

Industry and Academia: A partnership to VDC Curriculum

Arundhati Ghosh
Allan D. Chasey, Ph.D, PE
Arizona State University
Tempe, Arizona

Scott Root
Kitchell Contractors
Phoenix, Arizona

The Architecture Engineering and Construction (AEC) industry at large has adopted Building Information Modeling (BIM) as a key process for Virtual Design and Construction (VDC) to aid the goals of effectiveness, efficiency and collaboration. To become a part of the process, Construction companies are investing in software training of current employees and are expecting new hires to have the technological skills in addition to the knowledge of the subject area. At universities, incorporating VDC/BIM, as an integrative part of the existing Construction Management curriculum, requires the development of a knowledge base of BIM tools, methods and processes, creating a library of appropriate tutorials, assignments and case studies, and adopting new teaching methods that combine theoretical fundamentals, practical experience and the adaptation of new technology. At Arizona State University, academia has partnered with industry to ramp up the process of VDC/BIM education, bringing the best of both worlds to the students. This paper addresses the four years of BIM education at the Del E. Webb School of Construction, Arizona State University, the challenges faced, the lessons learned and the plan for the upcoming semesters.

Key Words: BIM Education, VDC, Collaboration, Construction Management curriculum

Introduction

A common goal within the construction industry is finding innovative ways of adding value by increasing the efficiency and effectiveness of work processes. Alternative project delivery methods such as Design-Build, Construction Management at Risk, Integrated Project Delivery and their combinations are designed to achieve this goal. As noted (Pavelko 2010, Konchar & Sanvido 1998, Eastman 2008) adapting such collaborative methods of decision making helps reduce design coordination errors and change orders, shorten construction times, create clear channels of communication, reduce rework, and share lifecycle information between different stakeholders. The industry at large has adopted Building Information Modeling (BIM) as a key tool for Virtual Design and Construction (VDC) to aid the goals of effectiveness, efficiency and collaboration. Research done (McGraw Hill 2009) indicates that companies that offer BIM services report that it has helped save time and money by reducing rework, enhanced the understanding of a project in any/all stages by providing a platform for collaboration and visualization and also helped market new business to clients. The same report also found that more than half of the respondents felt that the best way of improving the value of BIM would be to increase its knowledge internally and hire new employees with existing BIM skills. While the industry deals with unemployment, additional skill sets such as BIM, can become a crucial deciding factor for succeeding in the competitive job market. However, in order to maintain a standard of quality, it is important for companies to be particular about the skill levels of their new hires. To bridge this gap between industry expectations and the shortage of qualified personnel, industry and academia must work together to train and educate the next generation workforce, as written (Pavelko 2010). This partnering assures a smooth transition between education and practice and paves the way for research areas that have a direct impact on the industry.

Any new integrative concept can be taught in several ways - as an elective or stand-alone class, as part of different courses, or as an advanced degree program (Deamer 2011). Construction Management programs accredited by the American Council for Construction Education (ACCE) do not have requirements for a VDC/BIM class per se, making it difficult to offer a stand-alone class that teaches such tools and processes. However, they do have topical content to allow for 'Computer Applications' in the construction curriculum categories. This allows for the opportunity to include BIM in several different classes that teach subjects directly related to a BIM function, such as - Construction Documents, Estimating, Scheduling, Project Management and/or Materials and Methods. At Arizona State University, this integration has been an iterative process, beginning with research to support the motivation for including BIM in the Construction Management curriculum.

