

BIM Class Project for Learning by Doing

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ABSTRACT

Due to the lack of trained individuals in the construction industry and to its potential impact on construction planning, Building Information Modeling (BIM) has been one of the popular topics taught in academic institutions in the U.S. in recent years. Although it is necessary to master multiple BIM applications in order to fully employ BIM in construction, teaching college students all of these applications in one semester is challenging. This paper presents an industry-sponsored class project developed to help students learn the principles of BIM in a short time. It also presents the opportunities and challenges you may encounter in implementing this class project.

KEYWORDS: BIM, Construction Management

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 parameter-based or object-based 3D modeling, which is now known as Virtual Design and Construction (VDC) or 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. 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."

According to the AIA, BIM helps architects "reduce risk, maintain design intent, streamline quality control, enhance communication, and better access to higher analytic tools". 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 the approval process, use more pre-fabricated materials, and reduce waste. 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. Four-dimensional (4D) representation of the BIM for construction sequence helped those who came to the MEP coordination meeting better understand the construction schedule and time-space issues between the sub-concreters on the schedule.

Aware of the benefits of using BIM for clash detection and other practices in construction management, government agencies recently started mandating the use of BIM for their projects. The General Services Administration (GSA), US Army Corps of Engineers, State of Wisconsin, City of Dallas, and City of San Antonio are some of those agencies demanding that BIM be used in their projects. As a result, more general contractors started seeking BIM experts in order to meet with the demands of government agencies.

BIM Courses at Texas A&M University

The goal of the BIM course offered by the Department of Construction Science at Texas A&M University is to help students develop an understanding of Building Information Modeling (BIM) for project acquisition, construction planning, and project control. Specifically, this course teaches students how to use BIM to explain a construction project, including construction schedule and equipment utilization. Students enrolled in the course learn how to use Autodesk Revit, Goggle Sketch-Up, Google Earth, Autodesk NavisWorks, and Microsoft Movie Maker collectively in order to produce a 4D computer model explaining a construction project. Autodesk Revit is used to produce a parametric 3D computer model of a building; Google Sketch-Up is used to handle a 3D model of construction equipment such as tower crane; Google Earth is used to explain the location of the project; Autodesk NavisWorks is used for combining the 3D model and construction schedule in order to produce a 4D model representing the construction

sequence; and Microsoft Movie Maker is used to produce a video clip showing the construction sequence and equipment utilization.

BIM Class Project

The aforementioned applications are collectively used for clash detection, construction scheduling, and project control. One has to know how to use all of these applications to some extent in order to understand how BIM can advance these construction management practices. However, most students on the BIM courses at Texas A&M University are exposed to these computer applications for the first time. Teaching them how to use multiple BIM applications collectively for construction management in one semester would be challenging if a traditional instructor-led training method were used.

The BIM courses offered by the Department of Construction Science use the industry-sponsored class term project to teach students how to use multiple BIM application for construction management in one semester. This project-driven BIM class asks students to create a video clip explaining the construction sequence of the sponsor's ongoing project, for which they need to produce a 4D computer model by combining the 3D computer model of the building and its construction sequence. Students create the 3D computer model using 2D drawings provided by the sponsor. They are requested to design the construction sequence by themselves and, after creating the 4D computer model, they are then requested to

