Making Evidence Visible: Using Mock-ups in Healthcare Design

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ABSTRACT: While the healthcare design community has increasingly focused on using research evidence in design decision-making and on using collaborative practices, there has been very little research into how interdisciplinary design teams operate in the real world and especially how they communicate and attempt to integrate evidence from different sources into architectural practice. This paper reports on one focus within a long term ethnographic study of the design of a community hospital. It explores how physical mock-ups allowed multidisciplinary teams to collectively experiment and to gain shared understanding of affordances and constraints within the design of the patient room, and particularly how the teams explored the impact of design on visibility within the patient room within the context of new models of distributed nursing.

In our systematic observations, mock-ups emerged as key media to represent actual spaces to facilitate and support interdisciplinary decision-making. The 'interactional expertise' of project architects combined with interactive properties of mock-up rooms, which acted as 'boundary objects' among participants with different disciplinary backgrounds, helped this particular community to conduct a local research activity in order to generate first-hand evidence with regards to the design of patient rooms.

KEYWORDS: Healthcare design, ethnography, mock-ups.

INTRODUCTION

Real-world architectural practice is complex, with multiple stakeholders, numerous constraints and ongoing invention. Healthcare design is particularly multifaceted. In addition to the routine complexities such as budget and time constraints or specific programmatic requirements, there have been recent calls to employ integrated methods of project delivery in healthcare design and to base design on research evidence (Zimring and Bosch 2008). However, 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 final architectural design. This paper relies on ethnographic systematic observations of a healthcare design project *in situ,* with the aim of developing an enhanced understanding of actual collaborative healthcare design practice.

The specific focus of this paper is on the use of physical mock-ups, which were intended to facilitate crucial discussions and negotiations among participants including architects, planners, engineers, managers, physicians and nurses. Mock-ups have long been used within the healthcare design community and have been shown to be effective in testing key spaces *(*King, Marans, and Solomon 1982; Pietroforte, Tombesi, and Lebiedz 2012). One important feature of mock-ups is that they embody and make visible affordances and constraints that are only implicit in drawings. In this paper we are particularly interested in the potential of mock-ups in making design ideas from the research literature and local design experiments visible. These design ideas are intended to engage participants with a variety of disciplinary backgrounds.

Rather than viewing mock-ups as yet another form of representation utilized in design processes, we aim at accounting for the unique contributions of mock-ups in local design experiments and in generating first-hand evidence to be translated into design work. In a broader sense, the paper aims at contributing to the developing literature between design and research.

1.0 CONCEPTUALIZATION

It is necessary to clarify the use some of key terms. Many of these are not well defined in the literature or have multiple interpretations.

'Research' in this study means not only academic research presented in reports or refereed journals, but all the activities encompassing the systematic search for knowledge to be utilized in practice. The term 'evidence' is used in this study refers to the types of information in various representational forms (i.e., documented or anecdotal) providing a basis for belief about a phenomenon, which, in turn, are used to support or challenge design decisions. In that sense, evidence encompasses information emerging from scientific research, expert opinion, or even the anecdotal stories of individuals. This can include, for example, users who actively engage with the phenomena on daily basis. Furthermore, evidence can be embodied in publications, physical mock-up exercises, current or precedent practices, anecdotes, or regulatory documents. 'Information', on the other hand, 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. Within the user group meetings observed in this study, for example, the designers had extracted information with regards to spaces, devices, and processes within environments of care, a sub-set of which were then utilized and presented as evidence in subsequent interactions.

2.0 METHODS

This research adopts long-term ethnographic inquiry to provide a description of the practices of an interdisciplinary healthcare design team. These practices occur in situated contexts that include systems of people, tools, and representations. Ethnography is defined as "sustained, explicit, methodical observation and paraphrasing of social situations in relation to their naturally occurring contexts" (Weick 1985, 568). Rather than starting with a theory or a preconception, this research aims at observing emergent phenomena related to our broad research questions concerning the nature and use of evidence in healthcare design. The goal is not to test a hypothesis, but to better understand webs of significance in studied practice. Rather than generalizing from our limited analysis, our concern is to describe the properties of the emergent phenomena observed, and to determine significant findings that have the potential to transfer across situations.

