

Integrating BIM to the Construction Industry: The Hardships, Benefits, and an Unyielding Educational Gap between Technology and Field Application

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In recent years, Building Information Modeling has taken the construction industry by storm and revolutionized the construction process entirely. It allows for trades to coordinate more efficiently and effectively, while providing a hands-on, 3D overview of a structure being built. Certain characteristics are more easily adoptable by existing companies than others, but technology means progression. With technology, there are usually intensive educational proceedings to aid in the adoption process. This study will examine the effects as BIM becomes more widely used in the construction, and its effect on existing companies either progressing or phasing out entirely based on their ability to adapt. In addition it will observe the gap developing between students exiting the university setting that has a strong emphasis on technological integration, and the actual implementation of technology associated with field activities from a superintendent stand-point and a superintendent's proficiency with the software.

Key Words: BIM, building information modeling, technology, adaptation, growth, challenges, implementation, 3D modeling, cost, coordination

Introduction

The construction industry is a subject of continuous innovation and progression with a mindset to improve quality, increase productivity, create efficiency and optimize coordination. Arguably the biggest movement to addressing all of these benchmarks is the development of building information modeling, or more commonly referred to - BIM. According to a case study by Salman Azhar on the BIM effects on industry, a BIM model "characterizes the geometry, spatial relationships, geographic information, quantities and properties of building elements, cost estimates material inventories, and project schedule." The possibilities of BIM and what the technology strives to do are without a doubt revolutionary and hold an unbroken realm of technological potentials...if everyone on every project team knew how to operate the systems perfectly. Reality takes precedence, and there is an immense cost and time factor associated with not only purchasing the software to make a project coordinate seamlessly with BIM, but also to train the employees to be well versed in the programs for the software to reach its maximum potential. Most discussions of BIM illustrate the benefits and improvements the technology will bring to industry production, but more times than not there lie multiple "fallacies of hype" (Fox).

The biggest idea that has to be taken into consideration in terms of building information modeling is the notion behind various stakeholders holding an obligatory investment in the process of developing and updating a BIM model throughout the lifecycle of a project (Barlsih). For coordination through the model to operate in its intended way, each stakeholder needs to understand the functions of BIM and update their respective pieces. These stakeholders range from architects and engineers, to the project management team, superintendent and subcontractors. If a model is completed correctly, it can be used to obtain information regarding precise geometry and support design, procurement, fabrication and construction activities (Azhar). However, it must be brought to the forefront that BIM is largely disconnected from the real life physical building process (Chen).

While construction is known for innovation, it is also stereo-typed with traditional practices, methods and minded people in the field, i.e., subcontractors and superintendents. For BIM to operate correctly, onboarding these field personnel is essential, but many times industry gets push-back from the field. It is the purpose of this paper to

investigate those push backs, their effects on BIM implementation, and how this is developing a gap between field operations and today's technology-minded graduates.

Methodology

This project combines the idea of a case study, or case studies, through interviews and data collection via online surveys. The goal of this research is to investigate the following ideas:

- Does company size in terms of project scopes, dollar amount and revenue affect whether or not the company chooses to integrate BIM?
- Is age a prominent factor in the integration of BIM?
- How are superintendents being affected by new technology, positively and negatively?
- What are some of the benefits and hardships of building information modeling?
- Does BIM possess the ability to phase out smaller companies?
- How are universities targeting the incorporation of BIM?

Data for this project was collected both qualitatively, and quantitatively. Online surveys were sent out to industry, as well as students, to gather information on who was using BIM, what programs they were using, how many students were proficient with BIM, etc. The surveys were comprised of yes or no questions, as well as extended response questions that provided interview-like responses. In addition, interviews were conducted with two different companies to get some more in depth perspective on their uses, experiences, and opinions regarding building information modeling, where the industry is headed, and how their company targeted efforts towards incorporating integrative technology. One of these companies uses a large amount of BIM, the other does not. The results of these research methodologies are divulged and interpreted in the Discussion, Research, and Conclusion portions of this paper.

