Implementing BIM Management and Process Optimization Tools in Construction Management Curriculum

Jake W. Castillo
California Polytechnic State University
San Luis Obispo, California

As the construction industry rapidly continues to adopt technology and Building Information Modeling practices, we need to ensure that Construction Management curriculum prepares students for what is expected after graduation. Cal Poly's Construction Management program currently have two Building Information Modeling courses in the curriculum that focus mainly on learning software and while this will be essential for students graduating the Construction Management program, there remains room to improve the courses as the industry adapts. Adding curriculum geared more toward managing the BIM process and learning process optimization skills will not only benefit a higher percentage of students, but will also keep the Construction Management program's courses up to date.

Key Words: BIM, process optimization, curriculum, management

Introduction

During my time as a Construction Management student at Cal Poly San Luis Obispo, I have had the opportunity to be exposed to many of the leading technologies of the construction industry. Through Construction Management curriculum and the annual ASC Region 6 & 7 competition, I have been able to bolster my repertoire in regards to the amount of technologies and software learned. Almost every major specific course in the Construction Management curriculum involves some use of technology, and this sets Cal Poly apart from many programs in the country. Specifically, there are two courses that deal directly with Building Information Modeling, CM 280 and CM 421. The former is now a required class that explores many of the technologies used in the industry and the latter is a more advanced topic elective course. This curriculum helped further my knowledge of technologies beyond the concepts taught in our other classes.

I was able to take what I learned in the Construction Management curriculum and apply my knowledge of software to my three internships. Working for three different companies, twice dealing heavily with Building Information Modeling, I was able to experience first hand the emerging trends of the construction industry. What I did notice, though, as important as the technologies were to these companies and their projects, the actual management and optimization of the Building Information Process was just as important. I realized that technologies are only useful for companies if they can properly implement successful systems on their projects.

The management and optimization strategies of the industry were something I found we lack in our Building Information Modeling curriculum at Cal Poly. This lead me to investigate in depth the effectiveness of the BIM courses and learn whether or not there was room to improve. I first needed to see if students and faculty would want management and process optimization strategies in our curriculum. If that proved to be true, I needed to narrow down on which processes would benefit the majority of Construction Management students.

General Background

Before diving into the conducted research, results, and recommendations, it's important to explain Building Information Modeling and the components that are included. Building Information Modeling defines a very broad

area of the construction industry that deals not only with technology and software, but also scheduling, cost, facilities management and much more. In this section, I will define the different components that together form Building Information Modeling.

Definition

Building Information Modeling, or BIM, can be described as the process the construction industry uses to create information models using different technologies (Epstein, 2012). Based on a 3D built environment, BIM allows construction companies to add an enormous amount of detail regarding the appearance of a building and even the properties of materials being installed. In addition to this, utilizing Building Information Modeling heightens the ability of contractors, architects, subcontractors, and owners to share information to allow for greater collaboration between all parties in the construction process. This has proved to be a very useful in the preconstruction phase, saving companies both time and money in their projects. In more recent years, BIM has further developed by adding the factors of time and cost, transforming the model into a 4D and 5D model. These processes allow companies to include not only 3D information, but also schedules and estimates in the same model. Furthermore, the introduction of recording detailed information, such as energy data, material product data and maintenance requirements, has created the latest division of BIM, the 6D process. The 6D Building Information process is only just starting to be used in the construction industry, but will surely become the norm in our world of data and information. By implementing a full dimensional Building Information Modeling process, companies can now store all relevant information of a project in one place.

Industry

While some companies have had a more cautious approach, those who have implemented Building Information Modeling have reaped the many benefits it offers. According to a study done by Engineering News-Record, about 50% of all contractors in the United States use BIM intensively on their projects (Jones & Laquidara-Carr, 2016). This may seem like a small percentage considering BIM has been around for decades, but a higher percentage of companies are adopting this technology process every year. In addition, 96% of companies that use BIM feel that it has already paid for itself (Dutt, 2018). Figure 1 reviews some of the main benefits found in a study by Dodge Data & Analytics regarding the use of BIM in the construction industry.

