Eighth International Conference on Construction in the 21st Century (CITC-8)
"Changing the Field: Recent Developments for the Future of Engineering and Construction"
May 27-30, 2015, Thessaloniki, Greece

BIM for Plan Reading Class: Lessons Learned

Julian Kang
(Associate Professor, Texas A&M University, College Station, TX, U.S.A)

Abstract
A plan-reading skill is one of the essential competencies sought in the construction industry. Most construction management programs in the U.S. provide a blueprint-reading course, where students learn how to read and understand lines and symbols on 2-dimensional (2D) drawings. The essential objective of most blueprint-reading courses is to facilitate students to pick up the skill to read 2D drawings and figure out the look of the objects in 3-dimensional (3D) world. Figuring out the look of the objects in 3D world requires a skill to convert those lines and symbols on 2D drawings into 3D components. In Spring 2015, the blueprint-reading class at Texas A&M University was taught differently to test how BIM could help students develop their plan-reading skill. This course was taught in an expedited framework, where students learn all topics in 7 weeks before the spring break started. Teaching how to use BIM tools and instruct students to pick up the plan-reading skill in 7 weeks was challenging, so the Goal Oriented Active Learning (GOAL) pedagogy was used to overcome the challenge. A class project was prepared with the sponsor, for which students read 2D drawings of a dormitory building in the campus, created its 3D model, and produced a short video presenting the configuration of the dormitory using the 3D model. All students successfully created the 3D model of the 5-story dormitory building, and then produced a short video presenting their project. This paper presents how the blueprint-reading course was designed, and how the GOAL pedagogy was working. It also presents some feedbacks from students, and a few lessons learned.

Keywords
BIM, Plan Reading, Goal Oriented Active Learning

1. Introduction

Being able to reading blueprints and figure out what they are going to build is an essential skill for construction professionals. Most construction management programs in the U.S. therefore provide a blueprint-reading course to teach students how to read and understand lines, symbols, abbreviations, and dimensioning on a blueprint. The essential objective of most blueprint-reading courses is to facilitate students to pick up the skill to read 2-dimensional (2D) drawings presenting the plans, elevations, and sectional views of a house or building, and figure out the look of the building in 3-dimensional (3D) world. Figuring out the look of the building in 3D world requires more than just understanding the meaning of the lines, symbols, and abbreviations on 2D drawings. One has to convert those lines on 2D drawings into 3D building components, and then figure out the spatial relationship between those components in 3D world. It takes time to pick up this skill. Even those who have been working on multiple construction projects sometimes have hard time to figure out the spatial relationship between building components and detect clashes between them in advance, which often results in reworks and productivity loss in field. This is the reason why many construction practitioners want to use a Building Information Model (BIM) before construction starts. Unlike 2D drawings, a 3D representation of the

building facilitates to figure out the spatial relationship between building components intuitively and detect hard clashes between building components or soft clashes between trades.

What would be the best way to help students pick up the skill to read 2D drawings and figure out the building's configuration in 3D world? Some blueprint-reading courses encourage students to visit the actual building and compare what are depicted on 2D drawings and what is built. It provides students with an opportunity to figure out how a certain building component is depicted in plans, elevations, and sections. However, most students do not try seriously to figure out the spatial relationship between building components, because they can easily see the real building components in 3D world. Although it has never been measured, many senior students who were instructed to build a 3D model in the BIM class admitted that they spent most of their time reading plans and figuring out how to interpret them. It may be because some students did not pick up the adequate plan-reading skill from the previous blueprint-reading course. If visiting the real building does not help students pick up the plan-reading skill effectively, what would be an alternative way for us to use? One may speculate that the best way to pick up the plan-reading skill is actually to build what we see on 2D drawings and learn from doing it. However, it would not be cost-effective. Alternatively, one can think about creating a 3D computer model instead, which should be almost identical to building the actual building.

Most BIM applications are developed to author a 3D model using plans and elevations. To create a 3D model, they need to create a 2D plans and elevations, which would give us a chance to see how a series of lines on 2D drawings are transformed into 3D building components. Therefore, theoretically, most BIM applications can be ideal tools to teach students how to read plan.