Method

Establishing the case for VDC/BIM Education

In 2008-09, Del E. Webb School of Construction (DEWSC), Arizona State University (ASU), in collaboration with Fiatech™, conducted a survey to gauge the requirements of industry with respect to BIM skill levels for new graduates and the corresponding academic support in the universities. Fiatech™ was founded in 2000 with funding support from the Construction Industry Institute (CII) and the National Institute of Standards and Technology (NIST), with the purpose of bringing the industry together with the mandate to identify research projects that may have a breakthrough potential for the construction industry (Fiatech History 2013). Responses were received from over 70 Engineering-Construction (EC) and Architecture Engineering and Construction (AEC) firms and over 50 academic institutions, offering Construction and Architecture programs. At that time, even though a majority (70%) required new hires to have knowledge of 2D CAD programs, they also foresaw an increased use of BIM (77%). It was also established that industry expects new hires to have a grasp on skill knowledge (95%) rather than the knowledge pertaining to a particular software program (5%) (Pavelko 2010). This reinforces the need for including BIM as a component of the mainstream curriculum so that students can gain a working knowledge of construction concepts, rather than teaching the software in isolation.

The academic survey indicated that 97% of the universities surveyed, currently have or will have a BIM curriculum included in their course. Most programs include some aspect of BIM in less than 3 courses (67%), while a few include BIM in more than 3 courses (18%) or offer a dedicated BIM course in their programs (15%). It was also noted that most schools used BIM for 3D coordination (82%), while only half used it for scheduling (46%), and even fewer for estimating (35%). Very few schools were addressing energy simulation or operations and maintenance activities within the models (Pavelko 2010). This seems to indicate a disconnect between the industry's use of BIM and the BIM education in universities (see figure 1 and figure 2). This research not only established the urgent need for BIM education, but also brought to light the differences in the perception of BIM in industry and academia.

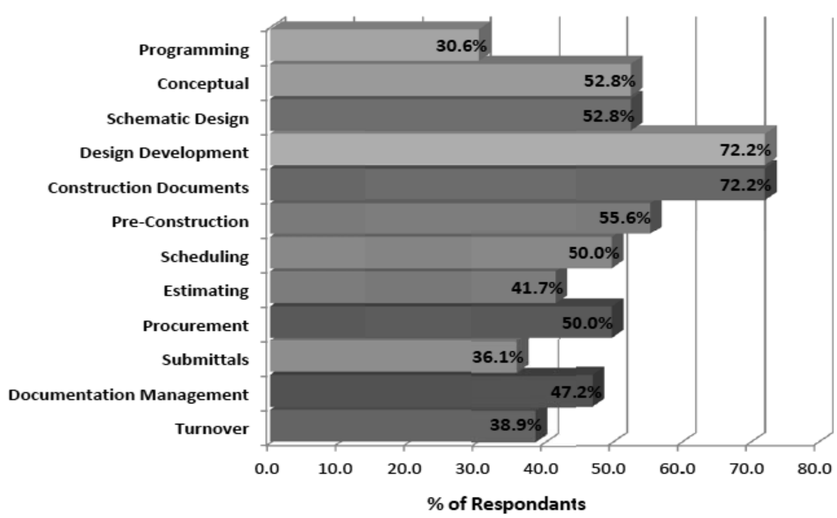


Figure 1: Industry use of BIM (Pavelko 2010)