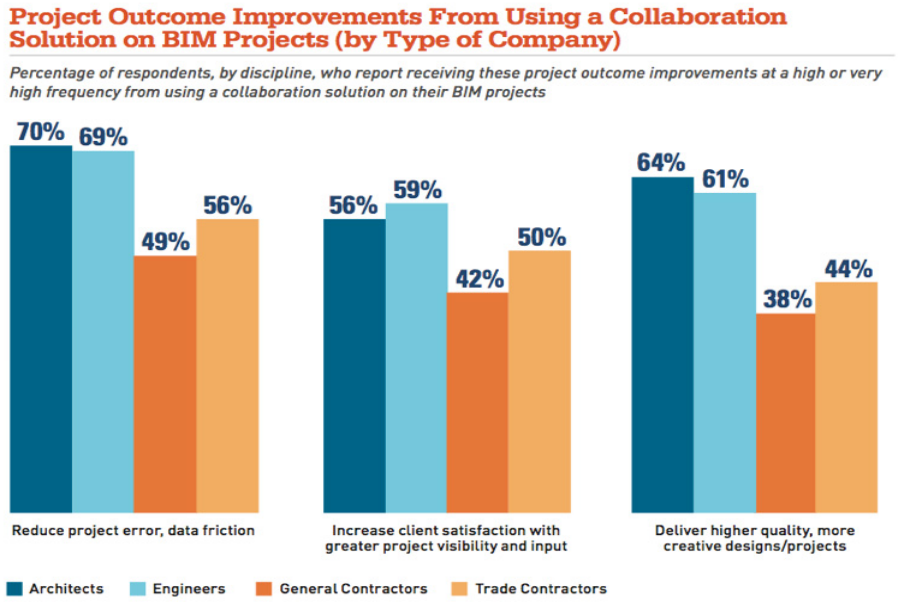

Figure 1: Project Outcome Improvements (Dodge Data & Analytics, 2017)

Although there is sufficient evidence that utilizing Building Information Modeling on construction projects saves time and money for all parties involved, the construction industry has been slow in adopting new technologies. As a

whole, the construction industry has been known to be very old-fashioned in the way they view new technologies. Also, it takes several years for progressive companies to ensure that new technologies actually save time and money. As it is a very expensive investment, utilizing Building Information Modeling and other technologies can be both risky and frightening. Unfortunately, this has caused many companies to fall behind in the adoption of BIM.

Objective

Through preliminary research, I found that the Cal Poly Construction Management curriculum could be improved by adding another concept to our Building Information Modeling courses, which is the management of the process. That said, the objective of this senior project was to explore our current curriculum to figure out if they are maximizing the department's potential, as well as to keep the courses up to date with the latest technologies and processes.

With the construction industry rapidly changing technologies, implementing new software in our curriculum can be quite confusing, as many companies have different opinions of the technologies they use on a daily basis. Instead, I set out to research management and process optimization strategies that could be applied to all current and future technologies used in our curriculum. This would create a consistent structure to the course, even when new technologies were introduced.

Methodology

In regards to research for this project, there were several necessary outlets I needed to follow in order to gain relevant information from. First, I needed to get the opinions of the students of the Construction Management department. The students of our department proved to be a valuable asset, as together we work for a diverse amount of contractors in different parts of the country. Each of these companies has their own unique preference of technologies, as well as their own way to manage and maximize the Building Information Modeling process. To get information from this diverse group of students, I decided to create a survey. It is important to note that the only students who filled out this survey had taken one or both of the BIM courses in our curriculum. The survey asked students several questions about their future aspirations after graduation, such as which career path they would follow and which sector of the industry they were planning on going into. This information would be extremely important for my project, as I needed to know which type of management and process optimization strategies to implement. Next, I asked students for their opinions of the current technologies being taught in the Building Information Modeling courses. For this portion, I listed out the technologies being used and asked students to determine whether they felt each was relevant or not relevant to their desired career path. Lastly, I simply asked if there was any interest in learning about BIM management and process optimization skills. Each question of the survey contained an additional space where students could write in an answer if it was not one of the ones listed. This information served as the base to the rest of my research, narrowing down the management processes I should focus on. The information I got from the students provided valuable insight into what technologies and concepts they want to be taught, but it was also important to get advice from the industry.

