USING AN OBJECT ORIENTED DATABASE APPROACH TO ENABLE STUDENTS IN LEARNING INDUSTRY PRACTICES

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ABSTRACT

Building Information Modeling (BIM) has earned its credibility in the construction industry as an efficient medium for life cycle project management planning, communication, and documentation. Engineering and Construction management programs are introducing BIM in upper level classes to familiarize the students with this technology. In order to better prepare the students understand and implement this technology, this project proposes an Object Oriented Database (OODB) approach to incorporate the teaching of BIM throughout the curriculum starting with lower level classes. Building a complete BIM model is a humongous task to be achieved in one class even at the upper or graduate level. The objective from this approach is to educate the students in the data collection and organization. Students will collect elements relative to design guidelines, code application, quality and resources throughout the various classes in the curriculum. The collected data is incorporated into the visual model at the upper level classes to constitute working BIM models. The paper will highlight the benefits of the proposed method, and discuss the results of the evaluation of the students' learning experience.

Keywords: BIM, Education, Construction, Object Oriented Database, Information Management

1. INTRODUCTION

There is an increasing demand to implement BIM in the curriculum of building construction management programs in American universities. Industry partners are pushing the curriculum to incorporate BIM classes, so that the new graduates are proficient in this technology. However, most of the AEC industry partners view BIM as 3D CAD software, used to visualize shapes, clash detection and do walkthroughs. The 3D geometric representation is only part of the BIM concept. The emphasis on Information "I" in BIM is critical to the successful integration of computer models into project coordination, simulation, and optimization. As a shared knowledge resource, BIM has the potential to serve as a reliable basis for decision making and reduce the need for re-gathering or re-formatting information (GSA, 2007).

The General Services Administration (2007) views Building Information Modeling (BIM) as the development and use of a multi-faceted computer software data model to not only document a building design, but to simulate the construction and operation of a new capital facility or a recapitalized (modernized) facility. The Building Information Model is a data-rich, object-based, intelligent and parametric digital representation of the facility, from which views appropriate to various users' needs. The power of visualization, coordination, and simulation allows to effectively meet customer, design, construction, and program requirements.

Eastman (2008) defines BIM as a modeling technology associated with a set of processes to produce, communicate, and analyze building models and interfaces, methods, and applications that are related to BIM technology, including but not limited to the following: sustainable practices, management and organizational issues around technology, and assisting technologies and methods. The National Institute of Building Sciences

(2007) views Building Information Model (BIM) as a cutting edge digital technology to establish a computable representation of all the physical and functional characteristics of a facility and its related project/life-cycle information, and is intended to be a repository of information for the facility owner/operator to use and maintain throughout the life-cycle of a facility.

Suermann and Issa (2007) identified three groups with different definitions of BIM. The first group views BIM as an open standards based information repository for a facilities' lifecycles. The second group views BIM as a tool for visualizing and coordinating AEC work and avoiding errors and omissions. The last group views BIM as a combination of the two and possibly including other factors. However, there are other aspects of BIM such as 3D modeling, interoperability, semantics, clash detection and process integration.

In response to the industry demands to incorporate BIM in the curriculum, various programs have incorporated classes to teach BIM either in the form of standalone classes, or by incorporating the BIM technology throughout existing classes. Woo (2007) believes that it might be a challenge for the faculty member to fit all course contents into one. In order to better prepare students for carreers in the AEC industry, BIM should be integrated into the various course contents to deliver a working knowledge on BIM software and a rich and rigorous learning environment. Sabongi (2009) shares the results from a survey of the ASC school of construction. He states that the most significant obstacles to include BIM at the undergraduate level are the already-existing requirements for graduation, the absence of room in the curriculum for additional elective courses and the lack of reference materials and established curricula. 90% of the schools plan to incorporate BIM principles in current classes, rather than create new standalone classes to teach BIM principles.

