IMPACTS OF BIM ON TALENT ACQUISITION IN THE CONSTRUCTION INDUSTRY

Wei Wu[1] and Raja R.A. Issa [2]

[1] *P.O. Box 8047, Department of Civil Engineering & Construction Management, Georgia Southern University, Statesboro, GA 30460, USA*

[2] *P.O. Box 115703, Rinker School of Building Construction, University of Florida, Gainesville, FL 32611, USA*

Building information modelling (BIM) is rapidly reshaping the construction industry. Profound transformations have taken place in organizational structure and business operation in construction companies when adapting to BIM implementation. During the transition, companies are facing an essential question: how to align intellectual preparation with the challenges and business opportunities associated with BIM and stay competitive in the market? Efficient talent acquisition seems to be among the list of priorities. Use of dedicated BIM job titles and the emergence of the "BIM department" as an independent functional unit in organizations justify the need for a closer scrutiny of the current strategies for talent acquisition in the construction industry. This research investigated the impacts of BIM on key aspects of talent acquisition, including: identifying (gap analysis of talent shortage and needs), profiling (job description), qualifying (job requirements), sourcing (intellectual pool), recruiting (candidate screening and interviews) and retention/management. Conclusions were drawn from the data gathered via an online survey. The survey findings suggest that the construction industry is still at the beginning stage of formulating holistic strategies for BIM talent acquisition, in comparison with a boom in global BIM adoption and market demand for BIM talent. This research has exposed some fundamental issues companies are facing or will face in BIM talent acquisition. It is also intended to initiate critical thinking among the professional community to adapt existing talent acquisition strategies to the BIM context. Last but not least, the research suggests that enhanced collaboration between industry and academia should significantly improve the education, cultivation and acquisition of BIM talent.

Keywords: building information modelling, talent acquisition, technology innovation, transformation

INTRODUCTION

According to the Bureau of Labour Statistics (BLS) of the U.S. Department of Labour, the demand for highly skilled construction professionals (architects, engineers and constructors) is expected to outpace the supply over the next twenty years (Smith and Tardif 2009: 101). This forecast bears special implications at a time when building information modelling (BIM) is gaining accelerated uptake in global construction industry. It is consistent with what many industry professionals and research scholars

---

[1] wwu@georgiasouthern.edu

[2] raymond-issa@georgiasouthern.edu

have observed that BIM-savvy people will be in high demand and the lack of adequately trained personnel is hindering the use and adoption of BIM in the industry (Sacks and Barak 2010, Becerik et al 2011). BIM generates new business opportunities but at the same time it raises the bar for competition. As more facility owners are embracing BIM, the project procurement process has started to incorporate BIM competency as desired qualifications in selecting project teams. Pioneers like the U.S. General Service Administration (GSA) have mandated basic spatial program BIM models as submittals for approval since 2007. On future transitions that BIM compels in the industry, Patrick MacLeamy (Chairman, buildingSMART International, Chairman and CEO, HOK) commented: "I think there's going to be a huge shake-out…Either change and get with this program, or go out of business" (McGraw-Hill Construction 2012a: 15). To stay competitive, companies have to be mentally and intellectually prepared for the upcoming transformation. A key task is to align human resources with organizational development challenges as they relate to understanding the need for BIM talent, finding it and then placing employees properly within the existing system (Joseph 2011). Therefore, this research aims to investigate: 1) how BIM is reshaping the skillset requirements for construction professionals; 2) what the current practices of acquiring BIM talent in construction companies are; and 3) what other transformation, such as enhanced industry-academia partnership in college-level BIM education, is needed to satisfy the growing market demand for competent BIM talent in the construction industry.

