Reforming Design Studios

Experiments in integrating bim, parametric design, digital fabrication, and interactive technology

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Abstract. Building Information Modelling (BIM) has been widely accepted as an integration tool that enables modelling of form, function, and behaviour of building systems and components. Using BIM, building design can be approached in a more logical way by integrating spatial, structural and mechanical systems as well as cost and energy performance in the early design stage. In this paper, we develop a design framework using BIM in varied design processes, including architectural programming, conceptual design, parametric design, digital fabrication, and interaction design. We conducted an experiment to reform design studios using BIM throughout the design process. A classroom of the future called iSTUDIO is constructed by applying BIM, parametric design, interactive technology, and digital fabrication.

Keywords. Building information model (BIM); Parametric Design; Digital Fabrication, Interaction Design

INTRODUCTION

In the past decades, much effort has been done in developing a centralized digital representation of the building that is used to facilitate the exchange and interoperability of information in the building life cycle (Eastman, et.al. 2011). Few research works explored the use of BIM in conceptual design (Clayton, 2006). Some designers argued that adapting BIM activities in the design studio may pose a threat to design thinking (Denzer, 2008). Another educator argued that BIM is useful in understanding of building tectonics and can easily support the craft of building, systems integration, and documenting design work much faster (Eirik, 2010). A strong argument is that architects could not draw a building design without knowing building tectonics and components. To select evidence to support the argument, we conducted an experiment to reform design studios using BIM throughout the design process. We develop a classroom of the future called iSTUDIO by applying BIM, parametric design, interactive technology, and digital fabrication. This paper reports the result of the iSTUDIO project, and describes how to apply a BIM-centered design framework to designing a classroom of the future. The iSTUDIO is a two-years project for developing an adaptable, interactive, and smart classroom. The iSTUDIO classroom has been designed using several design software and involved with cross-disciplinary collaboration with designers and engineers.
This paper describes the future classroom design process of integrating professional teams by using BIM and parametric design. In the design process, BIM plays a crucial role to control the design parameters and information exchange between software, machines, and applications. For example, CAD/CAM tools can compile 3D models to machine codes for CNC laser cutters. BIM not only can help designers to efficiently communicate with teammates, but also prevent construction problems. The method used in the process of spatial design, the troubles of Implementation, and the integration of software applications require us to develop a BIM-centered framework.

Two important criteria for future classrooms are interaction and engagement. To enhance interaction and engagement, we decided to design and construct an integrated digital-physical classroom of the future. The significant functions corresponding to the features are tree-shape digital fabrication, transformable furniture, smart floor, real-time broadcasting, and an instant feedback virtual platform.

To facilitate communication and documentation between project participants, we decided to use BIM as a single, parametric, 3D model to generate plans, sections, perspective, details, and schedules. Elements in BIM are managed and manipulated through a hierarchy of parameters. We used AutoCAD Revit Architecture as a BIM tool to construct 3D models. The 3D models support visualization of the design and allow us to improve communication and collaboration between participants. In the preliminary design phase, a 3D view of iSTUDIO was modeled, showing accurate physical conditions for the project, as shown in Figure 1.

**CONCEPTUAL DESIGN**

Inspired by Architect Louis I. Kahn’s notion of first school that “schools began with a man under a tree, and around him the listeners to the words of his mind”, we proposed an adaptive and interactive classroom with a natural atmosphere. The concept was implemented by making a tree shape inside the space. The tree shape was derived from an old banyan tree
of NCKU campus, which has long been considered as the symbol of NCKU. The tree shape was designed and turned out to be the section of the classroom, as shown in Figure 3.

The design project involved with a variety of professionals. Their background included architectural design, interior design, industrial design, interaction design, user interface design, computing, and mechanical engineering. Before implementation, our project team decided to use BIM as a tool to facilitate collaboration process and construction management of the classroom. The schedule included routine weekly meetings for five months.

PARAMETRIC DESIGN

The next step is to translate the sketch of tree shape into a real-world physical space. In order to implement the organic shape of trees, we used parameters to define a tree form and played its relations. The tree form turned out to be the section of the classroom.

The iSTUDIO prototype is implemented in a 40-square-metres classroom and can house up to 20 students. The classroom prototype was equipped with transformable furniture that can be dynamically reconfigured into both a large whiteboard and desks for group discussions. A section view of the classroom is shown in Figure 5.

CNC machine helped us to mock up the prototype of the classroom. We mocked up physical models by using CNC machines and laser cutters. Then we used the prototypes to examine some limitations of joints and conducted assemble tests, as shown in Figure 6.
BIM architectural software helped us to understand the process of design, control the detail of 3D models, connect different parts of design, and adjust parameters. BIM provided an efficient method to translate 3D models into several digital fabrication files. For example, FBX, gbXML, SAT, DWF files for different design software.

**DIGITAL FABRICATION**

The next step is to construct a full-scale classroom with digital fabrication. Before construction, we use BIM software to help us to find design problems, to reduce design loops, and to improve the quality of models.

There was a problem that we did not find in experimental construction. For example, the joint of each wood panel required intensive coordination between designers, engineers, and contractors. The workers had abundant construction experiences in different fields: wood, painting, glass, mechanics, electronics, and CNC machines. It was challenging to negotiate with professional workers. The construction process required discussions and negotiated with workers, such as the specific color of paint, special joint of each wood panel, or the camera angels... etc.

**INTERACTION DESIGN**

In addition to spatial design, the classroom is equipped with ubiquitous computing technologies for interactive and collaborative learning. For example, light controls are integrated into the floor. Teachers can control the intensity of the light or turn it on and off by stepping on sensors on the floor. A web-based platform called “SynTag” was implemented for knowledge sharing. Lectures will be recorded and archived online for e-learning purposes. These recordings will also be annotated with the real-time comments and tags so students can see which parts of the lecture received the most responses (Hsu et al, 2011).

A “Live” interactive tagging interface was implemented for collaborative learning (Chang et al, 2011). The interface contains a real-time broadcasting system and a real-time interactive tagging system. The result of the construction is an innovative classroom.
CONCLUSION

Our experiment reveals that BIM can be used as an integrated tool for logical design thinking. Another finding is that BIM supports a collaborative design environment. It helps us to have efficient discussions by sharing information and data exchange. We can synchronously drawings, select materials and tectonics in detail by using BIM. Effective change management is another improvement. BIM not only becomes a platform for integration, but also a communication tool between team workers. Building an innovative classroom requires interdisciplinary researches using combined skills of specialists in design, interactive technology, networking, mechanical electronics. The iSTUDIO project is an experimental outcome of integrated cooperation. This experiment shows that BIM helps us to manage the design and construction processes. It also helps our interdisciplinary cooperation efficiently. Structuring building information has the potential to speed up collaboration process, control the building cost, and also improve logical design thinking.

called iSTUDIO. The iSTUDIO classroom has been used for lectures, design critiques, and group discussion. Students enjoyed the iSTUDIO’s atmospheres. The new configuration of the iSTUDIO classroom creates more interactivity, flexibility, and engagement in learning.
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REFERENCES


