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BIM + HEALTHCARE

On the view of a primary healthcare renovation project

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Abstract. Currently BIM is at the forefront of the building industry. While useful for various building types the definitive nature of healthcare design benefits from the BIM process largely in comparison to other building types. In this paper BIM is employed for phasing the design process of the healthcare project, creating modelling prototypes and making reference to a baseline model in order to increase the overall success of the healthcare design project.

Keywords. Building information modelling; healthcare; evidence-based design; prototype; baseline model.

1. Introduction

Building information modelling (BIM) is cooperative actions between building industry professionals and client user groups, all using available 3D applications and other digital media for simultaneous and consistent data sharing in an on-going design project (Eastman, 2008; Park, 2008; Ozel, 2008). BIM provides the capabilities of interfacing and correlating multiple layers of various kinds of information. The categories of information are 1) visual representation, which is the information consisting of object properties and object-oriented graphic components database entries, 2) calculated information which includes specifications, costs and drawings schedules and 3) documentation of relationships and responsibilities consisting of contracts, warranties, maintenance information, etc. (Kennedy, 2008). Ideally, BIM would be fully integrated among all professions with various collaborative projects having a functional information processing linked to one another. While BIM has been applied to various building types, the methods used are not fully developed for healthcare projects. In the case of healthcare design projects, utilising BIM is an efficient process which supports the coordination of multiple variables found in healthcare facilities. Furthermore, the collected data from credible research, evaluations and evidence gathered from the operations of the patients, doctors, clients and other partakers of the health facility become critical factors to make design decisions. This type of design method has been developed as "Evidence-Based Design (EBD)". Since Ulrich (1984) pioneered the study of EBD in 1984 with his paper, "View through a window may influence recovery from surgery," EBD has become prevalent in healthcare design. Weill Greenberg Center in New York (Gaerig, 2008) is recognised for the exemplary use of EBD. In this paper, issues regarding healthcare facilities are presented and various strategies of using BIM are explored based on the specific nature of healthcare through a case study of a primary healthcare facility renovation.

Figure 1. Images of the case study for the renovation of a primary healthcare facility.

2. Case study

The case study is to renovate a primary healthcare clinic, one story building, approximately 8900 gsf of existing structure, housing facilities which provide basic examinations, imaging, pharmacy, laboratory, and minor surgical needs. The beginning phase is considered new construction adding to a total of 14,650 gsf by the end of the design project. While this building is undergoing renovation the design is managed in construction phases throughout the existing structure using AutoCAD 2D applications. The comparison comes from using a customised BIM process to perform the same tasks involved in the renovation project. Reflecting on the comparison between the traditional process and using BIM reveals the effectiveness of how information is managed. BIM is employed as a liaison in the design process for developing optimised BIM strategies in healthcare design.

3. Need for BIM in healthcare design

Healthcare design has a direct and intentional purpose to ally with healthcare professionals for promoting wellness. The consistency of the goals and repetitive activities that occur within the building, leads to regular processing of information (Ozel, 2008). BIM will support and permit advances in healthcare as a library of information relative to the building. In light of this, BIM also influences the quality of EBD. Healthcare design benefits from BIM because even with multiple layers of design data BIM guides a healthcare design direction toward promoting wellness effectively. The critical nature of healthcare corresponds to the methods of treating patients, providing functional space and housing tools and equipment.

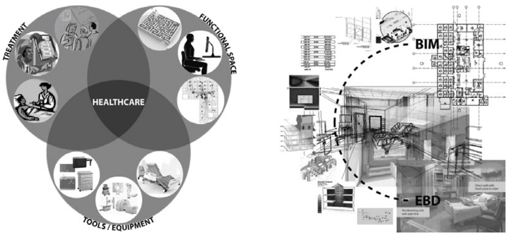

Figure 2. Nature of healthcare and BIM for evidence-based design

First, treating patients includes discussions, examinations, operations, and/or checking results. Treating patients revolve around the initial actions when a patient first arrives to a healthcare facility and any actions that may follow as a result of the patient's condition. Miscommunication and delay in productivity occur from the consultation between healthcare professional and patient, or administrative reasons such as form-filling, note-taking, and the clerical errors (Patel, 2002). Second, providing the functional space for healthcare professionals is another essential part in healthcare. The spaces for these departments are shaped differently based on activity, equipment and other specific needs. Third, housing the sophisticated tools and equipment also has a significant role in the nature of healthcare. Designing for healthcare equipment is vital because healthcare is so dependent on these sophisticated tools for diagnosis and readings' results. The difficulty comes with space designed rigidly to one piece of equipment when technology advances and redesigning for updated equipment or new equipment is required. Designing with anticipation of future developments in healthcare technology remains to be an issue (Maione, 2004). These issues make healthcare design more challenging.

