EVALUATION OF TRAINING NEEDS FOR BUILDING INFORMATION MODELING (BIM)

by

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ABSTRACT

EVALUATION OF TRAINING NEEDS

FOR BUILDING INFORMATION

MODELING (BIM)

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The basic premise of Building Information Modeling (BIM) is to use and share the digital model of a project as a source of information for all participants, in order to simulate and analyze potential problems during the project's life-cycle, from conception to operation. BIM is a relatively new technology praised by all participants in the Architecture-Engineering-Construction (AEC) industry for its innovative tools, and the promise of a high return of investment and productivity increase.

The construction industry experimented little growth in productivity in the last decades, and is heavily relying on technology rather than intense labor in order to boost productivity. BIM is positioning itself as the productivity solution that the AEC industry has been in need of for a long time. As demand for BIM rises, many companies will be looking forward to implement cost-effective training methods and will see an increase in their current training needs as part of their BIM implementation plan. Little theoretical or quantitative research has been done related to training needs for companies in the AEC industry that are in the process of implementing or increasing the use of Building Information Modeling (BIM).

This thesis evaluated current needs and trends for BIM software training at a national level in the AEC industry. In order to gather information two sources were used. First, a literature review of the subject matter; and second, an online survey performed among 46 companies between March and April of 2011.

The survey results show that the cost of training staff to become proficient in BIM software can be high but justified by a high return on investment. The data collected shows that the average cost of training a BIM design technician ranges between $2,500 and $5,000, while the cost of training BIM users in managerial positions ranges between $5,000 and $15,000. Another significant result of this study is that in terms of training duration, BIM design technicians complete training within four weeks, while training BIM managers require from two to six months. Association of research and information gathered through the research survey also shows that regardless of the nature of the firms, a general trend is to provide training by means of in-house personnel rather than contracting external training companies. It was also found that most respondent companies are evenly split on whether training is provided using extended or intermittent formats. Also, the results show that basic skills, 3D modeling, and collaboration, rank high in the priority of training subjects.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF ABBREVIATIONS

AEC: Architecture-Engineering-Construction

AGC: Associated General Contractors of America

AIA: American Institute of Architects

BEA: Bureau of Economic Analysis

BIM: Building Information Modeling

CAD: Computer Aided Design

CIFE: Stanford University Center for Integrated Facilities Engineering

CII: Construction Industry Institute

CM at risk: Construction Management at Risk

CO: Change Order

GDP: Gross Domestic Product

IPD: Integrated Project Delivery

MEP: Mechanical-Electrical-Plumbing

NBIMS: National Building Information Modeling Standards

NIST: National Institute of Standards and Technology

RFI: Request for Information

ROI: Return on Investment

CHAPTER 1

INTRODUCTION

Construction companies of all sizes are implementing Building Information Modeling (BIM) to improve their bottom line in all major areas of design and construction phases. The basic objective of BIM is to use and share the digital model of a project as a source of information for all participants, in order to simulate and analyze potential problems during the project's life-cycle, from conception to operation. When the model is completed, a great amount of important data is available to complete the construction and procurement activities necessary to build and run the project.

Although BIM software is relatively new, it originates from Computer-Aided Design (CAD) programs that were widely developed in the 80's and were originally used to generate 2D plans (Eastman et al., 2008). However, the parametric building modeling structure of BIM software is very appealing for construction companies, and is being implemented at a fast rate because it overcomes many of the limitations of CAD programs that are geometry based (Williams, 2007).

Many different BIM software packages are out on the market for architectural and civil design; however, it is important to note that the transition between CAD and BIM consists not only of a software update, but the adoption of new processes and workflows in the project delivery. Transition to BIM affects the organizational structure of the company, and the delivery process itself. This thesis focuses on the software part of the implementation, and does not address other type of needs due to BIM adoption.

Using BIM software requires a high level of training, and although it shares some of the characteristics of 2D geometry based software, new users are exposed to a whole new range of features and possibilities that require the acquisition of new sets of skills, ranging from understanding the software potential to complex interoperability applications.

Proper training is critical to increase productivity gain. Some companies already have trained

or are willing to train employees that will become in-house designers, while others companies hire services of external firms for either training or outsourcing entire projects. In a general consensus, all segments of the construction industry agree that BIM basics is the most important training needed (McGraw-Hill Construction, 2008). In spite of this widespread agreement, training methods and procedures seem to vary according to the companies' needs and will be addressed in following chapters.

In general, designers, consultants, owners, contractors and facility management companies are taking advantage of BIM technology. BIM solutions can provide a wide range of benefits for Architecture-Engineering-Construction (AEC) companies that transition into BIM, depending on the scope and depth of the implementation. Some of these benefits are:

- Improved visualization of the project
- Facilitates the evaluation of different scenarios
- Facilitates generation of construction documents
- Facilitates construction coordination
- Enables the addition of schedule into de model, also known as 4D
- Enables the addition of cost into the model, also known as 5D
- Analysis tools that can be used for complex solutions

According to a 2008 SmartMarket Report by McGraw-Hill, about 50% of architects, engineers, contractors, and owners are using BIM technology at different levels. Numerous surveys and research show that construction companies are increasingly using applications such as clash detection, scheduling, and planning as some of the most effective BIM tools that show tangible results, which positively affect their bottom line.

1.1 Problem Statement

The construction industry represents a big percentage of the Gross Domestic Product (GDP) in the United States and around the world in general. Table 1 presents a steady increase in the construction industry between 1997 and 2005, and a decline in 2008 and 2009, which is consistent with the economic recession.

Table 1 - Gross Domestic Product (millions of current dollars) (BEA, 2011)

Construction - United States ($M)	
1997	346,739
1998	383,658
1999	428,385
2000	467,308
2001	490,525
2002	494,328
2003	515,929
2004	554,433
2005	611,652
2006	651,096
2007	661,206
2008	639,322
2009	578,329

Table 2 presents the compensation paid in the construction industry from 1997 to 2008 which has been uninterruptedly increasing from 1997 to 2006 and slightly dropped in 2007.

Table 2 - Compensation of Employees (millions of current dollars) (BEA, 2011)

Construction - United States ($M)	
1997	227,391
1998	251,982
1999	278,310
2000	307,282
2001	325,502
2002	327,835
2003	339,863
2004	357,371
2005	390,730
2006	425,827
2007	442,261
2008	438,038

Figure 1 illustrates a side by side comparison of the data provided in Tables 1 and 2. It is evident that within the last five years the compensation paid has exceeded the GDP contribution of the construction industry to the national economy. This is a clear indicator that BIM has come at the right time to revolutionize the AEC industry by finding solutions to increase productivity.

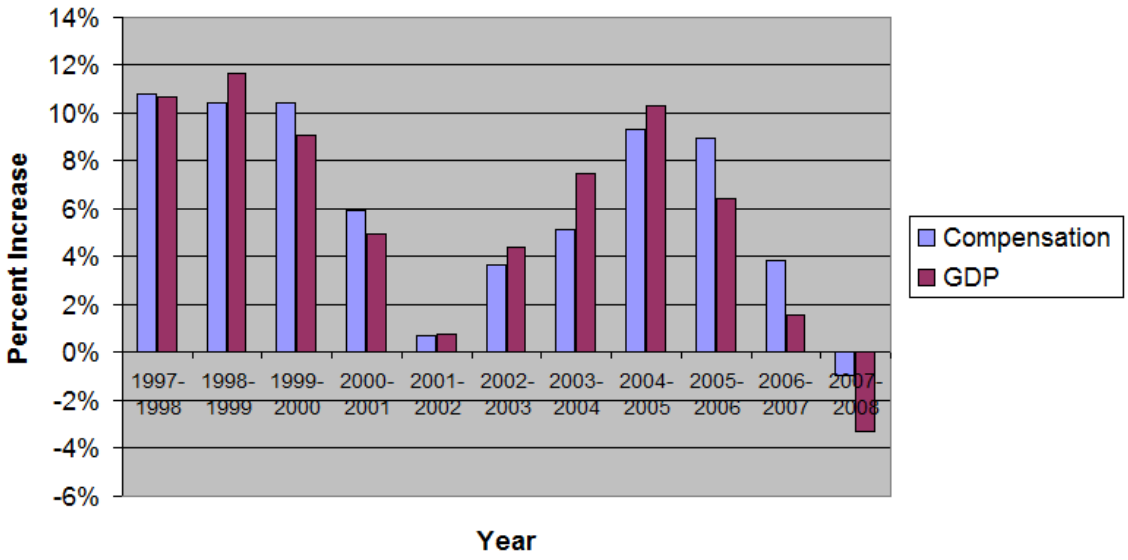


Figure 1 - Compensation and GDP Increase in Construction

It is somewhat complicated to pinpoint the specific factors that affect productivity because a breakdown of the compensation was not provided along with the statistics shown in Tables 1 and 2. However, it is known that lack of collaboration and information communication have contributed to the decrease in construction productivity over the last decades (Hardin, 2009). It is safe to say that if BIM can perform as expected, the communication process among all parties involved in construction projects that adopt BIM technology will be highly improved. As a result, the overall productivity of the construction process will increase, thus, stimulating the country's economy.

In an effort to improve productivity and, hence, the bottom line, AEC companies are implementing BIM at a fast rate. The implementation process begins with the clear establishment of company goals which facilitates the estimation of expenses related to the purchasing of hardware, software, and training

when implementing BIM solutions. Estimation of hardware and software are a relatively straightforward calculation; however, training is a budgeting item which is more difficult to estimate and directly affects the compensation expense within a company.

BIM training is a significant expense and a somewhat unexplored topic, which has not been extensively documented in part due to the relatively new concept of BIM. Therefore, research on this topic will offer very valuable information for companies that are either going through the process of BIM implementation, or have BIM training programs already in place.

Depending on the nature of the company, its role within the construction process, and the depth of involvement in BIM solutions, a company that is aware of its BIM training needs might have a smoother transition into BIM solutions. This, in turn, will enhance the project delivery process as a whole.

1.2 Objective of the Study

The objective of this thesis is to evaluate training needs and trends for BIM software training at a national level in the AEC industry. This thesis is mainly of a quantitative nature; however, it will be supplemented with a literature search of information available on the topic in order to gather valuable data that AEC companies can use at different stages of BIM implementation.

1.3 Methodology

In order to fulfill the objective of this thesis, it was necessary to collect information about current practices for BIM training in the AEC industry. Consequently, topic data and information are presented in two different ways: first, a literature research on BIM and BIM training, and second, a discussion of results from an online survey administered to 46 companies within the (AEC) industry. Finally, conclusions and recommendations are given based on the findings of the literature review and survey results.

1.4 Scope

The evaluation performed in this thesis has been limited to companies within the AEC industry in the United States that are currently using BIM solutions in active projects. Due to the unique nature of the construction industry and the particular of its project delivery systems, it is advisable that other types of industries that also use BIM solutions such as automotive, manufacturing, aerospace, management, and

others, develop a different approach in the evaluation of specific training needs. This study is not intended to provide an outline for training BIM users; however, future BIM implementation plans might find the information presented valuable when implementing comprehensive training programs.

1.5 Expected Outcome

This study aims to provide quantitative information about training trends and practices in the AEC industry. It is expected that the information gathered in this thesis can be used for AEC companies at different stages of BIM implementation either as a reference or as a point of comparison for their current or future training needs.

1.6 Chapter Summary

Building Information Modeling is a new technology that is being widely implemented by all participants in the AEC industry due to its benefits and high return on investment. The productivity levels of construction in the United States are considerably lower than other industries, and BIM technology seems to come at the right time to help boost the productivity levels.

In order to transition from CAD to a BIM environment, a proper implementation plan must be carried out. Proper training is critical within the implementation plan due to its high cost and the steep learning curve. As with any young technology, BIM is still not perfected and much research is yet to be done. This research aims to deepen into the training aspect of BIM technology in order to provide valuable data for companies that are implementing or increasing the use of BIM solutions.

CHAPTER 2

LITERATURE REVIEW

In this chapter, a general review on BIM and BIM training is provided to establish a context for the research. Due to the relatively new adoption of BIM in the AEC industry, the amount of information available about BIM training is very limited. Therefore, in addition to books and other published material, this literature review also includes technical reports and white papers from companies that specialize in providing BIM services or products.

2.1 Definition and Overview of BIM

The commercialization of the first personal computers at the beginning of the 80's inspired the creation of companies specialized in CAD software, that originally were used to generate 2D plans (Eastman et al., 2008). Since then, CAD programs have proven to be extremely useful for designers and constructors, and become standard in the construction environment.

The technological advances of processors and graphic capabilities, together with the conception of the World Wide Web at the beginning of the 90's, have allowed the creation of software far more advanced than CAD. One of the new technologies more widely accepted in the construction industry is BIM. The National Building Information Modeling Standards (NBIMS) Committee defines BIM as: "… a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition".

Although the concept of BIM has been around for over two decades, it just started to become very popular at the turn of the century (Eastman et al., 2008). BIM is both praised by construction industry groups for its outstanding features and its potential for developing customized attributes and 3D visualizations. But, as with any new technology, it is still under examination and some of its benefits are not entirely clear for potential or new BIM users.

The main advantage of BIM software over CAD is the parametric building modeling structure, because it will update and synchronize any changes in the model in all drawings and schedules. Furthermore, the updating process does not rely on the user to update the information. In contrast, CAD programs are geometry-based and the user is expected to update all the geometry affected by changes. Eastman, 2008, describes BIM models as characterized by:

- Parametric Components: Digital data with intelligent attributes and rules
- Non-redundant Information: Consistent data and changes that are automatically reflected in all views of the model
- Coordinated data: All views of the model are arranged in categories that facilitate construction.