Discussion

Background

This project interest stemmed from two vastly different internship experiences. One large-scale and prominent company in Colorado (headquartered in California), and another family owned, Wyoming based, smaller company. Throughout the internship in Colorado, BIM was an essential component to everyday operations, and team members sat through weekly BIM coordination meetings with the subcontractors that could last upwards of 5 hours. Some backlash was observed due in part to the BIM-minded and technology driven operations, from older, more traditional subcontractors who didn't have the money, time, or desire to adapt to the technology and properly update the BIM model with their progress and adjust post-clash detection. In addition, a 23 year old project engineer was running these meetings in conjunction with an off-site BIM coordinator; it became apparent that younger generations are more comfortable with the technologies involved with building information modeling. In an entirely different internship with a smaller company it became recognized that BIM was not even on that company's radar. Technology in Wyoming had not reached that point, there was not a need for it, there was no money to fund the training or the software, and ultimately the complications of integrating BIM outweighed any benefits. Their project sizes did not demand or need the coordination and clash detection involved in BIM. This drove and desire to investigate the uses of BIM throughout the scale of companies, how consistent the use among project teams was, and ultimately how construction as an industry was adjusting to the technology – or if not at all.

What is BIM, and its associated costs?

As noted in the introduction, the role of BIM can potentially wear various hats throughout a project, pending which entity of the design or construction team is using it. According to a study by Kristen Barlish and Kenneth Sullivan, BIM can act as a software application, a process for designing and documenting building information, or a new approach to advance the field in a new way to implement contracts, policies and relationships throughout the teams. For a seamless application of BIM in the industry, all stakeholders must be invested in the adaption of the new

technology. However, many studies today are beginning to question if it makes sense to adapt to BIM for some companies due to costs and company sizes (Barlish). Figure 1 below breaks down the costs of the most commonly used BIM software, as defined by survey information from this study, based on monthly fees for year-long licenses. Costs for software were found on the software developer’s websites for license purchasing. Tekla is the obvious winner in terms of obscene expense, but the capabilities of Tekla are also vast and incredibly detailed, in turn making it not only the most advanced form of BIM, but also the largest learning curve of the BIM software (“Trimble”). Autodesk software like AutoCad, Revit and Navisworks (a clash-detection software), work easily with each other and complete many of the tasks and functions the multiple hats of BIM users demand (“Autodesk”).

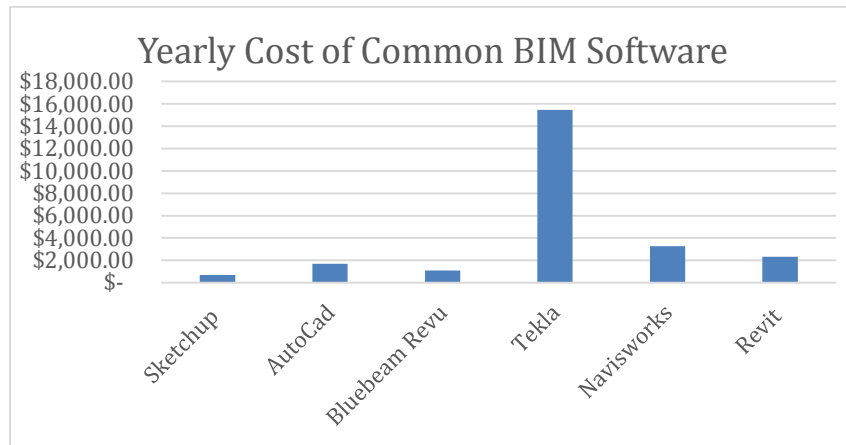


Figure 1: BIM Software Costs as Per Respective Manufacturer Websites

Results

Description and Data Interpretation – Industry

Originally the intended goal of this project aimed to see if technologies, like building information modeling, were phasing out smaller companies because of costs and ability to adjust to the technology. The extensive data collection ultimately led to complex findings in terms of BIM use amongst industry that did not necessarily point to smaller, more traditional companies facing extinction – but some uniformity emerged throughout the diverse responses. Many companies are implementing the same types of software when BIM is being used – and there is an industry wide gap between students emerging from universities with extensive knowledge in the realms of construction technology, but lacking in field knowledge, and conversely, superintendents lacking in technology know-hows but possessing vast knowledge in field work.