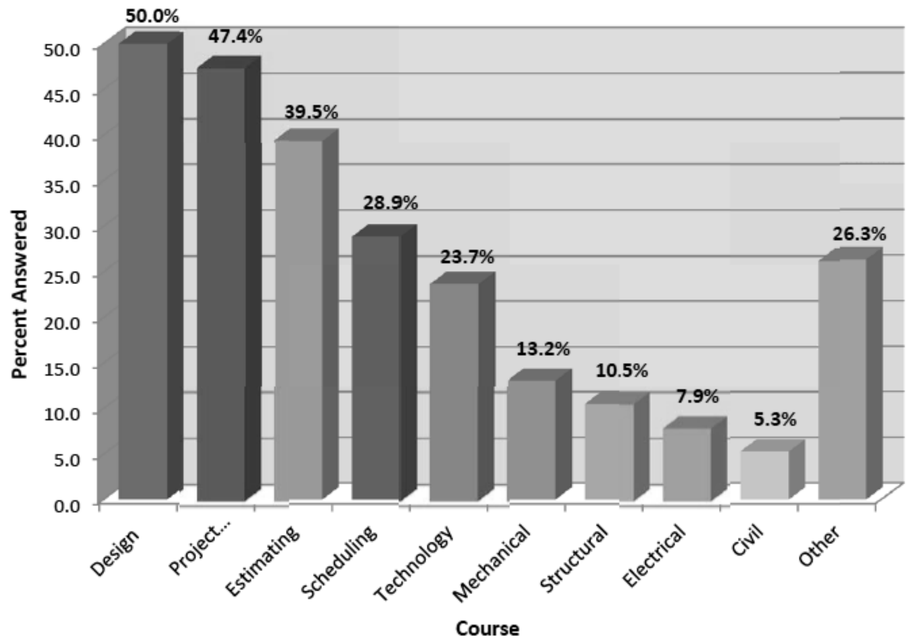


Figure 2: BIM Education in universities (Pavelko 2010)