BIM is an integrated database of coordinated information to which many participants in the design process contribute (Rosenberg, 2007). Aouad and Sun (1999) emphasize the value of structure for integrated database. This requires the establishment of a context model which can be used as a base for development and helps to keep the information in the integrated database within perspective. Object Oriented Databases (OODB) offer a framework for data integration and many advantages for gathering and sharing information in the settings of a construction project. As an approach, OODB allows to capture complex objects using concepts such encapsulation, class, inheritance, and association. OODB serves as an integrated repository of information that is shared by multiple users, multiple products, and multiple applications on multiple platforms. Using object identity and inheritance, OODB allows integration of heterogeneous systems, operating systems, databases, languages, spreadsheets, word processors, and Artificial Intelligence systems. Tah (1996) describes Object-orientation as a powerful tool that offers means of encapsulating knowledge in intelligent object classes, leading to efforts in developing application protocols and standards for data exchange and interoperability. OODB modeling approach provides knowledge-based decision support within large integrated project management systems. OODB combined with software engineering may potentially progress to software components for project management.

IFC is an object-oriented file format with a data model developed by the International Alliance for Interoperability (IAI) to facilitate interoperability in the building industry and a commonly-used format for BIM (Nemetschek North America, 2007). Wix (2008) defines Industry Foundation Classes (IFC) as standard format to define how information should be provided/stored for all stages of a building projects lifecycle. Starting from the lower levels properties of the individual object, to include from "very little" information to "everything". IFC hold data for geometry, calculation, quantities, facility management, pricing etc. for many different professions (architect, electrical, HVAC, structural, terrain etc.)

2. THE PROPOSED APPROACH

Students as future construction managers, have to adapt to new technology that is becoming part of the working environments. BIM with emphasis on Information, can help bridge the gap between academia and industry, and prepare the graduates for successful careers. The author believes that BIM is not just a tool or software students need to learn. Integrated in the curriculum, BIM as a methodology for learning, is a way to embrace new technology and make it an important part of the successful communication of information. BIM has the potential to shift the focus of the curriculum from transmission of contents to developing industry skills and professional judgment. Drawing from the concepts of Object Oriented approach, and using Object Oriented Databases, the objective is the integration of the information; the students gather and organize information relative to the various construction systems throughout the various classes in the curriculum. Using such methodology, the material taught in classes early on in the curriculum, is saved and integrated with the material taught at the senior level classes.

The Unites States Bureau of Labor Statistics has found that the construction industry has actually decreased in productivity since 1964, while all other non-farming industries have increased in productivity by over 200%. The Construction Users Roundtable has characterized the inefficiencies experienced in typical construction projects as "artifacts of a construction process fraught by lack of cooperation and poor information integration. Integration of information relies on a collaborative team including the architect, owner, engineers and constructors to share information and expertise as the project is developed. The flow of information is dictated by the type of relationship between the parties, and the type of contract that binds these relationships.

Along the guidelines as the Industry Foundation Classes (IFC) the students organize their understanding of the systems, and determine the roles and responsibilities of the various construction team members based on the project delivery method and the type of contract. Students learn to organize the material gathered from various classes and link it using the following six categories:

-"Actors": represents the people or organizations
-"Controls": represent rules controlling time, cost, scope
-"Group": represent collections of objects for particular purpose
-"Products": represent building elements
-"Processes": represent tasks and procedures
-"Resources": represent materials, labor and equipment

By following this thinking methodology, the students can relate the information learned in the systems class and apply it in the context of the safety or scheduling or estimating classes. At entry level classes, this methodology offers the students better understanding of the curriculum and the objectives from each of classes. The students are able to identify a road map, and have expectations of where the curriculum is going to lead them. At another level, it helps them understand the industry practices, where a successful job can only be achieved by covering all the bases and integrating the knowledge from design, to specifications to building code, and contract administration.

3. METHODOLOGY

Founded in the understanding of BIM as medium to communicate and document information throughout the life-cycle of the construction project, and in order to get the students to adopt the BIM methodology, i.e. to focus on gathering information and organizing it in tabular format and databases, modules are developed for every class in the curriculum. These modules are introduced to the students early on in the semester, where students are familiarized with Excel and the fundamentals of databases. In introductory classes to Construction Management, the students are asked to search for papers related to BIM, and to organize their findings in excel tables so they can keep track of the information. The objective form this exercise is to get the student familiar with the literature on BIM, and to start creating a methodology to organize information in tabular format. When the students are introduced to the various delivery methods and types of contracts, they are asked to do an exercise where they summarize in an excel table the various roles and responsibilities of the various team members and the rules that govern the flow of communication among the participants. The students need to be able to answer the questions "Who" is responsible to communicate "What" information regarding "Which" system, and "When" to share information, "How" to document the flow of information, and "Where" to find that information.

