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Employability Skills in BIM for Construction Managers: Recommendations for Education

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Abstract

Many mainstream architecture, engineering, and construction (AEC) professionals are using Building Information Modeling (BIM). Although more and more firms are using BIM and this trend is forecast to continue, it is unclear what skills and competencies a construction manager will need in five years related to BIM. This research aims to answer that question through the use of a Delphi panel comprised of AEC professionals. The panel consists of members with the following qualifications: a minimum of eight years industry or academic experience or a combination of the two, a minimum of three years BIM experience, and membership in a nationally recognized professional organization.

This paper presents findings from a research project based on BIM skills for the construction manager. This paper highlight the results of a three round Delphi study that identified skills and competencies in the following areas related to construction management: cost, scheduling and control, project administration, contract documents, and other skills that were not in other categories.

Although many "new" BIM related construction management skills and competencies, "traditional" skills and competencies are a top response in each respective category. Within these "traditional" skills was the reinforcement of soft skills. BIM is a collaborative project management system so many soft skills are more important than with traditional project management systems. BIM requires some efficient communication along with strong soft skills, an area reinforced by the findings of this research.

As BIM diffuses into the construction community, social systems interested in increasing BIM usage should augment "traditional" skill sets with the "new" BIM related skills and competencies. Any academic programs seeking to implement BIM related topics into existing courses should do so in a careful manner. This research revealed in five-years BIM will continue to enter the mainstream. Building Information Modeling theory suggests that AEC industry will completely change because of BIM. However, this is not the entirely the case. This research discovered that soft skills are more important because of BIM diffusion.

Keywords: BIM, Construction, Curriculum, Education, Management

Introduction

Currently, many professionals in the AEC industry are making a switch from computer-aided drafting (CAD) to BIM. The *McGraw Hill SmartMarket* report claims that in 2008, 45% of companies used BIM tools at moderate or higher levels and BIM has seen a 45% usage growth from 2009 to 2012. By 2014, BIM adoption will reach the following levels: over 70% of architects, over 40% of engineers over 50% of contractors, and over 40% of owners [17]. It appears BIM is becoming mainstream thus research on how to prepare the next generation of construction manager with BIM related skills is necessary.

Building Information Modeling tools have seen isolated usage currently in CM curriculums. Many Universities are working to identify best ways to integrate BIM into the curriculum. It is unclear how BIM will reshape CM curriculum or industry expectations of graduates in this area. Research by Taylor, Liu, and Hein [31] integrate BIM into areas of the ACCE curriculum, concluding, BIM is a powerful tool that construction management academic intuitions can use to deliver all aspects of the educational objectives within the curriculum. They recommend BIM find its way into multiple courses in the construction curriculum. Since this study was local to Auburn, the authors recommended expanding the study's geographic scope and including more industry influence. This study did not identify the specific skills and competencies required for this integration, a limiting factor for a school planning to implement BIM.

Implementation of BIM into university curriculum requires understanding of industry expectations of CM's in the field BIM. Without knowing what the desired outcomes are from industry, academia cannot properly prepare students in this area. A method of curriculum and course development uses an instructional design (ID) process. The first phase of ID is the identification of instructional goals - What should individuals know and be able to do and what are the skills and competencies in the area of BIM required in five years? Instructional design rests on numerous theory bases related to educational psychology.

Review of the Literature

Building Information Modeling (BIM) Overview

Building Information Modeling encompasses evaluating a building a structure in a virtual environment for a variety of issues prior to any construction begins. Once the virtual structure (BIM Model) is designed, various computer applications can evaluate the structure for energy efficiency, quantity take off, estimation, scheduling, and architectural renderings.[12] A BIM model is loaded with data that can be extracted in multiple ways to help with decisions and complex project planning.

At BIM's core is a three-dimensional parametric data rich model created in a virtual reality on a computer [7]. A BIM model will support the construction, fabrication and procurement activities throughout the buildings lifecycle [5]. Prior to using three-dimensional parametric modeling software, two-dimensional computer aided drafting / design (CAD) software was used. If an edit occurred in one area of the two-dimensional CAD views, all other views had to be updated manually; this process was a major source of errors. Building Information Modeling alleviates many errors that would hinder productivity [1].

