Bridging the Gap between Technology Usage in the Construction Industry and in the Classroom

Marco Maffioli
California Polytechnic State University
San Luis Obispo, California

As construction begins to advance more and more every day, technology is one of the most volatile aspects due to its ever changing nature. Technology, and all the software's that encompass it, is the future of this industry and if we want to keep improving and growing as an industry we need to better align our future new hires with the most prevalent technology and that starts in the classroom. Specifically, the Construction Management Department at Cal Poly, San Luis Obispo, one of the most advanced in Nation, still struggles to align with the expectations and reality of the CM industry. The software's that are being utilized everyday need to better align with what new hires are expected to know. The main idea is to analyze the most prevalent software's and technologies in the construction industry and bridge the gap between what is taught inside the classroom and what is used every day at the jobsite.

Key Words: Technology, Software, Curriculum, BIM, VDC, Cal Poly

Introduction

During my time at Cal Poly San Luis Obispo I have experienced quite a variety of different technology, and specifically a wide variety of computer software's. These construction software's are changing every day and are only getting more complex as the industry progresses. Within the construction management department I have been introduced to many of these programs throughout the curriculum. I have noticed how they have been strategically spread throughout the courses to maximize our competency and overall gain the most understanding possible. Coming from technologically deficient background I have made the most of these experiences within the classroom and looked to even get more involved outside of the classroom because I looked at these processes as the future of construction.

By taking the initiative to further educated myself early on I enrolled in the topic elective course CM 421 titled Emerging Trends, or known as the Building Information Modeling (BIM) class by the student body. This class was my first time being exposed to such a wide variety of software's and it was in that class when I decided that I wanted to make it my goal to be as technologically competent as possible. My idea was that after I graduate and go into the workforce my background and experiences would give me that edge to standout and rise above my fellow coworkers. I dove in full steam and never looked back. As my repertoire grew I found myself being able to not only complete assignments quicker but I was able to produce better quality work. Because of this passion to excel I became a member of the Virtual Design in Construction or VDC team that competes every at the annual ASC Region 6 & 7 competition in Reno, NV.

Being a part of this team for two years, once as a shadow my second year and as the team's co-captain my third year, I started to standout from my fellow classmates. The amount of time outside of the classroom that I spent preparing for these competition only gave me more exposure to the wide variety programs. It was a tremendous experience that I was able to be apart but I found that there were multiple programs that essentially operated the same but were just slightly different. Personally I begin to make my selections of which software's I liked the best for each certain task. Whether it was the unique functions or just the familiarity I had it wasn't hard for me to make my decisions. Being at Cal Poly I had access to such a large variety of programs due to my student title. I realized just how lucky I was when I began to find out how much each of the licenses cost to run each program. Once I started my first internship I came to realization that these construction companies didn't have the same benefit that I had.

It was at that point during my first internship when realized I no longer had a choice of what program I wanted to use but I was forced use whatever software the company had. I didn't think too much about it but over the years I interned at three different general contractors that all had different technology packages. It was a struggle at times because as similar as most of these programs are they all had their quirks and took time to become fully proficient. During these internships I looked at it as a learning experience and tried to absorb as many different processes as possible to further enhance my marketability once I graduated. I always thought to myself when I learned a new software, why haven't I been exposed to this inside the classroom? Wasn't that the reason to go to college, to further expand my knowledge and be as prepared as possible when I start working on the jobsite?

I recognize a discrepancy within the Cal Poly Construction Management curriculum that made me a little uneasy. It was frustrating that I spent all this time preparing to succeed to only find out that I was forced to use another program that I hadn't yet been exposed to. Once I progressed I realized that the reason I was being so called "forced" to use these specific software's was because they were superior. Everyone has the own opinion but it was evident that some programs really did standout above the others for a variety of performance reasons. I just kept thinking to myself why have I not being exposed to the latest and greatest program's and I set out to change that.

General Background

Before going any further I think it's important to define some of the things that makes up the wide variety of construction technology and software's. It is not an easy thing to fully comprehend, because of how volatile this certain aspect of the construction industry happens to be. I will try to clear things up as much as I can but note that even after being immersed within this sector for over four years I still struggle to stay up to speed at times.

