BIM Class Project: Application of Personalized Learning

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Abstract
A BIM class for construction often requires hands-on practice, from which students pick up skills and lessons in terms of using BIM for project acquisition, clash detection, estimation, constructability analysis. The BIM course offered by Texas A&M University use an industry-sponsored class project specifically designed to teach students how to use BIM for construction planning and acquisition. Students enrolled in the BIM class are supposed to produce a 3D model from scratch using 2D drawings, come up with their own construction schedule using basic information provided by the industry sponsor, combine the 3D model and construction schedule to produce a 4D construction sequence model. Upon coming up with the script explaining their construction sequence, students produce several time-line animation clips supporting their script, and edit them together to produce a 3-minute video clip explaining how they want to build the building. Students who took this process are well received by the construction industry because they gain a practical understanding of BIM in construction. One challenge for students though is that they need to learn how to use several BIM applications such as Autodesk Revit Architecture, Revit Structure, Revit MEP, Autodesk NavisWorks, Google SketchUp, Google Earth, and Microsoft MovieMaker in a very short amount of time in order to work on their class project. Considering the time required for producing a 3D model, 4D construction model, and video clip, not much time can be allocated to teach several BIM applications. This paper presents how the concept of the "personalized learning" was utilized to help students learn how to use multiple computer applications in a short amount of time and get their class project finished on time with a certain level of quality.

Key Words: *BIM, Personalized Learning*

1. BIM FOR CONSTRUCTION MANAGEMENT

When Three-Dimensional Computer Aided Design (3D CAD) was introduced to the Architecture, Engineering, and Construction (AEC) industry in the 1980s, industry practitioners soon realized that 3D CAD could be used to integrate design, engineering, and construction information. 3D CAD models integrated with the construction schedule becomes a valuable tool in helping project participants to understand the construction schedule and intuitively identify potential conflicts on the job site before the project begins. Riley (1994), Akinci et al. (2002), Guo (2002), and Kang et al. (2007) reported the advantages of 4D construction models in time-space conflict analysis and construction planning.

In the building construction industry, software packages such as AutoDesk's Revit, Bentley Systems' Architecture, Nemetschek's VectorWorks Architect, and Graphisoft's ArchiCAD offer object-based parametric 3D modeling, which is also known as Building Information Modeling (BIM). The American Institute of Architects (AIA) defines BIM as a

process of integrating 3D-2D model with information, which facilitates a faster, higher-quality, richer design process. BIM helps architects spend less time for drafting and allocate more time on design. The Associate General Contractors (AGC) of America states that "the Building Information Model is a data-rich, object-oriented, intelligent and parametric digital representation of the facility, from which views and data appropriate to various users' needs can be extracted and analyzed to generate information that can be used to make decisions and improve the process of delivering the facility." For general contractors, the BIM is expected to facilitate the detection of clashes in advance, reduce change orders, develop better construction plans, enhance constructability on the job site, speed up approval process, use more pre-fabrication, and reduce waste. Currently most benefits come from clash detection. Kang et. al (2008), empirically applied BIM to commercial building construction and demonstrated its merit in clash detection between the structural components of the building and the MEP (Mechanical, Electrical, and Plumbing) system. Clash detection helped general contractors to reduce change orders and facilitate the use of pre-fabricated duct components for the HVAC system installation. Some advanced contractors combine 3D model and construction schedule to visualize the construction sequence in four-dimensional world. Four-dimensional (4D) representation of the construction sequence helps to understand the potential time-space issues between sub-contractors and come up with solutions in advance to avoid any conflicts between trades on the job site. Knowing that information in the Building Information Model can also be utilized for maintaining the facilities after construction, industry professionals have discussed the best utilization of BIM for facilities as well. Government agencies also paid attention to activities going on in the industry with BIM, and recently started mandating the use of BIM for their projects. The General Services Administration (GSA), US Army Corps of Engineers, City of Dallas, City of San Antonio, and Texas A&M University System are some of those agencies in Texas demanding that BIM be used in their projects. In order to meet with the government agencies' demands, more general contractors seek BIM experts.