Building Information Modeling is not just a computer technology enhancement but also a process (workflow) change. Traditional methods for design were linear, meaning one person would finish with part of a design and send it over to the next person to work on (also called the pass-over method). The current AEC business model separates owners, designers, builders, and subcontractors and does not foster much collaboration early in the building design. All parties have individual party lines and are contractually loyal to themselves. BIM changes that flow, all parties are loyal to the project contractually, a true teamwork mentality is needed in a BIM project. Building Information Modeling requires collaboration of all parties early on [5]. It is important to understand this new revised workflow as a study revealed that employers want students that understand the conceptual knowledge of BIM and not just be BIM software operators [30]. To accomplish this, new project delivery systems and contracts need to be introduced.

Efficient BIM use will require a culture shift. Building Information Modeling use requires a firm to embrace the BIM philosophy and fully collaborate with owners, construction managers, architects, and other designers to work on the BIM design concurrently [7]. A BIM project philosophy is the most challenging step of full BIM implementation. Proper use of BIM will require a corporate paradigm and culture shift for its users. The implementation of BIM requires corporate change and top management support [28]. To see the full potential of BIM firms will need to embrace full collaboration [25]. This may be difficult for many organizations due to the complexity of BIM and a firm's willingness to adopt this complex innovation. Rogers's research shows that the more complex an innovation is, the more difficult it is to diffuse through a social system [21]. With the complexity BIM possesses including the culture shift for full BIM adoption social systems may delay full adoption of BIM. This has been the case in many firms that only use some BIM tools but not use contracts embracing BIM.

A cultural shift occurs when BIM is implemented; currently most projects are delivered using old project delivery methods of design-bid-build with designers and builders in different rooms [11]. Building Information Modeling changes that culture into something much more collaborative. Project delivery will use a more integrated project delivery approach [22]. Current project delivery systems offer a checks and balance system because of the adversarial nature of the contracts. Full implementation of BIM in project delivery should use a more integrated project delivery approach [22].

BIM climate and culture is different from others. Everyone works on a project design at one time and BIM is at the center of the project. All parties are loyal to the project contractually. To have this method of designing come to fruition, collaboration between all parties working on the design needs to be optimized. The current AEC business model separates owners, designers, builders, and subcontractors and does not foster much collaboration early in the building design. Building Information Modeling requires collaboration of all parties early on [5]. In the past, BIM models were created from plans and specifications created by an architect or engineer. This provided a critical check of the designers work. When all of the members of the team are working on the same design, this check will be removed and work may lack a critical eye [1].

Use of the BIM process has resulted in such benefits as 40% elimination of unbudgeted change, cost estimation within 3%, 80% reduction in time taken to generate a cost estimate, a savings of 10% of contract value, and a 7% reduction in project time [1]. Building Information Modeling leads to increased productivity, better engagement of project staff and lower overall risk distributed with a similar contract structure [15].

Existing BIM Curricular Research

Although BIM is relatively new, some research exists on curricular practices and the status of BIM implementation in existing curriculum. Much of the research is on methodology to incorporate BIM into curriculum, teacher experience of BIM, and student experiences using BIM. The research reviewed shows that BIM will continue to grow in the CM program of study, yet it is unclear what instructional goals, skills, and competencies individuals expect in the CM profession.

Integrating BIM into a CM curriculum poses an abundance of challenges. In a study of ASC schools, less than 1% responded that BIM is taught as a stand-alone course and 9% address BIM as being taught as part of an existing course [23]. The most significant obstacles identified were a crowded curriculum, lack of established curriculum, and lack of reference materials. Integration of BIM into CM curriculum is moving slowly compared to industry. Post-graduation employment depends on students having the knowledge and skills needed to serve in industry. Sixty-two percent of the survey respondents say that BIM education is not adequate and 75% feel that BIM use will increase in the next five years in the market place [23]. This is a call to action for education professionals our responsibility is to serve our students and provide them education that will provide gainful employment.

