Building Information Modeling/Vertical Digital Construction: Teaching Strategies and Preparing Students for the Workforce

Sofia Vidalis
Associate Professor of Civil Engineering at Penn State Harrisburg
and
Joseph Cecere
Associate Professor of Engineering at Penn State Harrisburg

Abstract

It is widely known that Building Information Modeling/Vertical Digital Construction is cutting edge technology which has changed the profession of Architecture, Engineering and Construction. It may be challenging and/or difficult if the university program is not concisely updating and teaching this knowledge in preparing their students for the industry. Programs must strive to keep abreast of this technology, its changes, and advancements being made, especially in the industrial world.

This preparation results in the students becoming more aware of Building Information Modeling/Vertical Digital Construction, its transformation, and the opportunities for them. In addition, partnering has resulted in an excellent relationship with the industry and construction program in educating its students. These approaches in introducing Building Information Modeling/Vertical Digital Construction in the Civil Engineering curriculum has provided a win-win situation between students and the industry. The paper will discuss the relationship between the industry and Penn State Harrisburg’s Civil and Engineering Technology programs in relations to Building Information Modeling and how it has prepared students for the industry.

Introduction to Building Information Modeling

Building Information Modeling (BIM) is a process of creating an intelligent virtual model which integrates the project data from design to construction. Visual representation of the project to be built helps construction professionals better understand the designer’s intention, reduce RFIs (Request For Information), detect clashes between the building components before construction starts, reduce change orders, reduce waste, analyze constructability for the sequence, deal with time-space issues, improve communication among project participants, speed up the approval process and develop logical construction plans.¹

Statistics show an increasing trend toward application of BIM in the Civil Engineering (CE) and Construction Management (CM) industry, however, the flip side to this is the lack of proper educated and well-trained students to meet the professional needs of the industry. Table 1 has
been modified from its original form to show faculty (authors) from various universities that have offered a BIM course in a civil engineering and/or construction program.²

Table 1: BIM Courses at CE and CM Programs in Universities²

<table>
<thead>
<tr>
<th>University</th>
<th>Author(s)</th>
<th>Program</th>
<th>BIM Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Florida</td>
<td>Walters</td>
<td>Building Construction</td>
<td>Intro to BIM</td>
</tr>
<tr>
<td>Auburn University</td>
<td>Taylor, Liu &amp; Hein</td>
<td>CM</td>
<td>Construction Information Tech., Digital Construction Graphics</td>
</tr>
<tr>
<td>California State University</td>
<td>Kymmell</td>
<td>CM</td>
<td>BIM I, II</td>
</tr>
<tr>
<td>University of Southern California</td>
<td>Becerik-Gerber</td>
<td>Engineering and CM</td>
<td>BIM</td>
</tr>
<tr>
<td>Texas State University</td>
<td>Mulva and Tisdel</td>
<td>Architectural Engineering</td>
<td>Design Studio I and II</td>
</tr>
<tr>
<td>George Mason University</td>
<td>George Mason University</td>
<td>Civil, Environ., Infrastructure Eng.</td>
<td>BIM</td>
</tr>
<tr>
<td>University of Washington</td>
<td>University of Washington</td>
<td>CM</td>
<td>Advanced Project Management Concepts</td>
</tr>
<tr>
<td>California State University</td>
<td>Kymmell</td>
<td>CM</td>
<td>BIM III</td>
</tr>
<tr>
<td>California Polytechnical</td>
<td>Korman and Simonian</td>
<td>CM and CE</td>
<td>MEP Coordination Studio-Laboratory</td>
</tr>
<tr>
<td>California Polytechnical</td>
<td>Dong</td>
<td>CE and CE</td>
<td>Int. Design Studio and Int. Bldg. Envelopes</td>
</tr>
<tr>
<td>Virginia Tech</td>
<td>Ku</td>
<td>CM, Building Construction</td>
<td>Several BIM courses</td>
</tr>
<tr>
<td>Texas A&amp;M University</td>
<td>Texas A&amp;M University</td>
<td>CM</td>
<td>Integrated Design Studio</td>
</tr>
<tr>
<td>Penn State University</td>
<td>Poerschke at al.</td>
<td>CE and CE</td>
<td>Integrated Design Studio</td>
</tr>
<tr>
<td>Georgia Tech</td>
<td>Georgia Tech</td>
<td>Graduate courses</td>
<td>BIM: Case Studies</td>
</tr>
<tr>
<td>California State University</td>
<td>Kymmell</td>
<td>CM</td>
<td>BIM IV</td>
</tr>
<tr>
<td>University of North Texas</td>
<td>Arnold</td>
<td>Construction Engineering Tech.</td>
<td>Senior Design Class</td>
</tr>
</tbody>
</table>