2. Blueprint-Reading Course at Texas A&M University

Department of Construction Science at Texas A&M University offers a "Construction Graphics Communication" course to teach freshmen and transfer students how to read 2D drawings and develop the 3D profile of building components. Students enrolled in this course are taught how to understand lines, symbols, abbreviations, and dimensions on 2D drawings. Students also learn how to slice up a 3D object and present those sectional views in 2D plans and elevations. Instructors often bring students to the actual building, where students can see the relationship between the 3D building components and associated 2D drawings describing them using plans, elevations, and sectional views.

In spring 2015, about 150 freshmen and transfer students took this course. To teach students in small classes, this course was divided into 6 sections and each section has 25 students enrolled. The noteworthy point is that 3 sections out of 6 were taught in an expedited manner. Students enrolled in these sections met more often than other students to speed up the learning process. They met twice every Monday and Wednesday from 10:20 am to 11:10 am and then from 11:30 am to 12:20 pm. The expedited sections started at the beginning of the spring semester, and ended before the spring break. All course materials were covered in 7 weeks. Immediately after the spring break, students started taking an "Estimation" course, which is another expedited course. Expedited courses are designed to help students take lower level courses quickly in an intensive environment. Theoretically, instructors spend an equal amount to time in class with students. However, the amount of time students can use to work on homework between classes is reduced, so it could affect students' learning experience.

One of these expedited sections of the Construction Graphics Communication course was taught differently in Spring 2015 to test how BIM could help students develop their plan-reading skill. Twenty-five students were enrolled in this section, and most of them were transfer students. Unlike other sections, students enrolled in this section learned how to use a BIM authoring tool first before they started working on plan-reading exercises. Teaching students how to use the BIM authoring tool in a very short amount of time can be challenging. No students can develop a BIM skill to create a 3D model simply from listening to lectures. They need to put their hands on the BIM authoring tool between classes to pick up the BIM

skill. Unfortunately, most students are reluctant to spend additional time between classes and do something with the BIM authoring tool unless they are highly motivated. What would be then an effective way to teach college students the BIM authoring tools especially when only a limited amount time is allocated?

3. Goal Oriented Active Learning (GOAL) Community for BIM Classes

The Construction Graphics Communication course at Texas A&M University used the Goal Oriented Active Learning (GOAL) pedagogy, which was developed by the instructor over years, to overcome this challenge. The GOAL pedagogy is in essence about setting up the goal for students, introducing them to essential skills they need to use to achieve the goal, showing them resources they can use to get additional skills, and encouraging them to achieve the goal using those skills.

The GOAL pedagogy provides students with a unique opportunity to pick up new knowledge in a personalized learning environment. Personalized learning is about providing students with learning environments to meet the needs of individual learners. David Miliband (2006), 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 (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

The GOAL environment helps students learn how to use BIM applications at their comfortable speed while working on the class project. There are a huge amount of resources available on the Internet, and students are encouraged to take best advantage of them to pick up new knowledge at their comfortable speed. 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.

To set up the goal for students enrolled in the Construction Graphics Communication course, the instructor developed a small class project using the on-going construction project sponsored by a construction firm. The goal that students were encouraged to accomplish through the class project was to read the 2D drawings of the 5-story dormitory building and create a 3D computer model of the building. The instructor introduced a BIM tool that would be used for the class project, and presented a step-by-step process of creating a 3D computer model using the BIM tool. The instructor then informed students of the online resources that may help them learn more about the BIM tool. The instructor also created an online learning community using Social Network Service (SNS), where students exchanged information and taught each other how to use the detail functions of the BIM tool.

4. Class Project

Students enrolled in the Construction Graphics Communication course learned how to read 2D drawings and figure out the look of the associated building components in 3D world while creating the 3D model of the sponsor's construction project. Before the spring semester started, the instructor looked up various construction projects around the campus, and decided to use the 5-story dormitory building construction project to develop a class project. This dormitory building was selected because the building's interior configuration is simple and repetitive to some extent, therefore students could create the 3D model

without getting too much workloads. Also, the general contractor working on that project was very supportive and willing to help students in class understand how to read 2D drawings.

Once the target project was selected, 2D drawings were collected from the sponsor and distributed to students. The sponsor's project manager then visited the class and helped students understand what were depicted in 2D drawings. At the same time, the instructor started teaching students how to use a BIM authoring tool. He demonstrated the process of creating a 3D model using the BIM authoring tool, and then asked students to create a 3D model of their dream house without paying any attention to dimensions. This homework gave students a motivation to put their hands on the BIM tool and start using it, which is a critical process to become familiar with the computer tool. For those who wanted to know more about the BIM authoring tool, the instructor also introduced the online resources presenting how to use the BIM authoring tool in detail. These online resources helped students learn more about the BIM authoring tool on their own pace.