The second source of information I chose to use for this senior project came from construction industry members. The way I gained information came through a structured interview with David Park, a BIM Manager for a medium size commercial company in the Bay Area. With extensive knowledge about Building Information Modeling and the process behind it, David proved to be a useful source of information. In this structured interview, I asked several questions related to both the practice of Building Information Modeling in the industry and the format of classes in college. In addition, I asked what he believes should be taught about management and process optimization strategies at an undergraduate level. Lastly, I concluded the interview by asking about new issues facing the BIM process and how we can prepare future students to combat those when they graduate.

Results and Analysis

The following information was gathered from both an online survey sent out to students in the Cal Poly Construction Management program and a structured interview with an experienced industry member. After gathering the information, I was able to combine both the student and industry perspective to get a better idea of

how we can improve the Building Information Modeling courses at Cal Poly. The sections below will go into greater depth and analysis of the results.

Online Student Survey

The survey yielded a total of 29 responses from anonymous construction management students, all of whom had taken either one or both of the BIM courses offered in our curriculum. I focused on this specific group because the questions in the survey pertained to the different technologies taught in CM 280 and CM 421. It was important to separate this group from all other students in the construction management program because the responses would be faulty and biased if a student did not know any of the technologies taught in the BIM courses.

The first question of the survey asked students to choose which career path they want to follow when they enter the industry. The choices were: Project Manager, Superintendent, Estimator, BIM Manager, as well as an option where a student could right in their own answer. Of the students who filled out the survey, 72% said they wanted to become a project manager in the future. This statistic is congruent with the preliminary research I had done in the beginning stages of this project. While no student put that they wanted to become a BIM Manager in the future, this should not take away from the fact that it is essential for students to learn technologies in the ever evolving construction industry. The information gathered from this question was important in determining that the BIM management and process optimization strategies taught in Cal Poly's Construction Management program should more be aligned with the responsibilities of a project engineer and project manager. Reference Figure 2 below for results of this question.

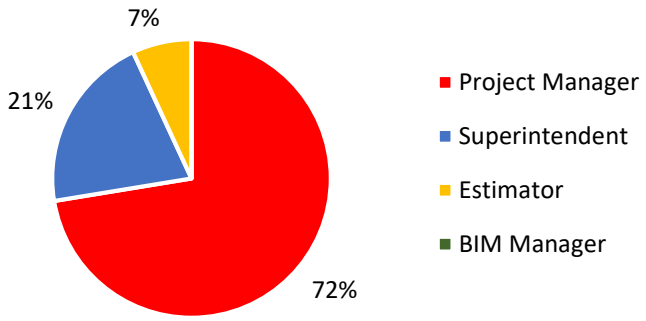

Figure 2: Student Desired Career Path (Castillo, 2018)

The next question asked construction management students to chose which sector of the industry they want to go into after graduation. The choices given were: Commercial, Residential, Heavy Civil, Industrial, Subcontractor, and another option for students to fill in their own answer. There proved to be a little more diversification in the results from this question, but still a large majority of 66% of students answered that they want to go into commercial building. The next two highest groups were heavy civil construction with 14% and residential building with 10%. Once again, this information narrowed down even further the BIM management and process optimization skills that should be taught in construction management curriculum. From the results, I have concluded that the processes taught should be relevant to project managers in the commercial sector of the construction industry. Reference Figure 3 below for the distribution of desired sectors of the construction industry.

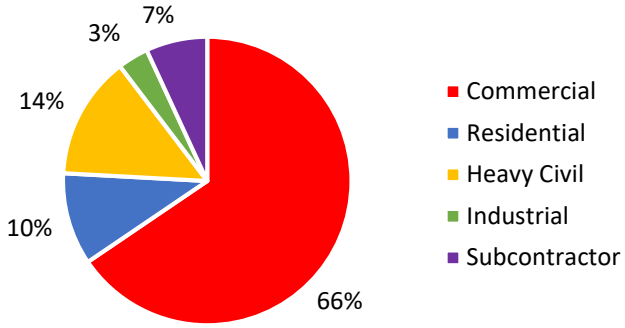

Figure 3: Student Desired Sector (Castillo, 2018)