BACKGROUND

Challenge: workforce shortage

The supply/demand equation for the global construction industry workforce has been imbalanced, with countries including the US, UK and Canada claiming a "crisis of skilled workforce shortages". Labour research has suggested that this crisis may be associated with the workforce aging, low attraction of profession to youth, lack of craftsman skills among younger generations, and challenges from new information and communication technology (ICT) implementation (ETA 2004, ConstructionSkills 2008). Within this context, despite the global economic downturn, BIM adoption is still accelerating. In North America, industry-wide adoption has surged from 28% in 2007, 49% in 2009 to 71% in 2012 (McGraw-Hill Construction 2012a: 7). In the UK, NBS (2012: 9) reported that from year 2010 to 2011, construction professionals using BIM were more than doubled (from 13% to 31%). This rapid uptake of BIM is largely attributed to proven business benefits from its implementation, e.g. increased profits and positive Returns on Investment (ROI). Owners who are BIM-educated and -sophisticated are usually more engaged with its implementation and able to reap the highest business value (McGraw-Hill Construction 2012a: 7). These owners are more likely to seek out to award projects to BIM-capable companies who rely on the professionals they hire to deliver the projects to meet outcome expectations. BIM's biggest opportunity in the future will be the direction that new personnel take BIM technology (Hardin 2009: 297). BIM-savvy people will be in high demand, and the projected supply/demand equation will place acute pressure on the industry to acquire or cultivate competent BIM talent to increase knowledge-worker productivity across the industry to meet the rising demand (Smith and Tardif 2009: 101).

Challenge: organizational resistance to change

In the short term, institutions of higher learning will be unable to satisfy the workforce demand of BIM, which means employers will have to rapidly develop BIM and

integrated project delivery (IPD) skills internally. Organizations that choose to repeat the conventional wisdom of the CAD era that employees will simply "pick up the skills on the job", will find themselves at a significant disadvantage (Smith and Tardif 2009). To adopt and implement BIM at its full potential will demand organization-wide strategic planning and stakeholder engagement to embrace and foster technology insertion, process change and cultural transitions.

From a technology innovation standpoint, adoption of BIM is often compared with CAD, which was introduced to the construction industry over an extended period. In contrast, the deployment of BIM is fast-paced (at least twice as fast as CAD, according to Neeley 2010) and considered to be "disruptive". This view is informed by the implicit switch from 2D to 3D working and by the opportunities that the dual (software and process) view of BIM will create to further address some of the problems inherent in the construction section, e.g. fragmentation (Watson 2010: 4). As such, BIM provides a vehicle for addressing the fragmentation of the industry and a platform for greater collaboration and information sharing across the entire construction supply chain (buildingSMART Australasia 2012: 26). From a business innovation perspective, BIM is "transformative", meaning that there is impetus for dramatic changes in the business practices (Jordani 2008, Mihindu and Arayici 2008). Companies are urged to manage change (operational and cultural, according to Smith and Tardif 2009: 35) and transition (Deutsch 2011: 8) to carry BIM implementation strategy through and foster its development. The impacts of BIM on organizational structure and construction companies' day-to-day business operations are extensive as well as intensive.

The resistance to change in organizations is most challenging when top management and senior personnel refuse to adopt new practices but would rather stay in their "comfort zone", which typically occurs in the course of new technology insertion and intellectual transition (Eastman et al 2008: 202). The financial and liability risks of innovation are common excuses for companies to deter their steps down the path to adopt BIM. As Smith and Tardif (2009: 58) noted, there are pioneers, innovators, followers and laggards distributed over the typical technology adoption life cycle. Yet companies that are adverse to the financial/liability risks of technology innovation because they are not convinced by the immature market might eventually find themselves at significant loss of business opportunities and market competitiveness. They did not realize or chose to overlook the cost of not doing BIM, as Yori (2011) warned the industry. "Business-as-usual" may eventually turn into "no BIM, no business". LeFevre (2011) endorsed this idea with genuine financial data in real construction companies and accentuated that the business case for BIM had already been made. He also explicitly pointed out that "changing mindsets is the biggest challenge" in BIM transformation.