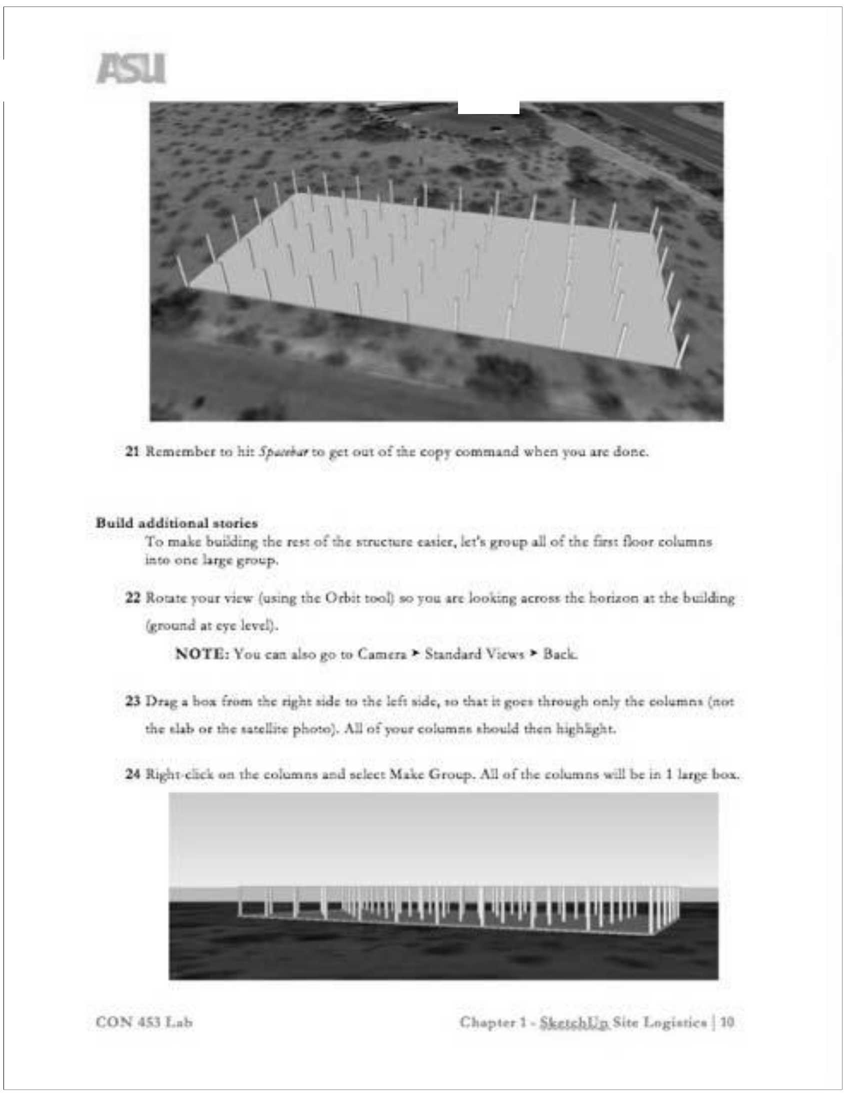
Integrating BIM with Project Management

Several factors shaped the incorporation of BIM in the 4 year undergraduate Construction Management curriculum at DEWSC; it had to be included in an already full course load, it had to be included as a component of an existing course to maintain accreditation criteria and had to be tailored to the purpose of construction management rather than architecture or engineering design as written (Ciszcon 2011). The initial experiments at XYZ included incorporating 'BIM' as part of the traditional Project Management class with no dedicated labs and all computer work had to be done outside of the class period. The response to this approach was met with skepticism and an overall lack of excitement from the students. After a few other iterations ranging from monthly guest lectures to basic tutorials, it was decided to include a 'BIM Lab' as an adjunct to a mainstream senior level Project Management course. The formalization of the lab period helped emphasize the need and use of BIM as a project management tool and showed a commitment by XYZ that BIM was a valuable tool for future professionals. The one (1) hour lecture meeting twice a week taught by a faculty member had an enrollment of 40 students. Guest lecturers from the industry were invited for presentations emphasizing the use of BIM and other VDC tools on real world projects. This helped in emphasizing the current trends in project management and the increased use of VDC and BIM. It placed BIM in the context of the entire AEC industry by highlighting the industry wide application of BIM in project management, alternative delivery methods, project life cycle and the development of a BIM Execution plan (Ghosh 2012). The original experiments included upwards to 40 students in a lab session. The class is now divided into smaller groups (20 students each) for the two (2) hour lab meeting once a week, taught by an industry instructor. The lab is designed to cover software tutorials for BIM topics such as Conceptual Modeling, Site Logistics, Scheduling, Estimating and Co-ordination. The challenge of such a setup is the availability of the industry instructor who has to commit to two days a week, which can be problematic depending on flexibility of work schedules.

Research led by Auburn University states that 'learning how to model is not a key skill for a contractor, but rather it is important how to utilize existing 3D models for construction analysis and to determine construction efficiencies (Taylor, Lui, & Hein, 2008). At first, this idea guided the development of the curriculum for the BIM lab. Adapting training material from software vendors and industry training programs developed self-paced tutorials (Figure 3). After discussion and demonstration by an industry professional and/or teaching assistant, students have the option of working along with the instructor or observing and attempting the module by themselves. Teaching assistants are available to help the students while they work on the tutorials. For assessment of the lab exercises, students are required to electronically submit a deliverable from the tutorial assignment.

Lessons learned

Even though this was a traditional and straightforward method of teaching, the tutorials become a great resource for the students to refer to when needed. It was made clear to the students from the beginning that they were not expected to be "BIM" experts, but they would benefit from the working knowledge of the BIM process. Opportunities would also be made available for further study in the VDC area. It was observed via assessments and surveys that several students failed to retain the skill as they were not using the software applications constantly and were not replicating its use for other classes or assignments. This lack of continuity was also attributed to the fact that students were involved in learning only a part of the process rather than understanding the information modeling process as a whole. The case study Revit models acquired from the industry instructors were data rich and great examples for learning BIM activities like data extraction and simulations, but the students failed to develop a sense of ownership of the project as they were not involved in a continuous BIM development process. Collaboration as an essential component of a construction BIM environment was also missing from the lab.



ASU

21 Remember to hit *Spacebar* to get out of the copy command when you are done.

Build additional stories

To make building the rest of the structure easier, let's group all of the first floor columns into one large group.

22 Rotate your view (using the Orbit tool) so you are looking across the horizon at the building (ground at eye level).

NOTE: You can also go to Camera ➤ Standard Views ➤ Back.

23 Drag a box from the right side to the left side, so that it goes through only the columns (not the slab or the satellite photo). All of your columns should then highlight.

24 Right-click on the columns and select Make Group. All of the columns will be in 1 large box.

CON 453 Lab   Chapter 1 - SketchUp Site Logistics | 10

Figure 3: Example of self-paced BIM tutorials (Ciszcon 2011)

Integrating VDC/BIM as a stepped progression

Learning from the past semesters, in 2012, BIM education was extended to additional courses. The vision was to introduce the students to BIM as a continuous process and apprise them of the steps that go into the creation, development, extraction and simulation of data that informs construction and project management activities as written (Figure 4).