Building Information Modeling (BIM) began as a concept in the early 1960s when Michigan Institute of Technology computer design pioneers Steven Coons and Ivan Sutherland introduced the idea of modeling "real-world artifacts and phenomena" digitally.³
The adoption of BIM became heavily owner-driven. Owners saw the benefit from BIM design and construction methods through reduced claims, lower administrative costs, reduced schedule and the model's valuable information on life-cycle costs. McGraw-Hill Construction's 2011 Smart Market Report "The Business Value of BIM: Getting Building Information Modeling (BIM) to the Bottom Line" examined the real business values that users were experiencing. Nearly half of respondents (49%) reported that they were using BIM tools, a 75% increase over the 28% BIM adoption rate measured in 2007.4

Owners saw BIM offering a new way of creating and leveraging digital models for the design, construction and operation of projects, and it is revolutionizing the way firms communicate, solve problems, and achieve better outcomes. The report also showed the following:

- Half of the industries are using BIM or BIM-related tools. This is 75% more than in 2007.
- Current BIM users of all skill levels expect to double their application of BIM on projects over the next two years.
- 42% of BIM users consider themselves experts or advanced. This is three times the amount in 2007.
- Experienced users are leveraging their BIM capabilities to win new work over their competitors, and rate this as among the greatest current benefits of BIM.5

The Construction Users Roundtable, an organization that includes over 50 of the largest corporations in the United States saw BIM as an alternative project delivery system to save billions of dollars in construction costs and add value and sustainability to capital facilities.5 BIM allowed the owner and designer to easily evaluate the cost-benefit analysis of an alternate lighting, HVAC design, or explore Leadership in Energy and Environmental Design in projects. Using BIM in the building project delivery system, owners could have a quality-assured product with up to 50% in schedule savings.6

The General Services Administration (GSA) began slowly requiring at least a spatial BIM for concept approval. After a successful completion of 21 pilot BIM projects, the Chief Architect (OCA), Calvin Kam, the GSA's National 3D-4D-BIM Program manager, said, "When project conditions are appropriate, we encourage all projects to leverage 3D, 4D, and BIM deployments beyond spatial program validation."7,8

The GSA cited the advantage of BIM implementation as the data generated by the model that contributes to special program validation, 4-D phasing, and improved energy and sustainability performance. As industry pushes toward greater use of BIM technology and experience the benefits of collaborative project management, they pave the way for the widespread adoption of BIM as a standard in the Architectural, Engineering and Construction industries. Design professionals, as the primary users of BIM software, have gained by the technology's growth.

Today's modeling software includes powerful suites that free the designer of many of the tedious tasks associated with paper-based and 2-D CAD. Data-based 3-D CAD applications store information on building components, making the creation of a door schedule as simple as a few key strokes.6 The objective of this study is to bridge this gap by distinguishing the current BIM needs and address these needs by establishing a relationship between PSH and the industry in and out of class.
University and Industry Partnership

The goal of any educational program is to provide each student with the necessary information and skills to perform successfully in a chosen career. Yet this goal may prove difficult if the program is not striving to keep abreast of the changes and advancements being made, especially in the industrial world. The relationship with the industry, that a program develops, is a critical element to its success. Programs must strive to foster and strengthen relationships with organizations that will not only benefit the program but also the organization. The BIM industry and Penn State Harrisburg (PSH) has developed a relationship through professional associations, software vendors, and the industry as a whole. These various activities are examples of a win-win relationship for the future of both university programs and industries.

Professional Associations

The Mid Atlantic BX (MABX) trade association provides access to a suite of technology-based information including BIM and business development solutions tailored specifically to construction industry. This central Pennsylvania organization understands the importance of partnering with higher education to prepare their member’s future employees. MABX offered a series of presentations on BIM to its members including an introduction to advanced training. They partnered with PSH in offering several presentations at the university. These allow their members to learn more about the college’s construction program while learning this technology. MABX invited students to participate in the events. Students learned about BIM and how they may use this resource in their future profession. This interaction with professionals and participants on exercises broaden the student’s BIM knowledge.

National Associated General Contractors of America (AGC), which is the largest contractor association in the United States, is a leader in BIM technology. Their national BIM committee continues to provide webinar presentations, seminars and other information about new BIM processes. AGC partners with higher education to promote BIM. University research proposals related to BIM have been initiated as well as allow students to participate in their activities. PSH students have attended their national conferences that have conducted seminars on various BIM topics. AGC also provided the program to link into webinar programs. Students are able to hear from leaders on this technology and how this is being incorporated into their future profession.