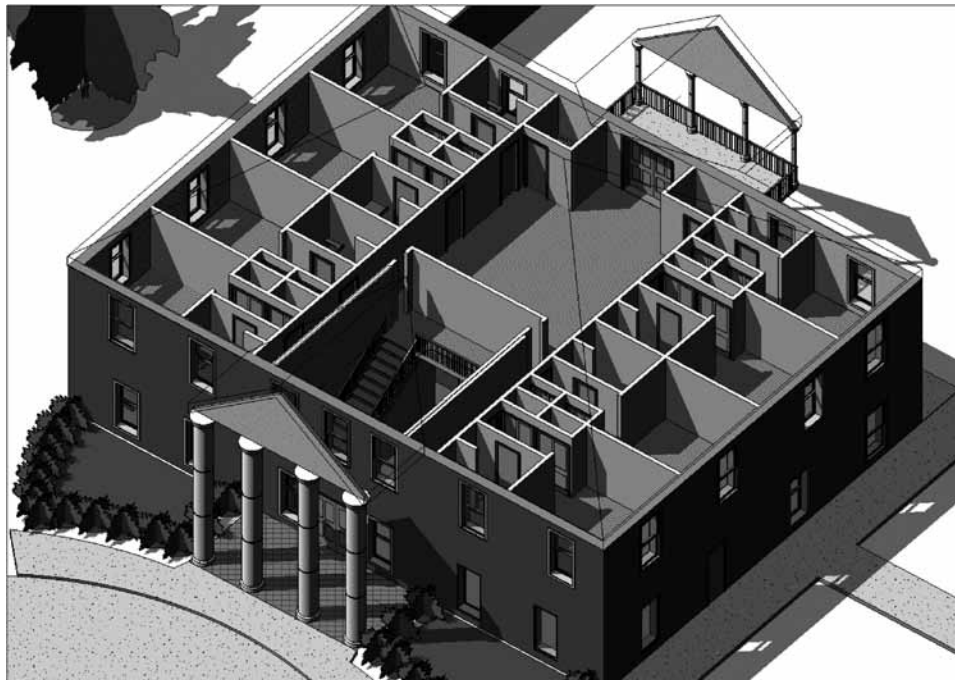


Figure 1: 3D model created by a student in one week

produce a video clip visually explaining the logic of their construction sequence.

The industry-driven class project had students actively engaged in class activities and students were excited about having the opportunity to work for the sponsor's real projects. The class project helped them understand what was really happens 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 contribute to training BIM experts and were impressed enough by the students' work to offer them jobs when the semester was over. For instance, one sponsor arranged a special interview session for those who took the BIM course and hired three students among them. The sponsors monitored the progress of the class project through the semester before they decided whom to hire. Another sponsor hired a student immediately after the final presentation. The experiences of these students helped others to be positive about BIM and hopeful that they too would find employment by impressing the sponsors. It gave students the motivation they needed to actively engage in the class project. 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. Figure 1 shows the snapshot of the Autodesk Revit model created by a student within a week of the instructor demonstrating how to use it.

Teaching students how to produce a video clip explaining the sponsor's construction project is a little more complicated. The instructor needs to take students through the step-by-step procedures and check if they follow them as required. The instructor's understanding of the entire process is therefore critical. The process of creating a 4D computer model takes a significant amount of time and most students do not know how long to allocate for the class project. They tend to wait until the last moment before getting their class project started and, therefore, sometimes find it impossible to finish on time.

For 3D modeling, the instructor invites the architects to explain the configuration of the building. The 3D model created by the architects is used to help students have a better understanding of what they will work on. If the sponsor's project is too big for one student, it will be divided into smaller sections and assigned to a group of students. These models are combined into one in the next step for 4D modeling. Figure 2 shows the snapshot of the 3D model of the Texas A&M Health Science Center Research Building.

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 design 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.