4. BIM + healthcare

BIM has the capacity to amalgamate a bridge between the healing environment and the services of the healthcare professionals. As a tool for evidence-based design, BIM is employed as a liaison between patient outcome data and specific building conditions and locations.

4.1 ENVIRONMENT OF PATIENTS AND CAREGIVERS

A few healthcare challenges centre on maintaining environmental control for patient safety in areas such as air quality, energy control, noise factor, communication and infection control. Solutions are developed by adapting healing patterns which are achieved by monitoring quality of design which can be done so by establishing parameters under BIM tools (Ozel, 2008). Also, administered by a hospital's facilities management department, a BIM model can be the reference library for all product and equipment information enabling the creation of maintenance schedules, standards manuals, and purchase orders (Kennedy, 2008).

4.2 HEALTHCARE MODULES USING BIM

Once BIM is able to network facilities data with financial analysis of the hospital services, BIM has the potential to be used as a powerful tool for strategic planning (Kennedy, 2008). A healthcare module is an assembly of organised components, based on healthcare department needs, contained together and maintaining an independent nature (Miller, 2009). Each department becomes a module integrated into BIM which contains specific combinations of building components needed for the specialise activities. The decomposition of BIM modules entails breaking down the hierarchy of groups, prototypes, components and further if necessary to objects and artefacts for isolated inquiry of design or redesign (Li et al., 2008). The decomposition is based upon the teamwork of the components. The possibilities for detaching information with the decomposition may pertain to further development or replacement of new and/or advanced information. Based on isolating the modules, future development can be focused on independent areas of a healthcare facility, avoiding disruption or distraction relative to other spaces and supporting scenario testing on various scales. Instead of the current method of seeking researched knowledge in hopes of validating a design approach, BIM would reveal all sorts of correlations of the modules and provide the evidence to facilitate long term controlled studies of a given design project (Kennedy, 2008).

4.3. MANAGING TOOLS, EQUIPMENT, AND OTHER DETAILS

Currently BIM has opened up opportunity to make collaboration more effective with provision of real-time data exchanges, which are detailed scheduling, geometric coordination of healthcare equipment along with mechanical, electrical and plumbing (MEP), and by providing an explicit library of information for future strategic planning (Manning, 2008).

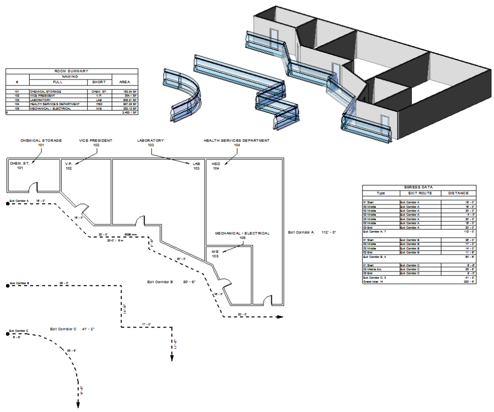

Figure 3. BIM coordination of egress routes along with schedules (from Stafford, 2008)

Figure 4. Full-scale mock-up (from Bell, 2007) and BIM simulation of patient room

BIM used for the special characteristics of healthcare design also include accurate as-built information of facility which can be critical to future renovations. BIM potentially reduces the need for full scale mock ups of patient rooms, surgical suites, etc. BIM is a repository of initial information provided by the client such as site information, area requirements and so forth which supports scenario testing for clients (Ozel, 2008). Creating a realistic scenario using BIM offers hard data information. This is useful for calculation and analysis to further develop healthy environments. Rather than creating a static full scale mock up, a much more flexible and transportable full scale virtual reality experience can be arranged by means of simulation provided through BIM (Bell, 2007; Dunston et al., 2007).

5. BIM strategies

Three BIM strategies for healthcare design suggested in this paper include phasing, prototyping and application of baseline model.

5.1. PHASING

Phasing process with BIM provides the ability to forecast the development of on-going design project and its schedule. Each control system includes a "look-ahead window," which is part of a scheduled structure. Activities according to a master schedule are advanced through the look-ahead window. It gives a preview of the next phase before the phase commences. With the ability to look ahead, assignments are made according to the project units' capacity. Completing sound assignments maintains productivity through each phase of the project. The confidence comes from testing and then evaluating operations by exploding the activities in accordance with the BIM model (Ballard, 1999b).

