Student Perceptions of BIM in the Classroom

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Over the past ten years, the use of Building Information Modeling (BIM) in the construction has grown from a competitive advantage to a necessity to compete in markets where owners are requiring its use. With more construction companies integrating BIM into their business processes it has become more important for construction related programs within universities to include relevant BIM-related instruction in the classroom. By doing so, the programs can provide the necessary skills and knowledge to the students so they are properly prepared when they enter the workforce. In order to make sure they are properly preparing their students, the Construction Science and Management Department at Clemson University, identified BIM-related topic areas, with the help of industry supporters, to include in their undergraduate curriculum. BIM-modules were then created and included in different classes throughout the curriculum. These BIM-modules were then piloted during the Spring 2014 semester using different methods of instruction. After completing the modules, students were surveyed to gauge their perception on which instructional methods they preferred. This paper discusses the instructional methods that were implemented in the BIM modules, the strengths/weaknesses of each as perceived by the students, and student preference. Instructor observations are also documented.

Key Words: Building Information Modeling (BIM), Undergraduate Education, Curriculum Design

Introduction

The growth of the availability of technology in different formats has led to an easier use of and wider adoption of Building Information Modeling (BIM) over the past two decades (Finch, 2012). BIM, or the use of digital models for analyzing and simulating design and construction processes (Eastman et.al, 2011), has proven to lead to contractors and owners saving money by providing enhanced coordination, better (more coordinated) design, fewer errors and work orders, as well as more efficient planning of construction activities (Ahn et.al, 2013; Hartmann & Fischer, 2008; Azhar, 2011; Giel & Issa, 2011).

With the growth of BIM use in the construction industry it is important for construction-related programs to adequately prepare their students with the BIM-related skills and knowledge they will be expected to have once they enter the workforce (Molavi and Shapoorian, 2012; Sacks and Barak, 2012). It is within this mindset, that the Department of Construction Science and Management at Clemson University undertook the tasks of identifying appropriate BIM-based learning outcomes to incorporate in their undergraduate curriculum. As previously presented in (Lucas, 2014), a combined literature search and survey of industry members affiliated with the program was conducted to determine what aspects of BIM should be taught within the existing courses of the curriculum. Due to accreditation constraints, university general education requirements, and limited faculty, it was chosen to include BIM throughout the coursework in a set of modules as opposed to creating a standalone class. During the spring 2014 semester, two sets of modules were developed to include BIM into the coursework. The first set was developed as an introduction to BIM and its capabilities. The second was a higher level module that included a MEP coordination exercise. Different instructional methods were used for the modules. Once the modules were completed, the students were asked to complete a survey to help identify weaknesses, strengths, and potential improvements that can be made. The students were also surveyed about their preference for each instructional method used. This paper presents the designed modules and the student perceptions documented through the end-of-course surveys.

Module Development

The developed modules include the introductory to BIM modules as part of CSM 2041, the lab component of Contract Documents. The use of BIM was introduced after the students were exposed to reading traditional plans. The higher level module was included in CSM 3050, Environmental Systems II, with the intention of exposing the students to clash detection tools and coordination of models using BIM. The objectives of each of the modules were developed around the identified learning outcomes that came from industry interviews as defined by Lucas (2014).

CSM 2041 – Introduction to BIM Module

The module for CSM 2041 to introduce the basics of BIM was developed in 5 parts. The first four parts consisted of an introduction to a specific topic with an in-class lecture and discussion followed by an in-class demonstration of the software that would be used as the tool to complete an assignment. The fifth part was a preview and discussion on advanced uses of BIM. Each assignment included a set of tutorials that students were able to use to refer back to in case they missed something in the in-class demonstration. The five parts were designed to address the identified learning outcomes:

- Develop the ability to navigate around a model for visualization purposes in performance of constructability reviews, looking at details, and producing meaningful detail views of the models to better understand the buildings construction.
- Demonstrate an understanding of how the model is created with different model elements and levels.
- Demonstrate an understanding of how a federated model of component model parts received from different trades is managed within a model viewer.
- Extract basic information from the model to create spreadsheets of information while demonstrating an understanding of what the information represents and where it comes from.
- Export information in needed file formats.
- Extract equipment information that may be needed for submittals, etc. during the construction process.
- Discuss, at a concept level, how BIM can be applied throughout the construction process and what its benefits of use are.