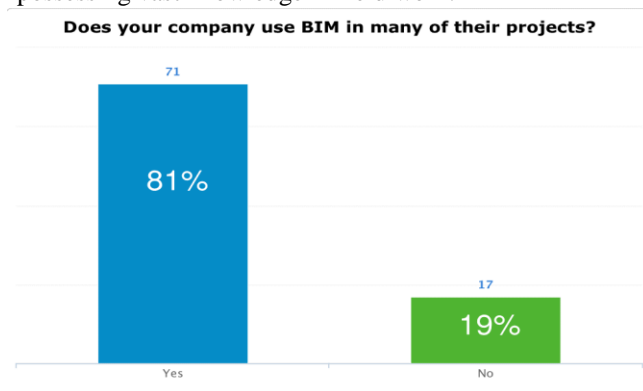


Figure 2: Industry BIM Usage

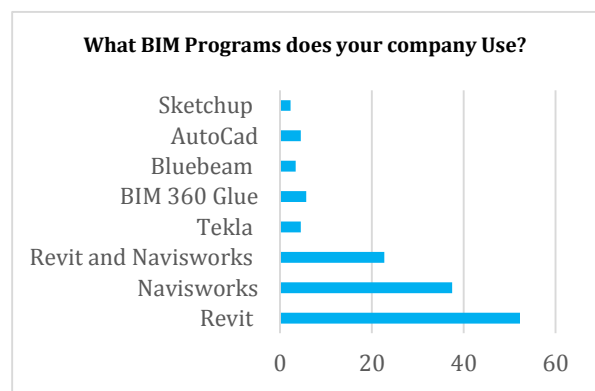


Figure 3: Company Software Preferences

After distributing the survey 88 responses came back from industry and about 81% responded back that they were implementing BIM in some fashion, as seen in *Figure 1*. *Figure 2* further dissects which software are being used among those companies, and in many cases both Revit and Navisworks are being used in conjunction with each other. It can be assumed from research, that Tekla costs outweigh the benefits and is mostly used among subcontractors like concrete subs that demand its multiple facets and detailed functions (“Trimble”).

