

Industry's Expectations of Construction School Graduates' BIM Skills

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Academia is expected to take a role in directing the industry and preparing the students for its needs. To do this, input and feedback from the industry are necessary. This paper presents the results of a survey sent to 180 regional, national, and international construction companies in the US to ask their opinion on Building Information Modeling (BIM) and what they expect from graduate of construction programs who will eventually become their employees. This survey is part of a larger research which aims at diffusing BIM into curricula of construction programs at Virginia Tech. This research mainly investigates if the industry is looking for a basic knowledge of BIM in its applicants, or it is interested in software skillful job applicants. Areas which are better to invest in at the construction schools for current and future of the industry is the other main question of this research. These points worth investigation because “learning curve” is mentioned as the main barrier of implementing BIM in the industry.

Key Words: BIM, Pedagogy, Survey, Industry

Introduction

Although the Architecture, Engineering, and Construction (AEC) industry is often criticized for its slow adoption of technology, BIM is one of the technologies which has gained momentum in this industry (Johnson and Gunderson, 2009). Today, many construction companies are involved with BIM by any means. Large owners, like GSA, define requirements for “spatial program BIM” on all major projects (GSA, 2006). While some researches in academia introduce BIM to industry and develop it, this trend must in turn be underpinned by educating and training BIM users and preparing future industry participants by modifying the curricula of construction programs.

The pathway of this industry should be observed and analyzed to better prepare construction students and keep education in line with the needs of the industry. This research aims to find such immediate and future expectations of construction industry.

Background

Suermann and Issa (2009) published a paper on the impacts of BIM on the construction industry. Through data collection in three surveys, they assessed perceptions about the impact of the implementation of BIM on construction projects. Survey questions centered on six primary construction key performance indicators (KPIs) commonly used in the construction industry as accepted metrics for assessing job performance. These include: quality control (rework), on-time completion, cost, safety (lost man-hours), dollars/unit (square feet) performed, and units (square feet) per man hour (Suermann and Issa, 2009). The results of this research showed positive acceptance by the construction industry towards using BIM in projects.

Johnson and Gunderson (2009) studied the activities of ASC members of construction programs relative to several recent trends including BIM. They surveyed 126 ASC administrators for member schools with a 34% response rate. The results indicate a wide range of adoption approaches of the identified trends. However, they did not address the specific teaching and the material they cover in their courses.

The research performed by Taylor et al. (2008) studied several discrete courses in which BIM were addressed. The courses cover introductory topics to BIM, CAD, and 3D modeling. They believed integration of BIM into academic construction programs should not be like a silver bullet shot into an already packed curriculum, but rather diffuse the topic to all the related courses in it. In their research, they did not indicate how those courses were designed or how the courses had incorporated industry needs.

Methodology

This research was one part of a wider research on diffusing BIM into curricula of construction programs at Virginia Tech. That research considered the potentials of BIM, needs of the construction industry, and ideas of professionals of construction at this school who teach BIM related courses. These would be checked against current curricula of construction programs to figure out the best way to diffuse the concept into them.

Since the authors needed feedback from an appropriately large sample of the construction industry, they decided to conduct a web-based survey rather than oral interviews to save more time and obtain more results quicker. To conduct this survey, a couple of online web surveys were evaluated and Qualtrics's service was selected.

After getting the certificate from the Institutional Review Board (IRB) of the university, the survey link was sent to a group of general contractors and some sub-contractors. In order to submit the survey to a sample group of contractors which sufficiently represent the US construction industry, the researchers decided to consider the ranking of US general contractors in Engineering News Record (ENR), which ranked 400 general contractors nationwide, and made a sampling of them. A higher response rate was anticipated if the survey was conducted between the general contractors and sub-contractors who were affiliated with Virginia Tech. The survey was sent to the selected firms and asked the recipients to forward the email to the contact persons in the company who have direct experience with BIM at the project management level or above, or those who oversee their BIM departments. The survey was sent out on August 31st to 180+ construction companies, and the deadline for returning the survey was set for September 10th. A reminder email was sent to them on September 8th as well.