2. BIM COURSES AT TEXAS A&M UNIVERSITY

BIM has recently become one of the most popular topics taught in academic institutions across the U.S. due to its potential impact on productivity improvement in construction and demands from the industry. The Department of Construction Science at Texas A&M University has been offering the following BIM courses for graduate and undergraduate level students since 2004:

- COSC 461 – Building Information Modeling System (for undergraduate students)
- COSC 650 – Construction Visualization (for graduate students)

In our BIM class, students learn how to better communicate with project participants using visual representation of construction plan, for which they get trained for multiple BIM applications to create an object-based 3D model of the building and combine it with the construction schedule in order to visualize the construction sequence in a 4-dimensional world. Students gain knowledge of using BIM for project acquisition, construction planning, and project control. Our BIM classes have been well received by the construction industry, and students who took them are now leading the use of BIM in the construction industry.

Students enrolled in our BIM class learn how to use Autodesk Revit, Goggle Sketch-Up, Google Earth, Autodesk NavisWorks, and Microsoft Movie Maker collectively in order to produce a 4D construction sequence model. Autodesk Revit is used to produce the object-based 3D computer model of a building. Google Sketch-Up is used to bring the 3D models of construction equipment such as tower crane. Students put their model in Google Earth to explain

the location of the project; Autodesk NavisWorks is used to combine the 3D model and construction schedule, and then produce a 4D model representing the construction sequence. Microsoft Movie Maker is used to produce a video clip explaining the construction sequence and equipment utilization.

Most students enrolled in our BIM courses are exposed to these computer applications for the first time. Teaching them how to use all these BIM applications in one semester has been challenging. Over the years, various experiments have been tried to come up with an effective teaching method to handle this challenge in class, and we found that the following three elements helped students to effectively gain necessary skills for BIM in a short amount of time:

- Fun and Excitement
- Motivation
- Personalized Learning

3. FUN AND EXCITEMENT

One question students ask almost always at the beginning of each semester is whether they need to have pre-knowledge on 2D or 3D CAD applications to take the BIM class. After getting informed of all class activities they will get engaged in across the semester, most students become wondering whether they would be able to pick up necessary skills for the class project even if they don't have any pre-knowledge on multiple BIM applications to be used. Therefore, the first challenge that the instructor would have to deal with is to provide students with a certain amount of confidence that they could manage all class activities. We managed this challenge by asking students to create the 3D model of their own house or a dream house after presenting overall process of creating the Revit Architecture model. About one hour is allocated to show students the step-by-step process of creating the 3D model using Revit Architecture. Students are also informed of any on-line resources they can access to obtain additional information. For 3D modeling, we don't ask them to get the accurate dimension of the house. We allow them to assume the dimension of their house or come up with fictitious dimensions to create the 3D model of their dream house. Students are given one week for this assignment. They are also informed that some of them will get a chance to show and tell what they have created in front of their classmates. The essence of this assignment is to encourage students to put their hands on the application and have fun while they create the 3D model for the first time. Students get the full mark as long as they produce any model using Revit.

Knowing that they have freedom for the assignment and there is no risk for their being creative, most students tried to create something unique and worth to get attention from their peers. One week later, the instructor simply asks students who wants to present what they have created. There have been always some students who were dying to show and tell what they have created, and instructor gives them a chance to do so. Not all students were getting excited at the beginning. However, after seeing what their friends have created, many of them started getting confidence that they also could produce the similar model. Once they believe that they also can create a nice looking model, students become ready to get engaged in more realistic tasks. Figure 1 shows the snapshot of the Autodesk Revit model created by a student within a week after learning how to use it.

Figure 1: 3D model created by a student in one week

4. MOTIVATION

Being able to create a fictitious model of their dream house in Revit does not necessarily mean that one can use BIM to enhance visual-based communication in construction. Students need to get engaged in more practical issues in terms of creating object-based 3D model, producing 4D construction sequence model, and produce a video clip presenting the construction plan. This is not an easy process and a short excitement may not be able to help students keep working on it. We get students motivated by getting them engaged in the real project, for which we invite the industry sponsors to develop the class project together. The class project is asking students to produce a short video clip explaining the logic of the construction sequence of the sponsor's ongoing project, for which they need to read 2D drawings provided by the sponsor, create the Revit model, come up with the construction sequence, combine the Revit model and construction schedule in NavisWorks to produce a 4D construction sequence model. The objective of the class project is to help students gain proficiency in terms of using BIM to enhance communication for construction management.

