Integration of curriculum between computer graphics technology (CGT) and Building construction management (BCM)

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ABSTRACT

In this paper, the authors present their experience at integrating the Building Information Modeling / Management (BIM) concepts between two departments; the Building Construction Management (BCM) and Computer Graphics Technology (CGT). BIM is the process of generating and managing building data, which encompasses building geometry, spatial relationships, geographic information, and quantities, and properties of building components. While the common approach is to incorporate BIM into engineering and construction, management programs, at Purdue University, we argue that there is more value in generating BIM models by joining efforts between the two departments. It reflects real world experience where construction managers seek the expertise of graphics modelers to produce the BIM model while they remain focused on the construction practices. Taking this concept beyond the curriculum of construction management and integrating with computer graphics technology proved very valuable experience for both departments. The CGT students found a context where they applied their graphics expertise while the BCM students provided the content expert of building systems. Teams of students from both departments joined efforts to generate a BIM model of an existing building. BCM students interpreted the existing 2D drawings and the CGT students developed the BIM model. The model consisted of a 3D representation of the existing building using Revit Autodesk software. The students used Revit architectural to develop the architectural component of the building; Revit structural to develop the structure shell; Revit MEP to model the mechanical, electrical, plumbing and fire systems, and Navisworks was used to integrate all of the developed models and create a simulation, walk through, and clash detection. This paper will highlight the challenges the students face in this setting as well as the software shortcomings in order to achieve a BIM model.

Keywords: BIM, Interdisciplinary approaches, construction management, construction visualization, computer graphics

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Introduction

Construction Management programs are working towards developing Building Information Modeling (BIM) emphasis within the curriculum. The construction industry is also requesting and pushing through their Curriculum Industry Advisory Boards towards such implementations. Owners are starting to require BIM as part of the specifications towards the award of the project. The challenges towards the BIM implementation is that the curricula are already charged, and adding new classes are going to be at the cost of deleting some existing courses. BIM courses vary from software courses where student become proficient with the BIM software, and BIM classes where students focus on the Information sharing and documentation. In order to implement BIM in the curriculum, the curriculum needs to be revisited. BIM modules, that target the Information management aspect of BIM, are introduced in the various classes and new classes are developed to teach the modeling part of BIM. Students who are currently going through the program will be better prepared and familiar with the new technology and BIM technology in particular. However the industry is filled with construction managers who are reluctant to jump on board of the BIM wagon, and concerned of loosing productivity by going through the learning curve and trying to take on new technology. As an alternative, current construction companies are creating positions for BIM managers, where they are seeking to hire technological savvy and modeling experts to bridge the technology gap, and come up to speed in the BIM area. These people can have architecture background, previous architects, or architecture students who can handle CAD software, and BIM software, or recent graduates who are experienced in BIM technology. In this paper we present another alternative to tackle the challenges that faces the construction industry. Computer graphics students are skilled in computer software, and visualization, which makes them strong candidates to fill the position of BIM manager once trained on the concepts of construction management.

Course rational

Introducing a new modeling class in the construction management curriculum required to bring a modeling expert to become part of the team. The challenge is that people with modeling expertise are not necessarily expert in construction practices. A joint partnership was developed among the departments of construction management and the computer graphics, in order to tackle these challenges. In an experimental class, students from computer graphics team up with students from the construction management to develop a BIM model for a facility. The construction management student helped the computer graphics students with blueprint readings, the operations and details of the various systems. The exercise was very well received by the students from both departments the construction management and the computer graphics. As both parties felt that they are facing a simulation of real life collaboration between two parties with different backgrounds. It was an interdisciplinary activity where students from computer graphics were getting ready to become the next BIM managers as they are building the expertise in BIM modeling, clash detection, and construction documentation. The construction students were observing the challenges of BIM modeling, getting involved

in the process and working closely with the graphics students - the future BIM modelers. The course was divided in 8 modules where the students were introduced to various concepts to better understand the goals, objectives, and benefits from having a BIM model.

Course Anatomy

The course was created around 8 modules that cover the modeling aspects of BIM and information sharing. Table 1 shown below summarizes the various modules as well as the intentions from these modules.

