* in favor of same-handed rooms, the participants mentioned internal anecdotes as one of the major reasons for the decision which introduced an extra cost for each patient room. This case exemplifies a variety of instances of adopting a particular design feature which "makes sense" for participants, but is yet to be scientifically proven to be beneficial.

The case of same-handed rooms also rendered another tendency in practice which involved exploiting research evidence from other domains that had the potential to bear on design issues at hand. The case of same-handed rooms introduced research conducted in aviation or manufacturing industries which suggested benefits of standardization. As the participants engaged with external parties, the statements involving scientific research which is being circulated in the larger community of healthcare design were observed to be infusing the practice where a local story around same-handed rooms was recreated, modified, and maintained within the group. Within these local stories, the segments involving research conducted in other domains (e.g. aviation) were consistent across participants with different disciplinary backgrounds.

In sum, scientific research, whether providing evidential support or not, offered *the themes around evidence* to be considered within the interdisciplinary team, rather than providing the definitive direction to pursue. Starting from the pre-design meetings, where the team was exposed to the set of developing scientific research conducted in healthcare environments, participants embraced the issues, rather than the scientific outcomes and reasoning processes that were explicit in research studies.

Mock-ups as embodied evidence

Another variety of evidence, different from the available precedents, provided first-hand experience for the participants: *embodied evidence*. This kind of evidence, which was not already in place from the very beginning (e.g. the green zone), was initially generated through a series of mock-up exercises which were strategically created by architects of the project. Particular design ideas, including the decentralized nursing stations which were not entirely familiar to the nurses from the old facility, were made visible to all participants as they engage in these exercises and situated the models offered by the mock-up.

By their very nature, the mock-ups utilized in the project allowed participants to modify the initial layout (only for a given set of constraints), further experiment, and tune the configuration to fit their needs. In this sense, the mock-ups enhanced interaction between the design and participating parties, which, in turn, facilitated a process of problem identification and solution development. Embodied experience of the animated care activities involving people, equipment, and processes provided an ecology that was superior to other forms of representations (i.e. orthographic drawings or digital models) in deriving and generating evidence on use.

The mock-up exercises also afforded a secondary means of generating and capturing evidence that was specific to the activities taking place in these rooms. These practices, including attaching external representations (i.e. sticky notes) which communicate information about specific location of design elements and developing surveys for capturing the user feedback, provided evidence for the architects to be considered alongside readily available evidence embodied in mock-ups. The set of user-based feedback was then translated into design features which evolved from initial generic diagrams into a unique solution which was responsive to local needs. The mock-ups were instrumental in introducing the acknowledged features of EBD in the healthcare industry and in modifying proposed configurations as needed throughout the design process. The mock-ups had a significant effect on the design decisions by enabling local evidence to emerge from a form of in-house experimentation.

Though allowing certain design operations, the mock-up exercises did not, however, address concerns stemming from the entire set of disciplines. As was shown in the case on the corridor wall, for example, the architects and staff members invested time and efforts to develop proper configuration reflecting user-based evidence. On the other hand, the participants did not employ mock-ups to resolve the developing issue of displacement ventilation which was raised by the MEP engineering consultant. There was no attempt –not even a quick exercise to determine the budget needed for such experiments– to generate local evidence with regard to the unique configuration of the patient room developed for the future facility. ***M7***, who had limited interaction with the mock-up rooms, relied on a specific piece of scientific evidence, which he located through a literature search, in making a recommendation for the ventilation system to be implemented. In sum, mock-ups were utilized as exclusive tools to represent, blend, and generate evidence for designated topics involving architectural design.

Anecdotes

Within frameworks of evidence-oriented practices, anecdote has been characterized as the arch enemy of the paradigm in which scientific evidence is given primacy for guiding action. In the practice observed, however, the anecdotes were there to accompany design decisions at all scales, rather than to challenge the set of evidence offered by scientific research which was quite limited in this case. In this sense the present study demonstrated a role for anecdotal evidence as it is used in practice, which I observed to be critical in maintaining the interdisciplinary practice. The anecdotes, whether or not reconcilable with scientific research findings, were employed to *situate evidence* which facilitated negotiation between participants with different disciplinary backgrounds. Because they were accessible and easy to propagate, the anecdotes supported and sustained interdisciplinary interaction as the team progressed towards a consensus on design decisions.

The mechanism of situating evidence through the use of anecdotes was employed not only by the healthcare workers who were expected to introduce their everyday practices, but also by the designers who were the ones to take on what they had heard and observed as they interacted with frontline staff. This mechanism was observed to be critical in establishing a mutual sense of the situations involving design features, people, and processes.

The case of developing the fast track area, which was initially designed to accommodate both adult and children, demonstrated how anecdotes facilitate a simple and direct decision making in architectural design processes. ***O3***'s instant contribution in this short-span exchange (i.e. *parents do not want their pediatric patients sitting in the same waiting rooms with adult patients*) was rapidly acknowledged by other participants including the project architects, client representatives, and other staff members in the room. The decision, which involved spatial separation of pediatrics from adult patients, was quickly made and was never revisited as the interdisciplinary team progressed through design development and construction documentation phases. This particular case, which is similar to the utilization of the anecdotes to support same-handed configuration (Chapter 5), demonstrates the strength of anecdotes in providing situated cases which helped team members to reach an initial consensus.

Anecdotes which were introduced in project meetings were the consistent pieces in larger stories developing around design features considered for the new facility. With little or no variation across participants' accounts, the anecdotes were adopted and re-introduced as needed over the course of the project. Unlike other pieces in particular stories, which exhibited considerable variety in interviews with participants, the anecdotes were largely stable segments which significantly contributed to the understanding and persuasiveness of design ideas.

Stories as repositories of evidence

This current study introduced the notion of stories, which refers to a connected series of representations involving a phenomenon in the project observed through the cases of the ED and inpatient room design. Over the course of my observations, I have identified many stories with varying degrees of development. I have observed architects to be playing the central role in developing and maintaining these stories so as to bring together available pieces of information from different domains of expertise. For the architects, the stories were cognitive tools that gathered all kinds of evidence together for the purposed if influencing design decision making.

The architects' interactive expertise (Collins & Evans, 2002) in engaging in focused conversations involving complex care processes in emergency services allowed them to capture and translate critical feedback (e.g. users, mock-up exercises, research) into initial programmatic chunks and, later, into spatial configurations that corresponded to the developing stories. The stories consisted of a variety of segments including research findings (internal or external to healthcare), anecdotes, and precedents, and were sustained among the interdisciplinary team over the course of the project. Although some individual pieces did not support the eventual design decisions, the accounts of the participants suggest that the overall persuasiveness and reasonableness were key in making design decisions. As shown in the case of same-handed rooms, for example, while no single piece of evidence (e.g. research evidence, anecdote, precedent) was overwhelmingly convincing for team members, the story as a whole was effective in persuading the group of people involved in the project. Since the story, which was developed across people and over time, was regarded as "reasonable" and "making sense," the interdisciplinary team headed towards the direction of pursuing the same-handed configuration.

Also demonstrated through the cases presented in this research, these stories were not developed only around global strategies to be implemented across the facility (e.g. same-handed standardization), but also for areas at sub-unit level which required local solutions as the design progressed. For instance, the story of the fast-track area, which was initiated earlier with the green zone experiment in the old hospital, introduced for the team evidence that had bearing on the program and layout configuration in designing the area for the new facility. As repositories of evidence, the stories also incorporated a distinct history for individual design features, zones, or departments, in addition to the pieces of evidence deriving from scientific research, in-house experiments, and anecdotes.