As for the third and fourth questions of the survey, students were asked to evaluate the effectiveness of the technologies currently taught in the Cal Poly Construction Management BIM courses. The students related these technologies to their desired career path as well as the sector of the construction industry they wish to follow. Figure 4 below contains several pieces of information that are relevant in determining which kinds of BIM management and process optimization strategies should be taught in curriculum. Every student who filled out the survey selected Bluebeam as a relevant software to their career path. The next technologies students found to be most relevant were Autodesk Revit and Navisworks. Considering these are two of the main technologies for the clash detection portion of the Building Information Modeling process, this further reiterates that students are looking to learn software that are more involved with the management of BIM. On the other hand, Figure 4 also tells us which technologies students do not find relevant to their career paths. Of the construction management students that answered this question, 76% thought that Synchro was not relevant and 65% believed they would not use Tekla in the future. This suggests that students are not interested in these technologies and that this could be an area where other software is substituted. Also, this could be a possible area to incorporate the teaching of BIM management and process optimization strategies.

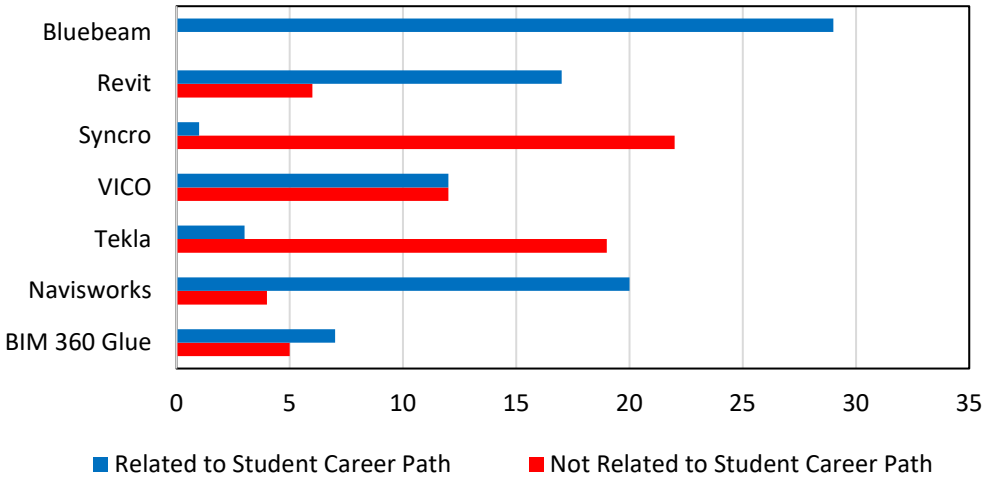

Figure 4: BIM Course Technology Evaluation (Castillo, 2018)

The final question of the survey was a very direct question, asking students if they had any interest in learning about Building Information Modeling management and process optimization skills in Cal Poly's Construction Management BIM courses. For this question, 76% of students said they would be interested in learning these concepts. With this percentage of students answering yes for this question, the Construction Management department should look into implementing management strategies in the Building Information Modeling classes.

Overall, the student survey showed that the majority of students want to become a project manager in the commercial construction sector of the industry, so our BIM courses should incorporate concepts relevant to them.

Structured Industry Interview

In a structured interview with a BIM manager, I was able to gain valuable industry insight on the state of emerging technologies to come and what professionals think students should learn as undergraduates. David Park is an extremely credible source, as he has over a decade's experience in the industry dealing with the Building Information Modeling process and the management of this on countless projects.

At the start of the interview, I asked David about the current State of Building Information Modeling in the construction industry. He explained that technologies are rapidly evolving and many companies are struggling to keep up. But, many companies have taken advantage of new technology, saving them time and money. The old issues of the BIM were getting subcontractors to learn the software and overall flow of the modeling process. As the

industry has started to adapt, subcontractors have gotten in tune with both technologies and the process, accelerating BIM and reaping even more benefits. However, there are still some problems facing the Building Information Modeling process for many general contractors. Below is a list of several problems the industry is trying to fix:

- Communication issues with owners, architects, subcontractors, and general contractors
- Figuring out what building data is important
- How long until new processes are proven to save time and money

Current and future undergraduate students will be solving these issues facing the BIM process, so they must be familiarized with them as soon as possible. With the advancement of the 4D, 5D, and 6D processes, contractors are now able to store almost all building data in a single model. While many companies do not yet have the processes to each dimension down, they will very soon in the future. The Cal Poly Construction Management program should incorporate all dimension of the BIM process in curriculum. But, more importantly, the department needs to start familiarizing students with the management process of these activities.

