Collaborating with Industry and Facilities Management to teach BIM

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Abstract

In Summer, 2011 Colorado State University (CSU) piloted an experimental course using Building Information Modeling (BIM) in collaboration with industry and the facilities management department. In the course, students modeled campus buildings to explore and leverage the opportunities to apply BIM to existing buildings and on-going facility management projects. A host of softwares were taught including Google Sketch-Up, Revit, Vico Office and Navisworks. Industry professionals served as visiting instructors to teach the various softwares. They coordinated and worked across software platforms to allow students to experience integrated software learning environments. Students created a model of a campus building and then continued to import, export, recreate and manage it using different software tools according to desired functionality(ies) (e.g.; scheduling, estimating, operation etc.) This paper discusses the pilot offering of the course, and presents student work and initial feedback. Findings are used to gauge the success of the course, assess its value and document the lessons learned regarding the benefits of exposing construction management students to facilities management work on campus.

Keywords

BIM, education, curriculum, facilities management, construction management

1. INTRODUCTION

Limited research exists regarding the use of Building Information Modeling (BIM) in construction management education. Currently many academic programs are struggling to meet industry and student expectations. Results of several university studies demonstrate dissatisfaction among students and educators with the advancement of technology-based curriculum and with the use of BIM in the classroom (Sylvester and Dietrich, 2010; Sabongi and Arch, 2009). Much agreement exists across current research regarding the impacts and benefits of using BIM in undergraduate AEC education. Benefits include proliferation of integrated design, an accelerated design process, added initial concept complexity, a more robust exploration of concepts, and an overarching gravitation towards more collaborative and coordinated teamwork (Denzer and Hedges, 2008; Hedges and Denzer, 2008). Using BIM as an instructional tool appears to ease the transfer of knowledge. Specifically, instructors tend to lose less information in translation when discussing buildings, compared to more traditional and two dimensional methods of instruction (Berwald, 2008).

It is generally accepted that different students learn best using different methods. Research suggests that the integration of the BIM helps a significant number of diverse students investigate more complex design ideas with greater success when compared to traditional two dimensional platforms. BIM allows instructors to teach an integrated process geared towards collaboration involving all the AEC disciplines by providing greater opportunity to visualize how building systems go together (Berwald, 2008). The learning objectives for the pilot BIM course offered at CSU in summer 2011 included: expose construction management students to campus buildings and facility management projects on campus, introduce students to a

number of BIM softwares, and allow students to experience integrated work environments and cross-platform coordination which simulate a real-world project. In addition, working with Facilities Management, an objective was to identify possible synergies on campus between student skill development and university need (i.e.; internships, marketing, building opperations). This paper presents student feedback and lessons learned from the experimental course offering.

2. COURSE STRUCTURE AND STUDENT WORK

The course was offered as an "Independent Study" for up to twelve students to allow the administering faculty, Caroline Clevenger, to organize the experimental course with sufficient flexibility to meet the diverse scheduling and academic requirements of the participants. Prior to acceptance, each student signed a course contract saying they would adhere to the proposed structure and schedule. In its pilot form, the course spanned eight weeks and students met with industry BIM experts for four-hour sessions in the department's computer lab each Tuesday afternoon. During these sessions, industry experts demonstrated various software packages and worked directly with the students to assist them in creating or recreating models of campus buildings using various softwares. During the intervening days, students worked independently or in small groups to complete the models to the level of detail specified by the instructors. Two campus buildings were modeled by the students. Images from the Natural Resources Building are used to illustrate the modeling sequence performed by the students during the course.

Google Sketch-up (Week 1)

During the first week, Zack Mertz, concept3D and Matt Hoff, Mortenson Construction met with the students two consecutive days to leverage the professionals' time since Zack had flown in for the training. To begin, students toured the buildings on campus and took numerous exterior pictures of the buildings to be modeled. The instructors then showed the students how to model the buildings in Google Sketch-up and to apply photographs as textures to the exterior surfaces of the models to provide a quick and realistic representation of the building. Final models were submitted to and accepted by GoogleEarth http://sketchup.google.com/3dwarehouse/details?mid=f90aa7e9edd4e0b94c12fff31b1ca82a&prevstart=0 .