One final remark to be made about stories is that they function to point out a variety of potential solutions around particular design features. As used here, stories do not have just one possible ending; instead they offer a multitude of potential architectural solutions through various combinations of segments within them. As demonstrated in the case involving the design process of the behavioral health section within the ER, the stories were extended to include specifics of the patient population (i.e. aggressive patients), priorities in care processes (i.e. complete observation) and local requirements which made the team abandon the same-handed configuration within that section. In this sense stories can be seen as *flexible* repositories of evidence that are created to accommodate more than one solution concerning a design feature.

8.2 Translating Evidence

In the practice observed, the evidence was initially introduced in diagrammatic (e.g. layout options), propositional (e.g. anecdotes), and embodied (e.g. site visits, mock-ups) forms which contributed to developing a shared understanding about the design at various scales during early phases. As shown in this dissertation, it took people, tools, representations, and time to translate evidence into the design developed for the new hospital facility.

Before it was pooled within the system in the form of stories (Figure 49), the set evidence emerging from scientific research and precedents was introduced through proposition representation, which were then coupled with anecdotes and diagrams that presented available configurations to be considered in the project. Introduced through site visits or presented by means of anecdotes and diagrams, the precedents which have been minimized in some accounts of EBD, were shown to be employed consistently, rather than being secondary to scientific research findings. Accordingly, the dissertation proposes an extended notion of evidence as employed in practice, to include precedents, anecdotes, scientific research, and in-house experiments.

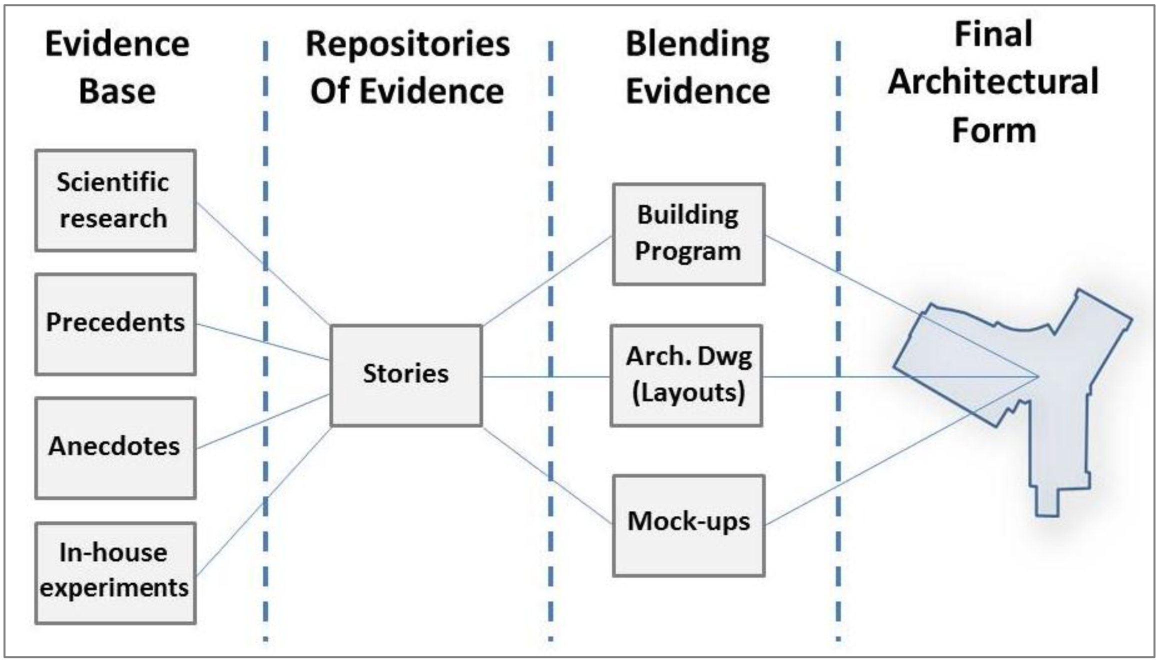

Figure 49. Evidence in architectural design practice.

Rather than a straightforward process, the diagram above conveys a process of translation where the entities continuously feed one another through various practices which are subject to social, cognitive, and material filters as the design progresses towards a final architectural form. The notion of filters, in this context, refers to representational mechanisms including, for example, distillations of lessons learned from the green zone experiment (from precedent to anecdotes, to a building program and layout configurations), or processing the four-to-one nursing model and translation to clusters and pods in care areas (from scientific research to inform care models and associated spatial configurations). These processes necessarily involve individual and collective expertise which is instrumental in re-representing and blending evidence in architectural representations including layouts and mock-ups.

As with the sources of evidence with which the participants interacted, there was variety in subsequent translations of evidence, as illustrated through descriptive episodes. The following three sections present the findings of this dissertation concerning the episodes of translating evidence within the complex socio-cognitive environment of architectural design.

Multi-step translational processes

The dissertation proposed that the translation of evidence into the documentation to guide construction phases mostly occurs through complex interactions involving people, representations, and tools. As opposed to the simplified accounts of how teams apply evidence within projects (Malone, et al., 2008), the episodes presented in this research suggest a series of sophisticated socio-cognitive operations taking place in multiple steps and scales. Furthermore, as the unit of analysis and the cases created out of the available data set for this dissertation suggest, the processes of evidence generation, propagation, and translation can be extended back to activities well beyond official project schedules. As shown in the case of the green zone, the early design-related exercises within existing facilities provided the interdisciplinary team with the evidence which was later considered in writing the master building program, configuring the sub-systems within the ER, and planning the mock-up exercises where the team had the opportunity to experience different configurations of the fast-track bays.

The case of implementing distributed nursing stations, on the other hand, suggested another form of translational process where the interdisciplinary team adopted a design feature which was favored by scientific studies, anecdotes, and best practices in industry. The idea, which was initially represented in generic diagrams, was incrementally developed through a set of representations including layout drawings and mock-ups before it was finally translated into construction documentation. Mock-ups in this project were key in making available evidence visible to all participants as the team attempted to make a general idea offered by research specific, by means of manipulating the mock walls, in order to achieve a proper fit between the design and actual practices.

The case of implementing decentralized nursing stations also demonstrated the need for interdisciplinary engagement at various steps within translational processes. The embodied experience that the mock-up offered afforded and enhanced the interdisciplinary interaction among the participants which helped the team to identify and fix the shortcomings of the design, most notably visibility from the station to patient heads. Thus, by means of providing an accessible representational state of the design, the mock-up was instrumental in bringing together the distributed expertise within the team to improve architectural solutions. It was shown from the study that mock-ups, as a strategic design tool, offer evaluations of design intentions that cannot be conducted through other forms of representations. In the context of healthcare design, we saw that it is critical to benefit from the affordances of mock-ups in order to avoid errors in key patient care areas that are massively repeated throughout buildings.

Shortcuts

Unlike costly translations mentioned above, there were also instances of translations which only required a quick processing of evidence as it emerged in interdisciplinary meetings. When the evidence at hand, whether scientific research or anecdotal evidence, facilitated an immediate formulation of a well-structured problem with a quickly recognizable and available architectural solution, it was translated into layouts without extended negotiations or experiments involving mock-ups. These single-step translations eventually became segments in larger stories around related design features.

Three episodes from the chapter on the ED design illustrated these translational practices where participants generated a solution in quick period of time which then was represented in layouts. First, the separation of pediatric patients from adult patients presented a case where the emergent anecdotal evidence challenged the existing configuration and the decision to alter the design was made in the same meeting. Second, the experiments in mock-ups, where the participants derived a solution for a configuration to accommodate two beds in an examination room, was again introduced a case of a single-step translational process. The agreed solution, which involved determining the locations of medical equipment within the rooms, was then translated into the next iteration of layouts of the new ED. Finally in a third case, the planning consultant quickly interpreted the requirement of clusters and pods as maintaining a precise nurse-patient ratio and accordingly offered a corresponding configuration for the emergency services. The initial evidence involving a desired care model was not necessarily space-related, but was translated into architectural representations without further negotiations.