Description of the Survey

Following the introductory page, the survey was composed of four parts (the survey is presented in the appendix):

1. Demographic data of the company
2. Position of the interviewee
3. Company's exposure to BIM and its experience with BIM
4. Expectations of construction students upon hiring.

In the demographic section, the authors tried to avoid usual marginal questions (Suermann and Issa, 2009) like genre, age, etc. After asking about the company name, which was optional, they were prompted to select the types of the projects they were dealing with. The rationale behind this question was to confirm that companies who deal with high profile projects usually implement BIM. They were asked about their contractual role to see the effect of contract type and contractual role on implementation and the way they implement BIM. The fourth question was about the volume of contracts in order to both double-check the diversity of our sample and to evaluate the effect of the company size on BIM. The other factor that indicated the size and concentration / separation of the company was the geographical spread, and was the subject of the fifth question. The number of employees was the last factor for investigating the demographic data of the company.

The second part of the survey investigated the person who was taking the survey. After asking their position in the company, they were asked how exposed they were to BIM. This was to verify the survey taker's level of expertise in BIM. It helped to evaluate his answers, by observing the effect of his knowledge on his responses and comparing them with other respondents. The following question asked about their academic background, job positions so far, and especially BIM related positions.

The third section investigated the company's exposure to BIM. The main parts of this section were questions 13 and 14. The goal of questions 13 and 14 was to ask about the specific areas in which the company was implementing BIM. At question 13 they selected the areas they implemented BIM from a list, and defined if they implemented them in-house, out-sourced them, or did not implement them. The options they implemented (either in-house or out-source) would be transferred to question 14, to specify the software they used and the process they took. Question 14 was designed to double-check the answers of question 13 to avoid counting on errant answers. Questions 15 and 16 separately asked their opinion about barriers of implementing BIM in the areas in which they do/do not implement BIM. Question 17 aimed to find a measure for the size of BIM implementation in their company and asked for the number of specialized employees they had in BIM. Question 18 and 19 targeted the same goal by asking the structure of the BIM committee in their company (if they had one), and the way they taught BIM skills and concepts to their employees.

The last question in this section asked about the spread of BIM and how dedicated they were to BIM. It asked if they concentrated BIM in one department separate from other, or if BIM was a general skill and culture in their company.

After evaluating the company and the survey taker, part four started to ask directly their expectations of graduates of construction schools. The first two questions asked which aspects of BIM were more important for them. Question 21 wanted them to prioritize five general aspects of BIM which were listed as:

1. Model specification
2. Model validation
3. Model access management
4. Model version control
5. Interoperability (file import/export related)

They were asked to rank them from one to six when one stood for the most important and six for least important. The "other" option was provided at the end to let them customize their answer. Question 22 used the same list from question 13 to ask which areas they felt they would be hiring for in the future. For each area, they selected if they needed it immediately, in the near future, or in distant future. In this question they expressed their needs in the areas they defined at question 13 in which they did or did not implement BIM. To see how specific, precise, and experienced they were in hiring BIM-knowledgeable applicants, question 23 asked them about the method they used for evaluating their job applicants.

To be able to find a basic direction for the curriculum, the authors asked them if they preferred their future applicants to have a conceptual knowledge of BIM or if they were looking for skillful employees on BIM software packages. The option "both" was provided for either more comprehensive or more conservative answers. The last question was a supplementary to this question in case they needed applicants skilled in software. It asked which software packages they expected their applicants to know.

Survey Results

Forty two companies replied to our survey which returned a response rate of 23%. They were able to select their project types between six categories: Residential, Commercial, Office Buildings, Civil / Infrastructure, Industrial, and Retail. Commercial and office buildings were among the most answered project types with 91% and 72%, and the least answers were on residential and infrastructure projects. Design-Build and Construction Manager were two top contractual roles that our respondents took in their projects. The third question showed we had a good sampling for our research; the annual revenue of the companies surveyed varied from less than a million up to 9 billion dollars per year with average of \$650M and standard deviation of 1580, which indicated fairly varied types of companies in our sampling.

US official regions based on Census Bureau information was used for the geographical spread of projects. The authors categorized the companies regarding if they worked on one, two, three, or four regions (nationwide). More than half of the interviewed companies were working on projects on one region, while 12% of them were nationwide constructors. Three companies between them (7%) were international companies.