Figure 1: A photograph (left) of the Natural Resources Building, Colorado State University, Fort Collins. A Google Sketch-up model (right) of the same building created by the students using photographs as textures for the model's exterior surfaces.

Google Sketch-up is a freely available 3-dimensional modeling program intended to be easy to learn and use. It allows users to place models using real-world coordinates and share them with other programs (Google Sketch-up, 2011). Several benefits emerged from introducing

the students to Google Sketch-up at the start of the course. First and foremost, by visiting the building and taking numerous photographs, the students were able to physically experience the building. Secondly, the numerous photographs served as a quick reference library throughout the course. Thirdly, by applying photographs as textures, the details (i.e.; building height, location of windows and door etc.) were easily documented and available for reference during later modeling exercises.

Revit (Weeks 2-4)

For the following three weeks Blake Sabo, SHP Leading Design was the instructor and taught the students Revit. Revit is a BIM software that allows the user to create models using 2D drafting elements and parametric 3D modeling functionalities (Revit, 2011). Using Revit, students constructed models of the campus buildings that included exterior walls and openings, as well as interior walls and openings (Figure 2, left). They modeled the interior by referencing 2-dimensional reflected ceiling plan CAD drawings provided by the facilities management department. In addition, they imported their Google Sketch-up models into Revit to provide a quick reference for building elevations and dimensions along the exterior.

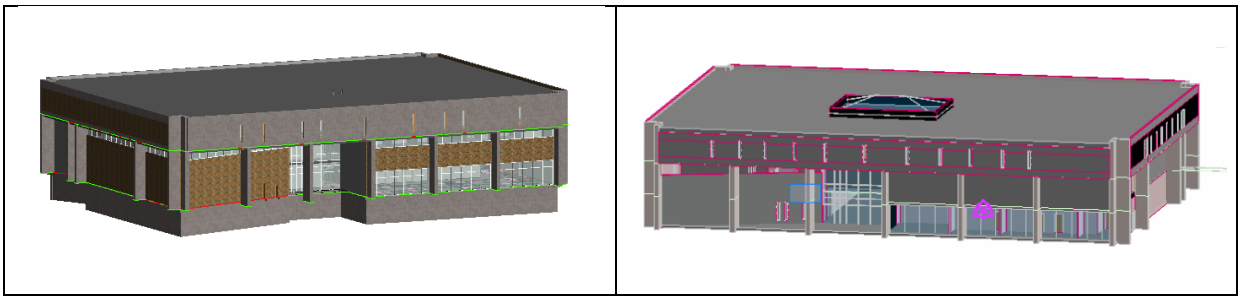


Figure 2: One student's model of the Natural Resources Building modeled in Revit (left) and another student's Revit model imported into Vico Office for analysis (right).

Students worked collaboratively in groups of 2-3 for this part of the course. All work was stored on a shared server, and the instructor helped the students set-up shared models so that each group could work concurrently on a single building model. The benefits of this increased level of collaboration were several: it allowed the students each to work on and collectively complete a model of an entire building. In addition, it provided them greater insight and understanding of the teamwork and technical integration required to implement BIM on a real-world project. Finally, working on a shared model simulated a professional work environment.

Vico Office (Weeks 5-6)

The next two weeks of the course were taught by Alan Fordham, the Weitz Company. He showed the students how to import their existing Revit models into Vico Office to perform various analyses. Vico Office is a BIM-neutral platform in which multiple types of BIM models can be published, synthesized, and augmented with cost and schedule information (Vico Office Suite, 2011). Once the students imported their Revit models (Figure 2, right), the instructor showed the students how to create a library of construction costs in Uniformat (Uniformat, 2009) using an excel spreadsheet. Once this data was linked in Vico Office, students created cost-estimates and location based schedules (LBS). As the instructor taught the students, the power of these analyses comes from the fact that they are created directly from the building geometry and material properties modeled rather than generated independently based on experience and take-offs as is traditionally done in practice. One of the more poign-

ant moments of the course occurred when the instructor, a professional construction manager and the "client," a project manager from facilities management debated the value of this distinction.

