AC 2012-5301: EXPERIMENTAL APPLICATION OF THE PERSONALIZED LEARNING METHOD TO A BIM CLASS

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Experimental Application of Personalized Leaning Method to a BIM Class

BIM for Construction

According to Smart Market Report on BIM released by McGraw Hill in 2009[1], there is consensus in the construction industry, especially among contractors, that Building Information Modeling (BIM) helps to reduce conflicts and changes during construction. It also helps to improve collective understanding of design intent and project quality. Most contractors, as many as 83% of them, who participated in this investigation recognized that the use of BIM produced the highest rewards on a project. When BIM reduces conflicts, the project team can reduce costly changes in the filed. Reduced changes during construction are another top benefits recognized by the majority of contractors. Most owners (73%) participated in this investigation recognized that they get the highest value of BIM when they use models to better understand and monitor the design intent. Some users recognized 4D scheduling would be one of the benefits they could get in the near future.

As reported in the McGraw Hill's investigation, when it comes to construction, BIM is most utilized for clash detection, spatial coordination, client engagement, shop fabrication, quantity takeoff, cost estimation, and 4D scheduling. Kang et. al[2], empirically applied BIM to a commercial building construction project and demonstrated how general contractors improved their productivity in construction by detecting clashes between the building's structural components and the MEP (Mechanical, Electrical, and Plumbing) system before construction starts. Project participants who detected clashes during pre-construction coordination meetings were able to fix the problems proactively and it reduced the change orders during construction. The project team was also able to use more pre-fabricated modules and saved time.

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 on the job site between sub-contractors and come up with solutions in advance to avoid any conflicts between them. Riley[3], Akinci et al.[4], Guo[5], and Kang et al.[6] reported the advantages of 4D construction models in time-space conflict analysis and construction planning.

BIM Class for Construction

As more clients begin to require BIM on jobs, contractors realize how critical it is to keep those construction professionals who are capable of using BIM in order to capture new business. While trying to get their employees trained for BIM, many contractors expect higher education institutes to teach students how to use BIM especially for construction management.[7] They expect students to know how to create a 3D model using a specific BIM application, how to detect clashes, and if possible how to create a 4D construction sequence model.

In order to meet the industry's expectation, many higher education institutes started offering BIM courses. Understanding what competency the construction industry is looking for, students also pay attention to these BIM courses. BIM has recently become one of the most popular topics

among students in higher academic institutions.[8] Most BIM classes are designed to teach students how to better utilize visual representation of construction project for productivity improvement. Students taking these BIM class gain knowledge of using BIM for project acquisition, construction planning, and project control.

One of the best ways to teach students BIM is to provide them with an opportunity to put their hands on it. Unlike other subject matters, it is not easy to pick up the BIM skill unless they have a chance to use BIM applications. In order to understand how BIM can improve productivity in construction, students need to get exposed to several BIM applications and learn how to create a 3D model, how to detect clashes between building components, and how to create a 4D construction sequence to visually present the construction schedule. Students taking our BIM class learn how to collectively use Autodesk Revit Architecture, Goggle Sketch-Up, Google Earth, Autodesk NavisWorks, and Microsoft Movie Maker. Autodesk Revit Architecture is used to produce the object-based 3D computer model of a building. Google Sketch-Up is used to manipulate 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 3D models, detect clashes among building components, and produce a discrepancy report. They also use NavisWorks to combine the 3D models 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 seniors and they were exposed to these computer applications for the first time. We did not offer any computer graphics class until recently, and most senior had no idea how to use computer applications for BIM. Teaching them how to use all these BIM applications in one semester therefore was a huge challenge. 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 effectively gain necessary skills for BIM in a short amount of time:

- Fun
- Motivation
- Personalized Learning

Fun

Students enrolled in our BIM class get engaged in a series of class activities. They are requested to create the 3D model of a real construction project using 2D drawings provided by the class project sponsor, detect clashes and produce a discrepancy report, come up with its construction schedule using basic information provided by the project manager, combine the 3D model and the construction schedule in order to produce a 4D construction sequence model presenting the construction schedule visually, and produce a short video explain their construction plan. After getting informed of all these class activities, most students become wondering whether they would be able to follow all activities even if they don't have any pre-knowledge on multiple BIM applications to be used. In order to encourage students to take this challenge, the instructor needs to provide students with a certain amount of confidence that they can manage all class activities.

For this, we ask students to create the 3D model of their dream house using the Revit Architecture without having to worry about the accurate dimension of the model. They are encouraged to assume the dimension of their house. In class, about one hour is allocated to show students a step-by-step process of creating the 3D model. Students are also informed of some on-line resources they can visit and obtain additional information. Students are given one week for this assignment. They are also informed that some of them will get a chance to present what they have created in front of their classmates. The purpose of this assignment is to encourage students to put their hands on the BIM application and have fun with it 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 there is no risk for their being creative for the assignment, most students tried to create something unique and worth to get attention from their peers. One week later, the instructor simply asks if anyone wants to present what he or she created. There have been always some students who were eager to present their model. Not all students were getting excited at the beginning. However, after seeing what their friends have created, many of them started to believe that they also could produce a similar model. Once they believe in what they can possibly do, students are ready to get engaged in more realistic tasks.