With regard to the unit of analysis, this study focuses on a larger system, involving people, tools, and representations, to pursue the research questions. The research adopts ethnographic field strategies, observations, open- and semi-structured interviews (Spradley 1979) as methods to capture interdisciplinary problem solving *in situ*. We have conducted 145 hours of observation, audio-recorded 31 interviews with 16 participants, and video-recorded 15 meetings with an average duration of two hours. We also have accessed project documents including drawings, meeting notes, memos and online exchanges between participants.

In the analysis phase, the research adhered to "grounded theory" (Strauss and Corbin 1990) procedures involving inductively developing a theory that was grounded directly in the empirical data collected. The typical steps of the grounded theory method, namely open, axial and selective coding, was employed in analysis of our qualitative data set. To achieve higher levels of reliability and validity, the research followed two strategies including triangulation and inter-rater reliability exercises.

2.1. Context

The hospital project observed in this research is part of a larger expansion project initiated by a Private Health System (PHS) in the U.S.[1] In 2010, the board of directors of the PHS decided to allocate approximately 140 million dollars to replace one of the hospitals within the system. The replacement hospital (PHSP) will include a 112-bed, state-of-the-art hospital with enhanced services and programs to be developed around specialty lines. In total, there will be eight floors which will make the hospital the tallest building in the county. All patient rooms will be same-handed, meaning each have identical layouts, and will provide a space to accommodate visitors staying overnight. As stated in the initial vision 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.

Firm A, a local architectural design firm, received the design commission for the hospital in December 2010, and engaged in steering committee meetings which were already being held for over a year. Although there was a certain circulation in human resources within Firm A, three members of the design team, D1, lead designer, D2, intern architect, and P1, programming and space planning consultant remained as the key members of the design team. On the other hand, O4, the president of the hospital, and O3, the vice president and chief nursing officer, were the client representatives who sustained a close relationship with the architects throughout the project.

Figure 1: Key actors involved in developing patient rooms.

3.0 EMERGENT ISSUES: DISTRIBUTED NURSING AND VISUAL ACCESS

The critical need for providing visual access emerged as one of the major issues on many occasions throughout the project. The design group revisited layouts in order to make sure that the design provided good visibility to people, spaces, equipment. Enhanced visual access was seen as important at multiple scales, such as across the nursing floor and within the patient room. In many exchanges involving designers, consultants, client representatives and staff members, the value of providing a better line of sight was repeatedly emphasized. The emerging narratives to emphasize the need for better visibility, which were provided by all engaging parties, clearly suggested the value of the concept which was deeply embedded and prioritized in care culture:

> ***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…*

Starting from the very early meetings, the project group had embraced several concepts to enhance the observation of the patient. 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. We have not recorded any resistance against the idea of distributed nursing.

A distributed (or decentralized) model of nursing care has been one of the hottest topics within healthcare design community. Different from the traditional unit configurations with central nurses' stations, this relatively new concept proposes distributing resources across patient care units. This concept seeks to improve monitoring of patients by clinical staff and reduce walking distance. The impact of distributed nursing has been documented in the research literature (Hendrich et al 2004, 41). Alongside novel care protocols to be adopted, the model introduced 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, 41).

In addition, the question of universal "same-handed" rooms and inboard-versus-outboard bathrooms are currently being debated in healthcare practice. Universal same-handed rooms are identical with the patient always in the same orientation to the door. (In this case, to the right as you enter the room.) This increases cost because a common wall cannot be used for utilities for the headwalls of two rooms but is argued to reduce error during emergencies because each room is identical, similar to airplane cockpits (Pati et al. 2010). Outboard toilets are on the outside window wall rather than the corridor wall of a room. This allows for a more transparent corridor wall to be used for visibility and other purposes but the toilet on the outside wall can reduce the size of windows.