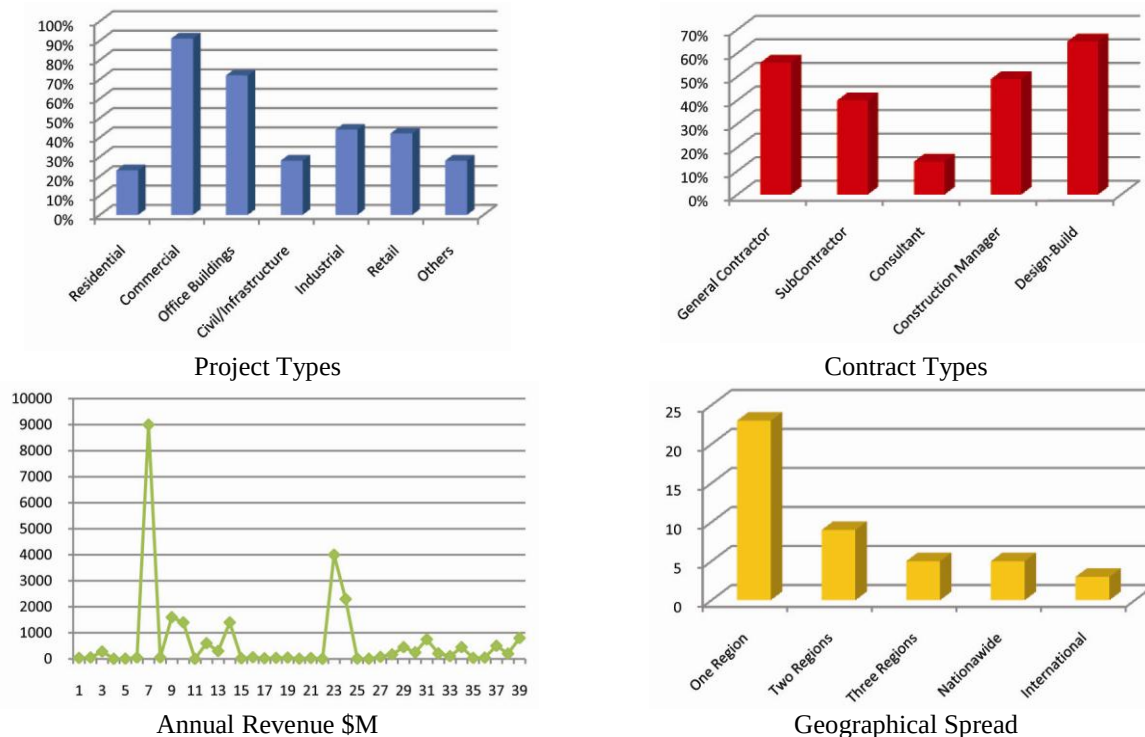


Figure 1: Demographic data of the companies

The number of employees within each company varied between four and 5000. The average of this statistics was 580 with a large standard deviation; ~1120. The seventh question was about the position of the survey taker in the company. Since it was an open question, the authors grouped the answers into four categories: Executive (President / VP / CEO), Sectional Manager, Project Manager, and PE / BIM Manager. Most of the respondents were on executive positions which made roughly 60% of the survey takers. Sectional Managers were in second place with 22%. Half of the respondents had enough self confidence with their exposure to BIM that they claimed to be fully exposed to it. More than half of the remaining survey takers claimed they only had a limited or indirect exposure to BIM. This shows that the responses from survey takers were reliable. It is necessary to say that not all of the survey takers took it up to the last question.

