EXECUTIVE SUMMARY

There is a disconnect between the design team and the end-users (caregivers and other staff) in the design phase of hospital construction projects. Often times, care spaces are designed by a group that will never end up having to perform real world tasks in the finished product. Most design firms currently use physical mock-ups in an effort to involve nurses, techs, and other end users in the later
phases of the design process. Physical mock-ups of room designs can be very costly, inflexible, and resource intensive. There is an answer to this solution:

The Virtual Design System (VDS) creates a virtual mock-up of the hospital layout designs to allow measurement, comparisons, and validation of designs. This allows a limitless number of users to evaluate room designs through a virtual environment that is cost-effective, flexible, and can model infinitely different care scenarios. As users navigate through the virtual environment to achieve their tasks, qualitative and quantitative measures can be recorded to help evaluate best practice design alternatives.

VDS will allow architecture and other design firms to take healthcare design to the next level by allowing a new echelon of patient interaction. Imagine allowing every caregiver to work in his or her care environment before it is built. In the future, the uses of VDS can extend upon decision support for hospital design into way-finding training, patient distraction, patient education, and even advertising through virtual hospital tours.

**PROBLEM DEFINED**

There is a disconnect between the design team and the end-users (caregivers and other staff) in the design phase of hospital construction projects. Currently design firms generally use physical mock-ups in the later stages of the design process. There are other creative ways of trying to include the end-users; however, there is still a large gap between who is calling the shots of how the
room will actually be laid out, and who will use the room. This practice leads to some of the following problems:

- Healthcare design is not accessible to all stakeholders.
- Environmental information can be very costly using physical mock-ups.
- Physical mock-ups are very inflexible to change.
- Environmental information is hard to portray in the early stages of design.
- There is a lack of utilizing current IT technologies in healthcare design.

Hughes Spalding is currently undergoing renovations and was the first candidate to explore the nuances of each of the problems listed above. The design firm, HKS, is currently working with Hughes Spalding. The team took several site visits to explore the virtual mock-ups HKS had created and found the following issues:

- The textures of the materials used were not very organic or life-like.
- The physical mock-up seemed fairly inflexible to change.
- The physical mock-up was resource intensive, requiring materials from around the hospital to be procured.

Considering these problems, the team sought out to find a creative solution.

**REVIEW OF EVIDENCE AND RELATED WORK**

Studies have shown that people navigating in virtual environments have similar performance in spatial knowledge to people navigating in the equivalent real-world environments (Jansen-Osmann & Wiedenbauer, 2004; Ruddle & Lessells, 2006; Wilson, 1999).
Hunt (1984) reported that people receiving a training in virtual environment can outperform those physically visited the environment. In his study, 51 older people (ages 57-79) were randomly divided into three groups: virtual environment group; site visit group; and control group. The evaluation demonstrated that the confidence in way-finding ability; the mental image of the building; and way-finding ability provided by the simulation technique was actually more useful than that provided by actual visits to the building.

A more recent study showed that people with in a VE training shows greater accuracy in making pointing judgments toward targets not visible from the pointing site, took shorter times to perform route tasks on foot, made better left-right directional judgments, and sketched better maps of the mall, than those without VE training, based on a sample size of 32 people (Foreman, Stanton-Fraser, Wilson, Duffy, & Parnell, 2005).

All these studies indicate the validity and usefulness of virtual environment. However, no study has used the tool to test design propose in a rigorous way.

**SOLUTION**

The team developed the Virtual Design System (VDS) as their solution. VDS answers each of the problems of current healthcare design by:

- Making hospital design **accessible** to all stakeholders.
- Providing environmental information to users in a **cost-effective** manner.
- Allowing **flexibility** in the design process.
- Exploring **future capabilities** of a socially driven virtual environment.
In finding VDS, the team made sure to approach each facet of the current problems in healthcare design with great detail.

For feasibility purposes, the team developed a situation based off of the Hughes Spalding renovations to compare two evidence-based design alternatives for an exam room (Figure 1):

Figure 1: The layouts of each of the exam room alternatives. They have exactly same size and dimension, however, have different furniture layout.