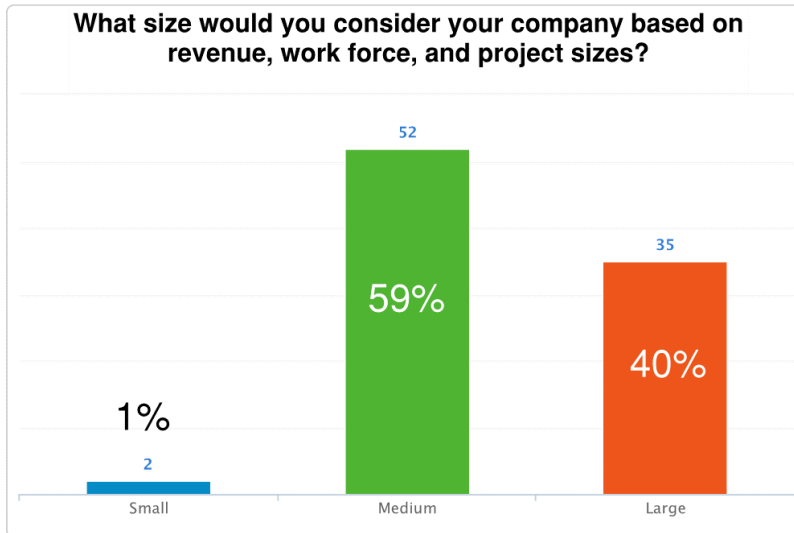


Figure 4: Industry Company Sizes

Originally, the project hypothesized much feedback and response from a large range of companies identifying as “small” that did not implement BIM. However, the responses identified a large number of “medium sized companies” – around \$100 Million per year and projects ranging in size from \$1 Million - \$70 Million, many using some form of BIM. From the two companies that did identify as “small,” one of them was not only a BIM user, but a user of Tekla and a structural concrete subcontractor. At this point, the original hypothesis would be difficult to prove and data needed interpolation in a different way to identify where BIM was being used and who specifically in project teams is struggling to adapt.

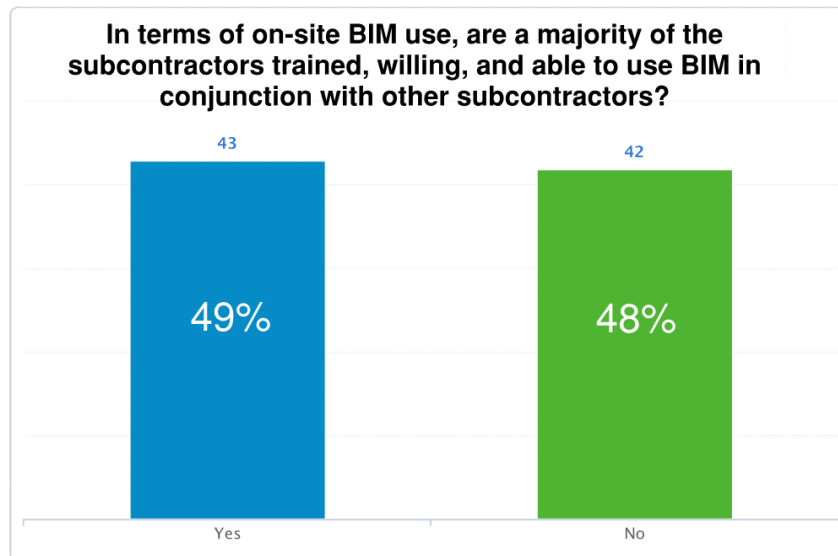


Figure 5: Subcontractor Compliance with BIM

About half of the companies responded in saying that subcontractors were not trained or willing to adapt to the technology involved with using BIM on-site. Without having these subcontractors on board, reaching the full benefits of BIM becomes impossible: a few people cannot orchestrate the work of many because they are the only ones versed in the software, as this will result in a decrease of productivity – as many companies identified in their extended responses about challenges associated with BIM (Fox).

