# AC 2012-3908: THE ROAD TO CREATING, EVALUATING AND CHANGING A BIM LEARNING ENVIRONMENT

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# The Road to Creating, Evaluating and Changing
# a BIM Learning Environment

Abstract

Architecture, engineering and construction (AEC) undergraduate programs continue to grapple with the task of developing meaningful learning environments that allow students to explore building information technologies in undergraduate course work. There are significantly differing approaches by universities and departments in the United States on how best to introduce and reinforce building information modeling (BIM) concepts and tools. This paper will review one university's continuing efforts to address the requests of industry advisory council members to produce high functioning AEC graduates with BIM knowledge and skill sets.

By reflecting on the "Lessons Learned" of the iterative process of creating, evaluating and modifying an undergraduate elective, "Introduction to Revit®", over seven semesters, this paper will document and reflect on the experiential knowledge of faculty, administrators and students. Additionally it will capture the process and progress made to develop and improve BIM learning environments.

Where we've been

In the past decade, building information modeling (BIM) has gained substantial popularity and is the emerging process that replaces the traditional separation of design, construction and facilities management. BIM covers geometry, spatial relationships, light analysis, geographic information, quantities and properties of building components (for example manufacturers' details). BIM can be used to demonstrate the entire building life cycle, including the processes of construction and facility operation. Quantities and shared properties of materials can be extracted easily and scopes of work can be isolated and defined. Systems, assemblies and sequences can be shown in a relative scale with the entire facility or group of facilities.

With support from professional organizations such as American Institute of Architects (AIA), American Society of Civil Engineers (ASCE), and the Associated General Contractors of America (AGC), in turn with large scale building developers and Owners mandating BIM delivery on their projects; the Architecture/Engineering/Construction (AEC) design professionals and contractors responded with project specific scaled adoption of BIM as a method of document and building construction delivery.

In a July, 2009 McGraw-Hill Construction survey[1], two-thirds of industry design company respondents believed that 50% or more of their company's design project work would be delivered in some level of BIM. This rise in expected industry adoption prompted corporations and industry advisory councils to recommend BIM seminars, course development in software and design course adoption of BIM analysis in AEC undergraduate programs.

In a 2007 study at Auburn University, Dean [2] carried out a research study to examine if BIM should be taught as a subject to the construction management students. He conducted two questionnaire surveys targeted at general contractors and ASC construction management programs in the Southeast. Based on the gathered data, he concluded in general the construction management programs should teach BIM to their students. His conclusion was supported by his research data that approximately 70% of the industry participants indicated that they are either using or considering using BIM in their companies. His trending data indicated that the BIM utilization in the construction industry was also going to increase. Approximately 75% of his survey participants consider employment candidates with BIM skills to have an advantage over candidates who lack BIM knowledge.

In a study on pedagogical challenges of teaching BIM, Woo[3] pointed out that properly structured BIM courses would provide industry-required knowledge to prepare students for successful careers in the AEC industry. Instead of teaching a separate course, he suggested to reconfigure the existing construction courses to integrate BIM into the course content. "If we are to someday have widespread integrated practice within the industry, it must first be adopted in the classroom....with project teams grouped to represent the different disciplines of the construction industry." "Centers of higher education in the AEC have to recreate this collaborative experience in the academic world" (Camps 2008) "Students must be trained to design for assembly and perhaps disassembly as we recycle/reuse buildings in the future." (Camps 2008)

A 2010 survey study at Kansas State University, Vogt[4] captured data from eighteen architectural engineering programs found that 88% of respondents had started regularly presenting BIM project case studies in class lectures, seminars and using guest forums where industry speakers would showcase their BIM projects, delivery methods and construction coordination. 77% of AE programs were offering an introductory BIM course to provide introductions to BIM software capabilities. Of which 100% were teaching from the Revit software suite. Eight departments responded that their program had infused BIM project assignments into one or more design/capstone courses.