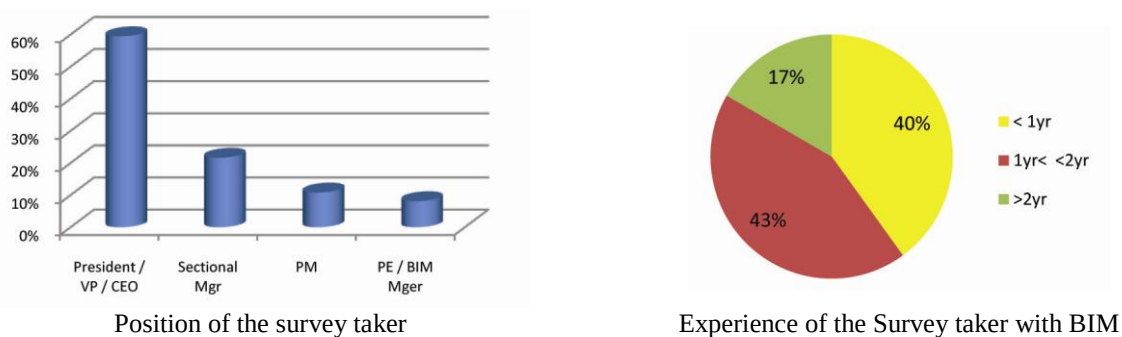


Figure 2: Information about survey takers

Survey takers were asked to describe their experience with BIM from “less than a year”, “between one and two years”, and “more than two years.” The majority of survey takers (43%) had between one and two years of experience. The authors believed the results of question seven were enough to skip question ten at this level of evaluation. Question eleven showed that 80% of the respondents had at least one academic degree in any architecture or civil related program.

While less than 20% of the surveyed companies had no experience with BIM, approximately the same percentage had more than five years of experience showing that the true industry pioneers of BIM were among our survey takers. Experience less than a year and between one to five years were around 30% each.

Four of the responding companies did not have any employees who worked on BIM, while the larger companies had totally around a 100 employees in their offices nationwide. More than half of the respondents (54%) had five or less employees who directly worked with BIM. Figure 3 illustrates their answer to question 13. “Constructability” and “Visualization” were two areas in which they used BIM more than the other areas. There remains the possibility, however, that they did not notice the difference between BIM and VDC and they considered both of them under the same umbrella when answering this question. This was the most controversial question of this survey that must be discussed more in the research that this study is part of. Although the next question, question 14, was designed to double-check their responses to the current question, the authors decided to stop discussion and leave it for another forum.

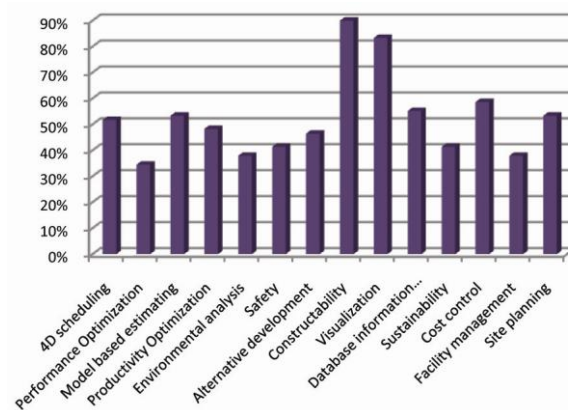


Figure 3: Areas surveyed companies implement

Question 15 was an open ended one asking about their opinion on the barriers of implementing BIM. Although this was an open question, the answers were not very different. The authors categorized the answers into six groups:

1. Learning curve / not having trained personnel
2. Cost / time
3. Reluctancy of “the others” e.g. owner, sub-contractor, designer, supplier, etc.
4. Interoperability / shortages of software
5. BIM is not developed enough yet
6. Legal / contractual

The first (learning curve / not having trained people) and the third (reluctancy of “the others”) group were the most answered ones with 30% of the responses each, followed by Cost/Time concerns with 18%. As expected, when asked about the barriers of using BIM in un-implemented areas, the answers were different from the areas they used BIM. For that question, the answers are grouped:

1. Cost
2. Learning curve
3. Software Shortage
4. Reluctancy of “the others”
5. The importance is not explored / knowledge is too limited

For this question most of the answers fell into the last group “The importance is not explored / knowledge is short” with a large difference from other answers. About 45% of the responses fell into this category.