Part 1 of the introduction module targeted the overall objective of "Understanding the different model types that are associated with design and construction." Within this part of the module the students were given an introduction to geometric, parametric, and building information models. The differences of each were discussed. The students were then introduced to Trimble Sketch-up, as a basic geometric modeling tool that is commonly used for simple 3D visualizations. Lastly, the students were given a series of written tutorials to assist them in completing an assignment in which they had to complete a basic wall section model.

Part 2 of the module covered the objective defined as "Understanding the basic concepts of BIM as a process and model". Within this section of the model, BIM as a process and model was discussed in greater detail. Autodesk's Revit as a tool for working with a model was also introduced. The students were then given a simple model to use in Revit. The model included the shell and interior features of the building. The students were charged with identifying certain aspects of the model, navigating to different views of the model, creating schedules of basic quantities, and identifying dimensions from the model. The students were given a series of previously created tutorials that were publically available on the internet to use in assisting them.

Part 3 addressed the objective "Understand how component models from trades are used to create a federated model." Students were introduced to how a contractor can work with different models supplied by different trades and how the process was managed through the creation of a federated model. A live demonstration of Autodesk's Navisworks was given during the class period and video tutorials were provided to the students for reference in completing the assignment. The assignment included students creating a federated model out of the component models that were given to them. They then had to navigate around the created model, create mark-ups on the model, and query information such as areas, perimeters, and distances. The students also needed to create walk-throughs of the model and identify specific details, producing snapshots of them. Lastly, the students were able to create a report of the redline mark-ups and detail views of the model.

Part 4, which was a continuation of part 3, addressed common uses of the model in construction management and how Navisworks can be used to get quantities from the model and conduct clash detections. This was accomplished with an in-class lecture/discussion followed by a live demo. The students were not assigned anything with this part of the module as they will go more in detail with these aspects in other classes.

Part 5 was on a conceptual, not technical, level of introduction to how BIM can be used for other things during the lifecycle of a facility. There was a discussion on the use of BIM in the field and how it can be used to influence the management of the project.

CSM 3050 – Coordination Exercise Module

The introductory module was all conducted with in-class instruction by an instructor who understood the software tools and their abilities enough to directly answer and deal with any issues that arose. The module conducted in CSM 3050, however, was done strictly with video tutorials and an instructor who had minimal experience using BIM for coordination in a tool such as Navisworks. Introductory slides were given to the instructor to help introduce the topic. The instructor was familiar with traditional methods of coordinating different trades so transferring those experiences to coordination with BIM did not require a lot of training. Two learning outcomes were previously identified for this course module:

- Demonstrating an understanding of the level of development, or level of detail of files in order to understand how accurate the clash detection is. There is a difference in accuracy and detail of models built for design versus those that are used as "shop drawings" for direct manufacturing.
- Perform a clash detection by coordinating models from different trades within a model viewer. This would include students developing an understanding of real "hard" clashes in a model versus clearance issues or soft clashes that would show up but not affect construction.

The module was a "learn at your own pace" introduction with exercises on how to combine different component models, define testing parameters, conduct a clash detection, review the clashes, and produce a report. The students were given one week to complete these exercises as homework and then were given an in-class quiz with a different component model set. The in-class quiz had the students complete a clash detection, identify three legitimate clashes, and produce a report.

Module Summary

In total there were four modules that covered technical learning objectives. Three were completed by the sophomore students in CSM 2041 and the last was completed by junior students in CSM 3050.

Table 1

Module Summary

	Instruction Type		Tutorial Type			Model Status	
Module	**Live (in class)**	**Video**	**Paper**	**Web**	**Video**	**Student Created**	**Model Provided**
2041 Sketchup	X		X			X	
2041 Revit	X			X			X
2041 Navisworks	X				X		X
3050 Navisworks		X			X		X

Student Survey

The students were asked to complete a survey at the completion of the BIM modules. The survey was piloted among select faculty and edited before given to the students. The students were asked to anonymously complete the survey after the last class of the module when the work was completed to promote honest and relevant answers.