Navisworks (Weeks 7-8)

Blake Sabo, SHP Leading Design returned to the classroom for the final two weeks of the course to teach the students the basics of Navisworks. Navisworks is widely used by the construction industry to perform clash detection. Students imported their previously created Revit models into Navisworks and experimented with clash-detection, fly-throughs and 4-dimensional (3D + time) visualizations of the building.

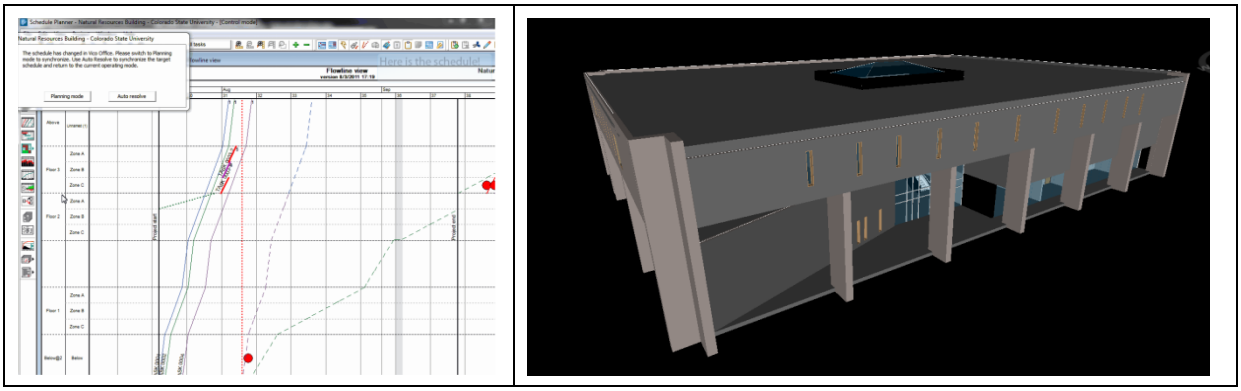


Figure 3: Location Base Schedule output from Natural Resources Building Vico Office model (left) and the Revit model imported into Navisworks (right).

3. STUDENT FEEDBACK

Five short surveys were administered to the students over the course of the summer session. The surveys loosely followed Kirkpatrick's model for evaluating training programs (Kirkpatrick, 1959). His model includes four levels of evaluation, i.e. reaction, learning, behavior and results. For all questions a bilateral five point scale was used. The surveys were distributed to 10 out 10 students who participated in the experimental class. Nine students completed the surveys resulting in a 90% response rate. Each survey regarding various softwares were administered the week following when the software was taught in class; the survey regarding the overall course was administered during the final class. A summary of the questions and responses are provided below.

3.1 Software

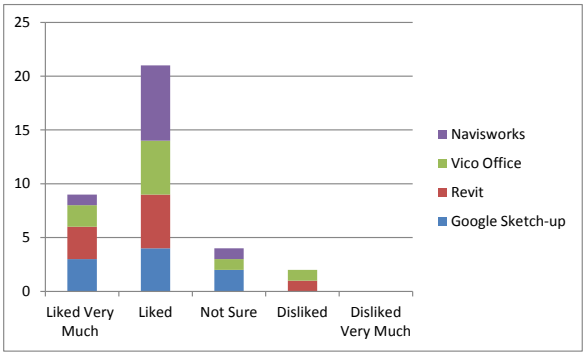
Reaction: Students were asked how much they like using the various softwares (1).

Learning: Students were asked how easy various softwares were to learn (2).