Industry

Looking at it in its entirety the construction management industry is one of the least forward thinking industrial sectors there is (Armstrong, 2016). It comes from a variety of reasons but most of it stems from the old mentality that if it's not broke don't fix it. As the time goes on and things continue to work well the motivation to become more innovative just wasn't there. However, things have changed in recent years and the innovative mentality has started to grow and adapt. It isn't quite to the level of excellence to be compared to other industries that are leading the way but that's only because of the same reason it took to get started in the first place. It can be seen by looking at Figure 1 below that the biggest majority of the industry sits at being an Industry Follower or Behind the Curve coming in at a cumulative 69%. Only 8% of the companies surveyed were determine to be cutting edge. It seems like companies are hesitant to fully commit and are waiting for these processes to be proven before they move forward.

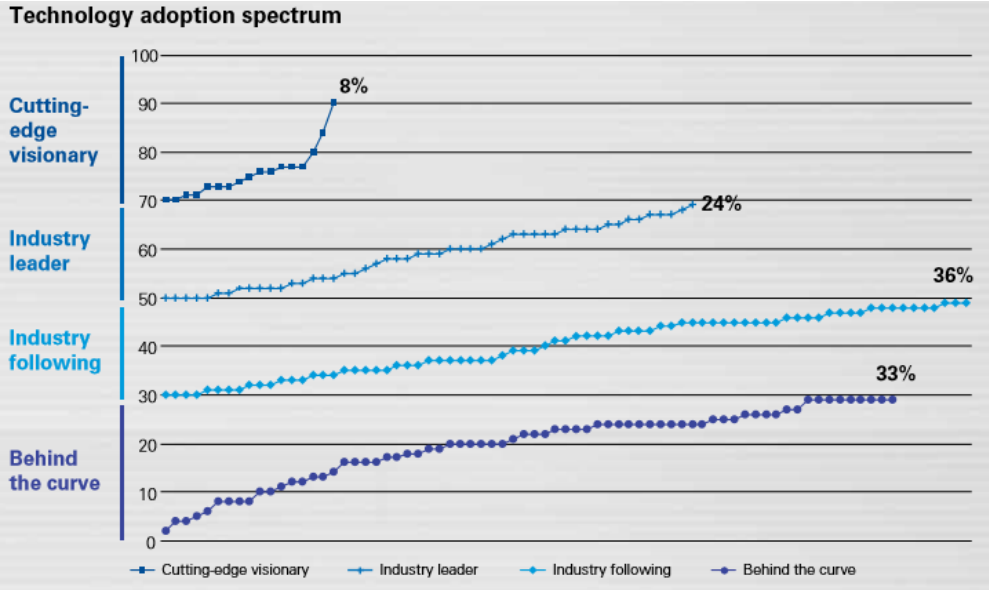

Figure 1 - Technology Adoption Spectrum (Armstrong, 2016)

Dimensions

To further understand just how many different program's there are that encompass what we call Building Information Modeling (BIM), or sometimes referred to as Virtual Design in Construction (VDC) you must first understand the dimensions that make it up. A full breakdown can be seen broken down in Figure 2 below. However, what isn't shown is the second dimension (2D), this dimension includes the processes of document control and project management. It is the most used dimension inside the industry which why I choose to include it in my study. Every day multiple times a day the common construction manager utilizes these document control and project management programs to track and organize all the information and data between the multiple parties involved. The dimensions that follow are also a vital part of the technology that construction managers exploit but are not as commonly utilized because of the ambiguity and differences mentioned above.