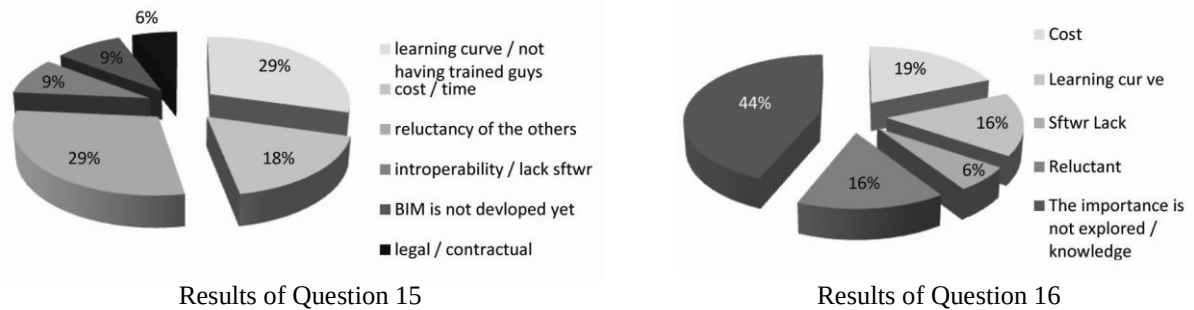


Figure 4: Barriers of implementing BIM

The answers they provided to explain the way their employees learn BIM knowledge and skills were categorized into five groups:

1. Self-Learning
2. Seminar / workshop / webinar / industry instructed
3. In house training sessions
4. Hiring previously trained personnel

Seventy-five percent of the responses related to categories two & three. This means that companies felt themselves responsible for teaching their employees this cutting edge knowledge. Twelve companies had an official BIM committee which showed how the issue was respected in their company. The committee members ranged from two up to 90 (total number of members from all offices within one company), while the number of positions in each committee ranged from one to six. Question 20 asked them if they had a dedicated department which handled all BIM affairs, or if the policy was that everybody in the company had to know BIM to manage his/her affairs. 32% of the responses showed there was no established policy regarding BIM, while the majority of responses (41%) showed the existence of a central office for BIM. This revealed that BIM was in the initial phases of use in their companies. Four companies out of 23, which completed the survey, announced their policy of requiring everybody to have BIM knowledge, and two companies claimed that in addition to requiring functional BIM knowledge, they also had a central BIM department.

The last five questions asked their opinion on different areas of BIM, to be used directly on course design. They were asked to prioritize five functions of BIM. They prioritized these functions as follows:

1. Interoperability
2. Model specification
3. Model access management
4. Model validation
5. Model version control

Question number 22 asked directly which skills they looked for when hiring an applicant. Again “Constructability” and “Visualization” were in the most demand between the mentioned areas. They were in such high-demand that construction companies asked for them “immediately.” “Cost Control” and “Model based Estimating” were the most demanding areas for the “near future”, and “Environmental Analysis” and “Facility Management” were the ones which got the most votes for the “far future”. This meant these two areas were not concerns of the industry at all.

The 23rd question of the survey asked them how they evaluated BIM knowledge of applicants. “Asking technical questions” was selected by 75% of the respondents, followed by “relying on students’ resume” which was selected by 50% of the companies (they could select more than one answer). The authors found the most interesting response to this survey in question 24, which asked if their primary expectation of applicants was conceptual knowledge of BIM or their proficiency in software packages. It was expected that the industry looked for immediate use of BIM tools, while the responses showed the opposite. 50% of the surveyed companies just looked for conceptual BIM knowledge while a mere two of them (12%) looked only at BIM software skills. The rest of 38% looked for both of them.

The last question, which was another open question, asked to see which software tools were more demanding to add to construction curricula. Two of them said they are not looking for software skills and they prefer conceptual knowledge. Among those who named software, Revit and NavisWorks, followed by AutoCAD were the most highly-demanded packages.