The integration of BIM in to the CM curriculum has been a topic of debate for some time. It is clear that the need to integrate BIM exists. However, the appropriate curricular location has not been decided. Some have suggested that BIM be part of a first level undergraduate course while other schools have placed it as a capstone project in their course sequence [13]. In a case study using the capstone project to integrate BIM, many students had to learn the software alone. This took up most of the time for the project but proved to be beneficial for future employment. Most of the students that worked with BIM as part of the project are using BIM in their current construction jobs. Furthermore, many are assuming company leadership roles associated with BIM, demonstrating the success of BIM integration into the CM curriculum.

Building Information Modeling helps students learn CM topics and a teaching paradigm shift towards a BIM integrated curriculum is suggested. Students verified that BIM provides a better understanding of the construction process. It was recommended that introduction of BIM be done early in the classroom to facilitate higher-level projects later in the undergraduate curriculum [24].

The researcher structured this study to help identify BIM instructional goals within a given BOK of CM professionals supporting integration into existing curriculum. In an undergraduate course, a case study by Hyatt integrated Lean, Sustainability and BIM into a scheduling course that produced a “highly successful course that engaged students and improved effectively introduced students to these important topics” [10]. Courses designed along this path will help solve the answers of a crowded curriculum. Taylor stated, “we do not advocate a silver bullet course to add to an already packed curriculum, but rather promote the use of BIM as a means of better integrating a construction curriculum” [31]. Building Information Modeling is an integrated project delivery method so it only makes sense that construction educational facilities adopt the method. In a survey of the students after the course, 57 % identified the BIM assignment as most beneficial in being able to visualize the construction process [10].

Taiebat and Ku [30] indicated that BIM skills are in demand in “Constructability” and “Visualization.” The authors admit further exploration into these areas is needed. This research focused primarily on industry perceptions and did not identify clear instructional outcomes that individuals should have when entering the work force. Various studies identified individual instructor experiences implementing BIM into a course. Wright suggested that BIM be used to design contract courses in the areas of IPD, claiming the teamwork component of IPD and BIM enhance learning [34]. Chen and Hildreth [9] suggested a program of study for BIM in a construction engineering program curriculum, claiming that BIM can be incorporated into a CM curriculum but conclusive knowledge of best practices or forecasted instructional goals is still lacking. Clevenger, Ozbek, Glick, and Porter [3] researched integrating BIM into Construction Management Education at Colorado State University. Their research focused on implementation of BIM into existing programs. In the pilot program, BIM became the tool used to deliver multiple subject matters [3]. This method of instructional design is favorable but lacks any information on instructional goals and is limited to Colorado State's population.

Building Information Modeling is new and many industry practitioners are not proficient in its usage. Research notes there is a shortage of competent building information modelers in the construction industry and their demand will exponentially grow with the passage of time [15]. This is an obstacle for members of industry to move forward. By providing the industry with students trained in effective use of BIM tools, the industry is in a position to better itself. Recommended research in training methods and programs of study for individuals will contribute to the adoption of the full BIM paradigm shift. In addition, it is unclear if any schools in engineering, architecture, or construction require BIM and IPD as a learning objective. Future research in the areas of how academia and industry can collaborate to move BIM forward and establish BIM's place in the CM curriculum.

BIM's Benefits to Students Learning Construction Management

Building Information Modeling research has demonstrated increased learning through student engagement and multiple modalities of learning. Many concepts students have difficulties grasping in the past are now easier to visualize with BIM. Shen (et. al) piloted a program to use BIM to teach design and construction of sustainable buildings. The case study designed a sustainable project and modified it, providing multiple sustainable "what-if" scenarios for analysis and design. Student feedback on this project supported positive usage and strong learning of both BIM and sustainable concepts in the classroom[26].

Taylor, Liu, & Hein [31] concluded, "BIM can be an integrative force within a construction curriculum, a vehicle for delivering all aspects of its educational objectives. Perhaps most important of all is the integration of knowledge about building that it provides within the mind of each construction student." In addition, BIM should be offered early in the curriculum [31]. It seems that BIM should be offered in a CM curriculum from the start as a design course and progress to advanced scheduling and estimating as the curriculum progresses.