Many universities, colleges and departments have built strategic partnerships with Autodesk Education Solution Specialists. http://usa.autodesk.com/education/post-secondary/ Autodesk provides educators with comprehensive curriculum resources and provides a threshold learning experience for students regardless of experience. Education Solution Specialists will help faculty design curriculum, provided resources, guest lecture and/or aid in preparing students for careers in architecture, engineering, and digital arts.

Where Are We Now

From this point forward in the text, the documentation and reflections are strictly related to a singular faculty and departments' journey on course delivery of BIM/Revit® Architecture from 2008 to present.

After beginning with resources that were provided through relationships with a Autodesk Education Solution Specialists in 2008 an "Introduction to Revit Architecture®" course was conceptualized and assigned by the Department Head to a Assistant Professor and novice BIM

user for development and future offering. In the academic calendar year of 2008/2009 this faculty prepared a self-study of the materials and resources currently available, discussed options for curriculums with an Autodesk Education Solution Specialists, reviewed textbooks currently in publication, looked at course scope and software options for an introductory course on BIM, generated learning outcomes, advanced lecture materials, and evaluated a project student workbook.

The first two credit elective offering for "Introduction to Revit Architecture" was administered as a resident on-campus course. The course was delivered during a university intersession consisting of five days per week for three weeks and three hour per day. The enrollment consisted of 12 undergraduate AEC students, all junior or senior standing in architectural engineering or construction science and management degree programs. The course was delivered each day with a 40 minute lecture and then skill/activity workbook assignments and quizzes. The TEVALS and feedback for the course was excellent. But recurring themes to the student comments were noted.

> *"I find it easier to ask the students sitting next to me in the classroom for assistance and guidance because they are doing the exact same steps I am."*
> *"It would be nice to be able to do these assignments on my personal PC instead of having to come to campus."*
> *"I wish this course was offered online so I could start my internship sooner and work on this course in the evenings and weekends."*

The department and faculty planned for a subsequent offering as an elective during the university's intercessions each year in January and May. A one-credit "Introduction to AutoCAD®" was still to be the only required course for computer aided drafting required for the program of study. Thus, there was considerable discussion about delivery options for the two-credit Introduction to Revit elective. Faculty considered student comments, faculty self assessment, lab access, remote access accommodations. It was determined that the nature of the course contents, the delivery time frame and the relationship to the learning of computer software technology supported an on-line delivery that stressed high levels of interaction between students and faculty through internet supported classroom message boards, online assignment submissions, faculty feedback and online virtual faculty office hours.

In January of 2010 the first online course offering was delivered. Thirty-eight undergraduates enrolled in the course with a minimum prerequisite of junior standing. Modifications for online learning that were made to the course content as follows.
1. Camtasia (mp4) recorded lectures
2. ADA online learning requirements were met by providing typed dictation of lectures with each Power Point slide in PDF format.
3. A workbook with unit divisions, each with step by step instructions was annotated and provided to students in a PDF version with additional hints and suggestions.
4. Terms and theory quiz questions were entered into assignments in the online classroom and scored electronically
5. Syllabus and internet classroom was updated for online learning with assistance from on-campus instructional developer

6. Online message board became a required activity for the course and points were assigned to capture student engagement.  Message board postings were required from students in one of three forms each day.  (a) question (b) response to student question (c) helpful hint

Course offering/usage statistics were documented:
1. Online classroom was visited maximum of 89 times by a single student in 21 day offering period, the minimum was 35 visits
2. The highest traffic times were 2pm (92 visits), 5pm (81 visits), 11am (74 visits) and 9pm (71 visits) each day
3. The highest traffic days were Monday (215 visits), Tuesday (208 visits), Wednesday (192 visits)
4. Grade distribution was A-28, B-10, C-0

Lessons Learned

Lessons learned and unforeseen challenges of this first on-line delivery are discussed below.  It was not until late in the process of course preparation did ADA access rights come into question.  It would be best for all faculty to understand early on in course preparation what your university policies are on information access for all students both for on-line and resident course delivery.