4.0 CONDUCTING VISIBLE RESEARCH

The client representatives were exposed to details of the idea earlier in the process through formal and informal presentations, and site visits which enabled them to see distributed nursing model in action. Our

interviews with both O3 and O4 revealed that the client representatives were well aware of positives and negatives with this new model, which was a different process from what was utilized in the old hospital. 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 required a "shift in SHSP's care culture." Throughout our field observations, we observed both O3 and P1 patiently and simply explain the set of new processes and design implications to staff members in each engagement.

Having all these initial principles and ideas at hand alongside budget and schedule constraints, the task for the project architects was to come up with a satisficing design for patient rooms. Particularly the design for the corridor wall of the room, which was expected to accommodate a nurse server, a hand-washing sink, a convenient entrance, and a nurse work station, consumed vast amounts of hours before arriving at a proper design solution. When it was the time to delve into details of the patient room, the project architects produced countless sketches to synthesize initial ideas (Figure 2).

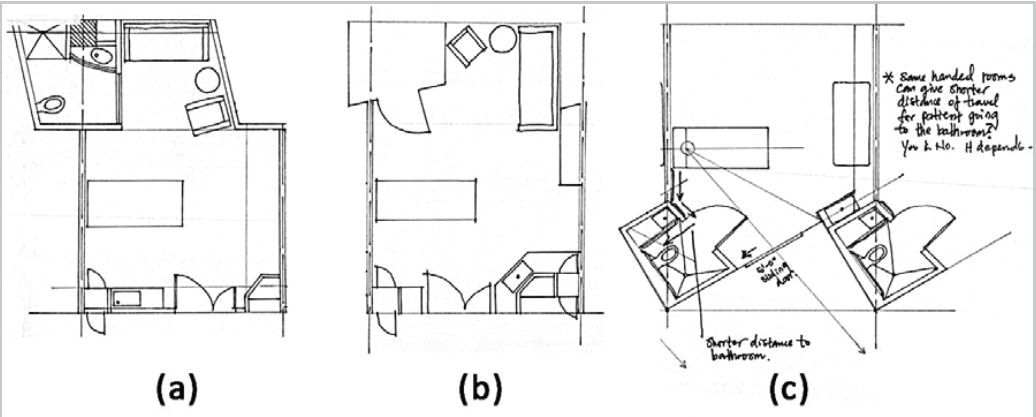

Figure 2: Developing the patient room.

Following comments from client representatives during late schematic design phase, the architects had narrowed down their attention to configurations with outboard patient toilets, which reduced the number of elements to be integrated into corridor walls. Another clear direction which came out of 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 had emerged during these exchanges with client representatives. We were able to identify several sketches dated in the schematic design phase which introduced an angled corridor wall (e.g. Figure 2c). In these series of sketches, the designers had indicated lines of sight which intersected 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 archived in the form of sketches, though it was not clear who first sketched the angled corridor wall.

The corridor wall angle in these sketches displayed a great variety, ranging from very tight ones (~5 degrees) to open ones (~30 degrees). The architects did not arrive at a final decision with regards to the particular configuration of corridor walls, as the team approached the deadline for schematic design. The plan was to continue developing the room design in both layouts and in mock-ups until they were refined as 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 design development phase. The versions of patient rooms included in the schematic design package did not communicate any of the experiments with the corridor wall.

As the team developed the strategy for mock-up rooms later in the design development phase, the architects focused their attention back to details of the patient room of the future hospital. P1 was the key person to develop mock-up exercises, which were based on a build-review-rebuild model in order to accommodate input from all participants. D2, who was tasked with developing the drawing for mock-up exercises, returned a set of drawings which included a series of features (e.g. outboard toilet, angled wall, charting alcove) integrated into room design (Figure 3).

The drawing below was adopted by the construction consultants to develop mock-ups, which initially consisted of constructing movable walls to define the room perimeter. The expectation was to engage in a conversation with a larger group involving a collective exercise utilizing movable walls, and, eventually, finalize the evolving geometry of the room.