Quantitative questions on a Likert scale as well as qualitative/subjective essay response questions were used in the survey.

The survey was composed of three sections. The first was designed to document general information, such as if they consider themselves proficient at learning new computer applications, the second was project specific to each project of the module, and lastly there were several written questions to judge their perceptions. Table 2 shows the general information breakdown for both sections. Within CSM 2041 there were a total of 35 respondents while CSM 3050 had a total of 37 respondents. The respondents were asked to rate their level of agreement for questions 1-4 on a scale of 1-5 with 1 being "do not agree" and 5 being "total agreement". Questions 5-7 were ranked on a scale of 1-5 with 1 being "not very" and 5 being "very". As can be expected out of such a larger group of students there was a range of prior computer knowledge and expertise. Some students felt they were "computer savvy" and were able to learn new software fairly easily while others did not. Trying to keep everyone's attention and interest with such a wide range of abilities and skills is a challenge when teaching technical objectives dealing with software. The design of each of the projects tried to incorporate different instructional methods to help gauge preferences among the different demographics of students.

Table 2

General Information

	CSM 2041			CSM 3050		
Question	**Mean**	**Med.**	**Mode**	**Mean**	**Med.**	**Mode**
1. I find it easy to learn new software and computer applications.	3.12	3	4	3.89	4	4
2. I consider myself very computer savvy.	3	3	3	3.32	3	3
3. After taking the classes, I feel I can discuss the use of BIM in respect to the subject matter.	3.25	3	4	3.42	4	4
4. I feel like the material gave me a good orientation so I can easily pick it up should I need to on the job.	3.14	3	3	3.63	4	4
5. How valuable do you view BIM in obtaining a job after graduation?	3.9	4	4	3.84	4	3
6. How important do you see BIM being for the construction industry?	4.37	5	5	4.51	5	5
7. How important is knowing BIM to your future success in the construction industry.	3.8	4	4	4.05	4	5

The students for both CSM 2041 and CSM 3050 were also asked to complete survey questions related to each project they completed. The results for the three separate module pieces taught in CSM 2041 are included in Table 3, Table 4, and Table 5 and the results for the CSM 3050 module are summarized in Table 6. The software with which students had the most prior exposure was Sketch-up, with a 2.143 average on the 5 point Likert scale to the question "I had experience using the software before." It is also noteworthy that the Mode was 1 on a 5 point scale for each of the software packages used when responding to this statement, suggesting most students had no prior exposure to the software. This would classify the group of students as "beginners", which is the level at which the tutorials were designed.

In all three of the CSM 2041 projects there was a balance of opinion between the tutorials were detailed enough to complete the assignment and the tutorials were not detailed enough to complete the assignment. The intention of the tutorials was to give a basic understanding and have the students extrapolate the skillset they needed to complete the project from the tutorials. There was also in class instruction used with the instructor available to assist with trouble shooting during the lab period. About 10% of the students expressed frustration in the written comments that one or more of the tutorials needed to be enhanced with more information. Most of these correlated with students who did not consider themselves computer savvy and also felt they did not learn new software easily. In the CSM 3050 section there was a higher level of agreement (4.5) that the tutorials were detailed enough to complete the assignment.

It was also interesting to note that when asked "The assignment was too time consuming" most rated their agreement with a Mean of over 3, with the Mode as a 5 for CSM 2041 assignment 1 (Sketch-up) and assignment 3 (Navisworks), and Mode of 4 for CSM 2041 assignment 2 (Revit). When this is compared to the documented average time spent on each assignment, the hours are about equal to the in-class time they were able to work on the projects during the lab periods. In the written comments at least 60% of the students had mentioned they would like to go more in-depth with the work. This would actually make the assignments more time consuming because the luxury of adding more class-time to the modules is not currently a possibility.