Building Information Modeling is a new concept that many educational institutions are attempting to implement within their organizations. Currently there is not an accepted instructional strategy to teach BIM in any AEC curriculum [33]. In a case study at Western Illinois University, AutoDesk Revit was taught as part of the CM curriculum. This course covered not only the technical aspects of the software but also the many technical components of building construction. The students were able to learn how to use the software and understand what they were building. This helped the students visualize, but the technical aspects of learning the software were difficult at first. Students also noted the high level of construction knowledge required for this course. The study pointed out that students were very motivated to learn this software and concluded that "properly structured BIM courses would provide industry-required knowledge to prepare student to successful careers in the AEC industries" [33].

Members of the Associated Schools of Construction Education (ACCE) have been working on implementing BIM into their curriculum [30]. The have recommended that educators should be investigating how this powerful tool can enhance their curriculum. Building Information Modeling can better integrate a construction curriculum [2]. During a class implementation case study, students learned BIM software and concepts and were required to learn the software on their own. The study concluded that BIM software was too complex to learn on its own without some guidance [31].

Students have different learning styles; teaching BIM modeling is a way to address a variety of these learning styles to bring students to higher success. Traditionally, students would have to create 3D models in their heads during a scheduling course. This high level of visual thinking may not be attainable for all students. This is not the case with BIM modeling software, which makes construction curriculum accessible to more visual learners without removing the other leaning modalities. Using BIM as a knowledge repository and primary teaching method in a course on residential construction was effective [19].

Methodology

Research Questions

The research questions for this study were based on Hildreth and Gehrig [9] identification of a common body of knowledge (BOK) for construction engineering and construction management (CM) programs. The BOK areas emerged from a review of requirements for accreditation from the following international sources: Accreditation Board for Engineering and Technology (ABET), American Council for Construction Education (ACCE), and Chartered Institute of Building (CIOB) accredited construction programs. The BOK areas are estimating, construction scheduling and control, project administration, and contract document knowledge [9]. The research questions for this study are derived from the BOK; they are:

1. In five years, what BIM skills and competencies, related to cost estimating, will construction management professionals need to possess?
2. In five years, what BIM skills and competencies, related to construction scheduling and control, will construction management professionals need to possess?
3. In five years, what BIM skills and competencies, related to project administration, will construction management professionals need to possess?
4. In five years, what BIM skills and competencies, related to contract document knowledge, will construction management professionals need to possess?
5. In five years, what other BIM skills and competencies, not included above, will construction management professionals need to possess?

Use of the Delphi Method

Since the problem of this study is complex, and somewhat open-ended, the researcher decided to use a Delphi panel with the goal of coming to consensus on the problems solution. A Delphi Method is the most appropriate method to solve this type of research problem in situation such as this. The Delphi Method is a method for structuring group communication process so that the process is effective in allowing a group of individuals to deal with a complex problem. The structured communication comes in rounds of anonymous discussion. A Delphi method gains consensus from a group on future uncertain issues. It is especially useful when expert opinions are geographically dispersed. The Delphi method has been used and endorsed in multiple disciplines to forecast content and objectives for instructional goals [27].

The researcher conducted this Delphi study in four steps. The first step was panel selection and recruitment and steps two through four comprised the three-round Delphi study. In the first round of the study, panel members received open-ended questions similar to research questions one through four. During Round Two, the researcher administered a Likert type scale survey questionnaire to the panel with responses from question one. The researcher calculated mean and standard deviation for Round Two responses and reorganized the Round Three instrument based on the descriptive statistics. The main goal was to gain consensus on what skills and competencies Construction Management professional should possess related to BIM in each BOK area.

Population

A primary component of a properly executed Delphi study is proper panel selection. The validity of the study rested on the qualifications of the panel of experts participating in the study. Selection of not only the size but qualifications of the panel is of paramount importance. Unlike a random survey, the Delphi recognizes experts through their expertise, leading to higher return rates from the study [29]. The target population for this study consisted of AEC professionals that use BIM tools and plan on maintaining or increasing their BIM usage over the next five years.