Undoubtedly, such translations occur frequently in a given design project. The conclusion that these cases of direct translations offer is that such processes, whether initiated by anecdotes or prescriptions developed in another domain of expertise, can impact architectural form at different scales concerning departments, areas, and rooms.

Community of evidence

The dissertation study suggests an existence and influence of a community which practices, develops, realizes, and disseminates an evidence-oriented praxis of architecture in healthcare design domain. Engagement with this “community of evidence” involved members of the design team visiting brand new hospitals, participating in conferences and colloquiums, talking to subject matter experts, and interacting with the research reports and white papers. The exchange with this community was continuously transferred into design meetings in the form of precedents in industry, anecdotes, and pieces of scientific research evidence with limited reference to the source or the context of such studies.

The dissertation also characterized a “praxis of EBD” which was described as an invasive process of developing, enacting, and propagating an evidence-oriented practice in architecture that infuses design thinking with its causal mechanistic models as basis of design decision making.

Evidence and mechanistic reasoning

The dissertation provided an analysis of how the participants were apt to formulate and explain their design ideas in terms of mechanistic arguments where scientific research, best practices, and anecdotal evidence were integrated into segments that formed *causal links*. A quick review of literature demonstrated that in the evidence-based practice literature, concerning both medicine and design, these mechanistic causal models are repeatedly emphasized. Such models were explicitly adopted by the interdisciplinary team members who were observed to put forward mechanistic models that incorporated evidence emerging from multiple sources.

As we saw, evidence made its way to design through different modalities and these modalities generally entailed instant or multi-step translations among various representational forms. Segments of chains of evidence, emerging from scientific research, precedents, anecdotes, and in-house experiments, were utilized within larger causal mechanistic models that eventually influenced both the building program and layout configurations at various scales. Further I argued that rather than being just structures within the specialized healthcare design knowledge base, mechanistic models, as normative constructs, infused the designers’ reasoning processes at a range of scales.

The architects are required not only to become knowledgeable in the available evidence on healthcare, but also in *interpretation, translation (re-presentation),* and *production of evidence* to meaningfully engage in interdisciplinary exchanges in the context of healthcare design. As the architects we seen to interpret and re-present causal models which are partially informed by scientific research evidence, they created a platform to display shortcomings of available evidence and to show where evidence needed to be created in situ. As evidenced in both the production of layouts and the mock-ups the architects continuously resorted to their expertise in re-presenting ideas which was shown to be instrumental to negotiation and consensus-building.

Architectural expertise

This dissertation offers two main conclusions concerning architectural expertise. In the design studies literature, the topic of expertise has been studied extensively, however researchers still note the need for more specific studies to answer the long-standing question of design expertise (Cross, 2004). The ethnographic research presented in this dissertation provides insights to extend our understanding of the use of expertise in situated contexts.

First, a particular aspect within architects' expertise, namely conversational competency, emerged to be critical in exchanges where user-based evidence was generated, extracted, and recorded. Conversational competence as an expert performance was studied by Luck (2007a) who suggested the influence of "the performance of facilitation had on the opportunity for user engagement in design" (Luck, 2007a: p. 217). In a parallel article Luck extends her analysis to include the use of artefacts in developing a design in tandem with users (Luck, 2007b). Accounting for the use of a model, product samples (bricks), color-rendered elevations and perspectives, Luck has suggested that "the users' understanding of the design was developed in the conversations around the use of artefacts, as well as the knowledge that is embedded in the artefacts themselves" (Luck, 2007b: p. 28). The architects observed in the ***PHSP*** hospital project frequently displayed their conversational expertise –evidenced in instances of re-orienting the discussions in design meetings or asking specific questions about locations of particular elements– over the course of the project.

The episodes presented in this dissertation corroborate Luck's findings, while extending the set of artefacts she mentioned through the inclusion of the mock-ups utilized in design conversations with users. Several episodes in this dissertation introduced the exercises with mock-ups which I argued to have a positive effect on productivity[47] within conversations with users, namely nurses and physicians, who had limited time to interact with designers. The embodied experience offered by mock-ups, in addition to architects' conversational expertise (e.g. oral introductions, exchanges), contributed to rapid generation of user feedback (occasionally embellished by anecdotes) at various scales from determining height for plugs to fixing the angle of the corridor wall of patient rooms.

Second, the episodes in this dissertation suggested that the architects' expertise in translational and re-presentational practices were critical in advancing the design work. Akin (1987) suggested that creating scenarios was one of the important strategies of expert designers in (re)structuring architectural problems. Following Akin's conceptualization, scenarios are organizational ideas to define proximities, hierarchical relationships, and other similar patterns manifested within programmatic chinks. Akin suggested that scenarios also provide "conceptual constructs which can be consulted in answering question that arise during design" (Akin, 1987). In the case observed in this dissertation, however, the architects were observed to employ and develop scenarios which were not created by them but offered by research or anecdotes emerging from other domains.

The care scenarios (e.g. distributed nursing model which maintained a specific nurse-to-patient ratio) that the organization desired to implement were adopted, translated, and re-re-presented to users which provided the team the opportunity to assess and further develop the care scenario through architectural layouts and mock-ups. As

[47] Here, the productivity refers to the number of resolved issues which are necessary for architects to advance the design work.

shown in the case analyses, the utilization of layout drawings, for example, was key in translating and blending evidence from multiple domains of expertise and to re-presenting it in an accessible way so as to become a ground for interdisciplinary assessment and consensus-making. This distinct *meta-expertise* to process what had been proposed by the multi-disciplinary team, and to put it together into representations of future spaces offers another dimension to the understanding of architectural expertise in design. The architects – always with a level of awareness of all aspects concerning a variety of disciplines – pooled the set of emerging evidence (e.g. user group meetings, mock-up exercises), recognized the set of programmatic needs (e.g. evolution of the fast-track area), incorporated specific needs concerning spatial configuration (e.g. visibility), and processed available solutions (e.g. examination room layout) all the while maintaining the overall integrity of the scenario considered for the new ***PHSP*** hospital.

8.3 Recommendations and Future Work

As presented in Chapter 2 and Chapter 7, there has been continuous criticism directed towards the theoretical foundations and practical limitations of evidence-oriented practices. However, these critiques focus almost exclusively on evidence from scientific research and by-and-large do not draw from close examination of situated evidence-based practices. In order to develop a comprehensive framework for evidence-oriented practice, there is a need for in-depth studies to better understand the nature of such practices in situated settings. The episodes developed here from a real-life design process, demonstrate how interdisciplinary teams operated with multiple sources of evidence in situated contexts. Although rich, the study presented here is of course limited. As with any ethnographic research on a topic, more studies are needed in order to extract robustly transferrable insights. Further investigations into actual EBD practices will provide a larger basis for comparison and transferability of concepts and characterizations. In healthcare design, however, a major challenge is that access such environments is limited by a significant level of resistance to observational research due to the set of legal and liability issues that are at stake.

Despite the limitations of just one study, my analysis clearly showed that, not just scientific evidence, but various types and sources of evidence came into play as the team progressed through the phases of the design process. Development of a more structured evidence base, addressing the sources and forms of evidence in practice, could serve as a first step in formulating a broader framework for an evidence-oriented design practice. The following recommendations, which involve three major sources of evidence, are a call for both generators (i.e., researchers) and users (i.e., design practitioners) of evidence to attend to and document these different sources and forms throughout the design process.