Description and Data Interpretation – Students

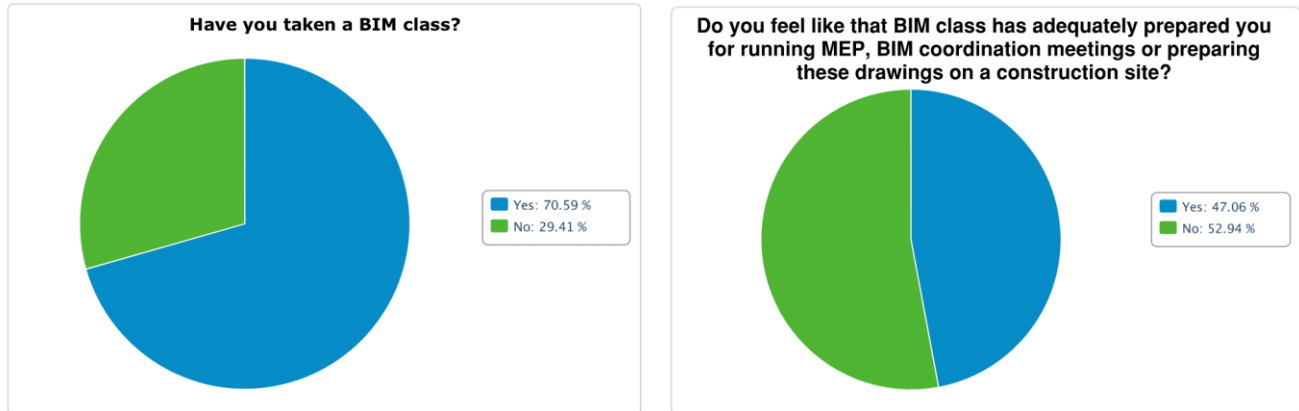


Figure 6: Student Outlook on Current BIM Courses

70% of Cal Poly students surveyed responded that they had taken the BIM course currently offered – CM 421 Emerging Trends. This course covers various software over the course of 10 weeks: AutoCad, Archicad, Revit, Tekla, Synchro, Vico, and Navisworks, as per the current class syllabus. The course essentially teaches students how to construct simple structures in each program, run clash detection and basic functions of how the programs might interact. Of those surveyed, 52% felt that they were adequately prepared and confident using these software forms in the field at an internship or full time Project Engineer job.

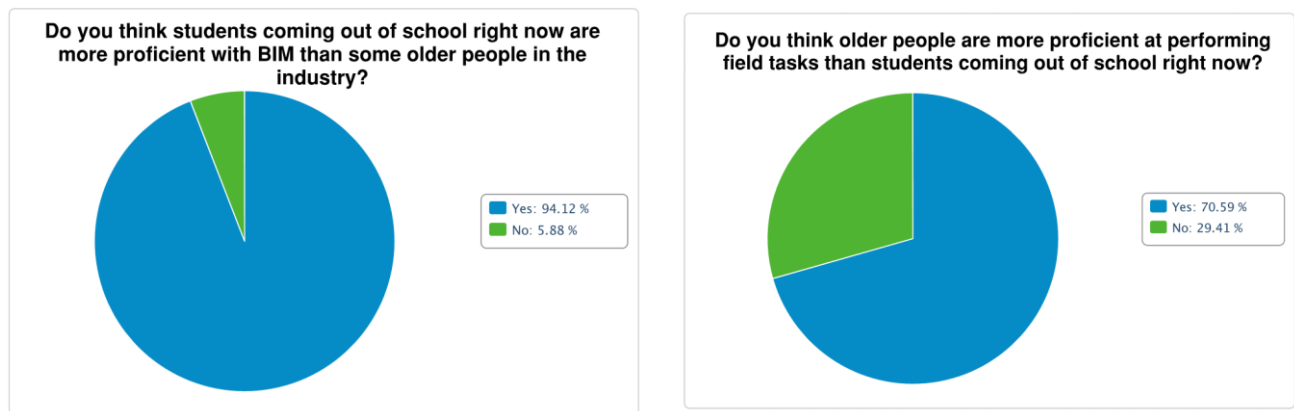


Figure 7: Age Correspondence to Technology Proficiency versus Field Proficiency

As seen in *Figure 7*, an overwhelming response from students identified themselves as the strongest users of BIM technologies, over the experienced industry professionals, who 70% believe are better versed in field tasks. This clearly identifies a conflict in the BIM transition – students are obviously gaining experience with the technology before entering the workforce, but upon entering the workforce they are lacking in field experience needed to construct the actual structures. This defends the idea where younger industry professionals pave the way for technology, and are often designated with the job of updating models and leading BIM coordination meeting, while

losing time in the field (Livingston). When the students were asked in an extended response form question about the implications of what students being more proficient in BIM means for predominately older companies, most students agreed that companies should “get on board or get out.” However all students responded that either more value should be placed on field work and the building taking actual form, or equal importance on BIM and field work. No students responded that BIM skills are superior to field skills. This is known as a risk called ‘blind and deaf’ where building information modeling cannot be synchronized with real time building, because BIM is merely “a digital representation of physical and functional characteristics of a facility and a shared knowledge resource for information...” (Chen).