Data Collection / Analysis

During Round One, the researcher sent an invitation to participate to participants via e-mail and the data was collected through SurveyMonkey. Respondents received a reminder after the first e-mail was sent out. The researcher collected data and prepared for the next round. During the first round of data collection, open-ended questions identified items that panel members felt were important skills for BIM employees. These items were entered into SurveyMonkey in random order with a Likert type scale for Round Two.

During Round Two, the researcher sent an invitation to participate to participants via e-mail and the data was collected through SurveyMonkey. Panel members had fourteen days to take the survey and received a reminder after the first e-mail was sent out. Round One data prepared for Round Two by calculations of mean and standard deviation. Finally, the researcher ranked data by mean score 5 to 1 (highest importance to no importance) for Round Three.

During Round Three, the researcher sent an invitation to participate to participants via e-mail and collected the data through SurveyMonkey. The researcher provided respondents seventeen days to take the survey and sent reminders three days after the first e-mail was sent. He sent a thank you letter to each of the participants. The researcher collected and prepared data for closing chapters. The researcher ranked Round Two data by mean score 5 to 1 (highest importance to no importance) for Round Three. Included in Round Three were mean and standard deviation scored from Round Two.

Results - Skills and Competencies Identified

In the following paragraphs, the researcher provides discussion on the top five skills or competencies based on mean and standard deviation from each research question and his interpretation of the results.

The top five in the area of cost estimating are:

1. BIM model-based quantity takeoff and verification (M = 4.33, SD = 0.77),
2. Understanding "hidden" materials needed for construction that are not well modeled in BIM (M = 4.22, SD = .65),
3. Ability to competently work with BIM software associated with the industry (M = 4.11, SD = 0.68),
4. Ability to validate model accuracy (M = 4.00, SD = .91)
5. Interrogate models; confederation and linking / mashable software fluency / manipulate multidisciplinary model (M = 3.94, SD = 0.73).

Of the top five, two are not explicitly BIM specific skills but rather prerequisite skills required to complete a BIM model. Understanding hidden materials and validation of model accuracy will require the construction manager to understand how the project is actually put together, the “hands-on” component of construction. This is what the researcher considers “traditional” construction management education. In examining the highest scoring item, BIM quantity take-off and verification, this skill requires both BIM knowledge to use the computer model to complete a take-off and traditional math skills to verify the take-off quantities. The results show that traditional knowledge is comparable to BIM knowledge in this area.

The remaining three skills are “new” construction management skills and competencies and have come about due to BIM usage in industry. Integration of models, competently working with BIM related software, and performing BIM based quantity take-off are all skills that should be supplemented into the knowledge base of a construction manager seeking to maintain or increase BIM usage in five years. This knowledge would be “new” knowledge that “traditional” construction managers would need to supplement their skills.

The top five in the area of construction scheduling are:

1. Knowledge of construction sequencing and installation details (M = 4.72 SD = 0.57)
2. Ability to competently work with BIM software associated with the industry (M = 4.61 SD = 0.70)
3. Theory of scheduling (M = 4.44 SD = 0.70)

4. Using software to accurately portray and simulate the events - not simply to show an animation (M = 4.39 SD = 0.70)
5. Construction methodology and processes (M = 4.39 SD = 0.61)

Of the top five, three are not explicitly BIM specific skills. Rather, they are prerequisite skills required to complete a BIM model. Knowledge of construction sequencing and installation details, theory of scheduling and construction methodology and processes are "traditional" skills and competencies required of a construction manager. These skills require knowledge in assembly of a construction project -- the "hands-on" component of construction management. The results demonstrate that "traditional" knowledge connects to efficient BIM usage.

The remaining two skills are "new" construction management skills and competencies that have come about due to BIM usage in industry. Users of BIM must competently work with BIM software associated with the industry and accurately portray and simulate the events; they cannot simply show an animation. Although these skills require some "new" BIM related technical skills to accurately portray and simulate events, the construction manager will need "traditional" skills in the construction field. Theses "traditional" skills supplement "new" BIM software operation skills to visualize events. If the construction manager lacks perquisite knowledge in sequence of construction assembly, there is a strong possibility the resulting BIM model will be flawed.