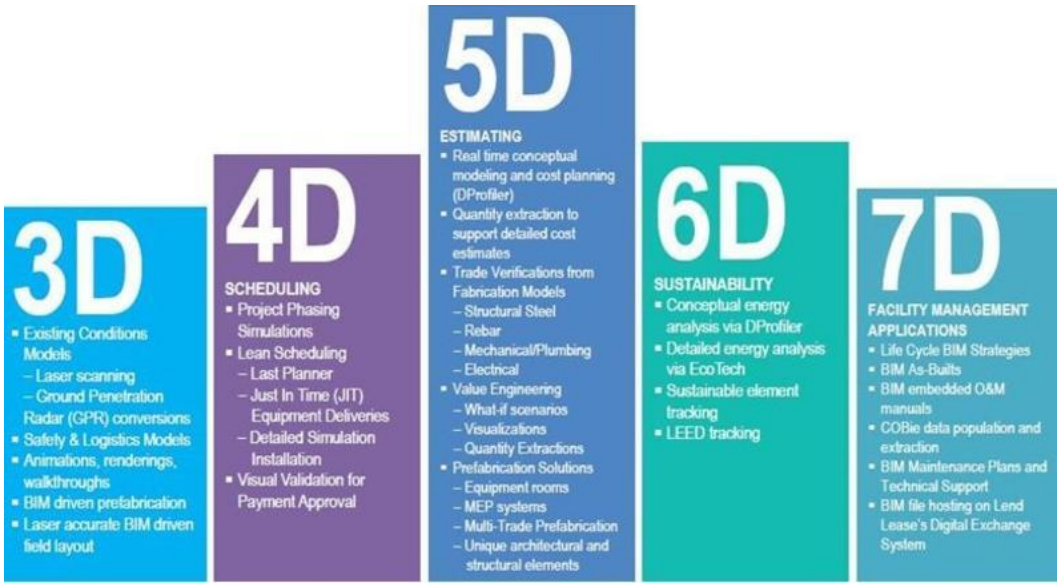

Figure 2 - Dimensions of BIM (Autodesk Revit, 2017)

The next dimension, 3D, is focused on the visual modeling of construction, this processes is the fastest growing because companies are starting to see the immediate benefits. Being able to virtual construct the building before actual building allows the contractor to recognize and resolve problems before they occur. Whether it's coordination between subcontractor trades or connections between all the systems the make up a structure, it has been shown to save time and money. The fourth dimension of scheduling is one that has been utilized for the longest time compared to other listed above. The ability to organize specific action items and properly sequence them to maximize efficiency has been tremendously successful to complete projects in a shorter timeline. The next dimension, 5D, has been around forever but once computers became so common it really began to take off. To be able to automatically count, track and measure certain materials can save large amounts of time and money, as well. The final two dimensions of BIM are the two that are not widely used but are continuing to make strides. With the growing demand to be environmentally cognizant the 6th dimension has grown and is becoming more popular but still is not to the level of popularity as others. The 7th dimension of facility management is unique but in the end can lead to a lot of money being saved during the lifetime of the structure. From 2D to 7D these are the dimensions that make up all of the construction specific technology that is used.

Software's

Time to dive into the specific programs that make up each dimension of the technology used within construction. This is designed not to make you an expert but give you a better understanding of what will explained deeper into

the paper. Below is a breakdown, not by dimension, but by the categories, or construction activities, of each software that was studied throughout this research process:

- Document Control – Bluebeam, Adobe Acrobat, Plangrid, Procore
- Project Management – Procore, CMIC, Timberline, Prolog
- Virtual Modeling – ArchiCAD, Revit, Tekla, Dynamo, Rhino, Sketchup
- Clash Coordination – Navisworks, BIM 360 Glue, BIM anywhere, Tekla BIMsite
- Scheduling – MS Project, Primavera P6, Synchro, Vico
- Quantity Takeoff – On Screen Takeoff, Planswift, Bluebeam
- Estimating – Navisworks, Vico, Assemble, DProfiler

Objectives

After recognizing an area that could be improved within the Cal Poly Construction Management curriculum I set out to learn more about the topic. The ability to align the curriculum perfectly with the construction industry is just an unattainable mark. The changes that occur on a year to year basis are so great that the department would need to update the course work every quarter just to keep up. As impossible as that mentality is, I still felt that there could be a closer resemblance.