It is important to note that using Building Information Modeling is not limited to the use of a software package, but it is rather a combination of software, collaboration processes, and workflows applied throughout the life-cycle of a project. Currently, the delivery process in the AEC industry remains fragmented, and it relies on 2D paper based drawing for communication. Claims due to errors and omissions, redesign, and improper sequencing of work, are frequent in construction projects that use typical delivery methods such as Design-Bid-Build and Design-Build (Villafana, 2011). The use of BIM allows project participants to make instant and synchronized decisions through collaboration, unlike 2D paper based models where the participants must make decisions based on given data that has been previously prioritized (Eastman et al., 2008). Figure 2 shows the distinctive collaboration framework of BIM, where all project participants work within a single model that contains all the information relevant to the project, and decisions that might affect more than one party are made using value engineering in a virtual environment.

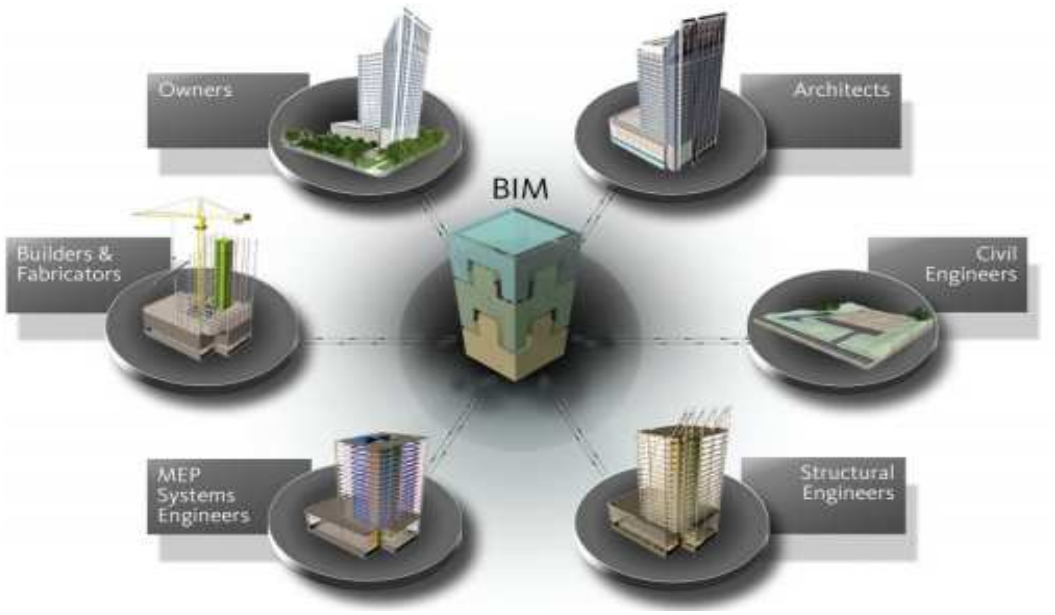


Figure 2 - BIM Collaboration Framework (Autodesk, 2011)

Figure 3 illustrates a typical BIM model as seen in a 3D view. Models like this allow running different types of sensitivity analysis, such as cost, schedules, energy, and clash detection, once the architectural, structural, and Mechanical-Electrical-Plumbing (MEP) models have been merged into one single file.

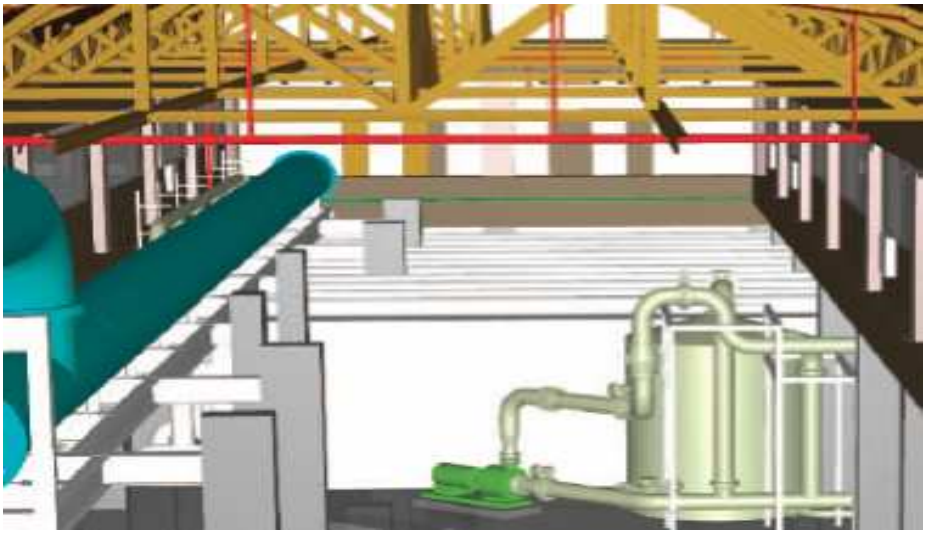


Figure 3 - BIM Model (McGraw-Hill Construction, 2009)

2.2 BIM Productivity

Historically, the level of improvement on construction productivity in the United States has been significantly lower than the increase of overall annual productivity. While the national productivity in 2002 was increasing at a rate of 2.7%, the productivity in the construction industry was increasing at 0.8% for the same year (Adrian, 2004).

During the last three decades the construction industry has continuously adopted new technological tools in order to help improve productivity; however, these tools tend to be implemented in stand-alone systems that do not allow for easy collaboration within the project team. Owners, designers, and contractors working on the same project have used different versions of the same software or different software altogether. In addition to that, CAD programs widely used up until today have been unable to effectively manage critical issues such as cost control and scheduling.

In order to successfully perform estimating and planning tasks, a company must be able to convey information to other project members. When lacking interoperability between companies and additional software needed to accomplish these tasks, the communication process becomes less streamlined because not all participants have available time and budget to implement new tools. In response to this deficit in organization and efficiency, BIM and the foundation of the Integrated Project Delivery method have focused on strong information sharing through the key elements of BIM, interoperability and communication. Many associations, including the American Institute of Architects (AIA), the Associated General Contractors of America AGC, and the Construction Industry Institute (CII) agree that the implementation of a fully integrated project delivery process in the construction industry will have a direct impact on productivity (NIST, 2009).

A research conducted by Autodesk in 2003 on architectural firms is illustrated on Figure 4, and shows the importance of BIM, where the productivity gain due to Revit© implementation ranges from 10% to over 100%.

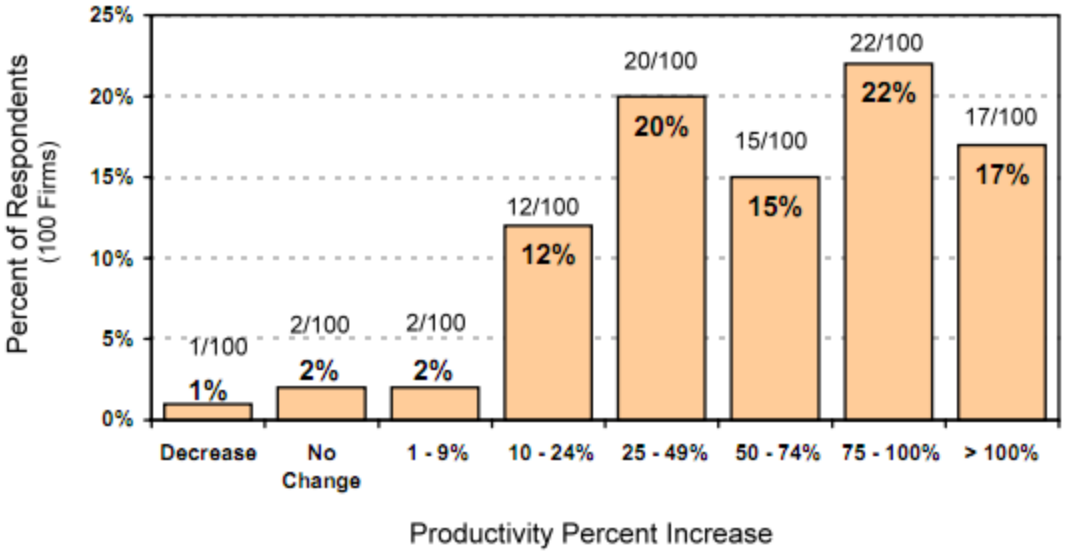


Figure 4 - Increase in productivity as a result of migrating to Revit© (Khemlani, 2004)

The use of BIM is encouraging the AEC industry to shift towards more collaborative project delivery methods; for instance, integrated project delivery (IPD). Owners that use these methods will be less likely to make changes to the design once they are able to see what is being built. A 3-D model will provide a better picture of the outcome of the project before the project starts, and any early changes in the model will be automatically reflected on the cost and schedule. This translates into less change orders and, consequently, better planning.

The AEC industry has been tracking the use of BIM in construction with many projects reporting productivity gain ranging from 20% to 30%, in addition to reduction of Request for Information (RFI) and Change Orders (CO) by a factor of 10 or more (CIFE, 2007). Table 3 presents the BIM's return on investment (ROI) for a few select projects in the United States.

Table 3 - BIM Economics (Azhar, 2008)

Year	Cost ($M)	Project	BIM Cost	Direct BIM Savings	Net BIM Savings	BIM ROI (%)
2005	30	Ashley Overlook	$5,000	$135,600	$130,000	2600
2006	47	Raleigh Marriott	$4,288	$500,000	$495,712	11560
2006	16	GSU Library	$10,000	$74,120	$64,120	640
2007	47	Aquarium Hilton	$90,000	$800,000	$710,000	780
2007	58	1515 Wynkoop	$3,800	$200,000	$196,200	5160
2007	82	HP Data Center	$20,000	$67,500	$47,500	240
2007	14	Savannah State	$5,000	$2,000,000	$1,995,000	39900
2007	32	NAU Sciences Lab	$1,000	$330,000	$329,000	32900

Based on Table 3 it is clearly not possible to either draw a conclusion or predict what would be the ROI's range for a construction project based solely on the BIM investment. This seems to be partly due the methodology used to measure the savings, and also due the actual scope of BIM on the project. However, it is clear that even for the lowest ROI at 140% the economic gain after implementing BIM technology is very significant.

A 2008 survey indicates that 62% of actual users will use BIM on 30% of their projects in 2009. It also shows that 82% of BIM users believe that their companies' productivity has increased. Also, 48% of BIM users actively track the return on investment of BIM (McGraw-Hill Construction, 2008).

Stanford University Center for Integrated Facilities Engineering (CIFE) reported statistics based on 32 major projects where BIM was used, and showed benefits such as (Azhar, et al., 2007):

- Cost estimation accuracy ± 3%.
- Up to 80% reduction cost estimating generation
- Up to 7% reduction in project time
- Up to 40% elimination of unbudgeted change.

Although many companies are focused on immediate productivity improvement benefits resulting from automatic drawing generation and collaboration capability, users will also capitalize on

other long-term benefits as they become more familiar with the software. These possible assets include faster and more effective communication of information, quicker simulations and adjustment of cost and schedule to name a few.

2.2.1 Measuring BIM Productivity

Due to the complexity of the construction industry and the numerous software packages available, many individual sources are able to produce information about the impact of BIM on the construction industry. However, it is important to notice the absence of an official entity that exclusively generates reports of BIM productivity.

In 2007, Autodesk presented an equation that takes into consideration many factors described in more detail later in this chapter, and uses them to calculate the first year ROI. This equation can be used to analyze the effect of productivity as follows:

$$First\ Year\ ROI = \frac{\left(B - \left(\frac{B}{1+E}\right)\right) * (12 - C)}{A + (B * C * D)}$$

Where:

- A = cost of hardware and software (dollars)
- B = monthly labor cost (dollars)
- C = training time (months)
- D = productivity lost during training (percentage)
- E = productivity gain after training (percentage)

This equation states that if the company is not more productive after the end of the first year, the left part of the numerator equals cero and therefore the ROI is also zero. In a better scenario, if the company doubles its productivity, then the labor cost is reduced in half (B – B/(1+1)) and the ROI will be 100%.

This equation demonstrates the importance of training to productivity. Three out of five parameters in the equation are linked to training itself. The first one is training time, which can be estimated based on the expected proficiency companies will achieve after training and the complexity of the projected projects for trainees. The main thing to plan for in addition to training time is the loss and recoup of productivity due to the learning curve during the implementation stage (Green, 2007).

Autodesk conducted an implementation Web Survey and cited half of the respondents in architectural practice having productivity gains close to 50%. In addition, about 20% had productivity gains close to 100%. Figure 5 shows the typical behavior of BIM implementation, where the initial productivity losses during implementation are quickly recouped and offset by productivity gains.

Autodesk reported that architectural firms that had just finished their initial training period had an initial loss ranging between 25-50%, but after three to four months of using Revit © continuously achieved the same productivity as with the previous software. After that, the increase in productivity ranged from 10% to over 100% as illustrated on Figure 4.