Impact: BIM talent skillset requirements

Transformative industry trends like BIM and BIM-related greater collaboration and integrated project delivery require workers to draw upon different skills than traditional positions do. The increasing need in construction for greater productivity is like to drive more rapid adoption of these trends, which will require a different way of looking at the skills a worker has to offer (McGraw-Hill Construction 2012b: 8). New job titles prefixed with "BIM", e.g. "BIM Manager" and "BIM Coordinator", and the advent of new organizational function units such as "BIM/VDC department" reflect the impetus to rethink the profiling and planning of workforce oriented to BIM tasks.

This is important to understand, because BIM is revolutionary shift away from drawing production in the CAD era (Eastman et al 2008). The set of skills needed is usually beyond the scope that is traditionally defined for CAD professionals. Barison and Santos (2010) conducted an overview of BIM specialists, which provided a preliminary outline of the areas of responsibilities, and contributed to better defining the professional skills required to performing BIM related functions in construction companies.

In the case when "dedicated BIM talent" (usually associated with BIM-prefixed job titles) is the target, the acquired BIM talent should not be an "add-on" to existing organizational structure, or a "plug-in" for existing business process in the companies. Rather, they should be organically integrated into the corporate structure, interdependent on current human resources (HR), facilitate and eventually transform the business process to be BIM-cohesive and BIM-productive. To facilitate the "naturalization" of BIM talent, top management should drive the change to place BIM into company's vision and identify BIM related business opportunities. The HR department should be educated about BIM to accurately create the job descriptions. The business department should review the core business services provided and the workflow associated to identify the gap between the desired BIM deliverables and existing capacities, so they could eventually determine the type of BIM talent (e.g. knowledge based, skill/project based, or corporate support & services based) that needs to be acquired (Joseph 2011).

In the case when companies choose to convert/redefine traditional positions to become BIM-capable, it is critical to create the baseline and targeted skillset requirements for the "converted BIM talent", to identify the relationship and gaps, and to make training plans. For instance, estimator as a traditional profession is subject to significant impacts from the implementation of BIM. Model-based quantity take-off (QTO) and "5-D BIM" have brought up heated conversation and debates in the professional community over whether estimating as a profession should be completely redefined. Another eye-catching discussion is centring on the comparison between a "CAD Manager" and a "BIM Manager". Quite a few companies have been counting on their CAD managers to take on the new challenges to lead their BIM expedition, and have been successful. Despite the few commonalities, the two job titles are actually fundamentally different in terms of the desired qualification, responsibilities and expectations (Kiker 2009).

Impact: BIM education and career preparation

For many, BIM training begins in academia. Education, particularly in universities, is where the ability to create new mindsets and exposure to new media is most effective (Hardin 2009: 298). BIM education is considered as a solution to quicken the BIM learning curve thus companies can recruit ready-made BIM talent when the students graduate (McGraw-Hill Construction 2008). Therefore, the effective inclusion of BIM into college curricula has become both a pedagogic and practical aspiration needed in preparing future BIM talent for the construction industry (Crumpton and Miller 2008, McGraw-Hill Construction 2009).

The classic gap between academia and industry does exist in college BIM education. In spite of the pervasive presence of BIM in college curricula, academic programs are struggling to meet industry and student expectations on knowledge coverage and problem-solving skills learned from the curricula (Clevenger and Rush 2011, Wu and Issa 2013). BIM is most productive when implemented in a multidisciplinary,

collaborative environment. However, in academia, the segregation of departmental units makes it very difficult to imitate this working environment. Students are typically trained with focus on technical skills. The lack of exposure to the essential BIM workflow and managerial aspects of delivering BIM projects is a major drawback of existing college BIM curricula and undermines students' learning outcomes. Wu and Issa (2013) also found that no incentives were in place to encourage college students to pursue BIM oriented career path. Similarly, companies tended to overlook college students as a potential BIM talent pool, and very few of them had considered college students in their BIM workforce planning. Despite the insufficient interaction between industry in BIM talent acquisition and college BIM education, industry and academia still share a common vision of desired skillset requirements for future BIM professionals. This can be the foundation to enhance partnership and collaboration between industry and academia in future BIM education, talent cultivation and acquisition.