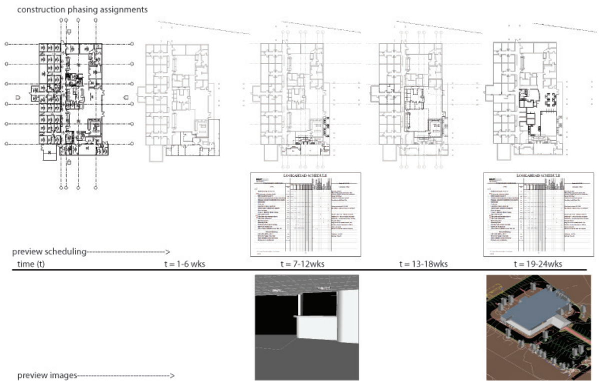

Figure 5. Overview diagram of forecasting/proceeding through BIM phasing.

Using BIM to evaluate phasing assignments before they are implemented supports necessary safety precautions. Previewing a phase helps prevent loose ends in design or scheduling before work is in motion. In a traditional design process, most project teams attempt to adhere to the long-term master schedule very closely. Decision-making and maintaining consistent drawings throughout the duration of the project can become tedious and can take up a lot of time and effort. The traditional design process has less accountability of the project activities and causes less accuracy in drawings and production. Specifically, coordinating phases is challenging in healthcare projects due to complexity and liabilities that regularly drive the healthcare market. Challenges arise especially during construction and even more so in renovation projects. During healthcare renovation projects, it is difficult to build out interior spaces of an occupied medical facility, safety is a high priority and managing ingress/egress routes, infection control, required operational downtime and managing temporary spaces are examples of some of the challenges (Sullivan, 2007). For instance, a MRI machine weighs approximately 30,000 pounds. Transporting this massive, expensive piece of healthcare equipment takes pre-planning. BIM can be used to find a precise date in the construction schedule and the optimal ingress route can be determined to ensure successful installation (Condit, 2006). Phasing in BIM provides an integral and prompt coordination between systems within the design documentation. It greatly reduces the contingency of delivering design intent with unaddressed coordination issues between building systems. In the healthcare design industry most of the problems occur in MEP construction coordination. Its cost increases to about 45%–55% of the total costs of the entire project (Sullivan, 2007). In the case study, phasing is arranged by setting up stages of evaluation. The reliability of data outputs is dependent on input setup of rules in BIM tools and how they communicate. Delineating design tasks in phases are enhanced remarkably when schedules are supported by prototype modules reviewed throughout the later phases.

5.2. PROTOTYPING

Defining a prototype starts from understanding a category. A category is made up of families and within families there are types. A type may exist in a family, singularly or multiple times, and each is known as an instance (Revit, 2009). This relationship exists on different scales but regardless of scale, the relationship is consistent. In the case of healthcare design, the category is healthcare and the families are specialised spaces such as the exam room, patient room, etc. Types of exam rooms are general purpose examination room, special purpose examination room, observation room, and treatment room; from these prototypes are generated. As prototypes are formulated, they are assigned to projects and the option to refine prototypes is available. Prototyping in BIM maintains certain levels of organised information preventing confusion or inconsistencies during the design process. It makes information accessible after the completion. The primary computer application utilised for this case study is Autodesk Revit 2010. In its database, Autodesk Revit stores the reference to *Design and construction of health care facilities* by the Facility Guidelines Institute (FGI) and the American Institute of Architects (AIA). Outcomes from the case study reflect that prototyping includes the availability for being useful in new and ongoing projects to be used and developed as is, or by specialists looking to identify environmental issues in a specific setting. The reference supports foundational parameters for the development of healthcare design. It provides close review of the development of selected spaces in this project.

Furthermore, parameters according to these guidelines are implemented through simulation function in the evolving process of prototype. In this process, most basic attributes are accounted for and included into an initial prototype. Further detail to the initial prototype relative to any project becomes a new level of prototype. A later stage of an evolving prototype results in a physical product. Variances and errors are likely to occur during and after the physical construction of the building. The reality of a building is reviewed and taken into account to consider for further development of BIM prototypes.