Once students got familiar with the tool from working on the first assignment, the instructor asked students to create the 3D model of the building foundation and structural components of the dormitory building. To reduce the workload, 25 students enrolled were divided into 5 groups. Each group has 5 members, and they were working together to create a 3D model of the 5-story dormitory building. Students in each group made their own decision as to how they want to slice up the target building, so each student could contribute to the team project equally. To encourage students to participate in the team assignment, the instructor came up with an intra-team evaluation procedure. Figure 1 shows the floor plan of the dormitory building.

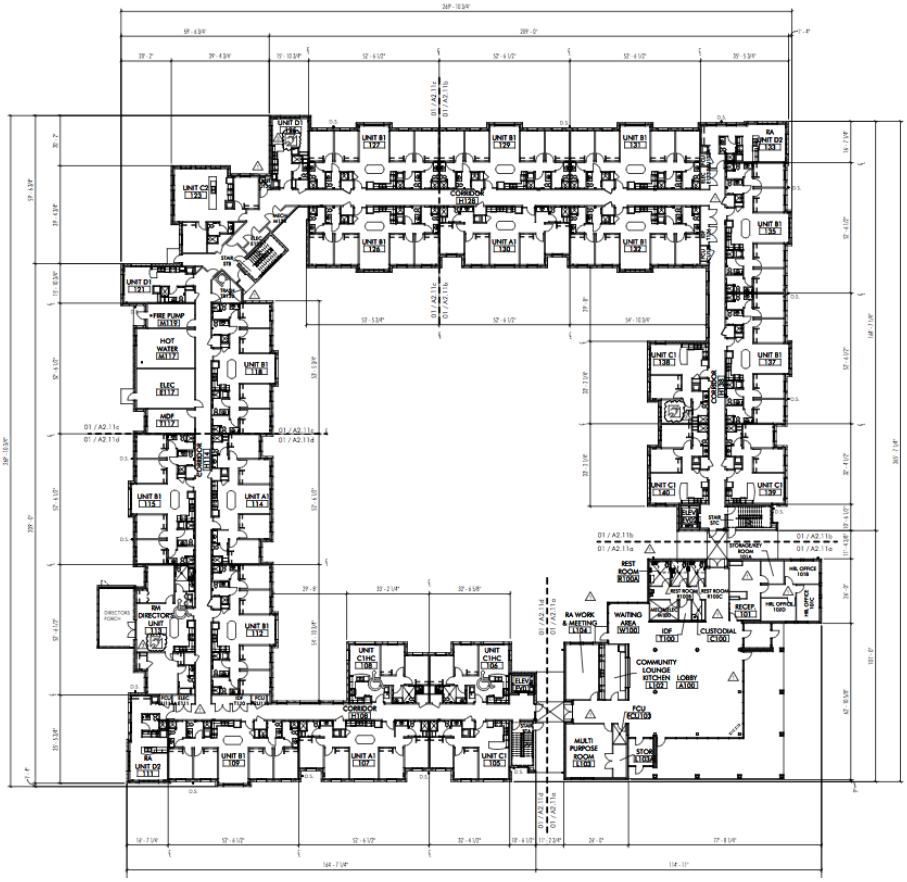

Figure 1. Floor Plan of the Dormitory

Once the 3D modeling of the foundation and structural components of the dormitory building was finished, students started working on the architectural components. They created the 3D model of the architectural components of the building, including windows, doors, and ceilings. Creating the 3D model of furniture was not included in the assignment, but some students got excited about the assignment and added some furniture into the model. Concerned about the workload, the instructor did not ask students to work on the Mechanical, Electrical, and Plumbing (MEP) components.

While students were creating the 3D model of the building, the instructor brought students to the jobsite, where they had a chance to see the actual building components. Students also had a chance to learn about some construction operations and procedures in fields. Figure 2 shows students listening to the project manager's presentation on the jobsite.