BIM TALENT ACQUISITION: CURRENT PRACTICE

The literature review confirmed the impacts of BIM on skillset requirements for future construction professionals and the needs for companies to adapt their strategies in talent acquisition to prepare for the transforming market. Yet there is very little published research that has evaluated existing practice in BIM talent acquisition in the construction industry. Without an established baseline case, it is difficult to assess the strengths and weakness of the current system, or to identify possible opportunities and solutions for improvement.

Survey Methodology

In order to address the three research objectives (ROs), an online survey was designed to gather information on the following aspects of BIM talent acquisition: demand, job profile and qualification, talent source, recruiting, talent retention and management, and future outlook. A total of 840 email invitations were sent through the recruiters' listserv from Rinker School of Building Construction at University of Florida and the buildingSMART alliance member listserv. Ninety-nine (99) completed questionnaires were collected, with a response rate of 11.8%. The low response rate is commonly seen in online surveys (Nulty 2008) and one of major limitations of this research. This yields a +/- 6.4% margin of error at 95% confidence level. The survey used various types of question design, including Multiple Choice, Matrix Table and Likert Scale. Skip logic was employed when certain questions were looking for participants with specific background. As a result, some questions might have fewer than 99 responses.

Survey Results

Architectural firms (24.2%), contractors (23.3%, including construction managers, general contractors and specialty contractors) and consulting firms (15.2%) are the top 3 groups of participants in this survey. Various engineering firms (civil, MEP and environmental) responded (14.2%) except for structural engineers. Other respondents include owners (8.1%), product manufacturers/distributors (2.0%), software vendors (1%) and others (12.1%). Most respondents are either directly involved (as final decision-makers, leading or supporting recruiters) with talent acquisition (41.4%), or have medium or high influence on it (39.4%).

Identifying BIM talent demand
To determine the demand for BIM talent, the survey focuses on: 1) how often do companies participate in projects that mandate use of BIM, which constitutes as a

challenge; and 2) how much BIM contributes to the annual revenue, which is an incentive. As shown in Figure 1, between the years 2008 and 2012, companies' business portfolio has been drastically transformed from BIM-marginal (low frequency of projects that mandated BIM, see the dashed trendline) to BIM-essential (high frequency of projects that mandated BIM, see the solid trendline). Notice that only exponential trendlines for "less than 10%" and "more than 75%" were illustrated in Figure 1. The purpose is to make the greatest contrast and show the rapid shift from low frequency to high frequency of mandated use of BIM in projects. Similar methodologies were used in subsequent Figures 2-4. During the same period of time, as shown in Figure 2, contribution by BIM to companies' annual revenue was increasing steadily, following an upward trend similar to that in Figure 1.
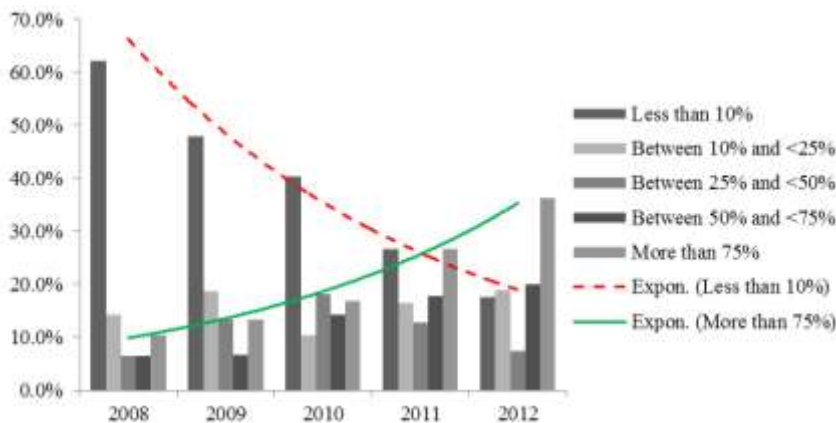