The American Society of Civil Engineers (ASCE) Penn State Harrisburg Chapter hosts dinner meetings for the industry and students once a month. During these dinner meetings, an invited guest talks and presents specific topics in civil engineering, such as BIM and other new technologies used in the industry. These dinner meetings are also a great place for students to network with the industry and learn about new technologies that the industry is currently using.

Invited guest speakers from the ASCE Central PA section have also been invited on campus, for both the ASCE Student Chapter and courses, that talked about BIM, their experiences using BIM, what they use it for, and how useful it is to their company. Some guest speakers include the following:

- Laser Scanning and its Role at Davis: This presentation describes how the laser scanning technology works, including how to create accurate models for facilitating trade coordination. In addition, different cases are used in the presentation to show how...
scanning technology is used to improve engineering, monitoring, and project documentation.

- **Virtual Construction: A Davis Case Study:** This presentation illustrates the benefits of BIM and Virtual Construction (VC). It also explores how VC is transforming the way a general contractor builds a project and is able to better control cost, schedule, communication through trade coordination, material fabrication, and how it impacts the construction process.
- **Estimating using REVIT:** This presentation showed an actual project by Wholsen Construction in REVIT and how to do a quantity take-off using REVIT.
- **Developing Project Schedules:** There were a couple of presentations on this topic by various companies in the area. The main focus on these presentations provided practical advice on various stakeholders perspectives, how to use and maintain a schedule, and steps to a successful project planning using various software programs.

All these professional associations give the opportunity for students to engage and network with people from the industry. In addition, students have the opportunity to attend workshops, webinars, conferences, and also professional meetings that invite guest lectures. Students that are members on any of these professional societies can also learn about new technologies being used in the construction and engineering fields from e-mails and magazines that each of these societies send out. In addition, each student can also receive news from these associations from smart phone applications, FaceBook, and Twitter. These are all very handy tools, especially when someone wants to be on top of all the technology being used in the construction and engineering fields in the palm of their hands.

**Software Vendors**

Software vendors offer universities significant discounts on their products. This allows universities to purchase current software so the students are exposed to these applications prior to future employment. BIM related vendors such as AutoCAD and Microsoft have hosted presentations to the program on this technology. The presentation made the students aware of BIM, its future, the educational requirements involved, and opportunities for students. The students were also given the opportunity for special software student purchases. In addition, AutoCAD/Revit allows students to download a free trial on the most recent software program for educational purposes. Moreover, students learn other software programs that can be used as a part of BIM such as Primavera 6.0 for planning and scheduling and also Heavy Bid or Sage Timberline for estimating. The program felt that making the students aware of all the software programs in BIM, this educational exposure provided an excellent foundation for the students with this technology.

**Industry**

The BIM industry is committed to its future. They continue be invited as guest speakers to various classes and student organizations in the program to demonstrate and inform students on the use of BIM. Some of these classes that are taught at PSH that bring an introductory of BIM into the classroom are: Construction Estimating, Construction Planning and Scheduling, Graphic Communications, Structures, Project Management, and Construction Management II. Other courses that are more advanced in BIM that are taught at PSH include: Building Information
Modeling and Civil Engineering Senior Capstone Project. Figure 2 shows an outline from the BIM course taught at PSH.

Conclusions

The various activities on and off campus such as networking events, guest lecturers, conferences, webinars, and professional associations, demonstrate the partnerships universities can have with the industry to learn the latest technologies from BIM. In addition, the vendors also help students by offering them a free trial of the latest software programs that BIM uses. The university and industry partnership is a successful relationship because at the end, they both help each other. They also both realize the need to work together for the betterment of the students and the construction industry’s future. The programs that foster and strengthen these relationships will not only benefit, but will give the students a better feel about their education.

References


Dr. Sofia Vidalis is an Associate Professor in the Department of Civil Engineering/Structural Design and Construction Engineering Technology at Penn State Harrisburg. She received her Ph.D., Masters, and Bachelors in Civil Engineering from the University of Florida. She has worked at Florida Design Consultants as a Transportation Engineer. She is an active national and local member of American Society of Civil Engineers and American Society of Engineering Education.

Dr. Cecere is an Associate Professor of Engineering and Program Chair of the Department of Civil Engineering/Structural Design and Construction Engineering Technology at Penn State Harrisburg. He is a member of AGC Education Committee, Killinger Research subcommittee, AIC Professional Constructor Certification board, and he just completed a six year term on the AGC Research and Education Foundation. Dr. Cecere’s expertise area is construction management, scheduling, safety and estimating.