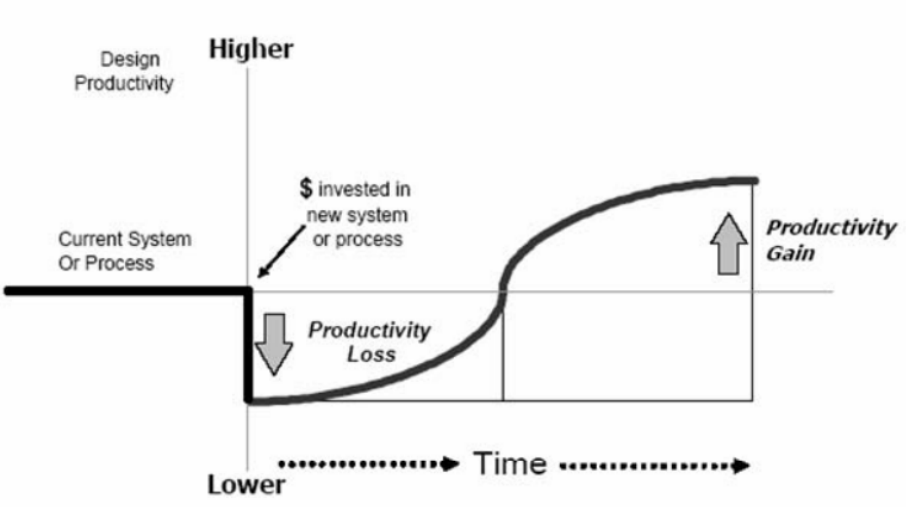


Figure 5 - Design Productivity during BIM Implementation (Autodesk, 2007)

It is safe to conclude that proper training enhances BIM's potential and increases productivity gain. Additionally, correct planning creates higher levels of productivity. Companies must be aware that

getting BIM models to perform optimally requires a combination of adequate hardware, correct choice of software, and high level of skill in the model itself, which in turn demands a proficiently trained staff.

2.3 BIM Training

In order to understand the different company needs at the individual and group levels, a company in the process of implementing BIM solutions must perform an assessment of current and future technical and human resources requirements (Ales, 2010). In fact, the assessment of available resources, more than any other contributing factor, guarantees a successful project implementation.

Careful consideration must be given to the assessment of training requirements, as receiving proper training presents one of the greatest challenges to BIM adoption. This especially applies to companies that have very limited staff with previous experience in BIM (Autodesk, 2008). Due to the high degree of sophistication, personnel who work with BIM software can only master it with continuous practice over an extended period of time. It is not advisable to train BIM users until the company has a training plan that allows for continued use of the software after the training sessions have been completed.

External companies and in-house staff, either separately or jointly, can deliver BIM training. In the first case, adequate external resources might be very limited depending on the geographic area where the company is located, and the nature of the company. Companies new to BIM more often use external training companies, which usually comes as a substantial expense that in some cases would affect the decision of whether to implement BIM. For many companies, migrating from 2D to BIM applications involves great cost, with difficultly to justifiable initial training costs.

Companies with more experience in BIM tend to have a formal BIM trainer or a BIM manager in-house that delivers training classes. Having these personnel within the organization benefits the companies through the reduction of training costs and facilitation of training customization (Green, 2007).

Although BIM modeling is based on computer aid drafting, it differs conceptually from geometric based CAD software. Therefore, companies new to BIM with users exclusively experienced in CAD can

easily underestimate the amount of effort and resources that must be put towards transitioning into BIM. In general, AEC companies seek out training for two types of users: office and field personnel.

2.3.1 Training for Office Users

Generally, design companies train personnel to work BIM software exclusively in the office. Office users include BIM design technicians, BIM managers, and other users with responsibilities exclusively related to the BIM environment. On the other hand, contractors might also need to train field personnel lacking expertise in BIM software, often only used intermittently in the field.

In order to facilitate implementation in the office, training should begin with the BIM manager and a small group of BIM design technicians (Green, 2007). A training program with a clear list of objectives must be set up in order to meet the company's demands. Before developing the first model for a real project, it is vital that all office users must have mastered the basic BIM skills. All the ACE companies perceive basic skills as the most important training need (Autodesk, 2008); some of these skills are:

- Understanding the purpose of BIM software
- Workspaces and interface
- Drawing and editing tools
- Use of object oriented 3D models
- Creation of details
- Plotting formats

The first group's main objective is to use the software in a project immediately after training in order to retain as much information as possible through practice (Hardin, 2009). The size of the first projects taken over by the BIM group vary from big to small; the company must make this decision based on financial resources and staff availability.

The first users that go through training most likely will take more time before becoming productive than successor groups, as they need to do the initial customization of the software and work out the majority of the system's problems (Eastman et al., 2008).

BIM trainers have a number of training methods at their disposal. Figure 6 illustrates popular training methods in relation to the structure required and the size of the groups.

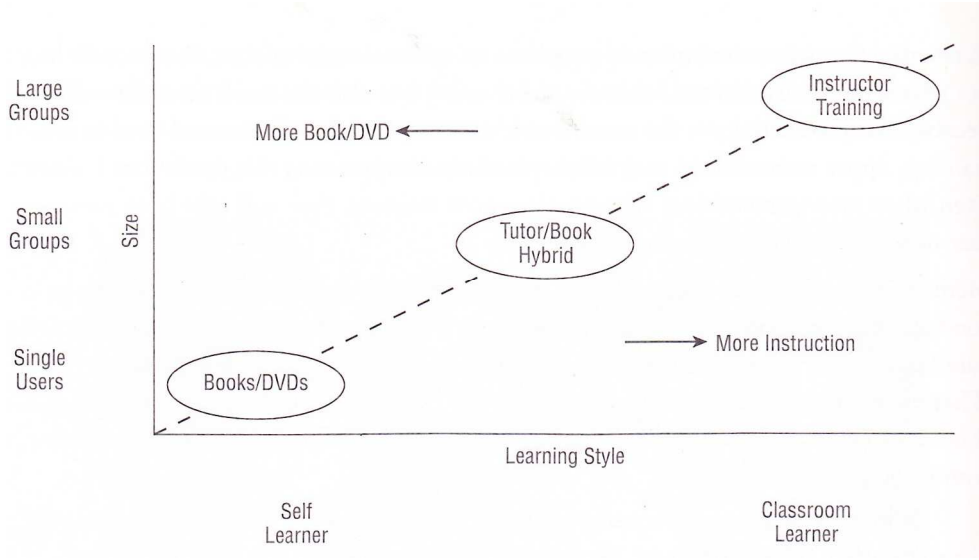


Figure 6 - Training Methods vs. Required Structure (Green, 2007)

The method of choice and duration of training is a decision that must be made by the company based on the company's objectives, and the financial, human, and technical resources available. Some of the most popular training methods are (Green, 2007):

- Traditional classroom training
- Leading in-house training
- Computer based training
- Traditional books and handouts
- Hands-on approach

After all basic needs have been satisfied and the teams are working on real projects, further training needs will arise and must be addressed through continuous training. One of the key factors that affect the level of productivity of BIM users is the gradual customization of the software and training material.

Custom components can be gradually implemented as needed and companies must provide continuous training in order to keep the company updated on methods, processes, and technologies.

2.3.2 Training for Other Personnel

BIM training is not limited to office personnel exclusively. In some cases, personnel not directly involved in the generation of drawings and documents also require BIM training; for instance, engineering staff and field personnel. This especially applies to construction companies that need project managers and superintendents who need to be BIM enabled in the field. For these users training must be relevant, concise, and specialized. Generally, the company sets up the organizational chart and decides the expected level of BIM involvement from each individual. Generation of RFI's, basic model updating, and in some cases punch lists and clash detection in the field are tools that field personnel are commonly trained on (Eastman, 2008).

Similar to the BIM design technician, the best scenario for training field personnel is to apply the concepts learned during training as soon as possible in a real project. Individuals who have been previously trained will not retain information for an extended period of time without real world applicability. If trainees do not apply the knowledge acquired from training soon, this might cause personnel to return to the old methods or procedures, which provide a higher level of comfort (Hardin, 2007).

The level of education and understanding of software can additionally challenge companies when training field personnel. New users might benefit more from one-on-one training in the field with more experienced users rather than relying on classroom group sessions or computer-based training. The following elements must be clear and available for field personnel to facilitate BIM learning (Hardin, 2009):

- A support system (in house or external)
- Basic understanding of the software functionality
- In-depth understanding of the benefits of new processes and why are being used

Once the field personnel feel comfortable with the adoption of new processes and software, the next step is to incrementally introduce more advanced features such as modeling and analysis tools.

2.4 Cost of BIM Implementation

BIM users represent all divisions of the construction industry and each company has different needs depending on its specialization, construction phase, and type of project. Designers, owners, and builders have particular requirements that up until today cannot be fulfilled by a single software package. The main costs associated with implementing BIM are the actual cost of the hardware, software, and training. In addition to these fixed costs each company might incur in additional expenses during BIM implementation such as network services, setup fees, peripherals, and others, based on goals that each company is trying to achieve with BIM.

2.4.1 Cost of BIM Hardware

The typical hardware components needed for BIM are similar to those needed for CAD software; but due to the advanced features of BIM, additional RAM, extended disk space, enhanced graphic cards, an network connections might be required (Hardin, 2009). The following items are an example of typical costs that a company might incur when implementing BIM (prices from 2009):

- CPU- Additional memory and enhanced graphic card: $2,400.00
- 32” HDTV LCD $1,200.00
- Dedicated Plotter-Printer: $2,800.00

2.4.2 Cost of BIM Software

BIM technology is still in its developing stage and there are several options in the market, including: Autodesk Revit©, AutoCAD Civil 3D, ArchiCAD, Digital Project, Bentley Architecture, Vectorworks, Tekla, Vico, and others. The choice of software is based on the needs of the company and must be carefully evaluated in order to get the maximum benefits with the minimum investment. If the implemented software does not match the skills of the user base, it provides no value to the company. Two situations may arise from this mismatch:

1. The users do not comprehend the software; therefore the software isn’t being used.

2. The users comprehend the software but there are not enough machines with the software installed.

In the first case, not being able to effectively use the tools will negatively affect productivity. In the second scenario, not having enough software resources will result in delays. Either way, software and user mismatches translate into money cost.

Regardless of the software choice, BIM software is a significant investment ranging from a couple of thousand dollars to several thousand depending on the number of licenses and capabilities of the program. For instance, the listed price for one license of AutoCAD® Revit® MEP Suite 2011 is $5,995.00; however, customarily the price varies depending on the number of licenses, subscription, additional tools, and technical support.

Companies that use 4D and 5D technology, as well as additional BIM analysis tools should include the cost of that software in their acquisition plan. Table 4 is an example of the cost of some popular software in 2009.

Table 4 - Cost of Additional Software (Hardin, 2009)

Software	**Cost (2009)**
Microsoft Office tools or equivalent	$300
Structural or energy analysis software	$1,000
Estimating software	$7,200
BIM model compiling software, such as Navis	$9,300
Software Subscriptions (After First Year)	$1,200

Companies can justify the software investment by performing relatively simple ROI calculations: the time that the user takes performing a task using old technology compared to the time saved using BIM. Nevertheless, the aggregated return on investment is far more complicated to calculate when labor and training are factored in.

2.4.3 Cost of BIM Training

Researchers have conducted little research on the specifics of BIM training, but it is known that the costs and the learning curve are often considered as a barrier for BIM implementation. Three different scenarios for training are possible depending on the company's resources and objectives:

- The company relies exclusively on external training
- The company relies on own in-house trainers
- A combination of both

When training is sought out from external companies, it facilitates the calculations of the direct cost of training. For instance, the price of a Revit© fundamentals class varies according to the service providers. A three day duration class for basic skills is $750.00 as reported by DKA Architectural Services in its website. Autodesk advertises another class for four days of training for $1,495.00. However, the actual total cost of fundamental skills training far exceeds the class price. As previous explained in section 2.2.1, the class amount does not take into consideration the productivity loss during training and other costs associated with the time spent in training sessions.

When companies have training resources available in-house the cost of training is significantly reduced, and can be customized to better fit the needs of the company.

Regardless of the training provider, the number of sessions that the BIM users must go through before reaching the desired productivity, even for basic skills, will vary depending on the goals of the company. The completion of a standard training program in fundamental BIM software skills does not guarantee trainees' readiness to take over a project. Many times, this basic training requires supplementation with extra training for procedures, standards, and best practices specific to the company.

Summarizing, the estimation of the cost of BIM training is a daunting task even at the company's internal level because of the multiple variables in the equation.

The author believes that the best approach for this estimation is to establish price ranges based on the overall analysis of information gathered through surveys, as the one performed in this thesis.

2.5 Roles and Responsibilities

In order to successfully implement BIM, companies must establish the roles and responsibilities of all key participants that are involved in the BIM implementation plan.

2.5.1 Upper Management

As the first step to guarantee a successful transition into BIM, companies must get full support from upper levels of management. As Villafana, (2011) explains, implementing new technologies like BIM have a deep impact on the organizational structure of a company because it affects workflows. Senior management makes decisions about software, training, best practices, and standards, and might tend to defend the status quo of the company (Deamer and Bernstein, 2010).

Upper Management must be prepared to set up a comprehensive BIM adoption plan. This plan should address not only training and roll out schedules, but also the work-flow and changes in the organizational structure (Rundell, 2004). The program must focus on the goals of the company, delegation of authority, and the selection of BIM users. It is very important that administrators involve all members of the management team in the decision making process, especially senior managers overseeing divisions directly impacted by BIM implementation, such as IT Managers and CFO's. If upper management does not understand its role in the transition, the chances that the adoption process might fail will significantly increase.

2.5.2 BIM Manager

The role of the BIM manager is similar to that of a construction manager as far as executing the project, coordinating information among all the participants, setting up the required tools, and heavily involving themselves in the decision making process (Hardin, 2009). In addition to that, companies must train BIM managers in all the software that the company uses in order to obtain comprehensive understanding of the BIM software applications and capabilities (Gu and London, 2010). It should also possess the ability to deploy and maintain all the software and hardware running properly. Some of the

responsibilities and skills of BIM managers are outlined in the article “The New ‘Must Have’ – The BIM Manager” by Dominic Gallego as follows:

- Understanding project flows and needs of the delivery team
- Set up of project structure and exchange formats
- Technical knowledge of BIM applications and network infrastructure
- Communication and training skills
- Strong teaching and coaching skills
- Objective decision making
- Flexibility and mobility

In general, a BIM manager should have a proactive approach towards implementation and a full understanding of the BIM environment in order to satisfy the company’s needs.