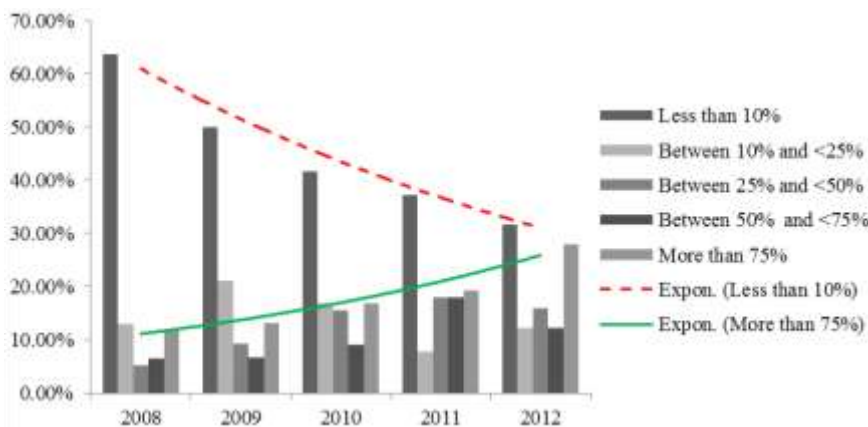*Figure 1. How often did your company participate in projects that mandated use of BIM?*

Figure 2. How much did BIM contribute to your company's annual revenue?

The demand for BIM talent has also been influenced by companies' workforce planning and the incentives that companies have perceived to adopt BIM. Most companies (53.6%) considered themselves "proactive" in workforce planning, driven by projected BIM business growth to acquire BIM talent. In contrast, about a third (28.6%) of the companies admitted to being "reactive", and only hiring when there is an immediate need for BIM talent (e.g. a project they were bidding on specified BIM as a desired qualification). In terms of incentives, companies felt most motivated by the perceived internal business benefits from BIM adoption (34.1%). They also felt encouraged to acquire BIM talent to more competently explore new business opportunities (20.9%). The third highest ranked incentive (16.5%) came from the owners' demand, as companies felt that owners might mandate BIM sooner or later.

Companies' historical hiring statistics offer reliable evidence for the rising BIM talent demand. Figure 3 provides a comprehensive summary of the participating companies' recruiting data over 2008 to 2012 in two major types: Type 1 - hiring that listed BIM as a qualification; and Type 2 - hiring that was dedicated to BIM. These exponential trendlines suggest that both types of hiring for BIM talent are increasing in terms of its percentage in total hiring, although at slightly different paces. The constituents of employee are shifting from BIM-marginal to highly BIM-relevant.
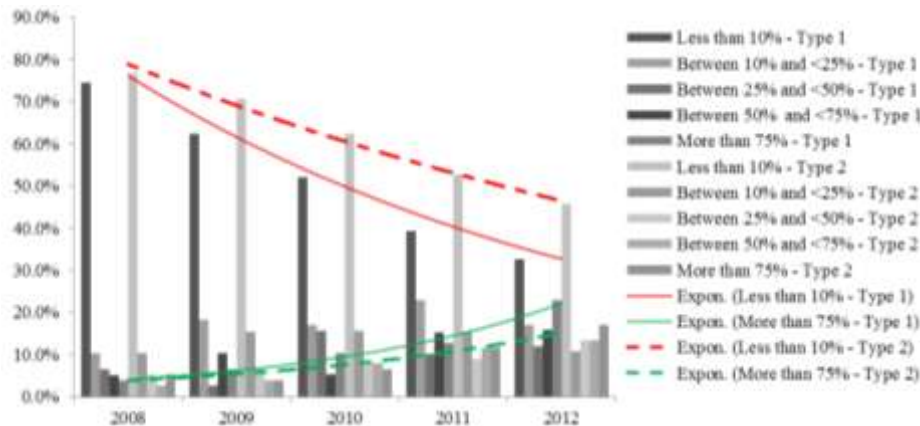

Figure 3. How many newly hired employees in your company were 1) listing BIM as a qualification or 2) dedicated to BIM?