In another module, the students are asked to research about the responsibilities of the different construction team members, their roles, and the tasks they have to perform on a daily basis. This exercise will familiarize the students early on in the curriculum, with the responsibilities of the construction team, and will help them determine a roadmap, where they see the goal they have to achieve. Organizing the duties of the construction team in a tabular format, is a first step in determining the rules and hierarchy of communication and information sharing among the various participants within the settings of the construction project.

At the sophomore level classes the students learn the basics for materials and systems. A module is introduced to these classes where the students are asked to demonstrate their understanding of the materials and systems by highlighting and categorizing the information in regards to pre-Construction, construction documentation, field related information, or post-construction information. The information is also organized in various categories, such as quality control, quality assurance, etc. As the student is progressing throughout the classes in the curriculum more and more information is weaved together to allow better and more comprehensive understanding of the materials, systems, documentation, and the relationship with safety, scheduling or estimating classes.

At senior level classes the students are asked to tackle a real case scenario problem, and develop a plan and schema showing the flow of information among the various teams and participants, showing "What" information, "When" is it needed, "Who" needs to know about it. To illustrate with an example, the following is the results of one of the assignments, where students were asked to:

1- Identify a construction component in the mechanical or electrical trade.
2- Analyze the information needed to successfully complete the construction of this component, Information pertinent to code, site supervision, site coordination, description, specifications, delivery logistics, etc.
3- Categorize the information relative to the different phases of the project, Pre-construction, construction or post construction.
4- Identify the key personnel who are responsible to gather, share and document the flow of information among the various parties involved in the procurement, installation, testing, and maintenance of this component.
5- Using a life cycle approach, develop a schematic approach demonstrating how to link this information.

One of the students studied the Air Handling Unit (AHU) in the settings of a commercial construction project.
Information gathered:

1- At Pre-Construction phase:

Specifications	Identify the governing specification sections
The governing Code	Identify the governing Code
Determine if it is a long-lead item	Identify Schedule contingencies to accommodate
The weight of the AHU	Identify the any for any structural reinforcement
The dimensions of the AHU	Identify any need for special installation accommodations
Delivery date	Identify the need for temporary storage of the unit
Information from manufacturer	Identify any additional recommendation from manufacturer
Manufacturer information	Address and contact information
Choice of Unit	Identify Value Engineering components
RFID	Identify any possible technology to monitor the equipment
Clearance requirements	Any special requirements for clearances, for access and maintenance
Electrical requirements	Any special requirements needed to be accommodated for

2- At Construction phase:

Equipment placement	Identify equipment needed for installation
Installation information	Identify any best practices for proper and safe installation
Labor needed	Identify the labor needed for the task
Coordination	Identify any possible conflicts with other trades
Unit Start Up	Identify procedure for unit start up
Testing	Identify testing procedures
Safety instruction	Identify safety requirements for potential operation hazards

3- At Post Construction phase:

Commissioning	Determine requirements for proper operation
Test and Balance	Determine the proper function of the unit
Maintenance	Determine the Maintenance requirements and recommendation
Maintenance records	Identify Maintenance records for best practices and proper log of maintenance work on the unit
Operation cost	Maintain operation cost log for future design recommendations
Manufacturer Information	Address and contact information for manufacturer
Safety instructions	Potential hazards to avoid

The roles of the key personnel. Office personnel refer to Project Engineer (PE), and Project Manager (PM). Field personnel refer to Superintendent (SI) and the personnel in charge of quality control and quality assurance. Scheduler (S), Safety personnel (SP)

1- At Pre-Construction phase:

Specifications	PE, PM, SI
The governing Code	PE, PM,, SI
Determine if it is a long-lead item	S
The weight of the AHU	SI, SP
The dimensions of the AHU	SI
Delivery date	S
Information from manufacturer	PE, PM
Choice of Unit	PM, SI
Clearance requirements	SI, SP
Electrical requirements	SP, SI

2- At Construction phase:

Equipment placement	SI, SP
Installation information	SI, SP
Labor needed	SI, SP
Coordination	SI, PE, S
Unit Start Up	S, SI, PE
Testing	PE, SI, SP, S
Safety instruction	SP, SI, PE, S

3- At Post Construction phase:

Commissioning	S, SI,PE
Test and Balance	SI, PE, S
Maintenance	PE, SI
Maintenance records	PE, SI
Operation cost	PM
Manufacturer Information	PE, SI
Safety instructions	SI, SP

Students developed a schema to share information among the key personnel throughout the life cycle of the construction project. Using the visual representation of the unit and Object Oriented Databases to share and communicate the information gathered throughout the project life cycle.

4. CONCLUSION

In this paper we have described the Object Oriented Database Approach and methodology to introduce industry practices to construction students. Over the past academic year, the modules were developed and incorporated in the teaching of the various classes within the curriculum. Students were very excited about this approach and senior students expressed regrets that they had not been exposed to such methodology early on in the curriculum. Offering such modules within the curriculum, enforced the student learning and helped define a direction and a roadmap for the students, so they can better understand the industry practices, roles of personnel, and the contractual settings that control the construction project. Future modules will be developed to cover all the classes in the construction curriculum. Future work will involve the refinement and extension of the learning modules to create learning material for future students.

REFERENCES

Aouad, G. Sun, M. (1999) "Information modeling and integration in the construction industry: a novel approach." Structural Survey, 2(17), 82-88.

Eastman, C.M., Teicholz, P., Sacks, R., & Liston, K. (2008) "BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Architects, Engineers, Contractors, and Fabricators". New Jersey: John Wiley and Sons.

National Building Information Modeling Standard (NBIMS). (2007, December) "United States National Building Information Modeling (Version 1-Part1: Overview Principles, and Methodologies)", 2007 National Institute of Building Sciences.

Nemetschek North America. (2007, April) "Nemetschek North America Announces Public Beta for Upcoming IFC Version 2x3 Plug-ins and GSA-compliant Space Object". Retrieve Jun 12, 2010, from http://www.nemetschek.net/news/pressreleases/2007/041807.php

Rosenburg, T.L. (2007). Building Information Modeling. Partnering for Success. Retrieve Aug 28, 2010, from http://www.ralaw.com/resources/documents/Building%20Information%20Modeling%20-%20Rosenberg.pdf

Sabongi, Farid J. (2009) "The Integration of BIM in the Undergraduate Curriculum: an analysis of undergraduate courses." Proceedings of the 45th ASC Annual Conference, Gainesville, Florida 2009.

Suermann, P., & Issa, R.R.A. (2007, October) "Evaluating the Impact of Building Information Modeling on Construction." Proceedings of the 7th International Conference on Construction Applications of Virtual Reality, State College, PA, 206-215.

Tah, J.H.M. (1996) "Towards Object Models for Integrated Intelligent Project Management". Construction Informatics Digital Library, 1-15. Retrieved June 10, 2010, from http://itc.scix.net/cgi-bin/works/Show?w78-1996-479.

U.S. General Services Administration (GSA). (2007, May) "GSA BIM Guide Series 01 (Version 0.60)",. Washington, DC: Office of the Chief Architect.

Wix, Jeffrey (2008) "The Stand-Inn Project, Overview of BIM/IFC and Sustainability Use and Potential. IFC/IFD/IDM Building Smart Alliance." Workshop Stand-Inn consortium, Europe Innova initiative. Retrieved June 11, 2010, from http://projects.buildingsmartalliance.org/files/?artifact_id=1611

Woo, Jeong Han. (2007) "BIM (Building Information Modeling) and Pedagogical Challenges." Proceedings of the 43rd ASC National Annual Conference, Flagstaff, AZ, April 12-14.