2.5.3 BIM Technician

As the front-end users of BIM software, BIM design technicians principally carry out the documentation of a building project. The role of BIM technicians is to work under the supervision of more experienced personnel in order to complete the modeling phase of a project according to directions from designers, engineers, or managers within a time frame. Companies must train design technicians from the outset to have a full understanding of the BIM software potential, basic skills, and industry standards.

In general, BIM design technicians bear responsibility for becoming proficient in the use of the BIM software and making it perform to the maximum of its capabilities following the company’s standards and best practices.

2.6 Requirement for BIM

BIM is rapidly gaining momentum. Research by McGraw-Hill Construction indicates that 49% of AEC companies have adopted BIM solutions at some level (Jones, 2009). Owners who have experienced the benefits of BIM more often seek out design and construction companies that are BIM engaged (Hardin, 2009). Owners tend to work with companies that have staff with specific job titles and functions related to BIM because this indicates commitment and recognition of working with BIM.

The General Services Administration, the US Army Corps of Engineers, and the states of Texas and Wisconsin are a few examples of entities that are heavily involved in the use of BIM technology. They also increasingly use BIM specific prequalification criteria to work exclusively with service providers that are BIM enabled (Eastman et al., 2008).

Research shows that companies in the AEC industry report high ROI returns due to BIM implementation. Furthermore, current users are starting to use BIM for all type of projects regardless of the size. Owners, designers, engineers, and contractors experience BIM benefits differently; however all parties perceive BIM as an investment that yields very positive results (Autodesk, 2008). This provides a good incentive for organizations that have implemented BIM solutions to start requesting their sub-consultants or sub-contractors to do the same (Ales, 2010).

BIM adoption is growing quicker than it was five years ago. Every year the percentage of companies that implement BIM increases. If this trend continues, in the near future BIM will become a standard rather than a voluntary commitment. Before the end of this decade, we will see the majority of AEC companies involved with BIM at some level in order to stay competitive in the market, just like decades ago when the same industry evolved from paper and pen drawings to CAD.

2.7 Chapter Summary

Building Information Modeling became very popular at the turn of the century but its concept has been around for over two decades. Although BIM has its roots in Computer-Aided-Drafting, the parametric building structure characteristic of BIM software offers unrivaled benefits compared to CAD. Research has shown that most companies which implemented BIM solutions have productivity gains ranging from 25% to 100% and a very high return on investment.

Understanding the training needs that arise from BIM implementation can help a company to improve its approach for transitioning to BIM technology. This chapter presents the factors that influence training and the roles and responsibilities of key personnel that training must be provided for.

CHAPTER 3

RESEARCH SURVEY

3.1 Objective of the Survey

An online survey was performed for this study in order to quantify data regarding practices and trends for BIM training at a national level across different disciplines in the AEC industry. This chapter presents the survey demographics and its participants. Chapter 4 presents a discussion of the survey results. Serving a vital part of the study, the discussion of results present new data of the BIM training needs within the AEC industry and, also, corroborate findings of the literature research. A summary report with raw data and percentages from the survey is provided in Appendix B.

3.2 Participants

This online survey was distributed to approximately 350 AEC companies of which 46 responded for an overall response rate of 13%. Companies' responses are and will remain anonymous according to the privacy statement agreement. The demographic information collected is broad in scope and will not allow for identification of individual companies from the information shown in the results. The companies were invited to participate in the online survey through personalized e-mails sent between March and April, 2011. In order to collect the information, the questionnaire was posted in the website keysurvey.com, which offers different types of membership, and also a free 30 day trial. Due to the number of responses received, a one-month membership was required for this survey with a total cost of $25.00. The geographical scope of the survey is at a national level, and the location of the companies that responded to the survey is shown in Figure 7.

Figure 7 - Company Locations

All the companies targeted in this survey belong to the ACE industry. At least 70% of the companies that responded to the survey were ranked in the 2009 Top 170 BIM Adopters list. Of those employees who responded regarding the position they occupy, 44 respondents (96%) held leadership, managerial, or executive positions within their companies, which strengthens the accuracy of the data collected. A breakdown of the respondents by firm type is presented in Table 5.

Table 5 - Breakdown of Respondents by Type of Firm

Type of Firm	**Response Percent Based on 46 Respondents**
Contractor only	24%
Architect only	30%
Architecture / Engineering	20%
Architecture/ Contractor	2%
Architecture / Engineering / Contractor	2%
Architecture / Engineering / Contractor / Consultant	2%
Architecture / Engineering / Consultant	2%
Engineering only	15%
Owner only	2%

The vast majority of these companies (up to 98%) are involved in schematic design, design development, and generation of construction documents. Between 80% and 85% are involved in predesign and construction services. Furthermore, close to 20% of the firms are also involved in fabrication processes, operations and maintenance, and a lower percentage (4%) are involved in post occupancy evaluation, and bidding-construction-administration.

Most respondent companies follow traditional delivery methods. A total of 91% of the organizations work with the well-known Design-Bid-Build method, followed by 82% that work with Design-Build, 68% use CM at risk. Finally, 48% of the companies use integrated project delivery. This delivery method is commonly associated with BIM because according to The American Institute of Architects. Its objective is to fully integrate project teams in order to take advantage of the knowledge and best available technology of all team members.

In order to establish a general profile of the companies, all participants were asked to respond to general questions relevant to the size of the companies in terms of number of employees and estimated annual revenue. Answers to these questions are presented in Tables 6 and 7.

Table 6 - Respondents' Percentage of Employees per Employee Range

Number of Employees	**Response Percent Based on 46 Respondents**
5 or less	0%
6 - 25	2%
26 - 50	9%
51 - 100	9%
101 - 250	30%
251 - 500	22%
501 or more	28%

Table 7 - Respondent's Percentage of Revenue per Revenue Range

Estimated Annual Revenue	Response Percent Based on 33 Respondents
5M - 25M	33%
25M - 100M	18%
100M - 500M	18%
500M - 1B	9%
More than 1B	21%

3.3 Questionnaire

The questions developed for this survey were primarily in a multiple-choice format, and focused on obtaining quantitative information about the respondents. A total of 39 questions were asked in order to determine current practices and trends for BIM training in the AEC industry. The full questionnaire as presented to the respondents is shown in Appendix A.

The survey was divided into three main sections. The first section was developed under the subsections Respondent Info, Company Info, BIM Usage, and Software. This section gathered general information about the nature of the firms, and the use of BIM software.

The second section asked questions about current practices followed before, during, and after BIM training. In analysis, this section is the core of the survey and provides data that allows for an extensive quantitative analysis about training practices and trends. The third section was intended to obtain professional opinion from the respondents in order to explore the perception of BIM among the respondents.

3.4 Chapter Summary

This chapter describes the methodology used in order to collect information through an online survey, and also provides demographics and general information about the 46 companies that responded to the research survey. Most respondents were big-sized construction companies with formal BIM

departments, and were ranked in the 2009 Top 170 BIM Adopters list. All companies surveyed belong to the AEC industry in the United States, and are currently using BIM in projects of all sizes in different stages of the construction process.

CHAPTER 4

DISCUSSION OF RESULTS

This chapter discusses questionnaire data from the online survey to which 46 companies from the AEC industry responded between March and April of 2011. Each company was asked to answer a series of questions related to their background and current training practices. The discussion of results is a vital part in presenting data that can be used to establish BIM training needs within the AEC industry, as well as corroborating findings of the literature research.

In order to facilitate the analysis of the raw data, this chapter has been divided in four subsections according to the organization of the survey. The first subsection is related to BIM usage and software, and the next three subsections are related to training practices before, during, and after the occurrence of training.

4.1 BIM Usage

BIM is one of the important technological advances in construction during the last decade, and has been gaining widespread acceptance across different disciplines in the AEC industry for a number of years. The survey shows that only 15% of respondents have been using BIM for more than 6 years, while 48% implemented it during the last three to six years. This confirms the statement that BIM is a young technology, and therefore it has not developed its full potential and many improvements are yet to be made. It is expected that similar to CAD programs, BIM software will continuously adapt and evolve over the years to meet the needs of the industry.

Companies from the entire AEC spectrum are increasingly using BIM for projects of all sizes (Jones, 2009). Figure 8 shows that the increase of BIM usage among the respondents is proportional to the size of the project, but nonetheless a significant amount of companies use BIM for small projects.

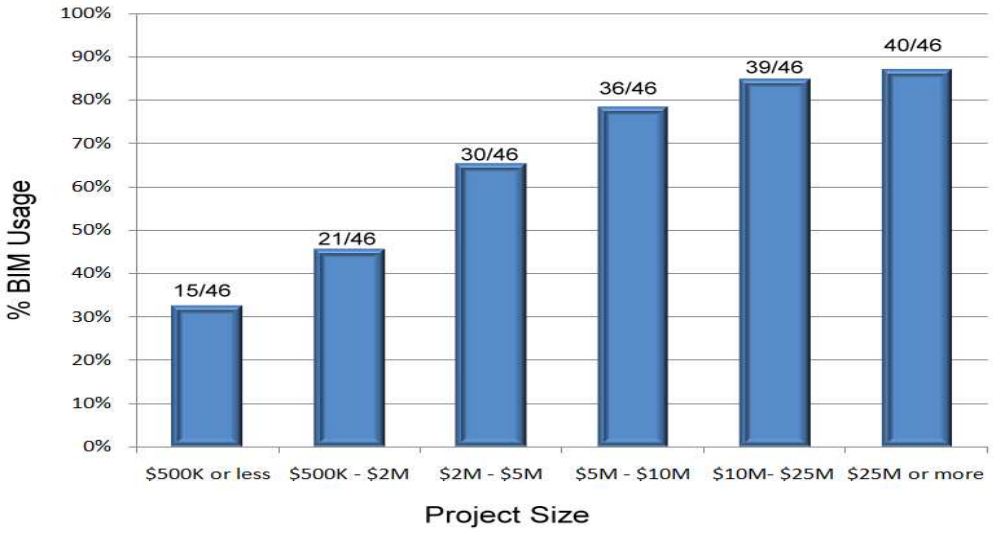


Figure 8 - BIM Usage by Project Size

4.1.1 Scope of BIM Use

McGraw-Hill Construction stated in 2009 that early adopters of BIM technology were likely to use BIM in 60% of their projects by 2011. The survey data collected for this thesis shows that this prediction is lower than expected as only 60% of the companies reported to use BIM in the vicinity of 60%; however, Figure 9 shows an upward trend where the revenue on projects that use BIM is higher as the total revenues of the companies increase.

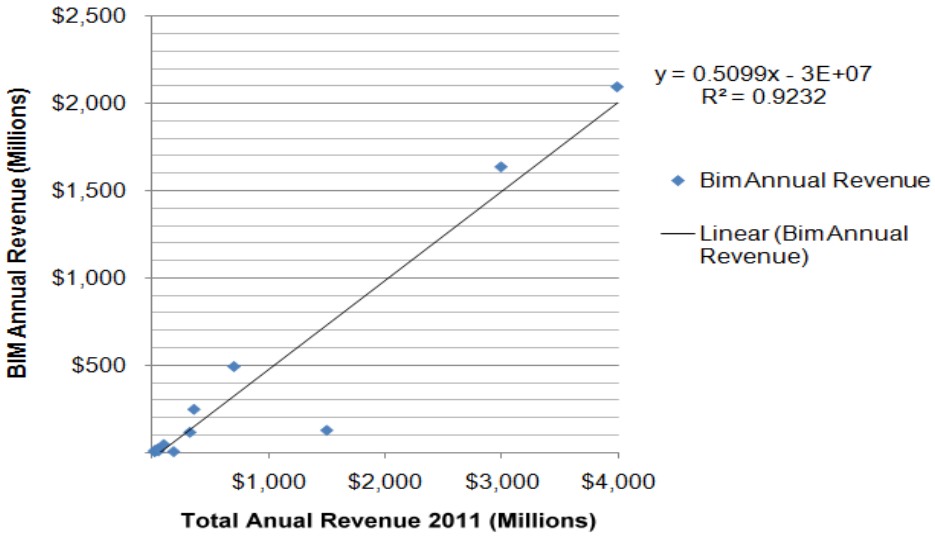


Figure 9 - Correlation Between Total Annual Revenue and BIM Annual Revenue

The high correlation value in Figure 9 indicates that companies with higher revenues are more likely to use BIM solutions for their projects than companies with lower revenues. This can be explained by the higher amount of resources that bigger companies can use in order to transitioning from traditional delivery methods to BIM.

Most participants (82%) do not to outsource any BIM related work. This is highly predictable and also consistent with companies that are training BIM users to work in their own projects, rather than hiring external BIM consultant firms. External companies that provide BIM training services employ highly trained professionals, and therefore are likely to charge high service fees (Hardin, 2007).

4.1.2 Use of BIM Software

Autodesk products ranked at the top of the list as the most used in the survey. Also, the majority of users agreed that Revit© software is easy to use, which in turns facilitates training. This finding is congruent with the actual market because a towering number of companies only provide BIM training services for Autodesk's software.

If training is available for given software companies are most likely to choose that software over other options. The survey shows that 48% of the firms take training availability into consideration when selecting the software. However, technical characteristics of the software weight more in the overall decision of the BIM package selection.

4.2 Before Training

4.2.1 Assessment

A comprehensive implementation plan must be created in order to successfully transition to BIM. This implies that a full assessment of the company's resources must be performed as explained previously on chapter 2. To perform this task, 39% of the respondents hired an external consultant to evaluate technical and human resources available for BIM implementation, while the remaining percentage performed the evaluation with their own internal resources. Almost 50% of the companies that performed the assessment reported that their hardware was not functional for the use of BIM software and had to be replaced.

This corroborates the fact that some companies might not be able to transition to BIM because of the high cost associated to equipment updates.