BIM job profile and qualification description
Aligned with Research Objective 1 (RO1), the impacts of BIM on skillset requirements for future construction professionals were directly reflected in the description of BIM job profile and qualification. The emergence of BIM-prefixed job titles provides some insights. As found out in this survey, BIM Coordinator (47.1%), CAD/BIM/VDC Manager (42.4%), BIM modeller (31.8%) and BIM Director (29.4%) are the most popular BIM job titles among participants. But there were also a considerable number of people (28.2%) who chose not to use BIM in job titles. Very diverse opinions were observed on whether or not the company should define Job descriptions and qualifications when advertising BIM positions, with almost equivalent proponents (54.1%, 52.4%) and opponents (45.9%, 47.6%). To go in more depth, more than half of the participants in this survey found Technical/Functional Skills (74.1%), BIM Workflow/Strategic Plan and Execution Knowledge (61.2%), Multidisciplinary Model Management Knowledge (55.3%) and BIM Communication and Collaboration Skills (54.1%) most desirable qualifications. Companies relied predominantly (58.8%) on previous experience and reference checks to assess candidates' BIM competencies when hiring. Some companies also used Internal Metrics and Standards (27.1%), instead of Industry Certification/Credentials (e.g. AGC Certificate of Management - BIM or Autodesk Certified Professionals) (5.9%), which revealed that there is a lack of common metrics and widely accepted standards for BIM competency evaluation in talent acquisition.

Identify the source of BIM talent
Sources of BIM talent are also important to RO1 since it reflects the overall quality expectation of the talent acquired by the company. Training and educating employees was the top option (chosen by 17.8% of the respondents in recruiting 80% or more of their BIM talent) for companies at this moment, followed by free-agent BIM professionals in the job market. College students (non-doctoral students) were receiving more attention from companies, although still not a priority. This is probably

attributed to the perceived strength of college students in BIM technical/functional skills, which was identified as a most preferred qualification of BIM talent. CAD managers were in an awkward situation. They received second lowest votes, only better than college doctoral students who typically would not choose a career in the industry. This may suggest that more companies have realized the substantial difference between CAD and BIM competency in talent acquisition.

Recruiting BIM talent
As directly pertaining to RO2, BIM recruiting is an important investment for companies. More than half (52.4%) of the companies set aside budget and personnel for BIM recruiting, and 9.5% of them even had this as a routine. Most companies (59.5%) still rely on conventional web-based job posting for recruiting, followed by conventional job fairs (32.1%). New generation social media is also gaining recognition (27.4%). Special attention was given to college BIM recruiting. About a third of companies either hired students to fill permanent BIM positions (34.9%) or BIM internships (31.3%). Yet, there were still more than a third of companies (38.6%) that did not recruit college students at all.

Retaining and managing BIM talent
Recruiting is not the end of BIM talent acquisition, but a starting-point. To further address RO2, it is extremely important to investigate what talent retention and management strategies have been taken to sustain the success of companies' transformation to BIM. Most companies (76.2%) did not have an established BIM career path (like the traditional project managers and estimators, etc.). Major efforts made to retain BIM talent include encouraging organizational learning and knowledge management (55.4%), cultivating BIM culture and celebrating BIM champions and success (42.2%), encouraging BIM career development (39.8%) and creating a clear vision and goals for BIM business (38.6%). In terms of managing BIM talent, most companies (59.0%) assign them as part of the conventional workforce, performing both ordinary and BIM-specific tasks. About a quarter of companies (22.9%) would put their BIM talent in existing departments and assemble them for project-based BIM tasks. Only 13.3% of the companies had BIM departments to accommodate their BIM talent to handle only BIM business.