Interview Findings and Discussion

In addition to sending out surveys, interviews were conducted with two companies to identify some differences between one that implements BIM on projects, versus another who does not. Both interviewees were Cal Poly graduates, ages 29 and 27. Ryan Swenson with Swinerton Builders in San Francisco has been using BIM extensively on a \$196 Million project to aid in the coordination of mechanical, electrical, plumbing, fire protection, and drywall. He identified Swinerton as a company that will “fund any technology that [we] see value on integrating into our company,” and funding training in conjunction with the licensing agreements of all software purchased by the company for employees.

Travis O’Neal with The Hanover Company, a large developer in San Diego, was also interviewed for the research of this project. He said in his 2.5 years with Hanover he had never used BIM, and had only implemented the use of software such as Bluebeam or Sketchup – not funded by Hanover. He identified BIM as having a steep learning curve with a large cost and not providing a benefit because “if the entire design and construction team doesn’t have the software then it isn’t as advantageous.” O’Neal discussed his thoughts on the idea that the corporate offices of companies should see the value of utilizing BIM and that the value and emphasis of coordination needs to be a function from top down in a company to have an impact – something he feels Hanover lacks currently.

While these two companies had vastly different responses in regards to BIM implementation within their own companies, there were many parallels in responses regarding the difficulties of BIM in association with subcontractors, superintendents, and current graduating student proficiency with technology versus field. Both interviewees stressed the importance of a superintendent and the irreplaceable importance they play in the physical building process, regardless of their proficiency with BIM. Both companies agreed that older generation, more “traditional” subcontractors and superintendents struggle with, or are resistant to, the BIM process in general. However, as O’Neal identified in his interview, “as the industry and market moves towards more BIM integration then then “old-school” subcontractors will have to get on board.” When asked about subcontractors and superintendent resistance, Ryan Swenson responded by saying “Yes, especially smaller subcontractors are more resistant to get on board. This is because that they’re not exposed to the technology as much and have the mentality that if they’ve done it a certain way before and it works, there is no need to change. I’ve experienced this with superintendents and triumphed past it by showing them the advantage with technology and drastically cutting down on the time to complete the activity.”

The two company representatives were also asked questions in regards to opinions about university prep of students with technology versus field application and field activities. Both Swenson and O’Neal agreed that the technology education in university classrooms currently is preparing students fine for industry and they are incredibly efficient with computer software. However, both companies also agreed that universities are losing emphasis on field activities in the classroom – but that there is strong emphasis on encouraging industry internships. As O’Neal phrased it “Construction is a hands on industry and you have to see and experience the process to best understand it.”

Conclusion

Building information modeling implementation is an immensely diverse and in-depth topic with multiple facets that could be further dissected and researched among students and professionals for years to come as more companies adapt. Ultimately, BIM integration cannot be described in a black and white response of success or failure. Many factors of the technology affect different companies in different ways based on the type of building, the

demographic of employees, the support from corporate offices, the expertise of employees, and the funds to incorporate the software. Various company types have moved to full implementation of BIM already because their trade benefits immensely from the visual representation of their work, i.e. concrete or steel subcontractors. Other trades have found the technology to provide minimal benefits, and the time needed to learn the software to not be of utmost importance at the current time, until it becomes essential as their industry partners incorporate it. The main idea is that BIM is still evolving and industry implementation is not consistent across the board or across the nation. Even sectors of California vary with progression rates and the technology is slower to be implemented.