4.2.2 Evaluation of BIM staff

It is also important to evaluate the desired educational background and experience of the staff that will be part of the BIM team, because this evaluation typically predicts the person's ability to learn and to be instructed effectively (Green, 2007). Respondents showed preference for individuals with a high level of education to fill BIM positions to the point of almost ruling out candidates that hold less than an associate's degree. For high level positions within a BIM department some companies are already looking for candidates with background from architecture, construction management, and engineering that have been exposed to a BIM environment during school years (Hardin, 2007). University classes that involve the use of BIM technology are already available and are very desirable on the candidate's background because it translates into potential savings of companies training costs.

Due to the technical characteristics of BIM, current users of CAD systems are the most likely candidates to become BIM users, but must be retrained in order to take maximum advantage of BIM's potential (Rundell, 2005). Over 70% of respondents said that current BIM personnel had background in CAD applications before transitioning to BIM, which is consistent with the statement above. Respondents also noted that new staff had a low level of BIM expertise at the time of hiring. This indicates that companies looking for new hires with broad experience in BIM must be prepared do an extensive search as the market for this type of professionals is very limited.

4.3 During Training

4.3.1 Training Budget

The majority of respondents (70%) had a budget assigned for BIM training for the current year, while the remaining percentage seems to assign financial resources based on immediate needs. There is no literature about what approach is more beneficial for the training process, but it is the opinion of the author that having a budget assigned will help improve the structure of the training program. Table 8 presents the average budget that will be assigned for BIM training in 2012 categorized by number of

people in the BIM department. However, when surveys were individually analyzed it was clear that the arithmetic mean of the group does not reflect individual trends. Some companies within the same group have radical differences in budget availability. This might be due to numerous factors such as number of users that have been already trained, future software rollouts, and others. It is concluded that further data is needed in order to obtain reliable results in this subject.

Table 8 - Training Budget for 2012

Size of BIM Department (# People)	Mean for 2012	Response Total No.
5 or less	$36,313	8
6 - 25	$36,875	8
26 - 50	$25,000	3
51 or more	$386,667	3

4.3.2 Training Means and Methods

The respondents were asked whether they have a standard BIM training plan or not. The answers were evenly split close to 45%, and the remaining companies mentioned several variations to the standard plan:

- Trainees are rotated through training as new projects start up
- Training is mixed, based on need and discipline requirements
- Trainees receive core training plus additional specialized sessions

The survey shows that most respondents (79%) use their own BIM trainers and do not tend to mobilize trainees outside their facilities. Figure 10 shows the relationship between total annual revenue from projects using BIM and the percentage of training that is provided by in-house trainers.

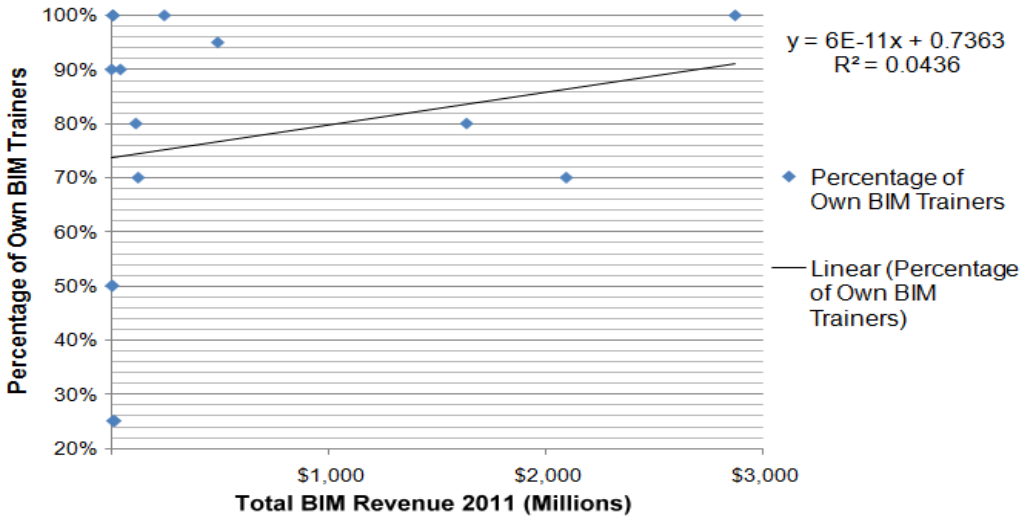


Figure 10 - Correlation Between Total Annual Revenue and Percentage of Own BIM Trainers

The low correlation factor shown in Figure 10 indicates that BIM revenue does not influence the companies' decision to use their own personnel rather than hiring external trainers. This might be due to the high cost of BIM professionals that render training services and the level of customization that BIM training requires.

An expected 80% of the companies created their own manuals for standards and procedures. This coexists with the idea that each company has different needs and must develop its own processes. Nevertheless, the origin of BIM training materials is equally distributed between materials created in-house and generated by external sources.

The survey shows a clear tendency to use group classroom training over one-on-one training, and also reveals that computer based self-training at workstations is recognized as the most beneficial for trainees. However, much research encourages the use of one-on-one training especially for users that might have more difficulties grasping the concept of BIM due to a lack of background in computer aided drafting.

Two options were given to the respondents related to the intensity of training: ongoing intermittent and extended training. The first one is designed to provide small amounts of information in

short training periods; for instance, training sessions ranging from two to four hours. This option was chosen by 40% of the respondents. On the other hand, 42% of the respondents preferred extended training. This is a multi-day intensive training where all day long sessions are common. The remaining 38% introduced variations to the two previous formats:

- Just in time training per project
- Monthly user groups
- Combination of short blocks and multi-day intensive

The main factors that respondents focus their training on are illustrated in Figure 9, it is important to notice that as highlighted in the literature research, the acquisition of basic skills before taking on a real project is crucial. The answers also show that most of the training time is spent in the BIM software features followed by workflow and protocols, and finally company and industry standards.

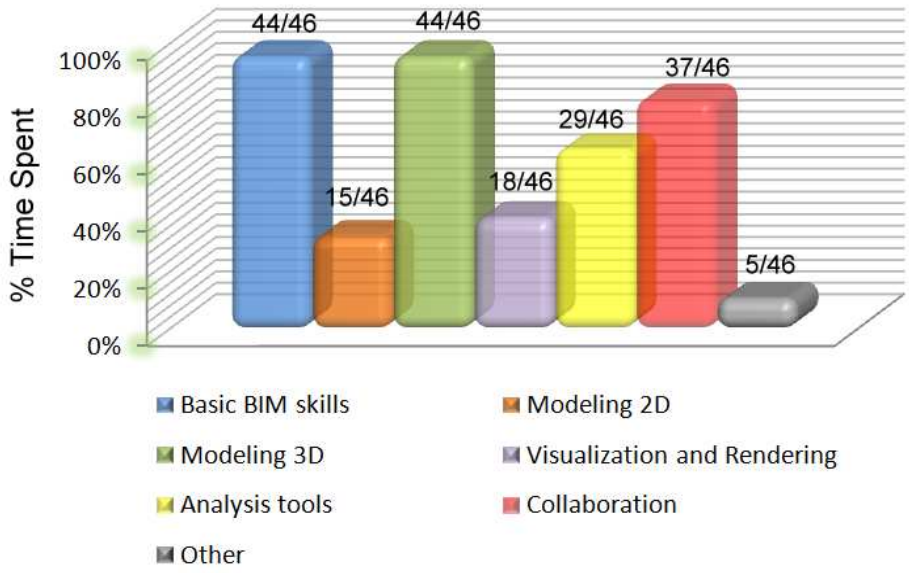


Figure 11 - Percentage of Time Spent per Training Subject

Figure 9 is also consistent with the specific areas that respondents would like new hires to have extensive knowledge of:

- Basic BIM skills and understanding of how the software works
- Best practices for BIM modeling/detailing
- 3D Modeling and detailing
- Construction means and methods, and knowledge of building systems
- Collaboration and coordination procedures
- Clash detection
- Estimating / Take-offs

4.4 After Training

4.4.1 Duration of Training

Training for BIM design technicians can be accomplished in less than four weeks according to 66% of respondents. On the other hand, training time for BIM managers was evidently higher with 20% of respondents spending between one and two months, and 36% more than three months to complete the training process as shown in Table 9. In addition to the initial training time, companies reported an average of 33 hours per year per trainee for supplemental training, which is typically provided to keep the staff up to date in software features and procedures.

Table 9 - Training Duration by Job Title

Job Description	**Response Percent Based on 44 Respondents**				
	2 Weeks or Less	**2 - 4 Weeks**	**1 - 2 Months**	**3 - 6 Months**	**6 Months or More**
BIM Design Technician	33%	33%	12%	7%	14%
BIM Manager	17%	17%	20%	17%	29%
Junior BIM Manager	16%	24%	22%	8%	30%
BIM Coach	23%	23%	17%	9%	29%

4.4.2 Productivity Loss and Gain

During the initial training period 80% of respondents estimated that the productivity loss is less than 50% before the completion of the first project. This agrees with results from an Autodesk's web survey that show an average productivity loss between 25-50% during the initial training period on Revit© Software (Autodesk, 2008). However, this productivity loss seems to be recouped in a short period of time, ranging between and one and six months for the majority of companies as presented in Table 10.

Table 10 - Productivity Recovery After Training

Time Frame	Number of Respondents	Response Percent Based on 44 Respondents
1 Month or less	11	25%
1 - 3 Months	20	45%
3 - 6 Months	8	18%
6 Months - 1 Year	3	7%
1 Year or more	2	5%

After going back to the original levels of productivity that were being achieved with the software previous to BIM, most companies reported and additional increase in overall productivity ranging from 25% to 50%.

4.4.3 Training Proficiency

Evaluating the skills learned by trainees is critical because no other factor will determine the degree of success as the user expertise (Green, 2007). The more skilled the users, the easier it will be for them to migrate from one software to another. On the other hand, low training proficiency makes implementation more difficult. When a skill assessment is performed, there are two components that are typically evaluated: knowledge of software features, and comprehension of standard practices. The survey shows that 93% of respondents allow trainees to work on actual projects right after training in

order to provide a hands-on experience and determine basic competency. Using this method instead of multiple choice tests or other methods facilitates the evaluation of both components. This confirms the literature findings which indicate that training must be immediate followed by applications of the concepts in a project in order to maximize the amount of information retained by the user.

4.4.4 Cost of Training

The approximate training cost per employee in 2011 as estimated by respondents is presented in Table 11.

Table 11 - Training Cost per Employee in 2011

Job Description	Response Percent Based on 42 Respondents					
	Less Than $2,500	$2,500 - $5,000	$5,000 - $10,000	$10,000 - $15,000	More Than $15,000	Uncertain
BIM Design Technician	17%	27%	17%	7%	5%	27%
BIM Manager	5%	15%	20%	22%	12%	27%
Junior BIM Manager	8%	28%	18%	15%	5%	26%
BIM Coach	14%	8%	24%	14%	8%	32%

As expected, managerial positions demand a higher investment for training. This is clearly reflected on 44% of the companies reporting training costs between $5,000 and $15,000 per BIM manager, and 12% of respondents investing more than $15,000 for the same position. On the other hand, the majority of respondents estimated the cost of training BIM design technicians to be less than $5,000. All these figures confirm that the cost of training can become a decisive factor in transitioning to a BIM environment, especially for small companies that are not able to offset the cost of training in a short period of time.

4.5 Validation and Applicability of Results

In order to verify the accuracy of the data obtained in this study, 10 AEC companies were invited to discuss the results with the author. Half of these companies were not among the companies that

participated on the survey research and the other half were part of the survey respondents. The companies were contacted via phone and e-mail, and were requested to answer 10 questions. The first six points in the questionnaire are statements intended to establish if respondents agree with some the main quantitative findings of this study. These statements are presented below and were requested to be answered in a Yes/No format.

- The overall cost of training BIM designers/technicians is around $5,000.
- The overall cost of training BIM managers ranges between $10,000 and $15,000.
- The average duration for BIM designers training is four weeks or less.
- The average duration for BIM managers training is more than three months.
- BIM training is provided mostly by in-house personnel.
- Basic BIM skills, 3D modeling, and collaboration rank high in the priority of training subjects.

The final four are open-ended questions of qualitative nature, and are aimed to engage the participants in the topic of the thesis, and establish the potential value of this study in the participants' line of work. These questions are presented below.

- Regarding the survey report, did you find information that previously you were not aware of?
- Regarding the survey report, can you identify what aspects of the report reflect your company's training practices and what aspects are radically different?
- Is there any information that you would have liked to see but was not presented in the survey report?
- Do you see any potential applicability of the survey results in your line of work?

A total of three companies responded to the invitation with the following findings: For the first six questions, all companies agreed that the cost of training BIM designers in their companies is around $5,000 and the average duration of training the same designers is four weeks or less. All companies also agreed that the actual training that they provide is almost exclusively in-house. In regard of the cost of

training users for BIM managerial positions, two companies agreed with the ranges given, but one firm expressed that BIM managers were hired rather than trained internally; and therefore, the cost and duration of training are significantly lower than $15,000 and three months respectively, because most of the skills needed are prerequisites to being hired as BIM managers. Likewise, all companies agreed that BIM skills, 3D modeling, and collaboration are the main training subjects, with exception of new hires who are expected to have these skills previous commencement of work.

Answers to the last four questions revealed that most of the report (shown in Appendix B) reflects current training practices of the respondent companies at some extent. The companies also expressed that the report provides an interesting array of information and metrics that could be taken into consideration for actual BIM implementation plans; however, it was suggested that it would be desirable to see a dedicated section about training specific technical aspects of the software, such as clash detection, energy analysis, and also, a separate section for training on BIM processes that are not related to software but rather to workflow and collaboration.