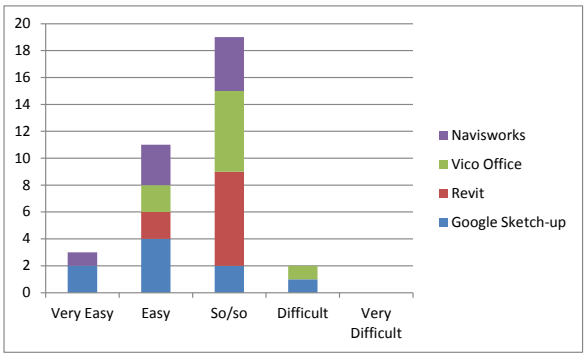
Behavior: Students were asked how much they expected use the various softwares in the future (3), and how it might impact their ability to get a job (4).

Results: Students were asked about the potential impacts of various softwares on the curriculum (5), or as used professionally for either graphics (6) or analyses (7).

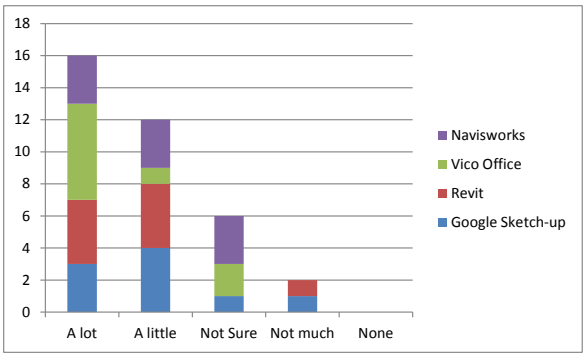
Results from the student surveys regarding various software packages are shown in Figure 4.



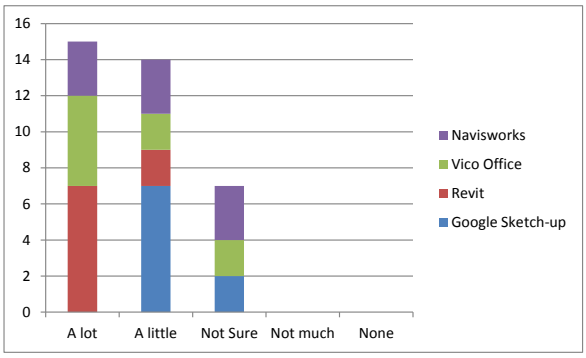
1. How well did you like using the software?



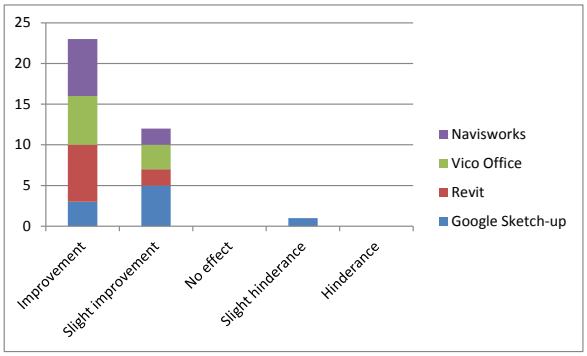
2. How easy was it to learn the software?



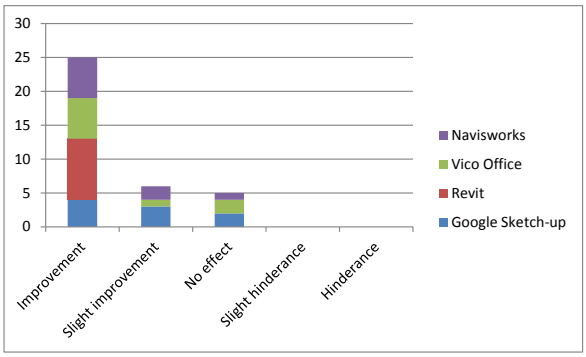
3. How much do you think you will use the software in the future?



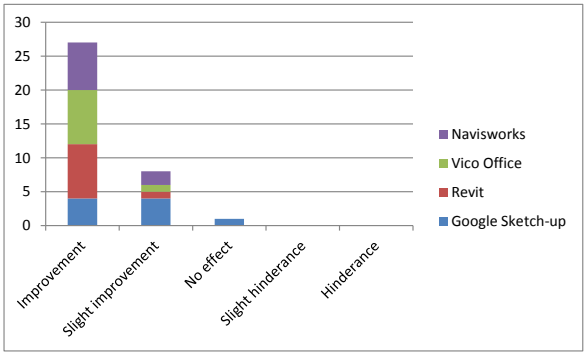
4. How much do you think you knowing the software will help you in getting a job?