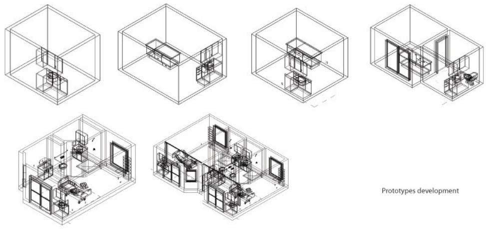

Figure 6. Diagram depicting iterations of BIM prototyping.

5.3. BASELINE MODEL

A baseline model is a post-construction BIM model that was originally developed during the design of the building as a new construction project or initially integrated into a project of a building as a renovation project. This model contains the previous design work and provides accurate information regarding the building's functions. Figure 7 illustrates a visual comparison between a redesign project using tradition methods and the one with a BIM baseline model. By the end of a project in a traditional design process, several connections of information are lost or kept within the boundaries of specialised groups who worked on the project due to the absence of a baseline model. However, a baseline model in BIM becomes the basis of the well coordinated building information model through various design phases. Passing on a baseline model for future design work or renovations prevents uncertainty regarding the current state of the building. At the completion of the design project the BIM model serves as a resource for future inquiry. Using a baseline model for the case study reveals the need for healthcare designers and professions to be in agreement concerning quantity and level of detailed information to be shared for future reference. Referring to the BIM model as the baseline model for any future alterations makes possible access to ready information to be extracted from the model and a record of ongoing work. The BIM baseline model becomes the key to the whole BIM process with consolidation of large amounts of 3D data from different applications into one model (Sullivan, 2007).

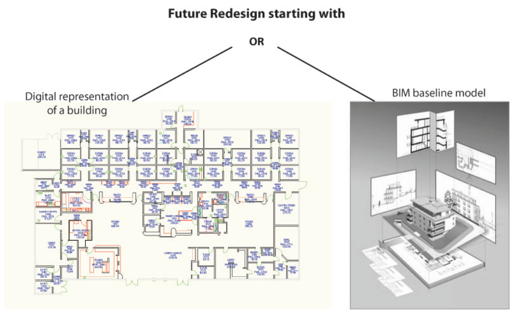

Figure 7. Comparison between digital representation and BIM baseline model

6. Discussion

In this research, the initial setup for applying building information modelling (BIM) in the healthcare design took a significant amount of time. This involved making decisions about what types of information are foundational and have priority throughout the design process and affect important decisions. Both building and healthcare professionals are responsible for continuous information exchange in order to utilise the collected data with BIM for applying evidence-based design (EBD) in the process of healthcare design development. The phasing, prototyping, and baseline model of BIM become a solid foundation for updating future redesign projects and as a standalone report of collected data for contributing to EBD. Results from the case study using these strategies reveal the learning curve for using BIM tools and applications in healthcare design is still challenging even though the productivity and quality of this healthcare renovation project increase remarkably with the

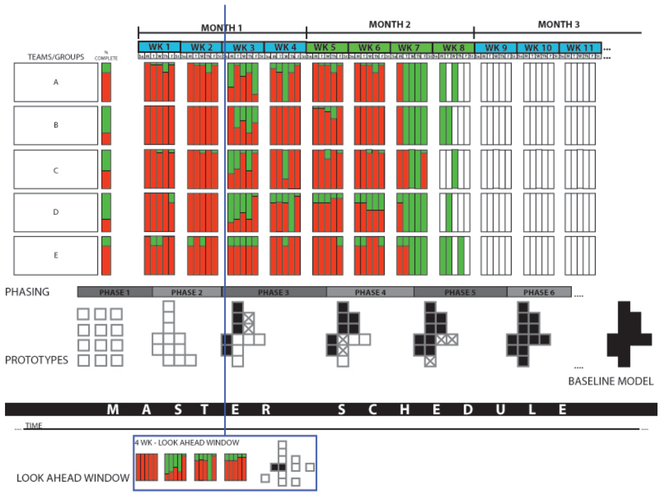

Figure 8. Diagram of combined BIM strategies

suggested methods of BIM. Currently BIM tools adequately support information transfers among building professionals compared to healthcare professionals. Therefore, each profession must be represented by its own BIM manager to facilitate the information and guide the BIM process for healthcare design. Until now, sharing of information is recognisably seamless when Autodesk applications are the main tools for design. However, in order to truly achieve promises of BIM, the sharing of information should not be exclusively based on the setup of the specific computer applications. BIM needs be brought down to raw data for their redistribution among other BIM tools outside of Autodesk package.

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