- **Working Drawings Analysis** (Sophomore Level core course): This course covers reading and understanding of Construction Drawings and Specifications. Modeling in Revit® is introduced in second half of the semester which helps students understand the process of creating geometry and entering and extracting data into a BIM.
- **BIM Tools** (Junior Level elective course): Taught primarily as a computer applications class, it is beneficial for those would like to pursue a career in BIM or want to study the subject in depth.
- **Project Management** (Senior Level core course): This is a capstone course, which utilizes BIM towards the application of the skills required to solve real world problems. It is based on the Project Management + BIM Lab from the previous year. Students meet in groups in a collaborative environment and work together on a sequential case study problem including - Site Logistics, Design Validation, Quantity and Estimate, Clash Detection and Time based Scheduling.
  - One example is the ‘QTO (Quantity Take-off) and Estimating Lab’. Each group in the class is assigned the role of a trade - Architecture, Structure, HVAC (Heating, Ventilation and Air Conditioning), and Plumbing etc. The objective is to use a BIM tool to derive quantities of materials and equipment and develop an estimate using a standard cost database. This helps the students understand the strengths and weaknesses of the data available from a model and the importance of data design and input during the preconstruction phase.

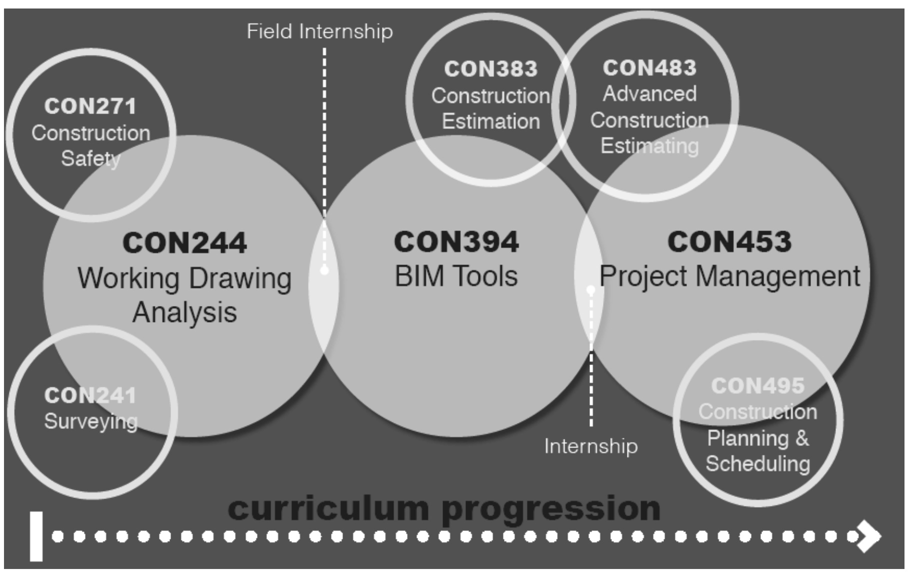


Figure 4: Integrating BIM as a stepped progression (Chasey 2012)

Other classes use single software or a part of a model, which fosters a continuous use of BIM tools and a better understanding of the design/construction process as a whole. Future semester courses are being developed for additional VDC tools to be introduced and integrated into the curriculum in such a way that students see it as a part of the construction process.

Plan for future semesters

From the experience of the past semesters, surveys, assessments and conversations with the industry, it is evident that integrating VDC as a core idea in Construction education requires some fundamental changes in existing teaching methods and philosophies. The ACCE accredited four-year undergraduate Construction Management program at DEWSC offers courses in a semester system. Table 1 is a sample of the courses in which the core concepts are covered; as part of the subject will affect future learning of VDC/BIM.