Best-practices/precedents: The precedents, which were introduced through anecdotes, diagrams, or actual spaces that participants visited during site visits, were not utilized for a cross comparison across situations. In most cases, particular design features were discussed apart from their actual contexts. A structured method to develop best practice cases can help teams in making informed comparisons and in-depth evaluations across precedents in industry. Battisto and Franqui also recognize the need for a method to consistently capture precedent information, and states that “while architects are notorious for using case studies to capture building precedents and best design practices, there is currently no publicly available resource in the architectural literature that captures facility case studies using a standardized framework and methodology." (Battisto & Franqui, 2013: p. 406). The existence of standardized and accessible bodies of rigorous case studies could facilitate cross comparisons and inform real-time decision making processes.

Scientific research: As mentioned earlier there is a literature on the gap between academic research and practices including design. The studies on this topic offer a variety of solutions including improving literacy skills or making scientific research accessible to practitioners. The observations in this dissertation suggested that although the body of research to influence design decision making is growing over the years, at least within the case of healthcare, attention to translational pieces within scientific publications is still very limited. By translational pieces I mean meta-analyses and reviews of existing literatures on particular topics. Within the context of healthcare, there is a comprehensive literature review conducted by Ulrich and colleagues dated 2008, which was known to participants in this study. However, more detailed reviews focusing on particular design elements, incorporating various forms of evidence, could impact research utilization positively. Such qualitative and quantitative reviews can offer significant insights as interdisciplinary teams engage in a host of issues in real situations.

Anecdotal evidence: The dissertation demonstrated the role of anecdotal evidence as users introduced their everyday experiences in design situations. Although anecdotes customarily are regarded as unreliable in a given evidence-oriented practice, they should be recognized as important constituents of the socio-cognitive environments – especially of interdisciplinary practices. Project records should enable participants to keep track of anecdotes that play a major role in driving design decision-making. Capturing these pieces of the decision-making processes in a structured way can help interdisciplinary teams to revisit these issues and re-assess in the light of emerging evidence coming from different sources. Although some participants might have remembered the anecdotal basis of decisions, I was able to uncover many of the anecdotes that played important roles in decision-making only by investing considerable effort in tracking down the situations, people, and available evidence base behind specific decisions. For example, I could only track down the decision concerning separation of pediatric and adult patients in video-recordings. Rather than recording only the outcomes of discussions held in meetings, explicitly keeping track of evidence used in decision-making can provide organizations with key topics to be further investigated by scientific research – or that might even already be supported by such evidence that the project is not aware of.

The findings of this dissertation can be considered in the context of architectural education, particularly within the graduate programs in healthcare design. The studio exercises within these specialty programs should recognize the need for socio-cognitive strategies to deal with the set of disciplines that enter into a design process and the varieties of evidence that will be encountered in real-life situations. Going beyond providing the necessary information to students, healthcare design programs should allow for an appropriate immersion into practice where architects require critical social, cognitive, and material skills within integrated project delivery teams.

There are several potential follow-up studies, qualitative or quantitative, that could address the findings of this dissertation. For example, the differences, if there are any, in the use of mechanistic models can be studied to develop a better understanding of the effects of these models on design processes. Second, a series of protocol-like studies could be designed to investigate evidence-oriented practice within structured, well defined design tasks. Although these would not be situated contexts, carefully designed protocol studies can provide further insights concerning designer behavior in situations informed by various forms of evidence. Third, our understanding of the "meta-expertise" of the architect relative to the domain expertise of other parties can be advanced through detailed studies to be conducted within situated or experimental contexts.

Further Interpretation

Although the final chapters emphasized the role of mechanistic arguments within the practice observed, my intent here is not promote a framework to reduce architectural design to a narrow set of causal mechanistically defined outcomes. Rather, the intent is to provide a cautionary picture that belongs to an evidence-oriented practice where the utilization of existing scientific evidence was considerably limited compared to other forms of evidence brought into actual design situations. Thus, the cases described in this dissertation amply expand beyond a narrow notion of evidence as emerging from scientific research alone. Rather, the design case showed the participants to be resistant to the push towards rationalizing design process by systematically integrating scientific research findings. Indeed, the participants maintained a healthy skepticism towards that source of information as they embraced various sources of information, such as anecdotes that were eventually used to challenge or support design decisions. The extended notion of evidence introduced in this dissertation, which goes beyond scientific research findings, has the potential to initiate fruitful discussions that will help clarify the nature and role of evidence in contemporary healthcare design practice.

Another venue for further interpretation involves the practice of architectural design from a constructivist perspective. Accounts by Donald Schön (1983), Dana Cuff (1991), and many other contributors, have produced a richer portrait of the profession of architecture based on narratives involving how design problems are construed and resolved in situated contexts, how interdisciplinary negotiations occur, and how architecture is produced through a set of complex interactions. Following Schön's framework, for example, the design process studied in this investigation can be re-interpreted as a "reflective practice" where architects constantly reacted to particular situations that "talk[ed] back" to them in an iterative manner. However, in contrast with Schön's case, where he painted a relatively less complicated situation within a studio environment, the series of cases in this dissertation expands the complexity of circumstances in actual design situations where many individuals, domains, disciplines, and representational practices talked back to architects who were expected to use their meta-expertise to manage the evolution of the design. The complex situations provided throughout the two core chapters – and the numerous others encountered but not written about in this dissertation – can lead to further analyses that expand on existing accounts of the practice of architecture.

APPENDIX A

IRB APPROVAL

Georgia Tech Office of Research Compliance

Protocol: H11191
Funding Agency*: n/a*
Review Type: Exempt, category 2
Title: Investigating collaborative architectural design in the context of multi-disciplinary healthcare design practice
Number of Subjects: 50
Number Enrolled: n/a

13 September, 2011

Nancy J. Nersessian
Interactive Computing
0280

Dear Dr. Nersessian:

The Institutional Review Board (IRB) has carefully considered the referenced protocol #*H11191*above. Your approval is effective **13 September, *2011***. However, the proposed procedures have been determined exempt from further review by the Georgia Tech Institutional Review Board.

Project qualified for exemption status under 45 CFR 46.101b.2.

Thank you for allowing us the opportunity to review your plans. If any complaints or other evidence of risk should occur, or if there is a change in the plans, processes, or personnel, the IRB must be notified via an amendment.

If you have any questions concerning this approval or regulations governing human subject activities,

please feel free to contact Dr. Dennis Folds, IRB Chair, at 404/407-7262, or me at 404 / 385-2175.

Sincerely,

Kelly Winn
Digitally signed by Kelly Winn
DN: cn=Kelly Winn, o=Georgia Institute of Technology, ou=Compliance Officer, email=kelly.winn@gtrc.gatech.edu, c=US
Date: 2011.09.13 08:56:02 -04'00'

Kelly Winn
IRB Compliance Officer

Enclosure
cc: Dr. Dennis Folds, IRB Chair

APPENDIX B

SAMPLE TRANSCRIPT

		Transcript_D1_AK_10_20_2011
		Interviewee: D1-1 - Interviewer: I1 - Location: FIRM A office - Duration: 01:15:31
0:48	**I**	Thanks again. I have a couple of questions about this project. First is… Could you tell me about you background?
0:54	**D1**	Okey. I went to Georgia Tech, studied architecture there. And after Georgia Tech, I started my, sort of architectural career in retail. I had, uhmm, handled John Deere and Timberland and different accounts like that. After about three years in retail, I got into... that's where I got my first job in healthcare, and it was working with D16. He and I have been working together since 96. So I'm doign healthcare since 96. Uhmm, and then I have been with basically three companies since then. Uhmm, I was with D16 at company called Firm E, and from there we went to Firm G, and from Firm G I came here to Firm A. And, uhmm, I have just been, been really doing healthcare largely and patient... Mostly hospitals, but some MOBs, some outpatitent specialties as well. But, it's just been my focus for the last fifteen years.
1:52	**I**	Did you have any healthcare experience during your years in Georgia Tech?
1:57	**D1**	Not at all.
1:59	**I**	No student project, no studios?
2:01	**D1**	Nope. They did not have, you know… The… Basically what I'm understanding from Josh and some others, sounds like with Craig Zimring and some others, that it's gotten more to where they almost have a little bit of a slant or kind of a specialty there, it's the way it's sounding... At the time, there was not. Nothing like that.
2:20	**I**	So you did learn healthcare design outside of school.
2:24	**D1**	Yes. 100%.
2:26	**I**	So when did you start working in this office?
2:33	**D1**	I've been here for seven years. A little over seven years. What, whatever year, 2000, almost two thousand and four, if I'm not mistaken. When I joined in October. Started out on the Kennestone, the first blue tower, that we're now working on the second blue tower, the companion to that. I was brought in on that project, and I've pretty much worked with Wellstar, and Kennestone ever
3:05	**I**	So you only did healthcare in Firm A?
3:09	**D1**	Yes.