It is also important to note that one company expressed that the study does not propose a step by step training model, and therefore considered that the applicability of the results is limited; on the other hand, it also noted that the information is very useful as a reference to explore what other companies in the AEC industry are doing in terms of BIM training. One company also suggested that the information presented in the survey might have a great value if it could be analyzed together with current hiring trends in order to improve academic curriculums for undergraduate or graduate programs, as this would give an advantage to students who graduate with extensive knowledge in BIM.

4.6 Chapter Summary

In this chapter the survey results were categorized and analyzed before, during, and after training. One of the key findings is that that most companies are spending between $2,500 and $5,000 to provide training for BIM design technicians, but this expense almost triples for training of BIM managers. Also, the training time ranges from a couple of weeks for design technicians to one to three months for the majority of managerial positions.

Most companies reported that training is focused on three key subjects: basic BIM skills, 3D modeling, and collaboration. The information gathered in this study was verified by means of an informal interview with AEC companies and shows that firms are using more in-house resources for BIM training by means of group classroom, one-on-one, or self training. Further analysis of the results presented in this chapter can expose other trends that are being followed by AEC companies in terms of BIM training strategies.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

5.1 Conclusions

All participants in construction projects are eager to benefit from state of the art technology, but only a significant change in the design and collaboration method will yield significant productivity improvements in the construction industry. BIM offers many benefits that allows for productivity improvement when used as a collaboration tool as corroborated by data gathered in the survey where most companies reported an average productivity increase ranging between 25% and 50% due to use of BIM solutions.

The education and training provided to users of BIM is crucial in order to develop the full potential of BIM and to grow the success of BIM solutions. Current CAD users are the most likely candidates to transition to BIM due to some commonalities between both types of software. However, CAD users still must be trained when transitioning to BIM, and circumventing training should be avoided altogether. Therefore, companies must implement training plans that fulfill their needs according to their resources. The study shows a tendency of assigning fixed budgets for training in order to avoid unsuccessful implementations that in the long run would discourage the adoption of BIM.

Implementing BIM technology is expensive not only because the procurement of software and hardware but also in terms of training. One of the important findings in this thesis is that most companies are spending between $2,500 and $5,000 to provide training for BIM design technicians, but this expense almost triples for training of BIM managers. At first glance, these figures can be discouraging for companies with limited training budgets, but it is important to take into consideration that in the long run the benefits of BIM more than offset the initial implementation costs as found in many research, and corroborated by an average 120% return of investment reported by the survey respondents.

This study also indicates that companies focus training on three key subjects: basic BIM skills, 3D modeling, and collaboration. The information gathered also shows that companies are using more in-house resources for BIM training, and tend to provide training within their own facilities by means of group classroom, one-on-one, or self training. However, users are evenly split on whether training materials are generated in-house or externally; but it is clear that most companies are developing their own BIM manuals to facilitate conveying of best practices and standards.

Current trends show that at some point in the future BIM will displace CAD programs. This is consistent with 85% of the survey respondents who strongly agreed that BIM will replace CAD drawings within the next 5 to 10 years. However, in the near future the coexistence of BIM and other CAD software is very likely until the construction industry feels that CAD has become obsolete and the benefits of BIM are broadly accepted and understood.

BIM technology will continue to evolve and as any other technology is expected to become cheaper and more user friendly. All type of participants in the AEC industry are predicting an increase in the use of BIM solutions as revealed by an overwhelming 98% of the survey participants who are planning to increase the use of BIM in the near future.

5.2 Recommendations for Future Research

Building Information Modeling presents a very exciting and ingenious array of tools for which research is increasingly conducted. However, issues that arise before and during BIM implementation are still a somewhat unexplored field.

For the construction industry further research can be conducted on training needs of BIM by design phase, company size, and project magnitude, because the origin of most data currently available is found in aggregated format and therefore difficult to analyze.

If further research on BIM training is performed it would be advisable to subdivide the AEC industry by discipline type in order to get more accurate results. This recommendation is derived from survey comments from the respondents, who believe that design and construction companies must be evaluated separately due to specific needs for each discipline. For instance, design companies might

spend more time training users due to increased complexity and level of accuracy in the design phase, while less complex features such as visualization, schedules, and estimates are commonly used by construction companies. It is also important to note that not all individual BIM users are 100% committed to the use of BIM in their job descriptions; therefore, a different type of approach can be explored for alternative training methods for these personnel.

APPENDIX A

SURVEY QUESTIONNAIRE

UNIVERSITY OF TEXAS ARLINGTON

BIM SURVEY

Evaluation of Training Needs for Building Information modeling (BIM)

Words followed by an asterisk mark (*) are defined in the glossary and list of abbreviations at the bottom of this page.

Submit date: **Apr 4, 2011**

1. RESPONDENT INFO

First Name
Last Name
Job Title
E-mail
Phone #

COMPANY OR ORGANIZATION INFO

2. Name and Location

Company or Organization Name
City
State

3. What type of firm is your company? ***Check all that apply when square checkboxes are shown.***

- ☐ Contractor (CM*, GC*, Trade Contractor, Fabricator)
- ☐ Architectural Firm
- ☐ Engineering Firm
- ☐ Owner
- ☐ Consultant
- ☐ Other (please specify)

4. What phases of the construction process is your company usually involved in?

- ☐ Predesign
- ☐ Schematic design
- ☐ Design development
- ☐ Construction documents
- ☐ Construction
- ☐ Fabrication
- ☐ Operations & Maintenance
- ☐ Other (please specify)

5. How many employees work in your company? ***Check only one answer when round checkboxes are shown.***

- ○ 5 or less
- ○ 6-25
- ○ 26-50
- ○ 51-100

- 101 - 250
- 251 - 500
- 501 or more

BIM USAGE

6. How long has your firm been using BIM?

- 1 Year or less
- 1-3 Years
- 3-6 Years
- 6 Years or more

7. How many employees work in the BIM department?

- 5 or less
- 6-25
- 26-50
- 51 or more

8. What size projects is BIM currently used for?

- $500K or less
- $500K - $2M
- $2M - $5M
- $5M - $10M
- $10M- $25M
- $25M or more

9. Does your company outsource any BIM related work due to insufficient technical or human resources?

- Yes
- No

10. What percentage of your active projects is using BIM or BIM related tools?

- 25% or less
- 25-50%
- 50-75%
- 75-100%

SOFTWARE

11. How would you rate your current BIM software in terms of ease of use?

	Excellent	Very Good	Satisfactory	Poor	Not Used
Revit Architecture					
Revit Structural					
Revit MEP					
NavisWorks					
Bentley Architecture					
Bentley Structural					
Bentley Mechanical					
Bently Electrical					
ArchiCAD					

Tekla Structures	○	○	○	○	○
Other (please specify below)	○	○	○	○	○

12. Based on what factors did you choose your BIM software?

- ☐ Compatibility with previous software
- ☐ Availability of training
- ☐ Compatibility with your hardware/operating system
- ☐ Ease of implementation
- ☐ Ease of use
- ☐ General functionality and features
- ☐ Integration with other technical software
- ☐ Price
- ☐ Other (please specify)

BEFORE TRAINING

13. As part of BIM implementation, did you hire an external consultant to evaluate your technical or human resources needs?

- ○ Yes
- ○ No

14. Before BIM implementation, what percentage of your computer units*...

...had to be replaced for use of BIM (%)
...was outdated but functional for use of BIM (%)
...was optimal for use of BIM (%)

DURING TRAINING

15. Do you have have a training budget for BIM?

- ○ Yes
- ○ No

16. Does your company have a standard BIM training plan?

- ○ Yes, all trainees follow the same training
- ○ No, BIM users* are trained according to immediate needs
- ○ Other (please specify)

17. What option describes your BIM training format better?

- ○ Ongoing Intermittent Training (short training blocks for several weeks)
- ○ Extended Training (multi-day intensive training)
- ○ Other (please specify)

18. What percentage of BIM training is provided by:

Company's own BIM trainers
External company / Consulting Services

19. Where is BIM training provided?

- ○ In-house

- At external facilities
- Both

20. What percentage of BIM training is...

	None	25% or less	25-50%	50-75%	75-100%
... group classroom training					
... one-on-one training					
... self-training					

21. What type of training material do you find more beneficial?

- Computer based self-training at workstations
- Traditional books and handout materials
- Other (please specify)

22. What percentage of BIM training materials is created in-house?

- None
- 25% or less
- 25-50%
- 50-75%
- 75-100%

23. Have you created a BIM manual for your company's standards and procedures?

- Yes
- No

24. What BIM features does your company focus training on?

- Basic BIM skills
- Modeling 2D
- Modeling 3D
- Visualization and Rendering
- Analysis tools
- Collaboration
- Other (please specify)

25. What percentage of total BIM training time is spent on:

	None	25% or less	25-50%	50-75%	75-100%
Software					
Company standards					
Industry standards					
Other (Please specify below)					

26. What is the user's average productivity loss during initial BIM training?

- 25% or less
- 25-50%
- 50-75%
- 75-100%

27. What specific area of BIM would you like your new hires or current users to have extensive knowledge of?

AFTER TRAINING

28. What is the average training time for the following postions?

	2 Weeks or less	2-4 Weeks	1-2 Months	3-6 Months	6 Months or more
BIM Design Technician*	○	○	○	○	○
BIM Manager*	○	○	○	○	○
Junior BIM Manager*	○	○	○	○	○
BIM Coach*	○	○	○	○	○
Other Position (Please specify below)	○	○	○	○	○

29. After training, what measures do you use to determine that basic competency has been achieved?

- ☐ Multiple choice tests
- ☐ Practical tests
- ☐ Evaluations of fictitious projects
- ☐ Work performance on actual projects
- ☐ Other (please specify)

30. After training, how long do BIM users take to return to the same productivity level that they had before migrating to BIM?

- ○ 1 Month or less
- ○ 1-3 Months
- ○ 3-6 Months
- ○ 6 Months-1 Year
- ○ 1 Year or more

31. After training, what is the BIM user's increase in overall productivity compared to previous software?

- ○ 25% or less
- ○ 25-50%
- ○ 50-75%
- ○ 75-100%
- ○ 100% or more

32. What is the approximate cost of training per person? (Training Cost = Training material + Salary + Lost productivity + Other relevant costs)

	Less than $2,500	$2,500 - $5,000	$5,000 - 10,000	$10,000 - $15,000	more than $15,000	Uncertain
BIM Design Technician	○	○	○	○	○	○
Junior BIM Manager	○	○	○	○	○	○
BIM Manager	○	○	○	○	○	○
BIM Coach	○	○	○	○	○	○
Other Position (please specify below)	○	○	○	○	○	○

BIM USER PROFILE

33. What degree of education is ideally required for the following positions?

	Graduate or professional degree	Bachelor's degree	Associate's degree	High School or GED	Less than high school

BIM Design Technician	○	○	○	○	○
Junior BIM Manager	○	○	○	○	○
BIM Manager	○	○	○	○	○
BIM Coach	○	○	○	○	○
Other Position (please specify below)	○	○	○	○	○

34. If you have hired new BIM users, what was their level of expertise?

	Beginner	Intermediate	Expert
25% or less	○	○	○
25-50%	○	○	○
50-75%	○	○	○
75-100%	○	○	○

35. What percentage of your BIM personnel was also proficient in 2D CAD software before BIM training?

- ○ 25% or less
- ○ 25-50%
- ○ 50-75%
- ○ 75-100%

PROFESSIONAL OPINION

36. Do you see BIM replacing conventional CAD drawings in the next 5-10 years?

- ○ Yes
- ○ No

37. Is your company planning on increasing the use of BIM in the near future?

- ○ Yes
- ○ No

38. The UTA Department of Civil Engineering (Construction Engineering and Management area) is planning to offer a BIM class. Would you be interested in...

- ☐ Receiving information about this class (schedule, cost, and content)
- ☐ Participate as a guest speaker
- ☐ None of the above

39. Would you like to receive a copy of the results of this study upon its completion? (Expected completion date: May 2011)

- ○ Yes
- ○ No

LIST OF ABBREVIATIONS AND GLOSSARY

Abbreviations

BIM: Building Information Modeling

CM: Construction Manager

GC: General Contractor

Glossary

Design-Bid-Build: Traditional method of project delivery for public construction that requires the selection of an architect who prepares

complete plans for lump sum bids by general contractors.

Design-Build: Method of project delivery in which one entity - the design-build team - works under a single contract with the project owner to provide design and construction services.

CM at Risk: Method of project delivery which entails a commitment by the construction manager to deliver the project. The construction manager acts as consultant to the owner in the development and design phases, but as the equivalent of a general contractor during the construction phase.

Integrated Project Delivery (IPD): Method of project delivery that fully integrates project teams in order to take advantage of the knowledge and best available technology of all team members. IPD is an advanced form of collaboration because all three parties (Owner, Architect, Contractor) are aligned by a single contract.

Computer units: Refers to CPU, monitors, plotters, and peripherals.

Network Hardware: Refers to servers, routers, adapters and similar.

BIM Design Technician: Responsible for 2D and 3D modeling in BIM software. Equivalent to CAD drafter.

BIM Manager: Responsible for BIM standards development, implementation, and enforcement. Equivalent to CAD administrator.

BIM Coach: Responsible for providing fundamental and intermediate training to staff. Equivalent to CAD trainer.

Junior BIM Manager: Responsible for assisting BIM manager and growing into manager position. Equivalent to CAD assistant administrator.

BIM User: Refers to employees that become operators of BIM software.

APPENDIX B

SURVEY RAW DATA AND PERCENTAGES

EVALUATION OF TRAINING NEEDS FOR BUILDING INFORMATION MODELING (BIM)
SURVEY RESULTS

ABOUT THE SURVEY

This survey is part of a research project which objective is to provide information regarding current practices and trends for BIM training at a national level in the AEC industry.