Table 3

Project Specific Results – Sketch-up Project

Question	CSM 2041 Sketch-Up Project			
	Mean	**Med.**	**Mode**	**Range**
The in-class instruction as appropriate.	3.571	4	4	1-4
I had experience using the software before.	2.143	1	1	1-5
The software was intimidating	3	3	2	1-5
The software was easy to get used to.	3	4	3	1-5
The tutorials were detailed enough to complete the assignment.	3.2	3	3	1-5
The tutorials were overly complicated and detailed and caused confusion	2.343	2	1	1-5
There were not enough details in the tutorial to do what was asked	2.829	3	2	1-5
I see the value of learning these aspects of BIM	3.971	4	5	1-5
The assignment was too time consuming	3.656	4	5	1-5
There was enough time in class to work on the assignment and get assistance from the instructor	3.029	3	3	1-5
The instructions for the assignment were clear	3.156	3	3	1-5
How many hours did you spend on each assignment?	4.586	4	3	1.5-12

Table 4

Project Specific Results – Revit Project

Question	CSM 2041 Revit Project			
	Mean	**Med.**	**Mode**	**Range**
The in-class instruction as appropriate.	3.235	3	3	1-5
I had experience using the software before.	1.735	1	1	1-5
The software was intimidating	4	4	5	1-5
The software was easy to get used to.	3	3	3	1-5
The tutorials were detailed enough to complete the assignment.	3.294	3	3	1-5
The tutorials were overly complicated and detailed and caused confusion	2.588	2.5	2	1-5
There were not enough details in the tutorial to do what was asked	3.182	3	4	1-5
I see the value of learning these aspects of BIM	4.294	4	5	3-5
The assignment was too time consuming	3.406	3	3	1-5
There was enough time in class to work on the assignment and get assistance from the instructor	3.029	3	3	1-5
The instructions for the assignment were clear	3.097	3	4	1-5
How many hours did you spend on each assignment?	3.485	3	4	1-10

Table 5

Project Specific Results – Navisworks Project

Question	CSM 2041 Navisworks Project			
	Mean	**Med.**	**Mode**	**Range**
The in-class instruction as appropriate.	3.5	4	5	1-5
I had experience using the software before.	1.324	1	1	1-4
The software was intimidating	4	4	5	1-5
The software was easy to get used to.	3	3	3	1-5
The tutorials were detailed enough to complete the assignment.	3.455	4	5	1-5
The tutorials were overly complicated and detailed and caused confusion	2.559	3	3	1-5
There were not enough details in the tutorial to do what was asked	2.727	3	3	1-5
I see the value of learning these aspects of BIM	4.382	4.5	5	3-5
The assignment was too time consuming	3.25	3	5	1-5
There was enough time in class to work on the assignment and get assistance from the instructor	3.205	3	4	1-5
The instructions for the assignment were clear	3.484	3	3	1-5
How many hours did you spend on each assignment?	2.912	2.5	2	1-6

Table 6

Project Specific Results – Navisworks Project

Question	CSM 3050 Navisworks Project			
	Mean	**Med.**	**Mode**	**Range**
The in-class instruction as appropriate.	4.162	4	4	2-5
I had experience using the software before.	1.486	1	1	1-4
The software was intimidating	2.657	3	3	1-5
The software was easy to get used to.	3.703	4	4	2-5
The tutorials were detailed enough to complete the assignment.	4.513	5	5	3-5
The tutorials were overly complicated and detailed and caused confusion	1.621	1	1	1-4
There were not enough details in the tutorial to do what was asked	2.054	1	1	1-5
I see the value of learning these aspects of BIM	4.378	4	4	3-5
The assignment was too time consuming	1.891	2	2	1-5
There was enough time in class to work on the assignment and get assistance from the instructor	4.027	5	5	1-5
The instructions for the assignment were clear	4.513	5	5	3-5
How many hours did you spend on each assignment?	1.486	1	1	1-3

As one might expect, there was some correlation (Pearson's 'r') between the student's agreement to "I find it easy to learn new software and computer applications" and the number of hours spent on a project. For CSM 2041, this correlation was more significant than that of the CSM 3050 students. There was also a weak correlation between the student's agreement to "I consider myself computer savvy" and the hours spent to complete each project. The general trend was those who expressed they were not as comfortable around a computer took more time in completing the assignments.