The top five in the area of project administration are:

1. Knowledge of construction processes (M = 4.72 SD = 0.67)
2. Understand liability of sharing models and willingness to collaborate (M = 4.59 SD = 0.62)
3. Virtual team collaboration tools (distance communication skills) (M = 4.56 SD = 0.70)
4. Ability to competently work with BIM software associated with the industry (M = 4.56 SD = 0.78)
5. BIM-based constructability review (M = 4.50 SD = .71)

Of the top five, three are not explicitly BIM specific skills. They are prerequisite skills required to complete a BIM model. Knowledge often construction process is a "traditional" skill and involve competencies required of a construction manager. Understanding liability of sharing models and willingness to collaborate is a "new" legal issue brought out by contract delivery methods utilizing BIM. Literature has demonstrated a need for better understanding of the legal aspects of BIM. The results demonstrate that "traditional" knowledge is important for BIM usage and that legal concerns are becoming more of an issue with the BIM movement in the AEC industry.

The remaining three skills are "new" construction management skills and competencies that have come about through BIM usage in industry. The ability to work with BIM software associated with the industry and BIM-based constructability reviews are "new" skills brought out by BIM. Although these skills require some "new" BIM related technical skills, to portray and simulate events, the construction manager will need "traditional" skills in the construction field. Theses "traditional" skills should supplement "new" BIM software operation skills to visualize events.

A constructability review is not a new concept, but with the use of BIM the process will become more streamlined and accurate. Nevertheless, the accuracy of the constructability review are based on the accuracy of the model. The last skill in this area relates to communication and virtual team collaboration tools. The BIM software along with distance internet technology has made it possible to design, review, and approve much of a BIM project from remote locations. This result points to the need for a construction manager to have the ability to work and communicate remotely with team members in a BIM environment.

The top five in the area of contract documents are:

1. Traditional contract knowledge / process / methods (M = 4.44 SD = 0.70)
2. Traditional construction installation methods / assemblies / processes (real world, "hands-on") (M = 4.24 SD = 0.97)
3. Model-based quantification (M = 4.11 SD = 1.18)
4. BIM-based supply chain management (M = 4.11 SD = 0.96)
5. Linking BIM elements to construction materials and services (M = 4.06 SD = 1.03)

Of the top five, the top two are not explicitly BIM specific skills rather prerequisite skills required to work on a BIM contracted project. Traditional contract knowledge / process / methods and traditional construction installation methods are both "traditional" construction management skills and competencies. Individuals will still need to understand the basic construction contact processes. These "traditional" skills will be supplemented with BIM in the next five-years. Based on this study, older contract delivery methods will not be abandoned in the next five years for newer contract delivery methods. Building Information Modeling will supplement the traditional methods of project delivery.

The remaining three skills are "new" construction management skills and competencies that have come about due to BIM usage in industry. Model-based quantification, BIM-based supply chain management, and linking BIM elements to construction materials and services are "new" skill brought out by BIM. Model-based quantification will still require some "traditional" skills to verify that the BIM model accurately quantity estimates.

The last two "new" skills refer to an efficient supply chain program for BIM. Literature shows construction projects are plagued with waste in material relating to such things as on site material storage and material movement. The panel revealed that in five years of utilization of BIM the efficient supply chain management will become more prevalent. Although not explicitly stated by this panel, this links to a new movement to a "lean construction" project delivery system that emphasizes efficient materials handling to eliminate waste on construction projects.

The top five other, not included in the construction BOK are:

1. Written communication (M = 4.72 SD = 0.57)
2. Ethics (M = 4.67 SD = 0.59)
3. Interpersonal skills (M = 4.61 SD = 0.70)
4. Verbal communication (M = 4.61 SD = 0.61)
5. Leadership (M = 4.56 SD = 0.62)

Of the top five, none are explicitly BIM specific skills. Rather, they are skills related to being a construction manager in five years using BIM. Due to the teamwork required of a true BIM project, ethics, interpersonal abilities, verbal facility and leadership skills will be very important, as recognized by this Delphi panel. A true BIM project places all members of the team on the same side and removes the adversarial nature of a traditional construction project. Therefore, these skills align with research on what BIM should look like. The final skill, written communication, is important because of the nature of construction, being able to communicate intent and requirements efficiently through writing. This has been and will continue to be a necessity in the industry.