This survey was fielded online to a total of 46 companies between March and April, 2011. At least 70% of these companies were ranked in the Top 170 BIM Adopters list. At the time of the survey, all respondents held leadership, managerial, or executive positions within their companies. This is a survey report that shows statistical results only. The findings of this survey will be used strictly for academic purposes.

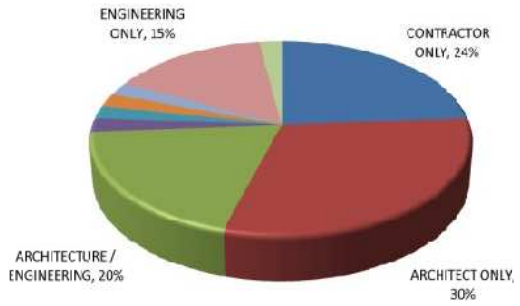
COMPANY LOCATIONS

ARIZONA	1
CALIFORNIA	3
COLORADO	1
DISTRICT OF COLUMBIA	1
FLORIDA	1
GEORGIA	5
IOWA	1
ILLINOIS	3
INDIANA	1
MASSACHUSETTS	1
MARYLAND	2
MINNESOTA	1
NORTH CAROLINA	1
NEBRASKA	1
NEW JERSEY	1
NEW MEXICO	1
NEW YORK	3
OKLAHOMA	1
PENNSYLVANIA	2
TEXAS	13
WASHINGTON	2
Total of respondents	**46**

COMPANY INFO

What type of firm is your company?

	Response percent
CONTRACTOR ONLY	24%
ARCHITECT ONLY	30%
ARCHITECTURE / ENGINEERING	20%
ARCHITECTURE/ CONTRACTOR	2%
ARCHITECTURE / ENGINEERING / CONTRACTOR	2%
ARCHITECTURE / ENGINEERING / CONTRACTOR / CONSULTANT	2%
ARCHITECTURE / ENGINEERING / CONSULTANT	2%
ENGINEERING ONLY	15%
OWNER ONLY	2%



Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

What delivery methods are usually used by your company?* Questions followed by an asterisk (*) mark are "*check all that apply*".

	Response percent	Response total No.
Design-Bid-Build	91%	40
Design-Build	82%	36
CM at Risk	68%	30
Integrated Project Delivery (IPD)	48%	21
Other (please specify)	16%	7

OTHER: ■ GMP ■ Design Assist ■ Integrated Enterprise ■ P3 ■ CM Agent ■ Hard Bid.

Total of respondents	46
Statistics based number of response	44
Filtered	0
Skipped	2

What phases of the construction process is your company usually involved in?*

	Response percent	Response total No.
Predesign	85%	39
Schematic design	96%	44
Design development	98%	45
Construction documents	98%	45
Construction	80%	37
Fabrication	24%	11
Operations & Maintenance	20%	9
Other (please specify)	4%	2

OTHER: ■ Post Occuppancy Evaluation ■ Bidding-Construction-Admin.

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

How many employees work in your company?

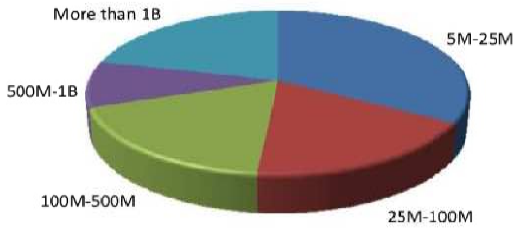
	Response percent
5 or less	0%
6 - 25	2%
26 - 50	9%
51 - 100	9%
101 - 250	30%
251 - 500	22%
501 or more	28%

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

What is your company's estimated annual revenue?

	Response percent
5M-25M	33%
25M-100M	18%
100M-500M	18%
500M-1B	9%
More than 1B	21%

Total of respondents	46
Statistics based number of response	33
Filtered	0
Skipped	13

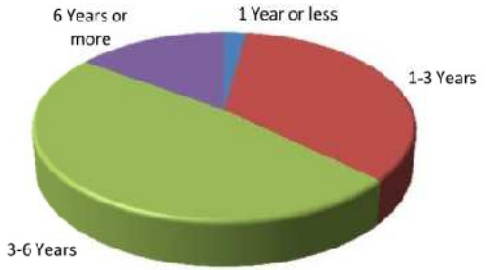


BIM USAGE

How long has your firm been using BIM?

	Response percent
1 Year or less	2%
1-3 Years	35%
3-6 Years	48%
6 Years or more	15%

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0



How many employees work in the BIM department?

	Response percent
5 or less	22%
6-25	39%
26-50	13%
51 or more	26%

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

What size projects is BIM currently used for?*

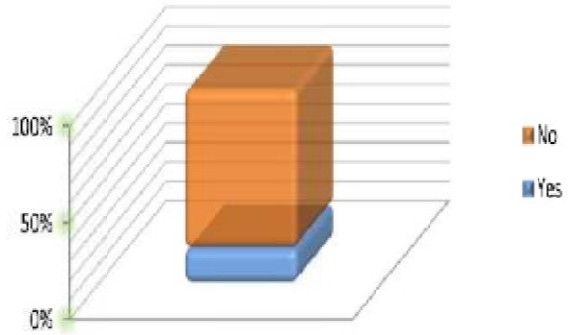
	Response percent	Response total No.
$500K or less	33%	15
$500K - $2M	46%	21
$2M - $5M	65%	30
$5M - $10M	78%	36
$10M- $25M	85%	39
$25M or more	87%	40

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

Does your company outsource any BIM related work due to insufficient technical or human resources?

	Response percent
Yes	18%
No	82%

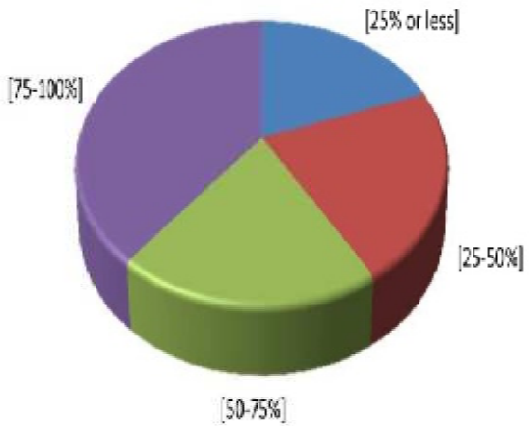
Total of respondents	46
Statistics based number of response	45
Filtered	0
Skipped	1



What percentage of your active projects is using BIM or BIM related tools?

	Response percent
25% or less	20%
25-50%	22%
50-75%	20%
75-100%	39%

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0



SOFTWARE

How would you rate your current BIM software in terms of ease of use?

	Response percent**				
	Excellent	Very Good	Satisfactory	Poor	Not Used / Not Rated
Revit Architecture	33%	49%	7%	0%	11%
Revit Structural	15%	43%	8%	0%	35%
Revit MEP	13%	22%	22%	7%	37%
NavisWorks	26%	37%	9%	7%	22%
Bentley Architecture	0%	2%	9%	7%	83%
Bentley Structural	2%	4%	4%	2%	87%
Bentley Mechanical	0%	0%	4%	4%	91%
Bentley Electrical	0%	0%	4%	4%	91%
ArchiCAD	11%	2%	2%	0%	85%
Tekla Structures	7%	2%	2%	0%	89%
Other (please specify below)	7%	2%	2%	0%	89%

Total of respondents	**46**
Statistics based number of response	46
Filtered	0
Skipped	0

Answers can be read as follows: **33% of the companies estimated that **Revit Architecture** is **excellent** in terms of ease of use.

If you indicated "Other" on the answer above please specify.

Solibri Model Checker
Tekla BIMsight
Innovaya, DProfiler, Synchro
FastTrack - Structural
Autodesk Civil 3D
Google SketchUp

Total of respondents	46
Statistics based number of response	6
Filtered	0
Skipped	40

Based on what factors did you choose your BIM software?*

	Response percent	Response total No.
Compatibility with previous software	50%	23
Availability of training	46%	21
Compatibility with your hardware/operating system	46%	21
Ease of implementation	48%	22
Ease of use	41%	19
General functionality and features	80%	37
Integration with other technical software	61%	28
Price	26%	12
Other (please specify)	20%	9

OTHER: ■ Client request ■ compatibility with client software ■ project requirements ■ trend for industry standard ■ most widely used product and comfort level ■ strictly Autodesk products.

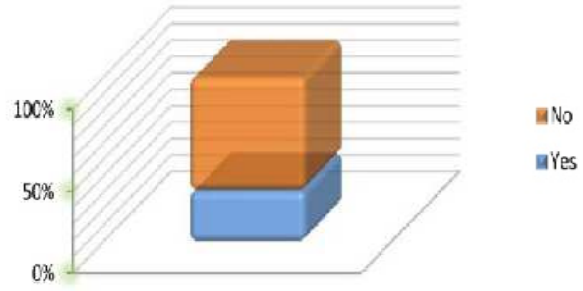
Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

BEFORE TRAINING

As part of BIM implementation, did you hire an external consultant to evaluate your technical or human resources needs?

	Response percent
Yes	31%
No	69%

Total of respondents	46
Statistics based number of response	45
Filtered	0
Skipped	1



Before BIM implementation, what percentage of your computer units…

...had to be replaced for use of BIM (%)	42%
...was outdated but functional for use of BIM (%)	38%
...was optimal for use of BIM (%)	20%

Total of respondents	46
Statistics based number of response	36
Filtered	0
Skipped	10

Before BIM implementation, what percentage of your network hardware…

...had to be replaced for use of BIM (%)	10%
...was outdated but functional for use of BIM (%)	30%
...was optimal for use of BIM (%)	60%

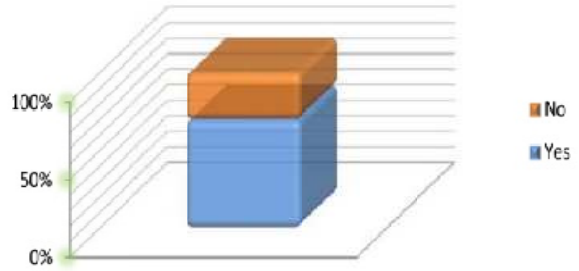
Total of respondents	46
Statistics based number of response	31
Filtered	0
Skipped	15

DURING TRAINING

Do you have have a training budget for BIM?

	Response percent
Yes	70%
No	30%

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

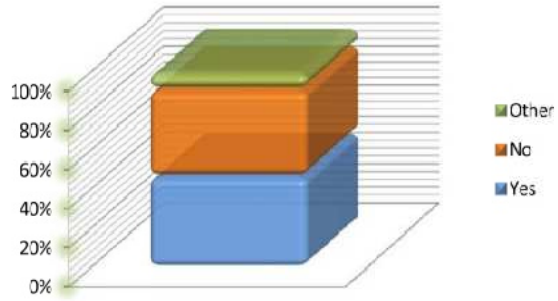


Skipped	0

Does your company have a standard BIM training plan?

	Response percent
Yes, all trainees follow the same training	47%
No, BIM users* are trained according to immediate needs	44%
Other (please specify)	9%

OTHER: ■ Varies depending on the title ■ employees are rotated through training as new projects start up ■ mixed based on need and discipline requirements ■ core training + additional specialized.

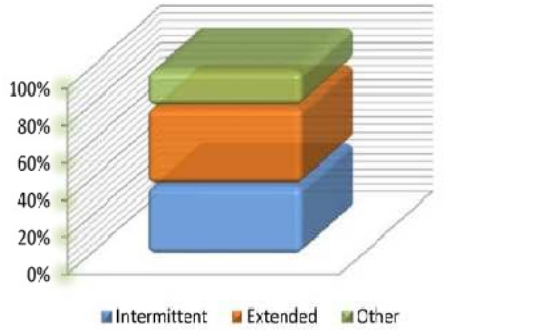


Total of respondents	46
Statistics based number of response	45
Filtered	0
Skipped	1

What option describes your BIM training format better?

	Response percent
Ongoing Intermittent Training (short training blocks for several weeks)	38%
Extended Training (multi-day intensive training)	42%
Other (please specify)	20%

OTHER: ■ Monthly user group ■ over the shoulder ■ just in time per project training ■ working on projects under the supervision of experienced users ■ multi-day initial training with monthly training hours ■ combination of short blocks and multi-day intensive.

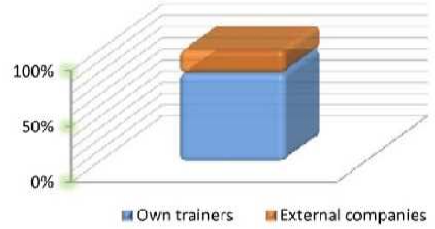


Total of respondents	46
Statistics based number of response	45
Filtered	0
Skipped	1

What percentage of BIM training is provided by:

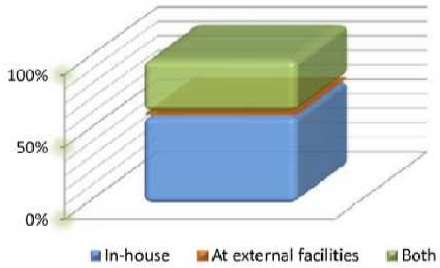
Company's own BIM trainers	79%
External company / Consulting Services	21%

Total of respondents	46
Statistics based number of response	45
Filtered	0
Skipped	1



Where is BIM training provided?

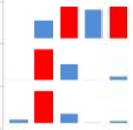
	Response percent
In-house	61%
At external facilities	2%
Both	37%



Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

What percentage of BIM training is...