Getting the technology to work was the largest "speed-bump" for this on-line course and student success.  It became evident that early contact with students via email to provide a course syllabus and reinforced instructions on gaining access to the proper hardware and software prior the beginning of class was very important.  A four week lead time was identified as being sufficient to allow students to read, digest the course syllabus and react.  Then weekly reminders were necessary to be sure those students had access to the hardware and  had downloaded the software prior to the first lectures/assignment release.  Often this was a student, first on-line learning course and so these steps were all new and/or different from their normal interaction with the university and faculty.

The most important step in this course particularly was to create an account with Autodesk and download the correct version of Revit to their personal PC for free with an education account login that was linked to their educational email extension (ex:  johndoe@xxx.edu).  The second step was to register that account to gain the full 13-month educational license.  Many students missed this second step and their trial license expired in 30-days, just a few days before the course instruction and assignments ended because they failed to complete step two of the registering process.

Another lesson learned is to consider providing the students with the link to Autodesk's website to check their own personal PC's hardware in relationship to the requirements to operate Revit files (.rvt).  http://usa.autodesk.com/revit-architecture/system-requirements/  And to provide the students with a Revit file that they can practice opening to be sure that their operating system can handle the file size without crashing their operating system one week before classes began.

By sending this information out in chunks, beginning four weeks in advance and planning weekly follow-up reminders and test materials to students to read and follow, reinforced the

syllabus instructions on setting up their workstations with the software necessary to complete the course greatly improved student satisfaction and success of subsequent course offerings significantly.

Finally, if a faculty chooses to go with larger course enrollments where one-on-one email interactions become cumbersome, the message board or course wiki is strongly suggested to catalog, in one location, all the student questions and responses.  By assessing and giving a score for student interaction(s) on the message boards, faculty can improves the collaboration and dialogue and foster a collaborative design environment.  By assessing value to students-helping-students through typing out solutions or researching solutions on-line through Blogs, faculty can easily document examples of student abilities in life-long learning for ABET purposes.  It also alleviates excessive one-on-one emails between faculty and students that can become too cumbersome to respond to during the progression of the course in this shortened intersession delivery such as this one.

After the first on-line offering in January 2010, this course has been offered in three week intersession in May 2010, January 2011, May 2011 and January 2012.  Enrollment in these course offerings has ranged from 25-45 students.  The student enrollment has broadened from architectural engineering and construction science and management students and now includes students from architecture, civil engineering, mechanical engineering, industrial engineering, professional from industry and those in open option.


Still on the horizon

Since 2010 Autodesk has been offering certification exams for each of their software types and annual releases.  To earn the credential of Autodesk Revit Architecture 2012 Certified Professional, you must also pass the Autodesk Revit Architecture 2012 Certified Associate and Professional exam which can be taken in any order.  Actual hands-on experience is a critical component in preparing for these exams.  The Certified Associate exam is intended for an individual who has taken an introduction to Autodesk Revit Architecture 2012 course plus 100 hours of additional hands-on application.  A successful certification of Certified Professional assumes an additional 300 hours of hands-on applications beyond the Associate Certification.

When considering, at the time of this paper, that only roughly 500 individual who are currently certified by Autodesk as Revit Architecture 2012 Certified Professionals, the question was posed:

> *"Would having student certified at either the Associate or Professional level upon graduation be a competitive advantage for them in gaining employment, higher annual salaries and successful careers in the AEC workplace?"*

The response from both an Architectural Engineering Industry Advisory Council and Construction Science and Management Industry Advisory Council was a resounding yes; especially for larger national firms working in complex building markets with multiple design and construction firms under contract.  So the question becomes, where does the exam fit into the curriculum or assessment of student skills upon graduation?  This is an issue that departments are

trying to grapple with. Existing faculty often lack the expertise to fully integrate BIM into existing design and construction courses and leave the responsibility on the student to learn and execute the software with little oversight or expertise. Many programs have opted to hire one or two industry experts in BIM as part of their faculty and almost all newly written employment postings for tenured track faculty positions for AEC curriculums discuss BIM skills as a preferred qualification.