Motivation

Creating a video at the end of semester presenting the construction plan is still a daunting task for students especially they have to learn how to use multiple BIM applications in the same semester. For our BIM class, a total of 12 activities are scheduled across the semester to guide students to take a step-by-step process of creating a 3D and 4D construction sequence model.

Project 1 – My Dream House (2 Weeks)
Project 2 – Architectural & Structural Model (1 Week)
Project 3 – MEP Model (1 Week)
Project 4 – Clash Detection (1 Week)
Project 5 – Construction Schedule (1 Week)
Project 6 – 4D Construction Sequence Model (1 Week)
Project 7 – Temporary Structure (1 Week)
Project 8 – Poster (1 Week)
Project 9 – Story Board (1 Week)
Project 10 – Animation (1 Week)
Project 11 – Video Production (1 Week)
Project 12 – Final Presentation (1 Week)

One week is allocated for each activity except the first one. Two weeks are allocated for the first project in order to create an environment where students have enough time to enjoy testing multiple functions of the BIM application and have fun while they create the model of their dream house. For all other activities, one week was allocated. Otherwise is would not be possible to have students to work on all 12 activities in 15 weeks. However, it is necessary sometimes to allocate additional time for the assignments to help students follow the process.

The short excitement that students experienced at the beginning of the semester helps them get engaged in class activities with some confidence, but it is not sufficient to keep them working on for 15 weeks. Students need additional motivation to keep working on these class activities across the semester.

In order to keep our students motivated, we use the industry sponsored class project. We invite the industry sponsors to develop the class project that asks students to produce a short video clip presenting the logical construction sequence of the sponsor's ongoing project. Students in our BIM class are requested to read 2D drawings provided by the sponsor, create a Revit 3D model, come up with the construction sequence, bring the Revit model into NavisWorks and combine it with the construction schedule to produce a 4D construction sequence model. 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?

Students were excited about having an opportunity to work on the sponsor's project because it helped them understand what was really going on in practice. Students wanted to get recognized by the industry sponsors because they believed it is connected to getting their future job secured. Some students took additional time for the class project to get the sponsors attention. The sponsors were also excited about the opportunity to get engaged with our BIM class. It gave them a chance to monitor the students' progress across the semester, and figure out whom they want to hire for their BIM practices. For instance, one sponsor arranged a special interview session at the end of the semester for those who took the BIM class, and hired three students immediately. Students who saw what happened in the previous semester wish to get similar opportunities and this wish keeps students working on the class project across the semester.

Personalized Learning

Teaching students all necessary BIM applications for the class project is another challenge the instructor has to handle. Only 15 weeks are allocated in one semester, and students had to work on 12 class assignments. Because of time limits, only a limited amount of time was allocated in class to teach students how to use Autodesk Revit Architecture, Google SketchUp, Autodesk NavisWorks, and Microsoft Movie Maker for the class project. Students had to learn these applications as they work on the class assignments.

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 can be a daunting task. Not all students can pick up these skills at the same speed. Some students simply need more time to gain necessary skills for the class project. Many educators discussed this individual learning issue, and they found that the personalized learning method helps students gain knowledge more effectively.

Personalized learning method is about providing students with learning environments to meet the needs of individual learners, often with extensive use of technology in the process. David Miliband[9], Minister of State for School Standards for the United Kingdom (U.K.), 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[10]:

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

The personalized learning environment is expected to help students learn a certain subject matter at their comfortable speed. There are a huge amount of online resources available on the Internet, and students are encouraged to take best advantage of them to pick up new knowledge at their comfortable speed. With the help of mobile devices, they can get engaged in the personalized learning environment anywhere and everywhere. The instructor's role is to set up the goal for students and monitor their progress in order to provide them with a competency-based progression model.

YouTube and Facebook

In our BIM class, the instructor uses a very short amount of time to show students how to use BIM applications because of time limits. Students are then requested to pick up additional functions of the applications by themselves while they work on assignments. Autodesk provides various online tutorials and students in our BIM class are encouraged to use them. They are also encouraged to watch the YouTube videos posted by industry professionals. Many YouTube videos show the step-by-step procedures to manipulate various BIM applications. Sometimes students learn how to use BIM applications faster than when they read the manual.

Facebook is another tool we use to help students exchange tips and information for class projects with other students. Users can create a group in Facebook, which facilitates to share information and discuss specific subjects. Members of the group can leave new comments, photos, and videos. Industry professionals were also invited to our group and they helped students figure out how to use a certain function of the BIM application. Other students were able to gain knowledge simply from monitoring the correspondences between industry professionals and some students. Figure 1 is the copy of the Facebook group page presenting how students used the Facebook group for exchanging information.