5. What would be the impact of using the software in the curriculum to help Construction Management students learn?



6. What would be the impact of using this software professionally to create 3D graphical representations of



7. What would be the impact of using this software professionally to perform analysis in construction?

Figure 4.: Graphs summarizing student survey results regarding their experience with and attitude towards Google Sketch-up, Revit, Vico Office, Navisworks based on participation in the experimental class.

3.2 Overall Class

Reaction: Students were asked how much they liked the overall class (1).

Learning: Students were asked how conducive the structure of the class was to learning (2), what was the value of having a series of professionals teach the course (3), and what was the impact of using a real building on campus as the "case study" (4).

Behavior: Students were asked how much they thought they would use what they had learned in the future (5).

Results: Students were asked what the impact might be of having such as class integrated into the curriculum (6).

Results from the student surveys regarding the overall class are shown in Figure 4.

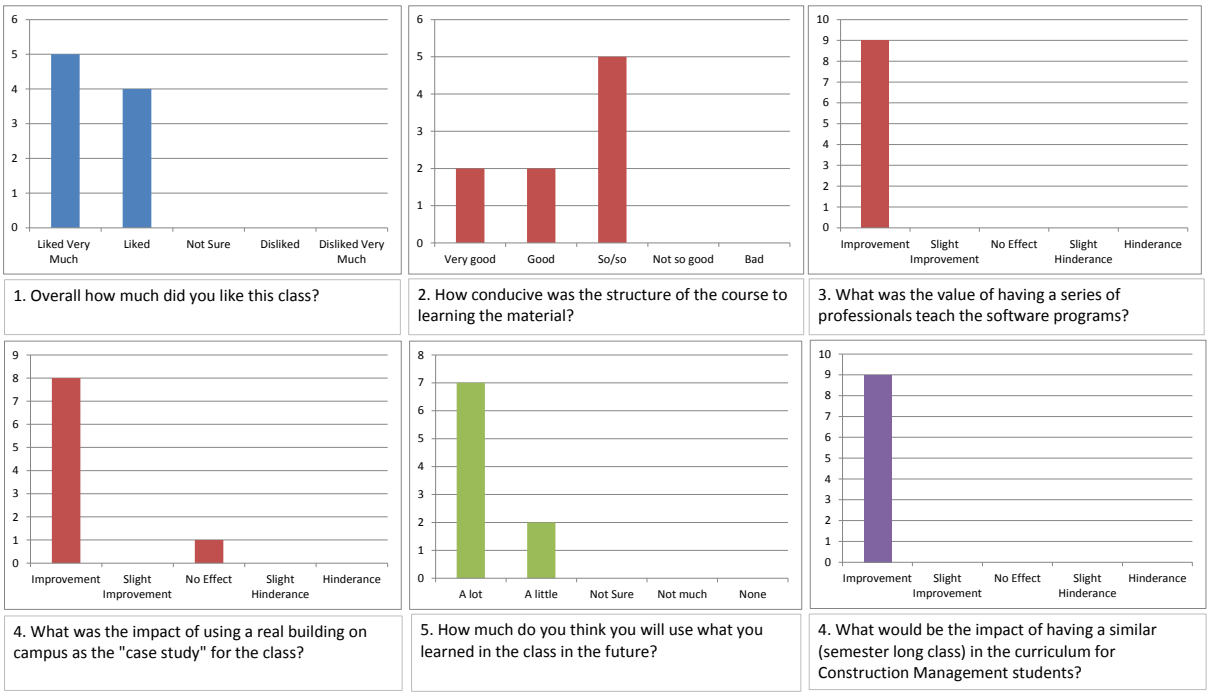


Figure 5: Graphs summarizing student survey results providing feedback on the experimental class.