The industry-driven class project got most students actively engaged in class activities. They were excited about having the opportunity to work on the sponsor's real projects. The class project helped them understand what was really going on in practice. They were willing to take additional workloads once they understood what was required in the construction industry. The sponsors were also excited about the opportunity to get engaged with our BIM class. They were impressed by the video clips student produced. Many sponsors offer students jobs when the semester was over. One sponsor arranged a special interview session for those who took the BIM class, and hired three students immediately. The sponsors had a chance to monitor the entire progress of the class project through out the semester, and they knew whom they want to hire at the end of the semester. The experiences of these students helped other students to get more

engaged with the sponsor's class project hoping that they too would get similar opportunities. When students are fully motivated, they begin to teach themselves and an instructor does not have to teach how to use BIM applications in detail.

5. PERSONALIZED LEARNING

Learning multiple BIM applications, creating the Revit model from scratch, developing the construction schedule, creating the 4D construction sequence model, and producing a short video clip in three months is still a daunting task. Students need to know how to use various BIM applications in detail in order to produce the video clip on time. Not all students can pick up these skills at the same time. Some students simply need more time to gain necessary skills for the BIM applications. Many educators discussed this individual learning issue, and they found that the new pedagogy called as personalized learning helps students gain knowledge more effectively. Personalized learning is the tailoring of the curriculum and learning environments to meet the needs of individual learners, often with extensive use of technology in the process. This term was used by David Miliband (2006), Minister of State for School Standards for the United Kingdom (U.K.), who stated that "personalized learning is the way in which our best schools tailor education to ensure that every pupil achieves the highest standard possible". Education leaders invited to the SIIA-ASCD-CCSSO Symposium on [Re]Design for Personalized Learning in 2010 jointly identified the following essential elements for personalized learning (Wolf 2010):

1. Flexible, Anytime/Everywhere Learning
2. Redefine Teacher Role and Expand "Teacher"
3. Project-Based, Authentic Learning
4. Student Driven Learning Path
5. Mastery/Competency-Based Progression/Pace

Symposium attendees also agreed that the elements in the following table represent some differences between the personalized learning system and our current education system.

Table 1: Comparison between Current Education System and Personalized Learning System

Current System	Personalized Learning System
Institution/Teach Centered	Student-Centered
Fixed Place; School-Based	Anywhere and Everywhere; Mobile
Comprehensive Teacher Role	Differentiated and Specialized Teacher Roles
Geographically Determined and Limited Instructional Sources (Teacher and Textbook)	Virtually Unlimited, Multiple Instructional Sources (Online Resources and Experts)
Informal Learning Disconnected	Informal Learning Integrated

In order to provide the personalized learning environment, our BIM class encourages students to use the online tutorials, YouTube videos, and Facebook to pick up detailed skills needed for the class project. Autodesk provided various online tutorials and students used them whenever they wanted to learn a specific functions of BIM applications. They also used the YouTube videos posted by many industry professionals explaining how to use BIM applications. These videos were particularly working well with students because they showed the step-by-step procedures visually. Most students found them easy to follow. Facebook was used to help students exchange tips and information for class projects with other students. A closed group was

created in the Facebook for students. Industry professionals were also invited to this group. Students were able to ask industry professionals directly. Other students were able to gain knowledge simply from monitoring the correspondences between industry professionals and some students. Figure 2 is the copy of the Facebook group page presenting how students used the Facebook group for exchanging information.

6. CLASS PROJECT

For 3D modeling, the instructor invites the architects to explain the configuration of the building. The 3D model created by the architects is presented in class to explain what students would work on. If the sponsor's project is too big for one student, it is divided into smaller sections and assigned to students. These models are later combined into one in the next step for 4D modeling. For 4D modeling, students import the pieces of the 3D model into Autodesk Navisworks and combine them into one integrated 3D model. They then divide the 3D model conceptually into work packages and come up with their own assembly sequence for these work packages. Upon identifying the start and finish date of these work packages, students put this information into the 3D model components associated with the work packages they designed. Figure 3 shows the snapshot of the 3D & 4D models of the Texas A&M Health Science Center Research Building created by one of students.