Overall, the initial goal of the project was to uncover some of the dimensions within technology usage at Cal Poly that could be improved. From there the CM department could better align its curriculum to the industry standards. With that set students would then be more prepared to succeed than previously before. In the end, the final goal is to adequately prepare students to be as technologically prepared to excel in a full time position once they graduated from the Cal Poly San Luis Obispo Construction Management Program as possible. This would allow them to grow within their careers at much quicker rate and become more successful in the long run.

Methodology

The methodology for this study would be classified as qualitative. The way I gathered information for this study was in the form of an online survey that was distributed to every student in the Construction Management program at Cal Poly. The survey was very direct and explicitly asked students to determine which program for each certain construction activity they were the most comfortable with. In addition, each section had an additional space for written comments if out of the options listed their preferred software for that task wasn't listed. This survey created a baseline of information of technology usage to work with, however it only captured student responses. If I wanted to accurately compare the abilities of the student body to the industry standard I needed to know the correct industry standard.

After to the recent creation of the Construction Tech Advisory Board, a subsidiary of the Construction Management Advisory Council (CMAC), one of their first initiatives was to discover what makes up each construction companies software packages. Through a similar qualitative survey of my own this Advisory Board was able to gather detailed information from a wide range of contractors. This enable myself to compare the two surveys and begin a thorough analysis. The areas that didn't align well stood out instantly. I would then present this information to the CM department for them to make their own decisions with what I found.

Results

The following information was gathered through an online survey directed at the student body that makes up the Construction Management Department at Cal Poly, San Luis Obispo and was compared to a professional industry survey. Once the industry standard for prevalent technology usage was recognized it was then compared side by side to then better align with the Cal Poly CM curriculum. Below is a breakdown, by construction activity, the similarities and differences between the Cal Poly Construction Management curriculum and the industry standard that was discovered.

Document Control

The first activity to look into is document control. This activity is the most common processes within the CM industry and is used every day not only in the CM industry but also other similar sectors, as well. It includes, but is not limited to, any work related to viewing, manipulating, and organizing PDFs. The clear front runner is a popular software titled Bluebeam, an advanced PDF reader, which came in at a 92% comfortability rating from the student body when compared to competing programs. This aligns well with the industry standard, the referenced survey has a 100% usage rate from contractors. This is the type of alignment there should be to ensure no surprises on the first day of work for future graduates. It aligns well because Bluebeam has been introduced to students two years ago and is now an integral part of many lab courses at Cal Poly.

Project Management

Project Management is a similar to document control, and up to just a handful of years ago was actually treated the same as well. Project management includes all activities such as RFI's, submittals, change orders, and much more. The results from my survey state a 56% comfortability rating for the cloud based software titled Procore, which may seem low but it's because of how recent Procore has been launched and the wide range of similar competing software's. From an industry standpoint Procore is also the most common program for project management but at a lower rate of only 45%. Timberline, Prolog, and CMIC, the three closest competitors, come in at 35%, 30%, and 20%, respectively for the industry. I see this number for Procore only increasing over the years in both categories, because of its functionality and user friendly design. Procore has recently been integrated into the CM curriculum, however, I would like to see it more emphasized because of its growing popularity.

Virtual Modeling

3D modeling has the widest variety of programs that can produce the same results, which lead to it being the most difficult to analyze. Virtual modeling is the process behind virtually constructing 3D buildings, see an example in Figure 3 below, which allows the construction team to recognize issues before they become a reality in your actual structure. This processes has become more and more powerful over the years with the ability to produce realistic animations, and construction ready documents. There are also different facets of virtual modeling, there is architectural, structural, and specialty, however I only surveyed for a general mix of all three and there was a clear frontrunner, Revit by Autodesk. Easily the most popular and user friendly out of the mix, which can be shown by a 68% comfortability rating by the students and a 75% usage rating by the industry. Autodesk, the creator of Revit, is the largest most established company that produces BIM products and it can be seen in there software. The amount of exposure to Revit that student receive is a perfect amount and the results speak for themselves.