4. DISCUSSION AND LESSONS LEARNED

Predominant student feedback about the course (Figure 5) and demonstrated learning outcomes (Figure 1-3) were positive and strong. Students felt that they were exposed to and learned about a wide range of BIM softwares. In addition, they experienced first-hand the integrated and synergistic nature of BIM, learned directly from industry experts, and were exposed to a number of work-flow patterns applicable to applying BIM to a real-world building project. To date, the authors have received strong industry support and interest in follow-on offerings as a semester long course. Specifically, industry recognizes the value of having students understand the potential of BIM and its various workflows above and beyond having proficiency in a single or even multiple software packages. Furthermore, having a series of industry professionals provide instruction meant that the students were exposed to a level of expertise that is difficult to find in an individual, or traditional faculty member.

Based on student survey responses regarding the various softwares (Figure 4), it is possible to draw a few simple observations about the softwares used including:

- Data suggests there is not a strong correlation between perceived difficulty a software, and how much the students like using it.
    - Anecdotally, one student wrote in her final comments, "Revit and Navisworks both are powerful tools for the construction industry, but when you add in the capabilities of Vico Office this is amazing! It makes me wonder why anyone who does estimating or scheduling wouldn't use this software. While the learning curve is very steep, I believe that teaching these tools is imperative to the success of students. . ."
- Students believe that knowing these tools will assist them in getting a job, and that Revit is the most marketable of the softwares learned.
- Students see teaching these softwares as an improvement to Construction Management curriculum.
- The opportunities available from partnering with industry and Facilities Management are valuable.

Facilities Management was instrumental in selecting campus buildings to serve as effective case studies, and supplied access to, and schematic models and building plans for the buildings selected. Finally, they provided input about the type of information and models that they consider to be the most useful on their projects. In the future, students may be able to produce models that are, in fact, useful to the facilities management department. Other universities have been successful in leveraging student work to model and map their campuses in 3-dimensions (Drury, 2001). The real potential, however, may lie in training students for synergistic internships with facilities management as well as developing models that can assist in real-time building operations.

Some of the challenges facing the course were logistics and excessive course content. Since industry professionals are busy, they met with the students for extended blocks of time. Many of the students noticed that it was hard to stay focused for these extended class periods. A second challenge was the number of software programs taught. While students liked being exposed to the various softwares and saw the value in experiencing a variety of workflows, they were, at times, frustrated by the amount of material it was necessary to learn and manage. The strongest lesson learned was that incomplete or imperfect models in one software package (i.e.: Revit) hamper the learning of the follow-on software (i.e.; Vico Office). Students suggested that in future offerings of the course, at the end of each software unit, a single well-crafted model of the building be supplied to the students to replace student created models. This way, all students could work from the same base model at the beginning of each unit and any previous modelling errors or inconsistencies would not persist.

5. CONCLUSION

Students' survey responses (Figure 5) showed that they generally liked the class, saw its value, and are eager to integrate such a class into the CM curriculum. While its format and structure need fine-tuning, supporting such a course through collaboration between industry experts, facilities management, and CM faculty appears fundamentally robust. Relying on industry expertise for instruction has several direct benefits. Students receive instruction on and exposure to industry's best-practice. Students benefit from having several subject matter experts rather than one instructor. Finally, industry instructors are particularly adept at teaching BIM workflows and integration issues since they deal with them daily on real-world projects.

Future research opportunities and significant potential for this course lies in the prospect of increasing collaboration between construction management students and facilities management personnel to cost effectively help to manage and monitor campus building operations using BIM software. Over the last several years, the Facilities Management Planning, Design

and Construction group at Colorado State University has developed an integrated design studio made up of students from the disciplines of Interior Design, Landscape Architecture and Engineering. Using various software, the students work on real projects for new facilities and renovations from conceptual design through construction documents. In parallel with the work being completed in the design studio, CM students in such a class could partner with University project managers to see projects through construction and occupancy. In the future, Universities may increasingly discover they have significant and synergistic resources available among their construction management students that can be leveraged to provide better facilities management across campus.

6. ACKNOWLEDGEMENTS

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