There was also a significant negative correlation between the CSM 2041 students who agreed "The software was intimidating" and their agreement on "The software was easy to get used to." There was a moderate negative correlation with the CSM 3050 students. These correlations are shown in Table 8.

Table 7

Student Perception of Ability Correlated to Hours Spent on Project

	CSM 2041			CSM 3050
Correlation	**Sketch-Up**	**Revit**	**Navisworks**	**Navisworks**
Student's ease of learning new software and	-0.308	-0.2895	-0.4675	.193
computer applications to hours spent on project	Moderate	Weak	Moderate	Weak
Student's consideration of being "computer savvy"	-0.2688	-0.129	-0.1791	0.0176
to hours spent on project	Weak	Weak	Weak	null

Table 8

Student Perception of Software Intimidation Correlated to Their Ease of Learning It

	CSM 2041			CSM 3050
Correlation	**Sketch-Up**	**Revit**	**Navisworks**	**Navisworks**
Student's agreement that software was intimidating	-0.636	-0.745	-0.682	-0.331
to their ease of learning the software	Strong	Strong	Strong	Moderate

Student Perceptions

In general, the students saw value in the learning of BIM and felt that BIM played a large role in the construction industry. They also saw the importance of learning the processes they were taught in the modules and how those processes related to the use of BIM in the industry. In the written comments, the students were asked:

- What they liked the best, the least, and what they would like see changed?
- What tutorial method they preferred out of the three that were used (CSM 2041 only)?
- How they thought BIM should be taught to future CSM students?

As with any cohort of students there were variances in their stated opinions.

When it comes to types of tutorials that were used, it was about even across the board on preferences for written and third party developed tutorials. The majority of the students preferred the video tutorials. Some issues may be the quality of the other tutorials used. However, the students who preferred the video tutorials stated reasons such as being able to see the steps of the commands, and having a visual aid instead of just pictures and text.

One of the complications that added to issues with students' success for the projects is that the Department does not have a designated computer lab for students to work in. Budget and lack of space prevent this from being an amenity available to the CSM students. In place of a centralized lab, students are required to have a laptop computer that meets specific requirements capable of running the software the students will be required to use in class. The required computer is a Windows-based laptop; however there were a number of students (many of which were change of major or transfers) who previously had Mac laptops and do not purchase the new required computer. Since Revit and Navisworks are Windows based applications, they do not natively work on Mac laptops which led some students to not be able to use the applications on their personal computers. At least 50% of the students with a Mac were unable to install and run the software on a partitioned hard drive which leads to a level of frustration.

Lastly, around 60% of the students had mentioned they enjoyed the hands-on experience of exploring how to use BIM for construction processes and being able to experience something new. Many felt that not enough time was devoted to the subject of BIM and many felt it should be a full course or elective. In the future, this may be the case, however with the current department staff and curriculum restrictions smaller modules for multiple classes have been created.

Discussion and Future Directions

For the initial incorporation of BIM into the curriculum, feedback from the students and other participating faculty has been mostly positive in nature. Challenges do still exist, especially with some faculty not having a very thorough and deep enough understanding of BIM to implement it in their domains. To assist the faculty, several industry members have offered to help develop one or two class period sessions on using BIM for certain topics. This has been the case with using BIM for estimating as well as using BIM with scheduling and 4-D simulation. These will be implemented in the next academic cycle.

The modules discussed in this paper will be incorporated into the coursework again. A little bit more time has been devoted to the CSM 2041 sessions to be held in the Spring of 2015. This will hopefully offer the students a little more direct feedback while working on the projects during class time. In the future, there is a push to closely review the curriculum to incorporate a full course on BIM and other specialty areas. This is being made possible by changes in curriculum requirements, and may take several years before any curriculum changes are implemented. Until then, the course modules have given the students a taste of BIM to help prepare them for working in the construction industry.

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