Figure 1: Screen shot of the Facebook page showing how students exchanged information

In Spring 2011, 22 students were enrolled in our BIM class. After having them to use Facebook for about two months, we asked them how they liked using Facebook in the BIM class. All 22 students agreed that the Facebook group helped them get informed for the BIM class. 95% of students thought Facebook helped them exchange information with their classmates. However, only 64% of students thought they get information from the industry professionals who joined the Facebook group. 10% of students thought they did not get any information from the industry professionals. 82% of students wanted other classes to use the Facebook group, but 9% did not want it. 77% of students wanted to communicate with the instructor over the Facebook group. However, 14% of students did not want it.

Some students commented that they liked using Facebook group because

"They could share information between classmates".
"Information can be exchanged quickly, easily, and from anywhere".
"They could get all questions answered by students or professor".
"Other students posted many helpful links".

"They were able to compare their progress with other students, and use it as a benchmark".
"They could post a question and someone helped with the answers".
"They could support each other with recommendations and information that might be useful".

Students complained because they could not easily locate information posted on the Facebook wall.

"Wall posts go newest to oldest. It is hard to find a specific issue you are looking for".
"Information that is posted on the wall is sometimes difficult to go back and find if there are many posts on the wall".
"Posts by the instructor get lost on the wall if many questions are posted above it".
"The updates could be sent out with specific labels such as "how to …" or "schedule update…" to keep information from getting lost in the numerous wall posts, and ease of locating at the later date".

Some students were concerned about the privacy. They did not want the instructor to see their personal comments posted on their walls.

"I think it might be inappropriate to be facebook friends with your professor".
"Less privacy, but not a big deal".

Conclusion

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. Our BIM class uses 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 requested 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 successfully took our BIM class were well received by the construction industry because of their practical understanding of BIM in construction.

One challenge is that students need to learn how to use multiple BIM applications such as Autodesk Revit Architecture, Autodesk NavisWorks, Google SketchUp, Google Earth, and Microsoft MovieMaker in a very short amount of time. Because of class assignments scheduled across the semester, the instruction was able to allocate a short amount of time to explain how to use these applications. In order to help students learn about the detail functions of the BIM application by themselves while working on their assignments, we empirically applied the concept of the "personalized learning", which encourages students to take a best advantage of online resources available on the Internet to pick up new knowledge at their comfortable speed. Students in our BIM class were encouraged to use YouTube videos to figure out how to use a specific function of the BIM application for the class project. We also used the Facebook group

to facilitate students to exchange information and discuss specific subjects. Industry professionals were also invited to our group to provide answers for the students' questions. As many as 95% of students who used Facebook group agreed that it helped them exchange information with other students in terms of picking up tips for the BIM applications and implementing the class project. However, a small number of students felt uncomfortable using Facebook for the course because they did not want to share their personal comments posted on their Facebook wall with the instructor. Other students complained about the difficulty in locating information posted on the Facebook group. Nonetheless, majority of students agreed that the Facebook group was an effective tool facilitating them to share information with other classmates and they suggested other courses to use Facebook group as well.

Bibliography

1. Young, N. W., Jones, S. A., Bernstein, H. M., and Gudgel, J. E. (2009). "The Business Value of BIM: Getting Building Information Modeling to the Bottom Line", SmartMarket Report, McGraw Hill Construction.
2. Kang, J., Smith, J., Kale, A., Jayaraman, N. (2008) "Empirical Application of Building Information Modeling to Commercial Construction", Technical Report, Associate General Contractors in America.
3. Riley, D. (1994). "Modeling the space behavior of construction activities," PhD thesis, Dept. of Architectural Engineering, Pennsylvania State Univ., University Park, Pa.
4. Akinci, B., Fischer, M., and Kunz, J. (2002). "Automated generation of work spaces required by construction activities", Journal of Construction Engineering and Management, American Society of Civil Engineers, Vol. 128, No. 4, pp. 306-315.
5. Guo, S.J., (2002). "Identification and resolution of work space conflicts in building construction", Journal of Construction Engineering and Management, American Society of Civil Engineers, Vol. 128, No. 4, pp. 287-295.
6. Kang, J., Anderson, S., and Clayton, M., (2007) "Empirical Study on the Merit of Web-Based 4D Visualization in Collaborative Construction Planning and Scheduling", Journal of Construction Engineering and Management, American Society of Civil engineers, Vol. 133, No. 6, pp. 447-461.
7. Chasey, A. and Pavelko, C. (2010). "Industry Expectations Help Drive BIM in Today's University Undergraduate Curriculum", Journal of Building Information Modeling, Fall 2010, pp. 31-32.
8. Sabongi, F. J. (2009). "The Integration of BIM in the Undergraduate Curriculum: an analysis of undergraduate courses", International Proceedings of the 45th Annual Conference. Associated Schools of Construction.
9. Miliband, D. (2006) "Choice and Voice in Personalized Learning", Personalizing Education, OECD/CERI, pp. 21-30.
10. Wolf, M.A. (2010). Innovate to Educate: System [Re]Design for Personalized Learning, Software & Information Industry Association, p.7.