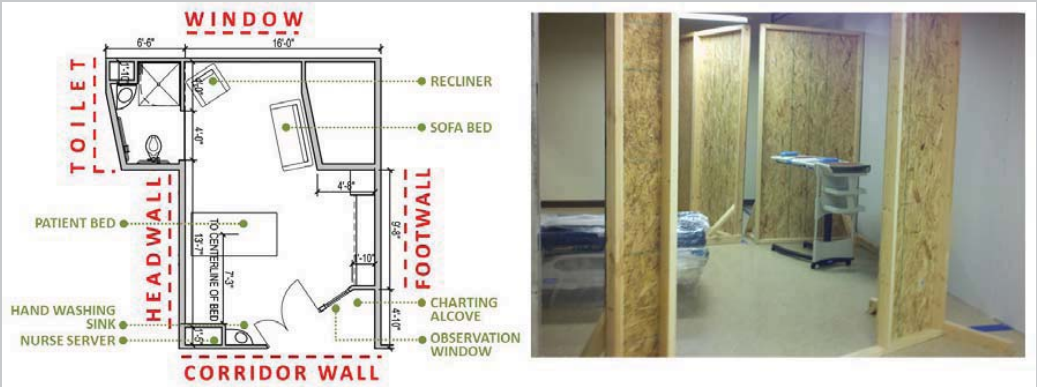

Figure 3: The layout diagram utilized in mock-up studies (left) and movable walls utilized in the first phase (right).

Even though the hospital staff was presented with computer renderings and the layouts of the rooms prior to their visits to mock-ups, they were amazed by the size of the room, which was significantly larger than the patient rooms of the old hospital. For the first mock-up exercise, 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 within the room perimeter defined by bare walls. In a later visit, however, a group expressed their concerns with regards to limited visibility to patient heads from workstations just outside of rooms. This comment, which was raised only once in a series of visits by staff members had significant consequences for the room dimensions and the angle of the corridor wall:

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…*

I *On the mock-up?*

D2 *Yes, on mock-up. They are working on it now actually.*

I *All right. So how did you decide on the angle in the first place?*

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.*

As D2 emphasized the architects "knew there was going to be some tweaking" following mock-up exercises, and they were expecting 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 which was initially studied by drawing sight lines on layout drawings (see for example Figure 2c), and by three dimensional renderings which provided views to patient beds.

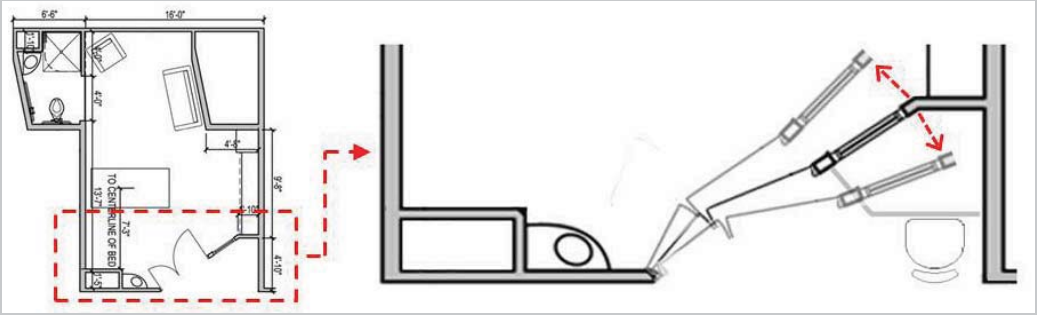

Figure 4: Finding the right angle for the corridor wall.

As opposed to other media, the mock-ups exercises were collective experiments, which led to generation of first-hand evidence involving actual staff members enacting their everyday practices in physical space. The comments with regards to 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 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 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.

I *So, how about discussing issues with users on the paper and on the mockups? I mean is there a difference or not?*

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, were the individuals to negotiate the corridor wall angle with the users, whereas D2 was the one to keep track of the progress on mock-ups and translate the "perfect" angle into layout drawings. What D2 stressed in above quotation with regards to the differences in utilizing drawings versus mock-ups during design review meetings exemplifies design team's view which was repeated by D1 and P1 in multiple interviews: Mock-up space was an "irreplaceable" medium which enhanced the crucial negotiations with users, which eventually, allowed architects to process and translate user input.