Module	Justifications
Study on Contracts and Project delivery methods	Understand the settings and boundaries of the project
Study on Integrated practices	Apply BIM in the settings of an integrated practices project such as Design Build project
Study on Parametric Modeling	Understand the nuance between 3D modeling and Parametric modeling
Study on BIM Standards and IFC	Understand the various standards that control the software interoperability
Study on Object Oriented programming	Understand the concepts of object oriented programming and how it relates to lifecycle project information management
Study on Information sharing and team responsibilities	Understand the various roles of the participants
Study on project documentation and communication	Understand the required documentation of work in progress
Study on collaboration and coordination	Leverage the BIM expertise towards the success of the construction project

Table 1: BIM modules and their rational

The table 2 shown below summarizes the various exercises the students had to complete in order to develop the complete BIM model. The students worked a series of exercises in preparation to developing the final project which consisted of recreating a complete BIM model of an existing building on campus. The building offered a unique experience to the students, especially that it was complex project designed using a mixture of systems steel structure for a frame, the outside shell was made out of precast concrete and bricks, the

inside walls are made of CMU and some are drywalls system. The HVAC systems was also challenging as some parts of the facility were on an independent system.
To add to the student challenges, the students were asked to work in groups, where each group was in charge of a portion of the building. The students needed to learn to manage and coordinate the BIM model development, just like in real life, where multiple parties are involved in the design process.

Lab	Challenges
Create a wall component	The walls used in this building were unique and no representation of the existing walls could be found in the Revit library. The students had to recreate the component to create true representation
Creating a host model	Students learned to develop a host model in preparation to link the several models, Architectural, Mechanical, Electrical, and Structural
Creating the Structural Model	The students worked on bits and pieces of the building, and had to link their parts to the host file to share with other groups
Creating the Architectural Model	The students worked on bits and pieces of the building, and had to link their parts to the host file to share with other groups
Creating the HVAC Model	The students had to work off the Architectural model to install the Mechanical components in the facility. In addition, each group of students worked on a part of the HVAC system for the building, and link their work to the host project
Creating the Electrical Model	The students had to work off the Architectural model to install the Electrical system in the facility. In addition, each group of students worked on a part of the electrical system for the building, and linked their work to the host project
Coordination using Navisworks	The students checked for clashes and spatial conflicts using Navisworks. The students learned valuable lessons on what can go wrong in the settings of a project collaboration, where multiple users are working on bits and pieces of the model

Table 2: Modeling exercises with their respective challenges and lessons learned

Table 3 shown below summarizes the list of software the students used to develop the BIM model for this collaboration class.

Model	Software
Architectural Model	Autodesk Revit Architectural 2010
Structural Model	Autodesk Revit Structural 2010
HVAC Model	Autodesk Revit MEP suite
Clash Detection and simulations	Autodesk Navisworks

Table 3: Software used in the class

Course Challenges and Lessons learned

The class proved to be a very valuable experience for both graphics students and construction management students. The first challenge was the communication between the construction students and the non construction students and their attempts to convey the technical knowledge in their respective areas to others who do not share the same technology and terminology. Modeling was a huge challenge as the students were working on separate parts of the project and have them all linked to a central file where theoretically all parts had to fit. The students learned the hard way the importance of setting up a consistent reference with the central file. The students also learned the value of having a BIM manager to manage the central file. As far the MEP parts, the students realized that lack of the understanding of the basics of the various systems made their modeling work much more challenging, as modeled parts always ran errors. Parts of the lessons were dedicated towards the explanations of how these systems worked. Students learned that Revit MEP suite expected the components and the systems to be built according code and standards, and they realized that they had to know the basics about these systems if they wanted to be able to model them. Finally, when it came to Navisworks and clash detections, the students realized that the value of the work is in having an accurate model, otherwise the Navisworks will not be as valuable.
Students felt that their job would have been much easier if:
1- Students developed their own complete models
2- Students worked independently from other teams
    a- to avoid delays in the process
    b- to avoid constant re-alignments of coordinates
    c- to avoid having redundant components
3- Students better understood the systems and the construction standards
The students also realized that even though the software they used were AutoDesk products, they did not talk to each other smoothly, and lots of tweaking was needed in order to get a working model.

Conclusions

The presentations of the students' final project demonstrated that the students were able to learn from each other. The construction students were more knowledgeable about the software limitations and capabilities. They had better understanding of the technology and how to put it to use in order to achieve their construction management objectives. Graphics student had a real life experience, and realized what are the tasks and challenges that await them once they work for a construction company. They had better understanding on reading the drawings, and where to look for information as well as the value of working closely with an experienced construction personnel to make sure they understand the details of the various systems they will be modeling.