APPENDIX C

CODING GUIDE

Coding guide for emergent categories and super ordinate categories:

Generating evidence			
1	**Testing and deciding with mock-ups**	Definition	The activities that utilize mock-up rooms, including testing, experimenting and manipulating, in order to generate input for design or care-process related decisions.
		Sample **(O2)**	*What we did is we started out just with cardboard walls to mock up the rooms. We looked at where the nurses would sit in the nurses' station outside, and if they could see the head of the patient. If they couldn't then we would tweak the angle of the walls, so that we could see the face of the patient. Everything from the angle of the windows, and where the bathrooms were in the adjacent room, what the angle of that wall was.*
2	**Partnering to do research**	Definition	Collaborating with internal or external parties to conduct research in order to inform ongoing design processes.
		Sample **(O4)**	*We're going to be participating with MK on doing some research on flooring.*
3	**In-house research or testing**	Definition	Research activities, including surveys, measurements and testing that are being conducted internally, within existing facilities, to test alternative processes and design options, or to measure satisfaction with existing or new procedures.
		Sample **(D1)**	*They have already been running trials, they've been testing certain ideas that they have, they got a green zone they've done in their ED which is basically a quick care area to try, and decongest the ED so that they can, you know, take care of the less acute and less critical, so that they can sort of streamline the treat-and-street sort of concept, and they've been testing things like that.*

Consultant involvement			
4	**Engaging consultants in design process**	Definition	Engaging with regular steering committee consultants (mechanical, structural, IT, etc…) or other subject matter experts (ICU experts, etc…) in order to inform design decisions.
		Sample **(D1)**	*But you need someone who has been there, done that, to say, because... I mean these are not small decisions. These are hundred million dollar plus commitments. You can't just do it on whim, you got to, you've got to, have someone who understands how to get from here to there. And you really need someone to navigate that. I think that's where they are trying to get, ImT to come in and really help them see the bigger picture and how you really pull that out without wasting a lot of money and a lot of time.*
5	**Interacting with researchers**	Definition	Engaging with researchers or research-oriented organizations to discuss emerging ideas and research-related issues, or to get help in designing and conducting in-house research.
		Sample **(O2)**	*And so they help us, you know, with the research, analysis of the data that we get from that. Uhh, in that respect it's formal. But a lot of the conversations are informal, just updates, how can we help you, this is what I need, that sort of thing.*

Community of evidence			
6	**Sharing evidence**	Definition	Sharing information, ideas, and experiences via formal (publications, conferences, etc...) and informal (conversations, blogs, etc...) channels.
		Sample **(O3)**	*I think there are several venues, I think because it's involving pharmacy and nursing, you can look at nursing journals and pharmaceutical journals, you can publish there, you can publish of course with the Center for Healthcare Design, you can publish with, I think, architects. You can use that evidence to publish in their journals. I think that I can also publish it in the nursing administration or **O4** can use it as well in some of hospital journals, so scholarly journals for sure.*

7	**Community and culture around evidence**	Definition	Processes, organizations and practices within healthcare community that focus on production and utilization of knowledge to achieve better care processes and physical environments.
		Sample **(D2)**	*There are several facilities around the country that are Pebble Projects. On each year they have a colloquium that goes and meets with these facilities and sees how each facility is impacting the outcomes, how the built environment supports the process, how the processes become leaner, how become more efficient when the built environment aids in that, and doesn't hinder that, uhmm, and how, you know, the science and studies that have impacted evidence-based design, are actually implemented into these facilities.*
8	**Role of evidence (-based design)**	Definition	The expectation or the role assigned to evidence or evidence-based design in healthcare design.
		Sample **(D1)**	*I guess evidence to me is anything I can, sort of, hang my hat on as far as, things that are just, definite items that just aren't negotiable. Things that really need to find a way into the project, you know, that are gonna help you navigate. When you could do A or B, you know, and you need to make a decision, I think, I think evidence to me is how much can we weed out all the arbitrary decisions, and make thoughtful decisions that matter. So, I think I see that, you see that with healthcare a lot more than anything else. Because there are real outcomes that you need to achieve. So, you're really trying to bring out the arbitrary to where you make very few arbitrary decisions.*
9	**Engaging with vendors**	Definition	Interaction with healthcare vendors in order to exchange information or to plan for future businesses.
		Sample **(Field Notes)**	*The issue they need to resolve is the room size which is closely tied to device dimensions. They talk about extracting information from Philips.*

Sources and forms of evidence

10	**Informal search methods**	Definition	Information search activities where individuals mostly access websites or blogs, or utilize their individual connections to learn about devices, materials, processes, or certain design features.
		Sample **(O9)**	*From my end, from transition planning, I'm reaching out not only internal to Pebbles, but… It's habit, I randomly google and then reach out to individuals who have, gone through a similar process, who are experts in the field, and I just ask; would you talk to me? Would you share what you know?*
11	**Published resources**	Definition	Published materials including magazines, journals, newsletters which provide an array of healthcare design related information including products, research or opinion articles, news, and updates.
		Sample **(O4)**	*Uhm, I've not followed HERD that well. I depended more on the summaries in Healthcare Design, then magazine. And so there's facilities management healthcare magazine that is out, that I look at quite often.*
12	**Codes, guidelines and regulations to inform design**	Definition	Reference to established codes, regulations, or guidelines from a range of disciplines including design, engineering and medicine, that direct, regulate, or inform design.
		Sample **(M7)**	*And, so, we have regulations, plenty of regulations in the book that are based on what someone thinks is a good idea.*
13	**Anecdotal evidence**	Definition	An account or claim, mostly based on individual experience, which supports an argument that has the potential to influence or challenge design work.
		Sample **(P1)**	*So as I say, a lot of it has been anectodal. I think if you would ask a lot of designers previously, they would say, well, that's what, just design is. That's what any talented, knowledgeable architect would consider good design. And I think that's still probably true. A lot of the things that intuitively we thought were the right things to do.*

		Sample **(O4)**	*I'm a respiratory therapist, I know when you go into a mirrored room, you always sort of a, you are adjusting a little bit.*
14	**Expert knowledge and judgment**	Definition	Instances in design process where informed opinions from individuals with particular expertise emerge to challenge or support design decision making.
		Sample **(M7)**	*Uhmm, basically it's consensus of what we think is appropriate. Uhmm, and off a lot of the decisions that we make, as engineers, as architects, as, I think, even physicians, are just, are based on our experiences, and what we have learned formally and informally. Uhmm sometimes with strong evidence, sometimes with just what we think as best, and there's a lot of judgment involved in every step of this profession.*
15	**Utilizing (ebd) checklist**	Definition	Instances in design process where participants refer to or run a checklist to guide or inform design decision making.
		Sample **(D2)**	*There is a checklist. Uhmm, does it have, you know, light, does it have lots of windows, lots of sunlight, I mean it's… I can look at our plan, I can look at the checklist, and I can go step by step by step by step, down it.*
16	**Evidence from rigorous research**	Definition	Information emerging from scientific or academic caliber research to challenge or inform design decision making.
		Sample **(M7)**	*Simulation, yes. Uhh, and the study was based on modeling the air flow and then introducing particulate from places where we expect particulate to be introduced in an OR, and watching what happens to that material. So, out of that came some recommendations to change the number of air changes and require an air distribution pattern which had been fairly common practice anyway but wasn't required. And said, this is the best way to do it and this is what's required. Uhh, so sometimes there is really pretty strong evidence like that. And sometimes...*