	Response percent**				
	None	25% or less	25-50%	50-75%	75-100%
... group classroom training	0%	17%	29%	26%	29%
... one-on-one training	7%	47%	28%	7%	12%
... self-training	9%	60%	20%	4%	7%



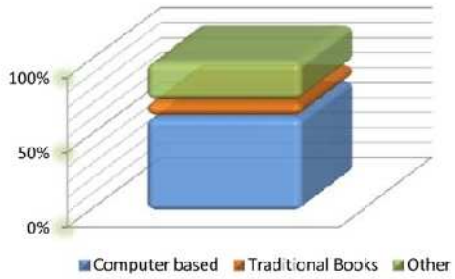
Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

Answers can be read as follows: **47% of the companies estimated than **25% or less** of BIM training is **one-on-one training.**

What type of training material do you find more beneficial?

	Response percent
Computer based self-training at workstations	63%
Traditional books and handout materials	11%
Other (please specify)	26%

OTHER: ■ Wiki base environment ■ hands on active involvement with real projects ■ web conference or classroom setting with laptops ■ lecture format followed by lab.



Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

What percentage of BIM training materials is created in-house?

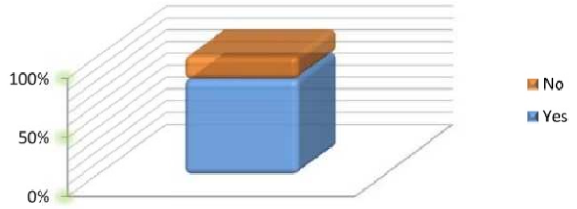
	Response percent
None	4%
25% or less	30%
25-50%	17%
50-75%	20%
75-100%	28%

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

Have you created a BIM manual for your company's standards and procedures?

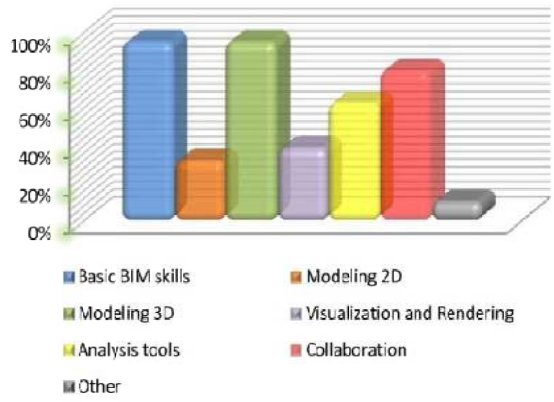
	Response percent
Yes	80%
No	20%

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0



What BIM features does your company focus training on?*

	Response percent	Response total No.
Basic BIM skills	96%	44
Modeling 2D	33%	15
Modeling 3D	96%	44
Visualization and Rendering	39%	18
Analysis tools	63%	29
Collaboration	80%	37
Other (please specify)	11%	5

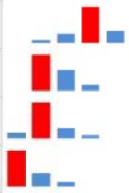


OTHER: ■ BIM management ■ work-flow ■ coordination tools ■ scheduling.

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

What percentage of total BIM training time is spent on:

	Response percent**				
	None	25% or less	25-50%	50-75%	75-100%
Software	0%	4%	15%	61%	20%
Company standards	0%	58%	33%	9%	0%
Industry standards	11%	65%	19%	5%	0%
Other (Please specify below)	67%	25%	8%	0%	0%



Answers can be read as follows: **61% of the companies estimated that between **50 and 75%** of training time is spent on **software**.

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

If you indicated "Other" on the answer above please specify.

Managing the collaboration process
Workflow, protocols, and processes
Analysis
Firm protocol

Total of respondents	46
Statistics based number of response	4
Filtered	0
Skipped	42

What is the user's average productivity loss during initial BIM training?

	Response percent
25% or less	37%
25-50%	43%
50-75%	15%
75-100%	4%

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

What specific area of BIM would you like your new hires or current users to have extensive knowledge of?

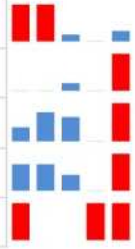
■ Basic BIM skills and understanding of how the software works ■ Best practices for BIM modeling/detailing ■ Construction means and methods, and knowledge of building systems ■ Collaboration and coordination procedures ■ 3D Modeling and detailing ■ Data extraction and integration ■ Document preparation ■ Facility Management ■ Clash detection ■ Estimating / Take-offs.

Total of respondents	46
Statistics based number of response	42
Filtered	0
Skipped	4

AFTER TRAINING

What is the average training time for the following postions?

	Response percent**				
	2 Weeks or less	2-4 Weeks	1-2 Months	3-6 Months	6 Months or more
BIM Design Technician	33%	33%	12%	7%	14%
BIM Manager	17%	17%	20%	17%	29%
Junior BIM Manager	16%	24%	22%	8%	30%
BIM Coach	23%	23%	17%	9%	29%
Other Position (Please specify below)	33%	0%	0%	33%	33%



Answers can be read as follows: **29% of the companies estimated that the average training time for a **BIM Manager** is **6 months or more.**

Total of respondents	46
Statistics based number of response	44
Filtered	0
Skipped	2

If you indicated "Other" on the answer above please specify.

BIM Coordinator: manages BIM coordination process for a specific project within a construction company

Engineer

Total of respondents	46
Statistics based number of response	3
Filtered	0
Skipped	43

How many hours of supplemental training do your users receive per year?

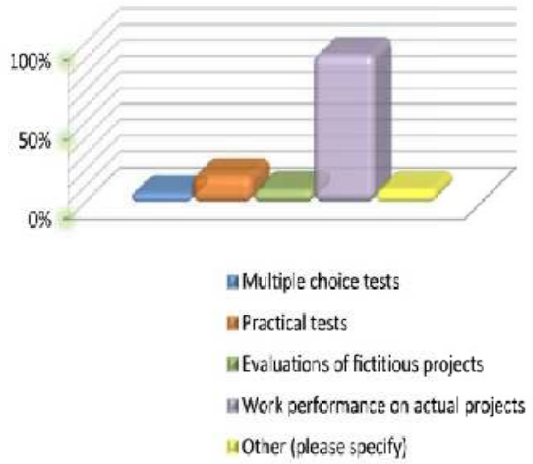
Mean 33 Hrs.

Total of respondents	46
Statistics based number of response	42
Filtered	0
Skipped	4

After training, what measures do you use to determine that basic competency has been achieved?*

	Response percent	Response total No.
Multiple choice tests	7%	3
Practical tests	17%	8
Evaluations of fictitious projects	9%	4
Work performance on actual projects	93%	43
Other (please specify)	9%	4

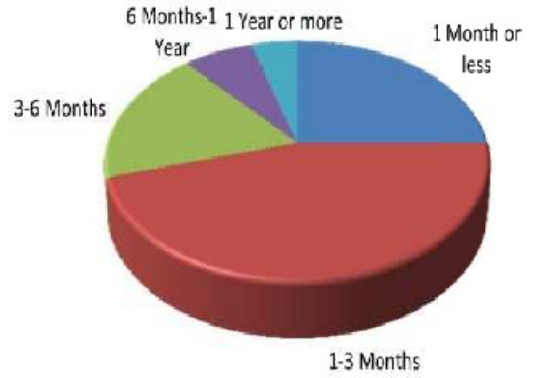
Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0



After training, how long do BIM users take to return to the same productivity level that they had before migrating to BIM?

	Response percent
1 Month or less	25%
1-3 Months	45%
3-6 Months	18%
6 Months-1 Year	7%
1 Year or more	5%

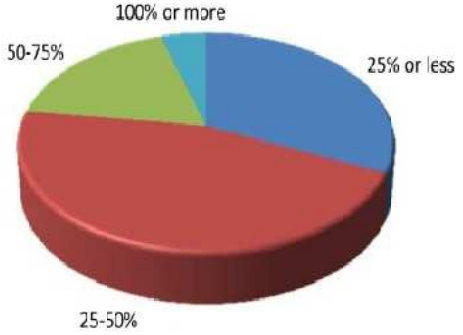
Total of respondents	46
Statistics based number of response	44
Filtered	0
Skipped	2



After training, what is the BIM user's increase in overall productivity compared to previous software?

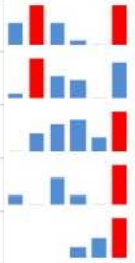
	Response percent
25% or less	32%
25-50%	45%
50-75%	18%
75-100%	0%
100% or more	5%

Total of respondents	46
Statistics based number of response	44
Filtered	0
Skipped	2



What is the approximate cost of training per person? (Training Cost = Training material + Salary + Lost productivity + Other relevant costs)

	Response percent**					
	Less than $2,500	$2,500 - $5,000	$5,000 - 10,000	$10,000 - $15,000	more than $15,000	Uncertain
BIM Design Technician	17%	27%	17%	7%	5%	27%
Junior BIM Manager	8%	28%	18%	15%	5%	26%
BIM Manager	5%	15%	20%	22%	12%	27%
BIM Coach	14%	8%	24%	14%	8%	32%
Other Position (please specify below)	0%	0%	0%	14%	29%	57%



Answers can be read as follows: **22% of the companies estimated that the approximate cost of training a **BIM Manger** is between **$10,000 and $15,000.**

Total of respondents	46
Statistics based number of response	42
Filtered	0
Skipped	4

If you indicated "Other" on the answer above please specify.

BIM Coordinator: manages BIM coordination process for a specific project within a construction company

Visualization Specialist

Integrated Construction Engineer

Total of responderts	46
Statistics based number of response	4
Filtered	0
Skipped	42

What will be your BIM training budget for next year?

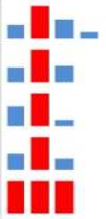
Size of BIM department (# people)		Mean	Response total No.
5 or less	$	36,313	8
6-25	$	36,875	8
26-50	$	25,000	3
51 or more	$	386,667	3

Total of responderts	46
Statistics based number of response	22
Filtered	0
Skipped	24

BIM USER PROFILE

What degree of education is ideally required for the following positions?

	Response percent**				
	Graduate or professional degree	Bachelor's degree	Associate's degree	High School or GED	Less than high school
BIM Design Technician	19%	45%	26%	10%	0%
Junior BIM Manager	23%	51%	26%	0%	0%
BIM Manager	34%	56%	10%	0%	0%
BIM Coach	26%	55%	18%	0%	0%
Other Position (please specify below)	33%	33%	33%	0%	0%



Answers can be read as follows: **56% of the companies estimated that the ideal level of education for a **BIM Manager** is a **Bachelor's degree.**

Total of responderts	46
Statistics based number of response	45
Filtered	0
Skipped	1

If you indicated "Other" on the answer above please specify.

BIM Coordinator: manages BIM coordination process
for a specific project within a construction company

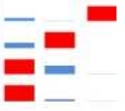
Integrated Construction Engineer

Architect

Total of respondents	46
Statistics based number of response	4
Filtered	0
Skipped	42

If you have hired new BIM users, what was their level of expertise?

	Response percent**		
	Beginner	Intermediate	Expert
25% or less	31%	28%	41%
25-50%	24%	76%	0%
50-75%	52%	35%	13%
75-100%	57%	24%	19%



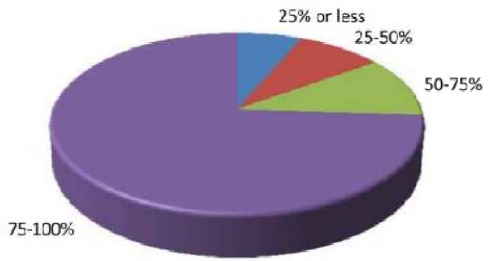
Answers can be read as follows: **76% of the companies estimated that between **25 and 50%** of newly hired BIM users had an **intermediate** level of expertise.

Total of respondents	46
Statistics based number of response	41
Filtered	0
Skipped	5

What percentage of your BIM personnel was also proficient in 2D CAD software before BIM training?

	Response percent
25% or less	7%
25-50%	9%
50-75%	11%
75-100%	74%

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0

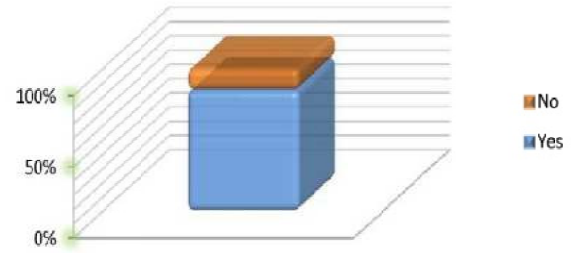


PROFESSIONAL OPINION

Do you see BIM replacing conventional CAD drawings in the next 5-10 years?

	Response percent
Yes	85%
No	15%

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0



What do you perceive to be your BIM's return on investment (ROI)? ROI (%)= (Gain from Investm. - Cost of Investm.) / Cost of Investm.

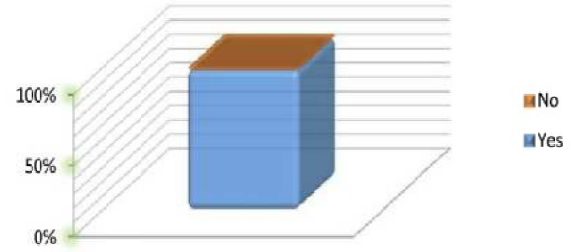
Mean	120%

Total of respondents	46
Statistics based number of response	28
Filtered	0
Skipped	18

Is your company planning on increasing the use of BIM in the near future?

	Response percent
Yes	98%
No	2%

Total of respondents	46
Statistics based number of response	46
Filtered	0
Skipped	0



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BIOGRAPHICAL INFORMATION

German Pena graduated from Universidad Santo Tomas, Colombia, with a Bachelor of Science in Civil Engineering. He has worked both in the United States and Colombia for companies that provide services in the construction industry. That helped him to develop a background in construction management and formwork structures.

He started his graduate studies at The University of Texas at Arlington in 2010. Upon graduation, Mr. Pena is looking forward to join a company in the AEC field that is actively using Building Information System solutions.