Each model was given its own dedicated layout of four rooms. The purpose and scenario of each room is as follows:

- Grey Room – familiarize user with empty room.
- Green Room – wash hands and greet child and family.
- Yellow Room - measure blood pressure and examine the ear cavities.
- Red Room - write a prescription and educate child and family.
Figure 2: The overall layout of the rooms for design A. There are four rooms with different scenarios and tasks for users.

Interacting in the scenarios of each room for each model will allow users to evaluate which design is optimal.

 Totally, we invited six people to participate this test. They are randomly divided into two groups: group 1, and group 2. In group 1, participants are required to explore Design A first, and then explore Design B. In group 2, participants are exploring two designs in the reverse order, Design B is followed by Design A.
Subjective and objective measures were developed to capture the effectiveness and efficiency of different designs.
The objective measurements includes handwashing compliance rate, walking distance, time to perform all task.
The subjective measurements include feedback to the following questions after our participants finish the experiment: do you feel the exam room: 1) dreary and boring, 2) cluttered and crowded, 3) having insufficient store spaces, 4) having major design problem. These questions are based on 1-3 scale: 1=agree, 2=somewhat agree, 3=disagree.

Our results from the objective measurements favor the Design A, which has slightly shorter walking distance, shorter time to finish tasks, and higher handwash compliance rate than Design B (Figure 3). However, the results from the subjective measurements are unbiased towards either design (Figure 4). None of difference was statistically significant. In the next experiment, it is necessary to enlarge our sample size because we don’t have enough statistical power with only 6 subjects.

![Graph showing objective measurements](image)

**Figure 3:** The objective measurements includes handwashing compliance rate, walking distance, time to perform all task. Subjects exploring Design A, tend to
walk more shortly, finish tasks more quickly, and have higher handwash compliance rate than those in Deisgn B.

Figure 4: our participants are required to answer the following questions after the experiment: do you feel the exam room: 1) dreary and boring, 2) cluttered and crowded, 3) having insufficient store spaces, 4) having major design problem. These questions are based on 1-3 scale: 1=agree, 2=somewhat agree, 3=disagree. There is no clear pattern of inclination towards either design based on the results.

PROCESS TO SOLUTION

The first step towards finding a solution was conducting Hughes Spalding site visits. At the site visits, the group achieved the following:

- Met with care-givers to determine needs.
• Met with design team to assess current state of renovation project and where they had room for opportunity.
• Viewed a physical mock-up model.
• Interviewed staff to determine common procedures that occurred in exam rooms.

In the next phase, the team worked with cross-functional professors to brainstorm unique uses of the virtual environment. The team ultimately decided that the most practical current use of the virtual environment lies within design alternative evaluation.

After determining the use of the virtual environment, the team decided to use Hughes Spalding’s exam room as an example. Another site visit was conducted and the two-dimensional drawing of the proposed exam room was collected. To compare the design, a revised HKS model was created by moving the placement of the furniture while leaving the room size constant.

The virtual environment was created for each alternative and was set on display side-by-side for users to evaluate which room would be better suited for their practice. In the future, the team would like to explore the use of more quantitative analysis including process measurements, and usability rating.

REFLECTIONS

The team consisted of two cross-functional members;
• Yi Lu – Doctorate student in the college of Architecture
• Joe Riley – Masters student in the Health Systems Institute

This diversity allowed for great things to happen throughout all phases of the project. While Joe served the roles of project manager and marketing of the idea, Yi Lu was the expert on designing the information technology (using the ‘Unreal’ gaming engine) backing of the virtual environment.

In the future the team would like to see more research performed in the following areas:

• Exploring the effectiveness of way-finding training via the Virtual Environment.
• Exploring the capabilities of process measurements (throughput, utilization, queue length, etc.) using the VDS.
• Rotating the room by allowing scenarios to be viewed through different perspectives (i.e. Child, Physician, Parent, etc.).
• How people would interact in a socially-driven virtual environment.
• Educational benefits of allowing patients to interact in the virtual environment.
• Selecting the most effective virtual design engine.
• Advertising opportunities using VDS to give virtual tours of hospitals.

The team feels that VDS may be used in the near future by architectural design firms. If these firms picked up this technology, it would enable them to take their practices to the next level through better customer involvement. More funding
into this concept would further prove its ability to serve as a cost-effective means of allowing design decisions to be made in an optimal fashion by more stakeholders.

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