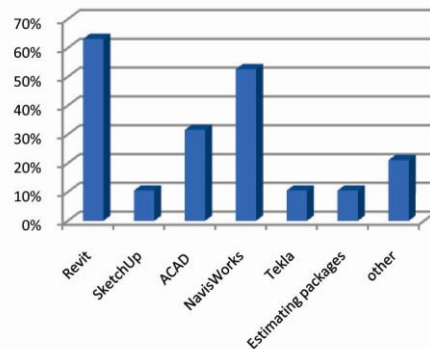


Figure 5: Proficiency in the needed software

Conclusion

In order to prepare students for their future jobs, the employer's needs assessment is an inevitable part of the study. The main findings of this survey revealed the attention of the industry on employing those who have a deep conceptual knowledge of BIM rather than hiring those only skilled on using BIM software. The survey illustrates that although the companies want all of their employees to know BIM, currently most of the companies concentrate on developing a specialized department support for BIM. The authors are currently conducting a follow-up study with a focus group of construction companies that will further identify the core areas of BIM knowledge and competencies they are looking for in construction managers.

Employers mentioned the learning curve as the first barrier for implementing BIM. Lack of understanding of what BIM is, what it can do, and what its capabilities are, were the other important factors which prevent construction companies to further pursue the implementation of BIM. Therefore, while this research reveals the needs of knowledgeable BIM experts, it indicates a few directions in which universities can prepare their graduates.

Acknowledgement

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Appendix A

Section One: Demographic data of the company

1. Company Name
 2. What are (is) the primary type of projects that your company delivers? (select all that apply)
Residential | Commercial | Buildings | Office | Civil/Infrastructure | Industrial | Retail | Others
 3. What are your company's primary contractual roles? (select all that apply)
General Contractor | Sub-Contractor | Consultant | Construction Manager | Design-Build | Others
 4. Total volume of contract per year (Annual revenue)
 5. Geographical spread of the company (Please list states for domestic work, and countries for International work).
 6. Number of employees
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Section Two: Position of the Interviewee

7. Your position in the company
 8. How exposed are you to BIM in your position?
 9. How long have you been working with or in the areas related to BIM?
 10. What are your work experiences in the industry/academia generally (positions, years)?
 11. What is your education background?
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Section Three: Company's Exposure to BIM and Its Experience with BIM

12. For how many years has your company implemented BIM?
13. Please specify for the areas you use BIM, which one you implement In-House, Out-Source them, or do not implement them.

4D scheduling	Performance Optimization	Model based estimating	Productivity Optimization	Environmental analysis	Safety	Alternative development
Constructability	Visualization	Database information management	Sustainability	Cost control	Facility management	Site planning

14. Which software packages do you use in each area? And what are the processes for implementing each area?

4D scheduling	Performance Optimization	Model based estimating	Productivity Optimization	Environmental analysis	Safety	Alternative development
Constructability	Visualization	Database information management	Sustainability	Cost control	Facility management	Site planning

15. What are the barriers of implementing BIM in the areas you are using BIM now?
 16. What are the barriers of implementing BIM in the areas you have not yet used BIM?
 17. How many employees specialize in BIM?
 18. How do your employees learn about BIM (select all that apply)
 19. Do you have a BIM committee (a group who steers the BIM activities of the company)? If you have one, please explain positions of the members of the committee, along with how many members they are. If you have employees who are semi-involved with BIM, please explain what their primary job function is.
 20. Do you have a dedicated BIM department that handles/supports all BIM requests in your company or do you require/plan to have all your employees to become BIM capable?
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Section Four: Expectations from Students upon Hiring

21. Please rank the areas of BIM knowledge that you think is most important.
Model specification | Model validation | Model access management | Model version control | Interoperability
 22. Which BIM skills are you looking for when you consider students for hiring? Please specify if you expect those skills immediately (1), in the near future(2), or in the far future(3)
- | | | | | | | |
|------------------|--------------------------|---------------------------------|---------------------------|------------------------|---------------------|-------------------------|
| 4D scheduling | Performance Optimization | Model based estimating | Productivity Optimization | Environmental analysis | Safety | Alternative development |
| Constructability | Visualization | Database information management | Sustainability | Cost control | Facility management | Site planning |
23. How do you evaluate the BIM knowledge of the current applicants of your company? (select all that apply)
Perform a test | recommendation letters on BIM skills | Rely on students' resume | Ask technical questions | Other assessment methods
 24. What is your primary expectation regarding BIM knowledge from your current/future employees?
Conceptual knowledge and understanding of BIM tools and processes | Proficient skills with BIM software | Both
 25. Which specific software packages do you expect your job applicant to know at the time of applying for the job?
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