Discussion

Implications for Construction Management Education

Curriculum developers and instructional designers should find this research particularly useful. In reflecting on the findings it is worthy to note that BIM education is not as simple as a technical skill or learning a piece of software. On the contrary, true BIM education within construction management should encompass and integrate much more. A major focus of this research was skills and competencies a construction manager would need in the area of BIM, so it was expected to see evidence showing traditional CM skills incorporated into the responses. What was not expected is the prevalence for traditional skills in the area of BIM for CM that is required for the CM professional. This speaks to the fact that BIM is not has diffused within the industry as some people believe.

Suggested implementation

The first implementation option would be to provide additional course work in the areas of the skills and competencies identified. As part of the program of study for Construction Manager's schools can add additional courses in order to teach necessary BIM skills identified in the BOK areas of study. This method would require at a minimum four additional courses of study leading to a degree in Construction Management (one for each BOK). Each BIM course should be sequenced after the theory of the particular topic within the BOK. For example, a student would complete a traditional scheduling course followed by a course in BIM scheduling. The BIM scheduling course would be based on the theory from the previous course and add in the technical BIM skills required of a scheduler. Although this method would provide a very in depth education of BIM and theory of CM, adding additional courses of study into an already crowded curriculum may not be feasible.

A second option is to add BIM modules into existing courses as required covering skills and competencies identified. This option would require curriculum developers and instruction designers to develop individual BIM modules for each course. The BIM modules should be taught after some theory or "traditional" construction management is delivered. For example, in a scheduling course, theory of scheduling would be taught (use of Gantt charts, critical path methods) and following the units on the theory, the students would be instructed in methods to schedule using BIM tools. There are some concerns with this methodology. Foremost, in order to use BIM tools for advanced functions a complete model must exist. So where will that model come from in order to overlay the schedule? Next, there is a time constraint in each of the courses. Where will the instructors find the time?

A third and most progressive option would be to use BIM as a complete curriculum delivery. With this philosophy curriculum developers and instructional designers would seek to replace the traditional course delivery methods by using BIM to deliver instruction. For example, the theory of scheduling would be integrated into BIM scheduling. Therefore, students would utilize BIM tools as a complete learning platform for the course. The first issues with this curriculum delivery is that very few individuals are proficient enough in BIM to integrate this methodology fully. Another issue is a concern of losing out on the traditional knowledge required of CM's. This research found that CM's would still need traditional CM skills and competencies; these will be overlaid with BIM knowledge. Although, research has shown that BIM can be used to efficiently deliver instruction, in five-years the industry may not be completely ready for this integration because many industry members, especially those not fully supporting BIM may not hire graduates. As BIM is implemented into a curriculum student skills and competencies need to match industry demands, this methodology may be too progressive. If graduates only have the most progressive skills and competencies (BIM) and construction management firms are only using traditional methods the skill set possessed by the graduate and the skills required by the employer would not match, resulting in inability to gain employment.

Conclusion

Although BIM is a new technology and many believe it will revolutionize the way construction managers do business, this study revealed an interesting trend; traditional skills are still relevant and required of a successful construction manager. Although this research identified many BIM specific skills, many of the top five items in each research question were related to traditional "hands-on" knowledge.

This research shows that BIM can change the way construction managers work but they will not abandon the old skills for "new" BIM. Building Information Modeling is an additional tool to be used to more efficiently perform items identified in the body of knowledge. Although BIM skills were identified in this study, it was notable that the need for good written communication, interpersonal facility, and ethical skills ranked very high in the other skills question. A major finding of this research is the new soft skills that BIM will require. Traditionally, construction mangers had clearer lines in contract and work expectation. BIM's collaborative nature is changing how construction managers complete work. As a result soft skills ranked very high in this study.

Currently many construction management programs are working to integrate BIM into curriculum. Integration should be completed in a prudent manner. Integration of BIM is an important step to stay current with industry trends and prepare the next generation of construction managers. Nevertheless, the traditional methods should not being replaced. Building Information Modeling can supplement the traditional knowledge bases and methods of construction management.

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