This specific department is currently considering allowing students to take and pass the Associate Certification for 1 additional CR of complimentary elective credit in addition to the 2 CR for taking the on-line course. The additional self-study and preparation up to 100-300 additional hours is easily within the range for 1 or more additional credits. It is a hope that graduates of the future (4-6 years from now) would be prepared through a required introductory class and repetitive use of BIM technology in follow-on design courses and internships to not only sit for the Associate Certification but the Professional Certification as well before graduation. And when offered by Autodesk, it would be highly preferred by the Industry Employers that students sat for disciple specific exams such as Revit MEP and Revit Structures over Revit Architecture.

In thoughtful reflection as to where to go with the next iteration of BIM learning environments, the most obvious answer is that more and more demand is being placed on hiring key individuals who not only know the engineering theory and posses the problem solving abilities of the past, but also now are highly trained in the software(s) that allow for the most efficient delivery of building construction documentation.

Conclusion

Assessment of hybrid and online learning environments effectiveness is ever present. Online learning environments for courses related to software introduction continue to be a necessary research topic that requires our attention.

The notable lessons learned and guides that were established from this singular assessment would be relevant for other department and faculty considering a similar type of course offering. These were:
- The ideal enrollment was found to be 30-35 students per offering. This quantity allowed for plenty of interaction on course message boards and excellent student-helping-student ratio of respondents.
- A junior level was established in part due to it being an upper level technical elective for many curriculum programs but the course could be easily be offered to underclassman if faculty resources were available.
- The inclusion of several disciplines of students choosing to enroll in the course has been a nice addition. Different student degrees bring different skills, internship exposure and personal interests are often expressed in message board conversations to the advantage of all who read them.
- Structured daily course activities and due dates that lag the assigned material by three days allows for amble 36 hour time frames for individual student effort, message board posts/questions and peer responses. After 36 hours if the initial question has not been

responded to or requires additional clarification, than the faculty or GTA can add additional insight. This should leave 24 hour for the student to finalize their assignment for submission.

- The daily class requirements facilitate total "immersion" into the material /software and mimics project design work that will help to build and retain the learned skills.
- Message board requirements and assessment by faculty achieve excellent positive interaction from all online students.
- Online collaboration and assessment of this collaboration can be used to show a student's ability to capture and process information electronically. This supports lifelong learning through Blogs and Wikis which is a required for ABET program assessment.
- Repetitive experiences with the software through failure, collaboration and/or success will generate retention over time.
- Implementing additional credits for the Associate Certification is still being assessed, but has the support of industry that is looking to hire graduates with BIM skills.

In this specific instance, the online delivery method of this introductory course has been deemed a success but still lacks in certain areas. Faculty time and attention to developing their own skills and expertise in using the software is noticeably limited. This is part is due to capacity to engage the software daily between the two course deliveries each year. Daily interaction with the software allows faculty the ability to become experienced in common problems and their solutions in order to respond to issues when they do arise. And there is a noticeable lack of follow on courses that challenge the student's abilities to take their learned BIM skills onto additional problem solving, engineering and design related projects. This limits the retention of the material and does not support the 400 contact hours suggested for the Professional Certification Exam as the necessary exposure for successfully attaining this certification.

Continued research needs to be conducted into how to best "immerse" a curriculum through enhanced BIM learning without leaving the faculty and the engineering theory behind. We do not want to swing programs away from the theory towards a technology-only degree. By learning to use BIM as a tool to enhance education, as professionals do today in industry to enhance their services and integrate across multiple disciplines to achieve highly functioning buildings, educators can promote BIM and its abilities to reinforce the theory and engineering problem solving necessary to solve complex construction problems of the future. One might suggest there is research to be done in many areas. And that one possible path for this "immersion" would be to require additional graduate studies for all engineers and contractors to obtain licensure. Similar to doctors and lawyers, this time spend in graduate studies would allow for the exposure to project work using the current computer technologies and methods of their professional counterparts in industry similar to a residency. This professional schooling requirement would allow the time to reinforce through practice the readings, hand calculations and theory learned in undergraduate studies?

In all instances of application and research, BIM curriculum development and learning assessment is of utmost importance as we consider the expertise and experience required of the graduate engineer(s) of 2025. The market has shifted; it is time for faculty, their departments, the accrediting bodies and the curriculum and instruction to do the same.

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