Consistent ideas, opinions and experiences could be drawn out of the industry and student survey responses, however, to identify an ever-evolving gap between technology in the classroom of universities and the field application of that technology with “old school” superintendents and trade subcontractors in the field. The consistent response deemed students to either be proficient with BIM software or familiar with the learning curve associated with BIM. Industry identified the field teams to be less proficient with BIM, less willing to learn it, but completely irreplaceable based on the knowledge of physical building. Industry and students both identified a need for students to gain more field experience in the classroom. BIM is an incredibly efficient tool – but it is not a replacement for building in the field. While students provide a valuable asset to companies based on their proficiency with the technology, they must also know how to apply that technology to a field setting and understand how to use it in conjunction with physical building activities. There is also a clear need to get superintendents and subcontractors on board with the technology, and the younger people are more likely to aid in doing that if they can teach their team members in a way that the technology is applying to the field, rather than just computer jargon.

The key to closing the gap between technology and field application begins in the university setting. While the BIM class has become a required part of the Cal Poly Construction Management curriculum, it goes without saying that the ten week period of learning a vast amount of software does not make students ready to apply it to a field setting. Based on interview responses and survey responses from students and industry, the best way to close this gap is to have the education portion involving technology applied to field activities in the classroom setting. This will allow for students to more easily educate and assist the more “old school” employees of the industry to learn the software and adjust as it becomes more imperative over time. It remains apparent that the current BIM class offered is essential for being ready to enter today’s work force, but altering when it is required to be taken and how it applies to other required classes could help to close the occurring gap. CM 421 should be offered early on after introduction classes, like CM 115. It should focus on the current technologies most frequently used in the industry – like Revit and Navisworks; this offers the basic skills needed for learning the technology but those skills then need to be applied to our trade specific labs, i.e. residential, commercial, specialties, etc. Activities such as the shed construction in CM 214 or the metal structure construction activity in CM 313 could incorporate building information modeling to help students link BIM modeling with field activities to better understand how it applies in the real world.

Cal Poly Construction Management professor, and previous field superintendent, Troy Hart recognized some of his own personal struggles with learning BIM to be fairly consistent with industry response. He identified the technology as “a tool in the tool box, rather than an entirely separate tool box”. BIM technology is currently being taught as a separate tool box with minimal field application examples and practice in the university setting. In addition, many industry employees are resistant to the technology or struggle to adapt to the processes that entail fairly steep learning curves. BIM is intended to increase productivity and provide efficiency, however for that to happen the current gap developing needs to be addressed and BIM should be approached and taught as a tool rather than an alternative to employees in the field like superintendents. BIM implementation will continue to progress and as it does, it remains imperative for universities to address these issues and for traditional companies to get on board with the times to help along the journey to increased productivity and quality, and in the long run a better building industry.

References

- "Autodesk Launches New Solutions for Building Information Modeling: Updates to Revit Platform, AutoCAD Civil 3D and Autodesk NavisWorks Help Building Teams and Civil Engineers Create Better Projects Through Design Innovation." *PR Newswire*, (2008)
- Azhar, S. (2011). "Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry." *Leadership Manage. Eng.*, 11(3), 241-252
- Barlish, K, and K Sullivan. "How to Measure the Benefits of BIM - a Case Study Approach." *Automation in Construction*, 24 (2012): 149-159.
- Chen, K, WS Lu, Y Peng, S Rowlinson, and GQ Huang. "Bridging BIM and Building: From a Literature Review to an Integrated Conceptual Framework." *International Journal of Project Management*, 33.6 (2015): 1405-1416.
- Construction Industry Institute (2013) Transferring Experiential Knowledge from the Near-retirement Generation to the Next Generation, Research Summary # RS-292.
- Fox, Stephen. "Getting Real About BIM: Critical Realist Descriptions as an Alternative to the Naive Framing and Multiple Fallacies of Hype." *International Journal of Managing Projects in Business*, 7.3 (2014): 405-422.
- Livingston, Heather. "Get 'Em While They're Young." *CADalyst*, 29.1 (2012): 16.
- Suermann, P. C. (2009). Evaluating the impact of building information modeling (BIM) on construction (Doctoral dissertation, University of Florida).
- "Trimble Introduces Three Enhanced Tekla Software Solutions for More Efficient Construction Workflows." *PR Newswire*, (2016):