Figure 3 - 3D Rendering made in Revit (Autodesk Revit, 2017)

Clash Coordination

Clash coordination is a spinoff from virtual modeling, it essentially takes in all the models from the variety of special contractors and once aligned it spits out potential clashes and areas that need to be addressed. There is no virtual building to be done, instead it utilizes completed models to highlight specific problems that are found. There is a clear industry favorite, a program titled Navisworks, also an Autodesk software, comes in with a 90% rating. This is similar result to the student body's most comfortable software, with Navisworks coming in at a 45% rating. Think of Navisworks as the slow big giant that gets the job done, however there are other programs the a quickly rising, such as BIM 360glue with a 32% comfortability rating for students and a 45% rating from the industry. This is more of specialty activity, therefore it is not common within the Construction Management curriculum but is still taught in a few topic elective courses.

Scheduling

The next activity aligns perfectly with the 4th dimension titled scheduling. This dimension is where I saw the biggest divide and was one of the reasons that prompted this study. Scheduling is the act of organizing certain action items in a strategic order to maximize efficiency with your workforce for entire projects or sometimes just small tasks. There are two competing scheduling software's that lead the industry, MS Project and Primavera P6. Overall, both are well constructed programs but they each have their area of specialization. Within the students surveyed 60% felt more comfortable with MS Project compared to 25% rating for P6. This is opposite of what was discovered within the industry, a 72% rating for P6 was found while MS Project came in at 60%. This should be an area of focus for the CM curriculum, P6 is so widely used yet under emphasized inside the coursework.

Quantity Takeoff

The processes of quantity takeoff and estimating are very similar, which is why they both fall under the 5th dimension of BIM. Quantity takeoff includes the method of measuring, counting, and organizing designated materials to come up with a finished unit of supplies that is needed. A fairly simple activity but can get complex at times so it is vital to have a good working software to help along the way. Bluebeam was found to be have the highest comfortability rating among its competitors with a 64% rating. That was also found to be the industry standard with an 82% rating. Bluebeam is only growing and should be a focus point within the Cal Poly CM curriculum because of its popularity amongst the students.

Estimating

The final area of focus is estimating, the processes that includes calculating specific costs to reach an "estimated" project or activity cost before it is actually constructed. This is the activity behind winning new work within the industry. There are quite a few software's that aid in the procedure but a plug in for Revit was found to be the most common within the CM industry with a low 35% rating. This didn't align with the 48% comfortability rating for Navisworks found amongst the students. A reason behind the low ratings is because of how specialized this processes is. It is not a daily activity among construction managers, yet instead people focus on this area meaning it is usually something you pass off to another department. However, it was still interesting to be able to analyze the comfortability levels just to make the comparison.

Conclusion

Over the years my experience with technology inside the construction industry is that not only is it constantly changing but it is also being dramatically improved in the process. We need to keep that same mentality inside the classroom if we are going to maintain the same level of excellence. This research project was designed to adequately prepare Cal Poly, San Luis Obispo Construction Management students to be as technologically advanced as possible in order from them to succeed in their future endeavors. Through improving the CM curriculum to better align with the industry standards it will only teach students more practical information. Overall, I did not find as much divide between the CM industry standard and the Cal Poly CM curriculum as I thought I was going to find during my

initial study. It was still very worthwhile to be able to analyze such a hot topic within the Construction Management Industry.

References

Armstrong, Geno. Gilge, Clay (2016). *Building a Technology Advantage.* KPMG Magazine

Autodesk Revit (2017). *Built for BIM* [WWW Document]. URL https://www.autodesk.com/products/revit-family/overview

BIMPanzee (2016). *I'm 3D, 4D, 5D, 6d, and 7D* [WWW Document]. URL http://www.bimpanzee.com/bim-3d-4d--5d--6d---7d.html

Reed, Matty (2017). Technology Utilization in AEC Industry. [Professional Survey]

ResearchGate (2003, September). *How innovative is construction? Comparing aggregated data on construction innovation and other sectors – A case of apples and pears* [WWW Document]. URL https://www.researchgate.net/publication/24077668_How_innovative_is_construction_Comparing_aggregated_data_on_construction_innovation_and_other_sectors_-_A_case_of_apples_and_pears