Table 1

Course Name (Offered at present)		**Concepts covered**	**Future application of these concepts in understanding the VDC/BIM process**
Year I	Building Construction Methods, Material & Equipments	- Tangibility of materials, visual understanding of equipments, developing a sense of how a building comes together - Identifying roles in the process of construction	- Introduction to 3D models and navigating
Year II	Working Drawings Analysis	- Learning how to read and understand construction drawings, symbols, specifications and terminologies - Introduction to 3D modeling and visualizing information	-Introduction to hand drawing to CAD drafting and a glimpse of 3D modeling. -Visualization of digital 3D information
Year II	Microcomputer Applications for Construction	- Geometric modeling to represent operation of construction equipments (such as a crane) - 3D Visualization	Spatial requirements for productivity and safety
Year III	Introduction to BIM	- Software applications taught at present: Revit Architecture, SketchUp, Navisworks - Future: Bentley Systems, Synchro etc.	Learning BIM as a tool for future use
Year III	Planning & Scheduling	- Project Scheduling methods such as Bar Charts, CPM and PERT, AOA, AON and VPM techniques; resource allocation and time/cost analysis - Software used: Primavera P6, MSProject, Navisworks for linking to a model and simulation	Creating schedules, and simulating activities
Year IV	Advanced Estimating	- Concepts of pricing and markup, development of historic costs, life cycle costing, change order and conceptual estimating - Groups work with Construction companies on real life projects	Extracting quantities and applying cost and estimate using BIM
Year IV	Project Management Capstone	- Using case based scenarios for simulating common Project Management issues faced during pre-construction and construction	Collaboration, interaction and preparing for real life challenges faced in the industry

The VDC/BIM Environment

The construction industry is characterized by diversity of stakeholders, trades, people, locations and ideas, and how well innovation can be fostered within these groups through effective collaboration. Existing methods of working, inter-dependencies and fear of risk complicate the adoption of innovative technology (Harty 2005). In an academic setting, introducing these factors through project-based scenarios encourages critical thinking. While the curriculum makes room for such situations through assignments and group work, an additional benefit is creating a physical environment for these activities to occur. Modeled on the interior of a modern construction trailer or the 'communication hub of a project' as mentioned (Hardin 2009), DEWSC has a dedicated physical lab that is used for collaborative projects. It is designed as computer equipped, technology ready 'pods' of workstations with movable furniture, work surfaces and multiple projection screens as written (Ghosh 2012). The room can be configured as per the needs of the course, the project and the students.

Conclusions

ASU has explored several areas of BIM integration and after careful consideration has determined that implementation throughout the curriculum is the most advantageous way to achieve both academic and industry expectations. The link between academia and industry is also a critical component in bringing guest and adjunct lecturers to teach the BIM exercises. The industry professionals, who volunteer their time in the classroom, are themselves pioneers of VDC and BIM technologies in the field. They use the programs and implement them as part of their daily jobs, which may be one or the many fields of Architecture, Engineering, Construction and Facility Management. Professionals from various designation levels are invited to lecture; executive level, manager level and the engineering, design and implementation levels. Each one of them brings their unique experience to the classroom, which exposes the students to the variety of the needs and differences or similarities in thinking of the various people within the industry. The 'real-world' examples they bring to the classroom help emphasize the drive to use VDC and BIM as a way of making the building process more enjoyable and profitable. The students are exposed to the technology and the various sociological and cultural aspects of working with new technologies in practice. The industry lecturer's benefit from this arrangement is to help students become familiar with their future workforce. They are able to participate in the development of the next generations of construction professionals who may not be BIM experts but are capable of applying their BIM knowledge to their every day job task.

The overall experimentation at DEWSC, ASU was mostly centered on vertical AEC industry projects and has yet to integrate expertise from civil and horizontal construction projects. The major challenge is not that the horizontal (Civil) industry is not in tune with BIM modeling, it is finding guest lecturers who have the time to commit to assisting XYZ University. The other major area that has yet to be tapped into in DEWSC's curriculum is the integration into facility management. The data richness of BIM is an excellent tool for future facilities managers and the evolution of the curriculum work towards developing this information. The industry input and participation is critical in continuing to move the curriculum forward to closely mirror or surpass the current state of construction and help incorporate areas that have yet to benefit from the possibilities of BIM.

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