For the video creation process, students need to understand how to tell a story in a 3-minute video clip. To help them decide how they want to use a visual expression for their video clip, they are shown movie trailers and clips produced by students in the previous semester. Most students strive to produce better video clips than those produced in previous semesters.

At the end of the semester, the sponsor's representatives are invited to evaluate the class project using the following guidelines:

- Level of Detail: Does the 3D model presented in the video clip have an appropriate level of detail to explain the construction activities?
- Logic of the Construction Sequence: Does the construction sequence presented in the video clip make sense?
- Presentation Skill: Does the video clip explain the construction project professionally?

Figure 2: Screen shot of the Facebook page presenting how students exchanged tips

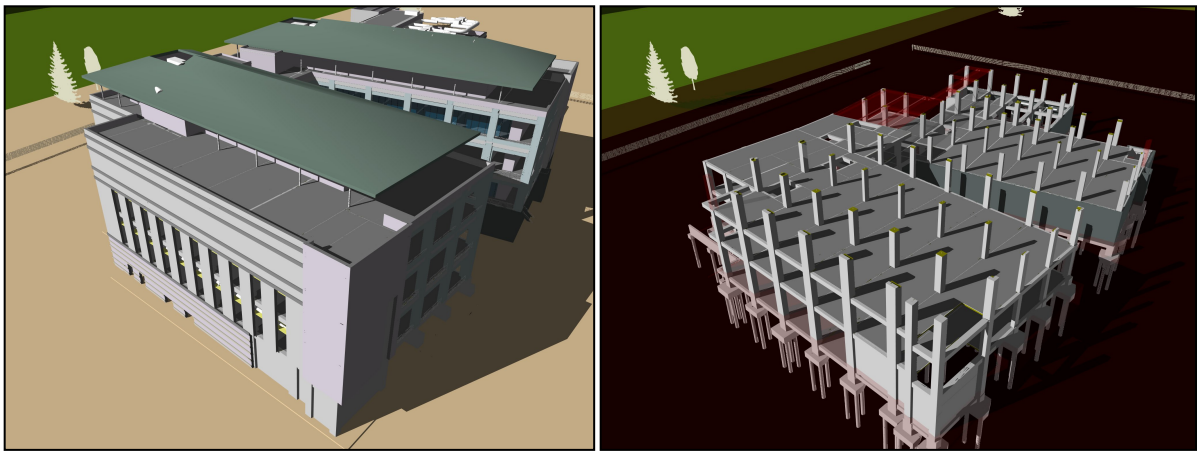

Figure 3: 3D and 4D Models created for the class project

7. LESSONS LEARNED

The MEP model plays a critical role in helping students understand how BIM can be used in construction. Most clashes take place between the building's structural components and the MEP system. However, creating an MEP model is often too overwhelming for one student to handle in a very short time-span. The instructor needs to make a decision whether students will model the MEP system or not based on the complexity of the sponsor's project. Most students are wondering what would be the right level of detail for 3D modeling; obviously, this depends on the time allowed for the class project. It is not, however, easy for students to decide upon the correct level of detail they can deal with within the given time and it should normally be the instructor who decides what should be modeled for the class project. The students have ot be informed of the level of detail required for the 3D model for the class project in advance, otherwise they can end up wasting too much time working it out by themselves.

8. CONCLUSION

This paper presents some of the lessons learned while using the industry-sponsored class project to teach college students Building Information Modeling (BIM). The class project presented in this paper is focused on using BIM for project acquisition. Students produce a video clip to promote the sponsor's construction project using BIM. The industry-sponsored class project motivated students to learning BIM. In order to make sure that students stay interested throughout the semester, the instructor has to carefully determine the scope of the class project, and appropriate level of detail for 3D and 4D modeling based on the complexity of the sponsor's project. The personalized learning environment provided using Facebook, YouTube Videos, and online tutorials helped students exchange information successfully and pick up necessary skills rapidly.

9. REFERENCES

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