17	**Learning from precedents**	Definition	Activities, including formal and informal research or site visits, to access, evaluate, and consider information emerging from previous design work or established practices in industry.
		Sample **(O3)**	*I think that we've learned from our other Pebbles hospitals visits tremendously. It was very nice to go back two years later to find out which designs that they were staying true to, and which ones they had abandoned and why they abandoned the design. We learned a lot from that and...*

Nature of evidence in design			
18	**Evidence as proven facts**	Definition	Considering evidence as non-negotiable, hard, proven facts to inform design decision making.
		Sample **(O2)**	*Evidence to me is a proven fact. Uhmm, you know, I can say something will facilitate better patient care but me saying means nothing if it hasn't been tried before, uhmm, and proven before. An evidence doesn't have to mean success. You can implement something that could end up failure. And that's evidence as well. Because it's evidence something didn't work. So it's just... To me it's proven fact. If you do something, something else will happen. And that's evidence.*
19	**Hypotheses to influence design**	Definition	Considering hypotheses, mostly cause-effect statements, to support or abandon particular ideas in design processes.
		Sample **(O4)**	*But the hypothesis makes sense. And if the hypothesis makes sense, and it doesn't cost you a significant increase in your budget, that's sort of what we feel why not have it.*
20	**Chain of causality**	Definition	Instances where participants refer to or utilize causal arguments to explain an idea or a mechanism behind a particular design decision.
		Sample **(O2)**	*...the bathroom is on the headwall with a railing, so the patient's in control of it, so falls then reduce.*
21	**Thickness of evidence**	Definition	The strength of evidence (strong, weak, or inconclusive) that is being considered in making recommendations or in design decisions.

		Sample **(M7)**	*So, if this person is ill, that person is receiving more germs. Uhmm, and some of those situations they modeled were things like a person sitting on a bed next to a patient and that's a worse environment. So… I don't know that evidence is conclusive either. But it's certainly enough to raise a question about whether it's the better system for patient room than what we have been doing. Uhmm, we actually stopped moving forward on that for [PHS] project.*
22	**Narratives of evidence**	Definition	Instances where participants invoke narratives combining precedents, anecdotes or academic research to explain the reasoning behind a particular design strategy or decision.
		Sample **(O3)**	*Because if you look at the IOM report that patients are being harmed everyday within healthcare and one of those largely harms from the medications that we give them. That's why joint commission came out that we need do a medication reconciliation at every hospital visit, well part of those errors happen in hospital, I mean patients are harmed everyday from giving the wrong dose, the wrong time, the wrong medication and we've experienced some of those medication errors ourselves. We have medication errors all the time, so we need reduce those errors to make a safer environment. So that was one reason and another reason is nurse fatigue, nurses travel up and down units all the time. And if we can decrease those steps, decrease the time that gives the medication then we can put more time back at the bed side, and that's the reason nurses got into nursing, it's to spend time with patients, not doing task.*
23	**Design to affect outcomes**	Definition	Considering or implementing design features that are assumed to carry the potential to affect care-related outcomes positively or negatively.

		Sample **(O3)**	*We can improve outcomes with whatever we're doing in the design. About making improvements for the nurses, for staff, for all staff, not just nursing, all staff. Or making better outcomes for the patient. This is a patient centric business. So, ultimately it's all about patient outcomes but you gotta take care your staff, too. You can't put anything that may be harmful for them.*

Implementing evidence			
24	**Propagation of evidence within team**	Definition	The process of explaining and disseminating design-related information to other participants.
		Sample **(M7)**	*But so for this step, for this piece here, we actually had a meeting in our office. We invited the mechanical contractor, several folks from **PHS** including **O1**, **O5**, **O8**, and we had the architect here, and several folks from our office, too. We just kind of went through and described each of these systems and how we judged each of these criteria. And uhm, it was two hours or more, going through this stuff.*
25	**Prioritizing concepts**	Definition	The instances where participants, mostly the owner, prioritize concepts and associated evidence to inform or guide design.
		Sample **(M7)**	*Uhmm, so one of their criteria was patient safety. So is safety is really important, then that pretty much eliminates a whole class of mechanical systems. The ones that are recirculating air within the room. All those got a strike against them in that category. And that category is a very important one to them.*
26	**Cost of implementation**	Definition	The cost or cost-related consequences that are associated with accessing or generating, translating and implementing evidence in design work.
		Sample **(O9)**	*The same with the nurse server, we're going to meet, I think it's next week, we're gonna sit down, and say these are very important to us. We have the Cadillac model in the room right now, here's the full cost. The initial purchase cost, to put it in, the machine, the badge access. Here is the operational cost.*

27	**Building support**	Definition	The process of utilizing certain outcomes or metrics (satisfaction), structured narratives, or representations, in order to gain support from owners, key participants or users for a particular design feature or decision.
		Sample **(O2)**	*They're very large, they're very aesthetically pleasing, you walk in it's warm. We actually had community and staff members joke that they want to come and no one is gonna leave these rooms. Because they're so nice. We have large TVs, uhmm, we had patients joke that they wanna come and watch the Superbowl in these rooms. Because they're so nice. So I really don't think there's any other room like this in PHS.*
28	**Translating and implementing evidence**	Definition	The process of translating information emerging from a range of domains into architecture and implementing or embodying them as particular physical environment features in design or as segments within care processes.
		Sample **(O4)**	*If you think about the patient room, then, from a lean concept, the nurse is not going to achieve success always sitting in the nursing station. So what we have done is we provided a computer at the bed side, a computer outside the patient room, then we provided perches for every six beds. We don't have centralized nurses' stations. so that's gonna put the nurse close to where the work is being performed. We're providing the, uhmm, nurse server, which will have, uhhmm, significant amount of the supplies.*
29	**Competing evidence**	Definition	Instances where available sources suggest competing evidence to challenge design decision making.
		Sample **(O2)**	*Uhmm, the one that jumps to mind is the idea of the standardized room versus the same-handed rooms. It's something that debated a lot in evidence-based design. Whether or not having a same-handed room is actually better, reduces errors than a standardized rooms.*
30	**Filtering and processing information**	Definition	Assessing, comparing, contrasting, or filtering emerging information in order to make a decision whether or not to utilize it in design process.

		Sample **(O9)**	*While there's tons of research, it doesn't always apply consistently across the board in every facility. It has to be molded and changed to fit the population, to fit facility, to fit operational structure, as well. So it's not just taking, when somebody says this is the right thing to do. It's challenging it.*

Interacting with users			
31	**Educating staff**	Definition	Activities associated with informing or educating staff on how to run new processes or how to operate in space in order to run those processes efficiently and effectively.
		Sample **(O9)**	*Especially when you have a new hire. They should be challenging them, maybe if you do it this way versus that way, it's a continuous pace, it doesn't stop. And it's teaching staff throughout this process of how to adapt that bubble up, and the managers how to encourage it.*
32	**User involvement**	Definition	Instances or mechanisms where design team members or owners interact with users, including hospital staff members and other representatives, in order to solicit their reactions to design or to nurture new ideas to inform design.
		Sample **(O2)**	*First is, the route we took is, we have user group meetings, you know, all the time. And we're all exhausted from the amount of meetings we had but our staff truly created their own units, designed their own units based on their needs. And we helped them to see the future, and see things that they're capable of, and they truly design their own units. I think that would be the difference maker. Because when we get there, they'll be excited. they will make those spaces work, and they will create processes that will make the successful.*
33	**User reaction or resistance**	Definition	The instances where hospital staff reacts, positively or negatively, to a particular process or a design feature to be implemented in the new hospital.