Figure 2: Students listing to the project manager's presentation on the dormitory construction site

As usual, 2D drawings provided by the sponsor were not perfectly error free. There were some inconsistencies between drawings, and students sometime had no clue which page had correct information. To help students better communicate with the sponsor and other students in class, the instructor created a closed space on the Social Network Services (SNS), where the instructor, students, and sponsor's project engineer can join and share information about the project. Using this SNS space, students posted questions about the project, and the instructor or the sponsor's representative provided answers to those questions. Other students, following these questions and answers, were able to pick up information they needed without asking the same questions repeatedly. Figure 3 has the snapshot image of the question posted by a student on the SNS space.

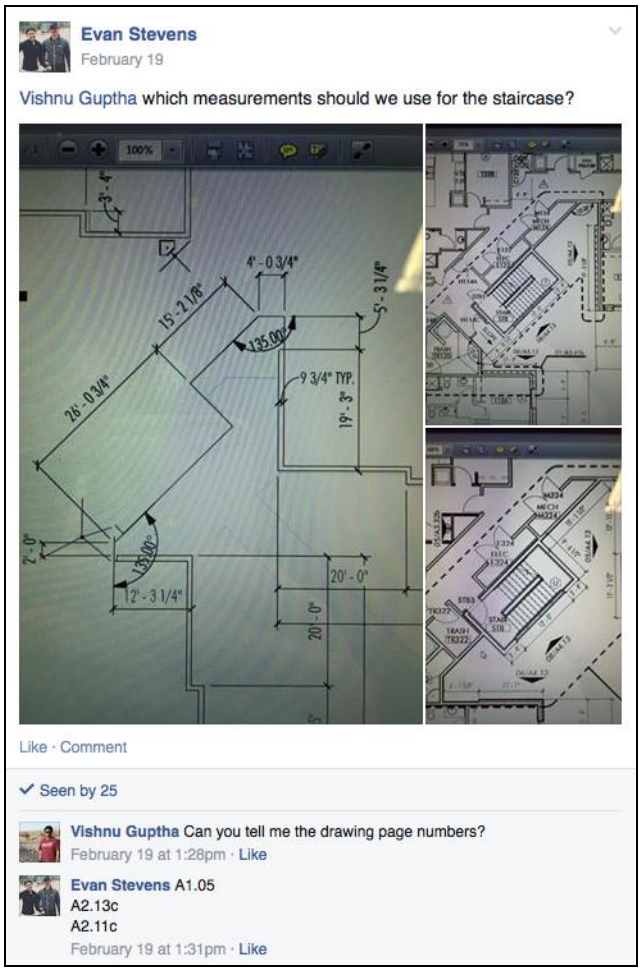

Figure 3: Screenshot of the Facebook Group message left by a student asking for clarification.

With the 3D model of the dormitory building created, students started producing the animation clips showing various parts of the building, and then putting those animation clips to produce a short video presenting the project. This assignment was designed to help students develop a communication skill they will need to explain their construction projects. The instructor taught students how to use a BIM reviewing tool to produce walk-through animation clips, and how to use a non-linear video editing computer application to stitch those clips together and produce a short video. Students then came up with the script they wanted to use for the video production, created fly-through or walk-through animation clips according to their script, and produced the short video presenting their class project.

All class activated mentioned above were executed in 7 weeks with the following schedule.

Week 1: Learn what BIM is and why the construction industry uses BIM.
Week 2: Learn how to use a BIM authoring tool and create a 3D model of a dream house.
Week 3: Learn how to read 2D drawings, and start working on the class project. Read the 2D drawings of the dormitory construction project, and create a 3D model of the building foundation and structural components.
Week 4: Create a 3D model of the building's architectural components.
Week 5: Create a fly-through animation presenting the building configuration.
Week 6: Create a short movie presenting the building configuration.
Week 7: Present the 3D model and movie.

Figure 4 shows the 3D model created by students. Figure 5 shows the snapshot image of the video produced by students.