Implementation

After combining the results from the student survey and the input from the industry, we can implement an improved form of curriculum that benefits the majority of students in the Construction Management program. The BIM courses already have the relevant technologies for commercial building and using these the department can implement new curriculum that also involves the management of the BIM process. Below is a detailed module that combine both learning technology and managing the Building Information Modeling process. This module contains all developing components of the BIM process and has an emphasis on group work and communication skills. The current BIM courses already incorporate 3D modeling and clash detection, so this module goes a step further in including the management of the 4D, 5D, and 6D processes.

4D – Scheduling

In this section of the module, students will be split up into small groups. The entire small group of students will form the general contractor. Each student will be assigned their own trade to carefully construct a schedule for in the project. Then, they will have to coordinate together which activities need to go first and how the overall flow of the project should go. The students will then create a master schedule for the project and turn it in to the owner (professor).

5D – Model Based Takeoff

With a 3D model already constructed in Autodesk Revit or another modeling software, students will form groups in which they will explore the many kinds of information available. A common practice starting to be used in the industry is model-based takeoff, where a contractor can simply import a model into a software that will perform a quantity takeoff of the entire building. This is extremely important for general contractors, as they must back check numbers given to them by subcontractors to ensure correctness. While much of the industry still uses software such as On Screen Takeoff or Bluebeam to perform takeoffs, there are technologies that can perform this much quicker. In this module, students will import a model into Vico Office to perform a quantity takeoff and compare the results to a given document of subcontractor quantities. Next, they will complete the estimate by assigning costs to the specified items. Students will be communicating with both the owner (professor) and subcontractor (assistant professor) about any discrepancies. After the quantity takeoff and estimate is complete, the students will perform a detailed cash flow for the project using the schedule they created in the 4D section of the module.

6D – Project Lifecycle

In the last section of the module, students will be utilizing the Revit model and Revit Express Tools to perform a data analysis. The Revit model contains a great amount of information regarding the product data of materials in the building and owners in the industry and starting to require this data to be sorted through and tracked. As general contractors, our job is to ensure that subcontractors have properly inserted all necessary information for the owner, so getting familiarized with the management of this process is key. Students will search through the Microsoft Excel

spreadsheet containing all information in the building, finding the specific data required by the owner, such as the type of door or window installed.

Conclusion

The construction industry is rapidly evolving in regards to the development of technologies being used and the majority of companies are starting to incorporate the Building Information Modeling process in their systems. The Cal Poly Construction Management department has put an emphasis on teaching students the emerging technologies and must keep this up if we want our students to be prepared coming out of the program. But, another side of the BIM process, management and optimization, are essential skills students need to learn if they plan on becoming project managers someday. Through improving the curriculum of the BIM courses, the Construction Management department will ensure that its students will enter the industry as some of the most prepared and well-rounded industry members.

References

Dutt, Vikram. (2018, January). BIM is Disrupting Design and Engineering. *Convergence.* [WWW document] URL https://projectdelivery.autodesk.com/blog/aec-industry-trends-bim-dodge-analytics/

Epstein, E. (2012). Implementing Successful Building Information Modeling. Norwood: Artech House.

Jones, Steve. Laquidara-Carr. (2016, July). New Survey Reveals How GCs, CMs and Subs Engage with BIM. *Engineering News-Record.* [WWW document] URL https://www.enr.com / articles/39935-new-survey-reveals-how-gcs-cms-and-subs-engage-with-bim

Jones, Steve. Laquidara-Carr. (2017). *Leading the Future of Building.* Connecting Teams. Dodge Data & Analytics

Park, David. Castillo, Jake. Structured Interview. 2018, May 25.