Outlook of market demand for BIM talent
To address RO3, the survey revealed some deficiencies in current BIM talent acquisition. Companies attributed such deficiencies majorly to lack of competent talent pool (46.7%). Other challenges they found in acquiring BIM talent include tight budget versus increased recruiting costs (37.0%), lack of opportunities to conduct BIM business and gain project experience (30.4%). Lack of top management commitment (28.3%) was still significant but no longer a dominant obstacle. To facilitate acquisition of BIM talent, more than half (55.6%) of the participants believed the key would be the continued growth of BIM business market, Enhanced College BIM Education and Professional BIM Training (53.3%), Enhanced Partnership and Collaboration between Industry and Academia (50%) and Development and Implementation of BIM Standards (50%). In forecasting hiring (dedicated BIM positions) over the subsequent 5 years, Figure 4 shows that respondents anticipated significant increase in both frequency (as the "0" hiring trendline drops while the "20+" hiring trendline rises) and magnitude (percentage of "20+" hiring), where "0" and "20+" denote numbers of dedicated BIM positions budgeted.

CONCLUSIONS

BIM is drastically reshaping the construction industry at large, and acquisition of the desired BIM talent becomes critical for companies to address the dual technology and process challenge in the BIM transformation. After reviewing the challenges and impacts of BIM on workforce planning, an online survey to identify the key features that characterized current practice of BIM talent acquisition in the industry was conducted. The results of the survey suggest that BIM as a trend is strengthening, with further expanded business opportunities. The impacts of BIM on talent acquisition were confirmed yet very few companies had established holistic strategies to address such impacts. More sophisticated strategic planning and financial investment are desirable to improve the status quo. Among the various efforts in meeting the rising demand for BIM talent, organizational learning, knowledge management and industry-academia partnership in BIM education are facilitators that deserve stronger commitment and further development.
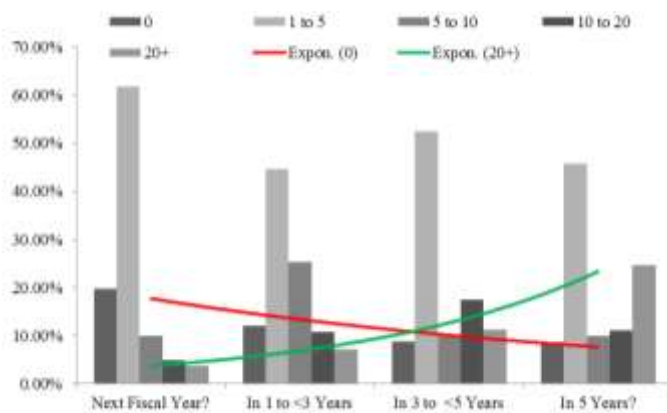
Figure 4. How many dedicated BIM positions do you company plan to recruit?

REFERENCES

Barison, M B, Santos, E T (2010) An overview of BIM specialists. In: Tizani, W (Ed), "The 13th International Conference on Computing in Civil and Building Engineering", 30 June - 2 July 2010, University of Nottingham.

Becerik-Gerber, B, Gerber, D J and Ku, K (2011) The pace of technological innovation in architecture, engineering, and construction education: integrating recent trends into the curricula. "Journal of Information Technology in Construction", 16, 411-32.

buildingSMART Australasia (2012) "National Building Information Modelling Initiative. Vol.1, Strategy". Sydney: buildingSMART Australasia.

Clevenger, C and Rush, M (2011) Collaborating with Industry and Facilities Management to teach BIM. "EcoBuild America 2011: BIM Academic Forum", 6-8 December, Washington D.C.

ConstructionSkills (2008) "2020 Vision - The Future of UK Construction". Norfolk: The Construction Industry Training Board.

Crumpton, A and Miller, B (2008) Building Information Modelling: State of the A&D Industry and BIM integration into Design Education. "Interior Design Educator's 2008 Annual Conference", 5-8 March, Montreal, Quebec, Canada.