		Sample **(O4)**	*First we're getting some new flooring in this facility that we plan on continuing to use in some way. Secondly, there is several of us including myself, that would like to see carpet on the nursing unit in the hallways. Uhm, our nursing staff is very, has been very opposed to it.*
34	**Extracting information**	Definition	Strategies, mechanisms or methods, including structured conversations and surveys, which help design team members learn about how hospital staff do their work and operate in space.
		Sample **(O9)**	*I just find it useful when I drop in, it lightens the mood and they start talking to me. As I lay it out, they'll [staff] say, no, no, no that's not what we really do, or, no, no, no, we have this point, or, we have this additional paper-work. And I can bend and flex it in a way where a flow chart doesn't. And it's not, and if I clean up some of the problems it's not nearly as difficult to understand.*

Interacting with owner			
35	**Owner preferences**	Definition	Instances where owner representatives favor an option, a process or a design feature over another.
		Sample **(O3)**	*...it's not the culture that we elected to go for us, we elected to put our resources on the patient side, and not on offices and administration side, and put a little bit in that wow factor when you come in, but not to the extent some other facilities did.*
36	**Designing within budget and schedule**	Definition	Recognizing the budget and schedule constraints, and following methods and strategies to keep the project on time and on project.
		Sample **(O4)**	*Uhmm, and then we had to narrow it down to where our facility, what we're building is a very cost effective facility. It's gonna be in the range of, uhmm close to a million dollars a bed which, for us, is not that expensive.*
		Sample **(D1)**	*And yet we're still responsible for not blowing the budget, not blowing the schedule.*

37	**Principles and strategies to guide design**	Definition	Instances where participants refer back to or strive to keep the pre-established principles, strategies and commitments that are expected to guide design decisions throughout the process.
		Sample **(O4)**	*And I think that is to make sure that the project doesn't run away without maintaining the key elements, the key principles and purposes that we had in our original visions.*
		Sample **(O9)**	*Wait, your concept was, I think it was 20 feet. The nurses are not, no more than 20 feet to any supply.*
38	**Owner involvement**	Definition	Instances where owner representatives engage, formally or informally, in design processes to manage, inform and influence design work.
		Sample **(D1)**	*But because they [owner] have, for instance, their own construction project managers. So if you consider that the owner's rep, or the owner's construction manager, because they have that component, the process is not totally dictated and driven by us. Whereas in a situation with a client where maybe you don't have that maybe we almost are the... Almost like the owner's rep in a way, you might really wholly dictate that process. Uhmm, but again, with them, it's really kind of a partnership where it's almost like on a day-to-day basis you are sort of figuring it out in tandem with them, as a partnership, not just us saying we see the process this...*

Challenges in design			
39	**Evolution or alteration in design**	Definition	Activities associated with making changes to design work in order to achieve a better or a satisfactory design solution.
		Sample **(O2)**	*And all of us, the management team looked at the plans and we blew the whole thing up, that we had. We started from scratch. We had a day, we stayed in a conference room for eight hours, all day long and we redesigned the entire emergency room. Literally right before the plans had to be solidified for the emergency room. And the design we have right now is a thousand times better than the old one we had, because the staff questioned it and*

			then they designed it again.
40	**Questioning design**	Definition	Instances where individuals critically evaluate design decisions or physical design features, and/or assess consistency of those decisions against pre-established project goals.
		Sample **(P1)**	*I personally tried to look at some design, or planning decisions that we make. Sort of, test them mentally against, uhm, do they match up, do they not? Is there a reason why we can't achieve something. Sometimes there are reasons where it's not possible. Uhmm, and also research that I may have come across or other guides, try to apply those as well.*
41	**Coordination in design**	Definition	The process of discussing and coordinating design-related information across participants.
		Sample **(M7)**	*There was going to be a need to coordinate that design with the architecture, and the millwork, and interior design, everything, to make that work. Uhmm, that was gonna be a challenge all by itself. Because that had not been integrated into the preliminary design of the room.*
42	**Sequencing in design**	Definition	Processes, problems and issues associated with timing of information flow or of pre-determined activities that affect progress in design process.
		Sample **(D1)**	*But, uhm, by and large it's really just starting with the big things you can kind of wrap your hands around, and then, uhm, it's just spinning a lot of plates at the same time, cause there is so much that has to... It's extremely important that it'd be sequentially correct for the most part. I mean there is things that have to come in at the right time. There is things that if you ask the question too early you won't get the information you need. But if you ask the question too late, it can upset the apple cart. So it's really having things fold in at the appropriate time so that you know when to, you know, there is a certain amount of time that has to kind of swirling in kind of unknown, checking things out...*
43	**Arbitrariness in healthcare design**	Definition	Statements or complaints where participants mention arbitrary practices or decision making

			in healthcare design.
		Sample **(D1)**	*But at the time, there's been a lot of healthcare design up to this point, that is terribly arbitrary. Like 90% arbitrary, maybe 10% good design. So I think, what I see with evidence-based design is I am very excited that it's going to turn the tables on that. So that hopefully 80 or 90% is evidence-based and only 10 or 20% is arbitrary. Does that make sense?*
44	**Exploratory design process**	Definition	Processes or issues associated with the exploratory character of design process.
		Sample **(D1)**	*In this particular case, because of what we have talked about before, this being a little bit of a unique process that is not your standard, if you were to just sit down and really write out how you think the process would go, this one has not been that linear. It's been more exploratory kind of...*
45	**Roles and responsibilities in design**	Definition	The specific roles and responsibilities that each participant is assigned within the team, and individual or collective activities or interactions that occur based on these roles and responsibilities.
		Sample **(P1)**	*I was originally retained by Firm A to do program, to update the program. Firm B stopped it at a particular point. They had a room-by-room listing of all the spaces. They had a very preliminary scheme that was intended to support a Certificate of Need application. For whatever reason, we got an opportunity to sort of revisit all that. So very quickly we, kind of, redid the program, updated it, conformed various parts of it, made some changes to it. And then, redid a scheme in order to submit a CON application.*
46	**Decision making in design**	Definition	Problems or issues associated with decision making, including delays, which affect progress in design work.

		Sample **(D5)**	*There was the time that we weren't making progress. We were talking a lot, not doing anything. We weren't making any decisions. Uhmm, we can't do that, we got to make decisions based on the evidence, maybe it's not the... You know, the best decision we can make at the time. Cause we can't just not make a decision, we don't have that option.*
47	**Evolution in healthcare design**	Definition	Reference to evolution or shifts in healthcare culture, practices, or technologies within the PHS or in larger industry.
		Sample **(D1)**	*Because then, there is the overarching operational issues of, well, but we're evolving, or, we're trying to go to a different standard, you know, there is a lot of new technologies coming in; MR, accountable care... And all these things are starting to change the face of healthcare.*
48	**Negotiation in design**		The process of negotiation between the participants to arrive at a final decision concerning a specific feature in the project.
		Sample **(D2)**	*And we are fighting battles in house with, you know window sizes, glazing, and, you know, evidence-based design said the more glass, the better, more natural light, the better. You know, them more... The surrounding area you can see, you know, vistas, the better. But our engineers would like us to rein in the glass. [laughs] The glass can get... The glass on the edge of the building is more expensive. So... So, it's a give and take, a little push and pull, so...*
		Sample **(D2)**	*The group that was there discussed it and we were part of that discussion. D1 was part of that discussion and she agreed with the group and the group presented their, you know, reasons for doing it and D1 looked at it and decided that it was a good idea, go ahead and try it out in the mockups. So we'll go ahead increase the angle in the mockup and try it again and bring the same user group again, and see it again. If they don't like it, than we don't have to change the drawings. But if they do like it than we change the drawings to match the mock-up. And that's precisely what I'll be doing over the next few weeks, going to*

			the mockup and making sure our drawings match what's being mocked up, and what the users are seeing.
49	**Multiplicity of variables and complexity in healthcare design**	Definition	Reference to multiplicity of variables, issues and complexities associated with healthcare design.
		Sample **(P1)**	*It's essentially many building types in one, there's that. A variety of physical requirements that have to be met, sometimes conflicting. Uhmm, not unusual or not specific to healthcare but working with users who probably only do a major building once or twice in their careers. So therefore they don't generally have a lot experience in the building process. And there is a lot to understand, and a lot of decisions to make. So that makes it complex as well...*