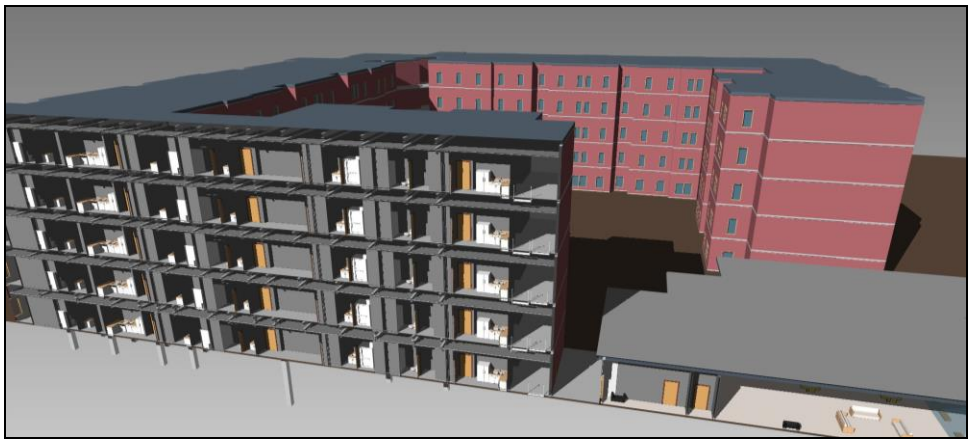

Figure 4: 3D model of the dormitory produced by students

Figure 5: Snapshot image of the video produced by students

5. Evalation of the New Pedagogy

Towards the end of the course, the instructor collected some feedbacks from students to get to know how the Goal Oriented Active Learning (GOAL) pedagogy was working. The first question he asked was "Did you set up a clear goal you wanted to achieve while taking this class? If so, what was you goal?" To this question, most students responded with the following comments.

> *"The goal was clear for the most part. My personal goal was to become better at Revit, which I feel like I achieved."*
>
> *"My goal was to create a good looking 3D model with all structural, architectural, and mechanical components as well as learn how to read plans efficiently."*
>
> *"My goal was to create a project that I was proud of. After a crazy amount of hours with my team, we achieved that goal."*

Other question that the instructor asked was "Although I showed you the entire process of creating a 3D model using Revit, I assume it was not enough. Describe how you picked up additional skills you needed to work on the class project". Answers to this question are:

> *"There was good information available on YouTube, but sometimes it took hours to find out how to do a certain simple task."*
> *"Some YouTube videos were helpful, but I still ran into many serious issues that should have been explained in class."*
> *"YouTube was a huge help but very time consuming. Revit is all about learning little tricks to make it go faster".*

Last question the instructor asked was "Now, after working on the class project, how much confidence have you gained (0% for no confidence and 100% for full confidence) in terms of reading 2D drawings and figuring out the spatial relationship between building components? Nineteen students responded to this question and the highest value received was 80%. The lowest value was 25%, and the average was 63%. The instructor did not have a chance to compare the outcome with other sections where students learned how to read 2D drawings with the conventional pedagogy. Therefore, it would not be reasonable yet to make any cases using these responses.

6. Conclusion

One of the sections of Construction Graphics Communication course at Texas A&M University was taught differently in Spring 2015 to test how BIM could help students develop their plan-reading skill. Twenty-five students were enrolled in this section, and most of them were transfer students. A unique challenge with the expedited course was that everything has to be covered in 7 weeks. Teaching how to use BIM tools and help student pick up the plan-reading skill in 7 weeks was challenging, so the Goal Oriented Active Learning (GOAL) pedagogy was used to overcome the challenge. A class project was prepared with the sponsor, for which students read 2D drawings of a dormitory building in the campus, created its 3D model, and produce a short video presenting the building configuration using the 3D model.

All 5 teams, consisting of 5 students, successfully created a building information model of the 5-story dormitory building, created animation clips, and produced a short video presenting their project. The instructor did not receive any major complains from students while they were working on the project. Two days before the final presentation, the instructor happened to find a group of students working on the project around 2:00 am, and they were not complaining about the workloads. Instead, those students wanted to do more so that their video will get distinguished from others. This is a good example showing that the GOAL pedagogy actually got students excited and learn the subject matter actively.

Some comments received from students also indicate that there are some rooms to improve the implementation of the pedagogy. More instruction has to be shared with students at the beginning of the semester to get all students are in the same page. The instructor may need to develop a list of online resources and share it with students, so that they don't need to waste their time searching for the right resource they need to use.

7. References

Miliband, D. (2006) "Choice and Voice in Personalized Learning", Personalizing Education, OECD/CERI, pp. 21-30.

Wolf, M.A. (2010). Innovate to Educate: System [Re] Design for Personalized Learning, Software & Information Industry Association, p.7.