Deutsch, R (2011) "BIM and Integrated Design: Strategies for Architectural Practice". Hoboken, New Jersey: John Wiley & Sons, Inc.

Eastman, C, Teicholz, P, Sacks, R and Liston, K (2008) "BIM Handbook: A Guide to Building Information Modelling for Owners, Managers, Designers, Engineers, and Contractors". Hoboken, New Jersey: John Wiley & Sons, Inc.

Employment and Training Administration (ETA) (2004) "America's Construction Industry Identifying and Addressing Workforce Challenges". Washington, DC: ETA.

Hardin, B (2009) "BIM and Construction Management: Proven Tools, Methods, and Workflows". Indianapolis, Indiana: Wiley Publishing, Inc.

Jordani, D (2008) BIM: A healthy disruption to a fragmented and broken process. "Journal of Building Information Modelling", Fall 2008, 24-6.

Joseph, J (2011) BIM Titles and Job Descriptions: How Do They Fit in Your Organizational Structure? "Autodesk University 2011", 29 November - 1 December 2011, Autodesk, Inc.

Kiker, M W (2009) BIM Manager - The Newest Position. "Autodesk University 2009", 1-3 December, Autodesk, Inc.

LeFevre, M (2011) No BIM for You: The Case for Not Doing BIM - Leverage Points, Reframing and Key Decision Factors in BIM Transformation. "Journal of Building Information Modelling", Spring 2011, 14-7.

McGraw-Hill Construction (2008) "BIM: Transforming Design and Construction to Achieve Greater Industry Productivity". Bedford, MA: McGraw-Hill Construction.

McGraw-Hill Construction (2009) "The Business Value of BIM: Getting BIM to the Bottom Line". Bedford, MA: McGraw-Hill Construction.

McGraw-Hill Construction (2012a) "Business Value of BIM in North America Multi-Year Trend Analysis and User Ratings (2007-2012)". Bedford, MA: McGraw-Hill Construction.

McGraw-Hill Construction (2012b) "Construction Industry Workforce Shortages: Role of Certification, Training and Green Jobs in Filling the Gaps". Bedford, MA: McGraw-Hill Construction.

Mihindu, S and Arayici, Y (2008) Digital Construction through BIM Systems will drive Re-engineering of Construction Business Practices. In: Ceballos, S (Ed), "VIS 2008", 9-11 July 2008, IEEE.

National Building Specification (NBS) (2012) "National BIM Report 2012". London: RIBA Enterprises, Ltd.

Neeley, D (2010) "BIM 1.0, BIM 2.0, BIM 3.0: 2010 Update", "Convention 2010: Design for the New Decade", 10-12 June 2010, American Institute of Architects.

Nulty, D D (2008) The adequacy of response rates to online and paper surveys: what can be done? "Assessment & Evaluation in Higher Education", 33(3), 301-14.

Sacks, R and Barak, R (2010) Teaching Building Information Modeling as an Integral Part of Freshman Year Civil Engineering Education. "Journal of Professional Issues in Engineering Education and Practice", 136(1), 30-8.

Smith, D and Tardif, M (2009) "Building Information Modelling: A Strategic Implementation Guide for Architects, Engineers, Constructors, and Real Estate Asset Managers". Hoboken, New Jersey: John Wiley & Sons, Inc.

Watson, A (2010) BIM - a driver for change. In: Tizani, W (Ed), "The 13th International Conference on Computing in Civil and Building Engineering", 30 June - 2 July 2010, University of Nottingham.

Wu, W and Issa, R (2013) BIM Education for New Career Options: An Initial Investigation. "Building Innovation 2013: BIM Academic Education Symposium", 7-11 January 2013, Washington, D.C.

Yori, R (2011) The Cost of Not Doing BIM: Education and Professional Development. "Journal of Building Information", Spring 2011, 28-9.