Briefly, the idea of introducing an angled corridor wall was developed and maintained in layout drawings before it was collectively reviewed within mock-up rooms. The anecdotal evidence emerging from conversations with users suggested a series of tweaks on mock-ups in order to improve visual access to patients. Furthermore, the mock-up enabled research in the form of in-house experimentation which, in this particular case, had a significant effect on the design decisions concerning visibility. The output of this in-house research activity was then captured within mock-up representations before they were translated into architectural drawings. The case presented in this paper epitomizes how a larger principle (provide better visibility) was collectively elaborated and grounded in fine-grained details through a series of experiments utilizing mock-ups.

CONCLUSIONS

In addition to typical challenges in any given architectural design project, a constant struggle in healthcare design is to meaningfully utilize emerging research-based findings and to satisfy critical requirements posed by the culture of patient care which is in constant transformation. The innovation-driven healthcare market requires architects to quickly adopt and implement research-based or evidence-based concepts such as distributed nursing stations. The design team in this study utilized mock-up spaces which allowed them to make visible and implement an emerging research-based feature while fine-tuning details through a series of tests involving participants with different backgrounds. In the case presented, the mock-up acted as a "boundary object" (Star and Griesemer 1989) to facilitate an interdisciplinary exchange between architects and healthcare workers. The architects in the project, who possessed interactive expertise (Collins and Evans 2002) to access nurses' practices and languages, utilized mock-ups to conduct a series of local experiments which made design decision making, to some extent, accessible to users. While making ideas visible for non-designer participants, the mock-ups aided architects in blending research-based evidence with local needs of users.

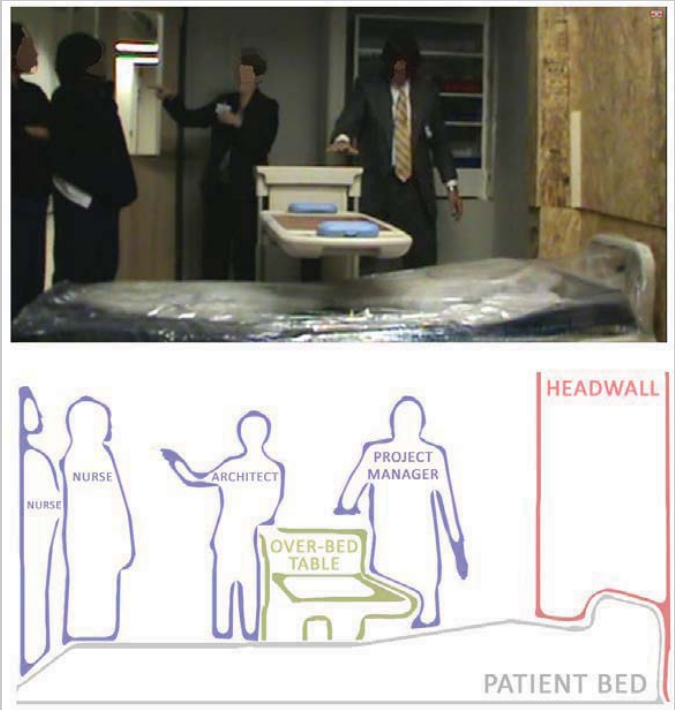

Figure 5: Negotiating in the mock-up.

With regard to visibility, the design intention, which was collectively formulated, was enacted and evaluated in mock-up space without any other form of mediation. Embodied experience of care activity animated, to some extent, people, equipment and processes in mock-ups which 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.

Emphasizing the role of architects in translation of evidence, the case presented in this paper provides a vivid example of how research, in forms of rigorous academic studies and in-house experimentation, shapes design of healthcare environments.

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ENDNOTES

[1] The names for the organization, the project, and people have been masked at the organization’s request.