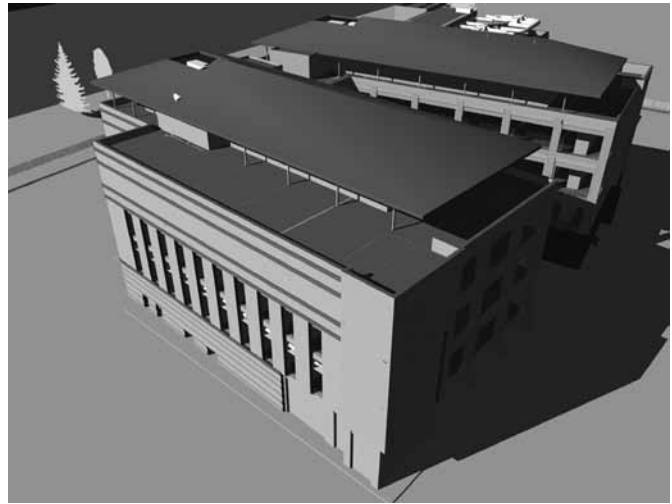


Figure 2: 3D Model created for the class project

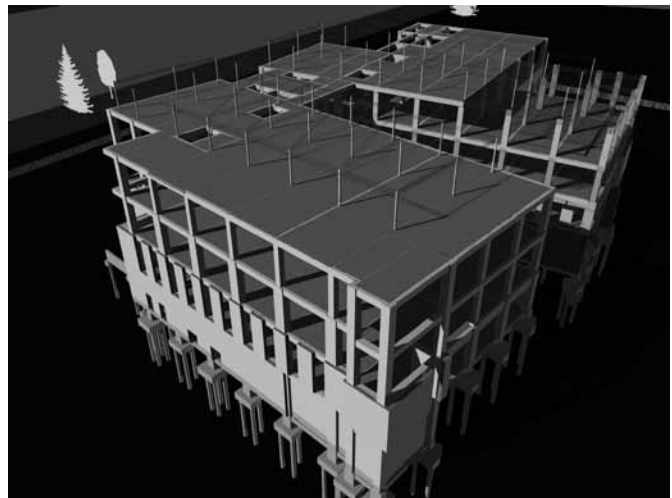


Figure 3: 4D Model created for the class project

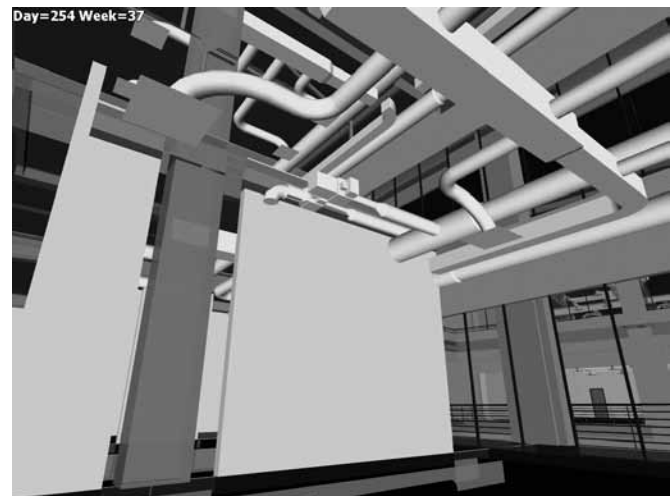


Figure 4: Video clip created for the class project

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?

Lessons Learned

While teaching the same class over several years, the instructor tried different pedagogies in order to improve the course contents. Not all attempts were successful, and those that were not were useful in teaching the instructor valuable lessons for the future.

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 decide whether or not students will model the MEP based on the complexity of the sponsor's project. Most students don't know what the right level of detail for 3D modeling would be. 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 to 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 on their own.

Another issue that the instructor has to carefully consider is whether the class project will be undertaken individually or in groups. This is particularly important when the project is very complex. The number of students enrolled also affects the decision, as it would be difficult for the sponsor's representatives to evaluate more than 10 projects. First, covering all presentations is a lengthy process and the sponsor's representatives often find it difficult to review numerous video clips that are very similar in content.

Students appear to learn more when they work on a project independently; however, by doing so, they miss out on the op-

portunity to work in a group situation where they may have to resolve differences of opinion with other members. When students are requested to work as a group for the class project, it is difficult to know who should have more credit for work accomplished within that group. The instructor often uses the intra-team evaluation at the end of the semester, but there is no empirical evidence supporting its effectiveness.

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 through students producing 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 difference between the individual and group projects is not easy to work out as yet. Each method has advantages and disadvantages and more research is needed to work out the effective class project delivery method.

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