APPENDIX D

INTERRATER RELIABILITY PROCESS INSTRUCTIONS

INSTRUCTIONS TO REVIEWERS

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1. Introduction

This study is part of an ethnographic research that aims at understanding the nature of interactions occurring within interdisciplinary teams with the task of designing a healthcare facility. The qualitative data set to be analyzed in this research includes a set of transcriptions of interviews which were conducted by participants. The research uses grounded theory coding as a basis for analytic induction. In order to validate coding and analysis processes, you're being asked to participate in a series of sessions involving coding (individual), discussion and evaluation (collective).

2. Research Questions

The questions that we pursue in this research are;

1. What is the nature of the research-design relationship in the context of healthcare design?

a. How is evidence represented by different communities within the socio-cognitive landscape of architectural design?

b. How do those representations afford, constrain, and impede problem solving in context?

c. Do those representations support and sustain interdisciplinary interaction? And, if so, how?

2. How are various forms of evidence being transferred/produced, negotiated, propagated and translated within interdisciplinary design teams?

3. Coding Instructions

The attached document provides a guide including the set of codes used by the primary researchers of this study in analyzing notes and transcripts from interviews and meetings. The guide includes all to-date codes and their higher level categories.

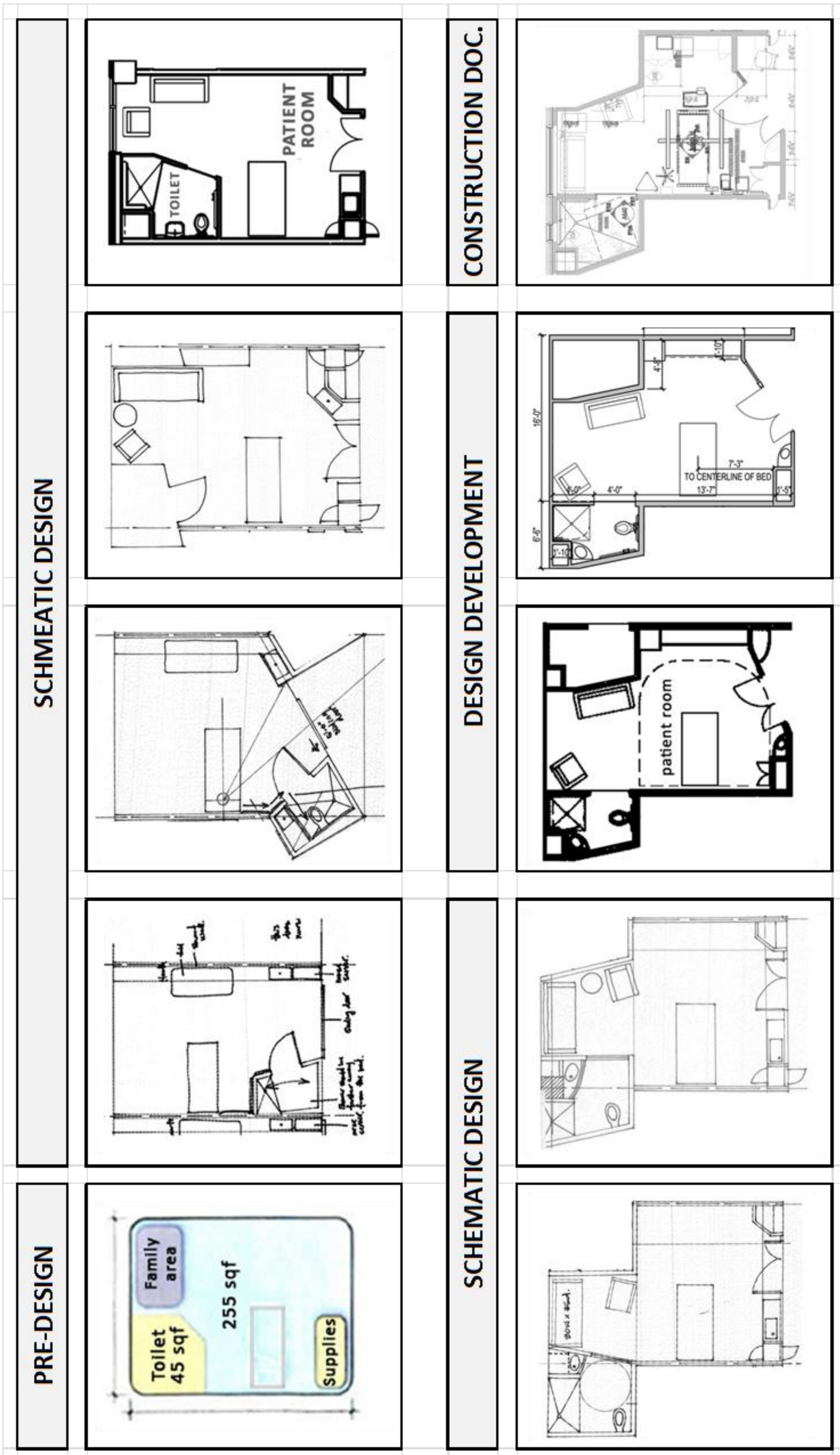
The section following the coding guide includes a sample transcript of a weekly (steering committee) meeting where all project leads from different disciplines (client representatives, consultants, architects, engineers, healthcare staff, etc…) some together and report, discuss and resolve issues, get specific direction from others and plan upcoming phases within the project. The attached transcript is from a meeting that was occurred during the late design development phase of the new PHSP hospital. The reviewer is asked to read the transcript carefully and use the provided codes and any other additional codes that he/she sees appropriate. The reviewer is asked to carefully mark the segments of transcriptions and indicate the associated code. The markings can be made on a hard copy, on the digital MS Word file, or by using a coding software.

Following this individual coding exercise, a meeting will then be held between the researchers and the reviewers to look at and validate this coding scheme according to their interpretation.

Thank you for your participation.

APPENDIX E

PATIENT ROOM EVOLUTION



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VITA

Before joining Georgia Tech School of Architecture's doctoral program in 2008, Altug Kasali had previously worked as a teaching and research assistant in Izmir Institute of Technology, Turkey, where he earned a Masters degree in Architecture (2006). At Izmir, Altug engaged in assignments in both design studio teaching at the undergraduate level and research projects where he had the opportunity to develop a knowledge base in architectural research, analysis, and dissemination.

During the course of his stay at Georgia Tech, Altug has matured into a role where he employs his research skills in translational research projects funded by prominent institutions in the United States. Altug Kasali has been integrally involved in research activities within the Health Environments Research Group and SimTigrate Design Lab which is in continuous collaboration with a variety of different sponsors ranging from healthcare providers and designers to advocacy organizations, all trying to solve the pressing problems associated with designing effective and safe facilities. Altug has been a key contributor in five externally funded projects, totaling over $1 million, where he has participated in research and management activities at all levels, ranging from methods development and field data collection to publishing.