BENCHMARKING BIM LEVELS OF TRAINING AND EDUCATION AMONGST CONSTRUCTION MANAGEMENT PRACTITIONERS

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UK Government created a strategic deadline of 2016 for the adoption and use of Level 2 BIM on all centrally procured projects. A shift from Computer Aided Design (CAD) to Building Information Modelling (BIM) has been driven by the need to improve the way that the industry delivers projects. It is believed that BIM better facilitates opportunities for collaboration and project enhancement than traditional project information management processes. It is also thought that by improving the quality of information, and adopting a more collaborative approach through a model-based design industry such advancements can be made. The originality of this research is in developing an understanding of the current-status of BIM training and education amongst construction management practitioners. The present research uses a quantitative survey approach to investigate the current-status of BIM awareness, understanding, use, and perceptions towards readiness for the 2016 mandate. Results highlight that approximately half of the sample have received some kind of education or training although there were higher levels of BIM awareness, use and understanding. Investigations also reveal that the majority of training and education received by practitioners is self-sourced, but amongst those respondents who have not received any education or training there are expectations that employers should provide these.

Keywords: Building Information Modelling, education, skills, training, survey

INTRODUCTION

Building Information Modelling (BIM) is presently of great interest to a range of construction stakeholders including governments, clients, practitioners and academics. Arguments for widespread implementation of BIM have emphasised the realised benefits disseminated through the publication of case studies (Barlish and Sullivan, 2012; Gledson, 2016; Bryde *et al*., 2013). However, the introductions of such disruptive innovations are not without problems (Loosemore, 2014; Poirier *et al*., 2015). Research to date has highlighted many barriers towards BIM implementation. Eadie *et al*., (2013) note one such issue, to be a lack of BIM expertise both within the project team and at an organisational level. This raises questions over the quantity and quality of BIM training and education available for construction management practitioners operating within the UK Architectural Engineering and Construction

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(AEC) industry. This cross-sectional research aims to determine the status, scale and suitability of BIM training and education in relation to these issues.

LITERATURE REVIEW

> BIM is a three-dimensional geometric model that is data rich. The information contained within it can be used for other purposes such as predicting energy consumption, structural performance, cost, scheduling, clashes between systems preconstruction, and [it] can even be leveraged for facilities management uses (Kensek, 2014).

Effective use of BIM facilitates collaborative working and improves the quality of production information across the project lifecycle (Crotty, 2012). Recognising existing benefits and opportunities for further improvements in project delivery afforded by better use of project information, in 2011 the UK Government mandated the use of Level 2 BIM on all centrally procured public projects from April 2016 onwards (HM Government, 2011). However several barriers to adoption exist, and the most frequently identified in the literature can be categorised under five headings: *Legal barriers, Technological barriers* (e.g. interoperability) and inter-related elements surrounding *Cost, People* and *Training* needs.

The cost implications associated with BIM adoption have previously been identified as a substantial barrier to BIM, and various researchers (Azhar, 2011; Becerik-Gerber and Kensek, 2010; Dowsett and Harty, 2013) have discussed the cost impacts of technology procurement, training of existing staff, and the employment of better-qualified BIM-ready staff. Human or sociotechnical barriers are also identified as an under researched, and underappreciated area that must be addressed when considering adoption (Davies and Harty, 2012; Gu and London, 2010).

As with any technological innovation, issues of training and education around BIM systems has already been identified by a range of researchers as being fundamental, not only for initial adoption but for its successful application (Davies and Harty, 2013; Yan and Damian, 2008), yet much of early BIM education disseminated at industry road-show events was directed primarily at more senior, upper management staff that held some influence over the strategic direction of construction organisations. Furthermore, whilst previous efforts into individual and organisational BIM awareness, understanding, use, and perceptions towards readiness for the 2016 mandate has been undertaken by a range of researchers (Eadie *et al*., 2013; Khosrowshahi and Arayici, 2012), and organisations (e.g. see the annual NBS 'National BIM Surveys'), such outputs, have not successfully identified industry needs in relation to BIM training and education.

Crotty (2012) and Loosemore, (2014) both argue that project-level personnel ultimately have responsibility for managing innovations into use, and that these practitioners have a tendency to focus only on innovations that can realise productivity, cost and time benefits. Therefore these are the individuals within construction organisations that will ultimately determine the success of such innovations, and who should benefit from targeted training and education that is tailored to their needs. Construction management practitioners are now more likely than ever to be interacting with model-based production information, so there is presently a need for research into the levels and effectiveness of such training and education received by these individuals to see if the potential benefits associated with BIM can begin to be realised.

RESEARCH METHOD

A web-based questionnaire survey was designed to primarily collect quantitative data over a cross-sectional time horizon. The target population of the study was construction management professionals working for or with, contracting organisations in delivering construction projects across any tier of the UK AEC industry. Various principles of effective web based questionnaire construction including length (Fellows and Liu, 2008), question design (Bryman, 2015), and attractiveness (Dillman *et al*., 2014), were followed and after an initial pilot questionnaire was tested, the finalised structured questionnaire survey was distributed in the early months of 2015 for self-completion initially to a handful of purposively selected construction management professionals. Thereafter a snowball sampling technique was employed with the initial participants used to provide the survey link to other individuals relevant to the research topic that matching the population of interest. The survey collected 50 full responses, however because of the sampling technique used a response rate cannot be calculated. Key to the success of the questionnaire was the incorporation of question logic that would filter respondents into one of two categories depending upon whether the respondent had previously received any form of BIM education or training. Once filtered into these sub-sets, all respondents were presented with similarly worded questions relating to BIM training and education. These would be answered either drawing upon their direct experience of BIM training and education, or from their perceptions of BIM training and education.

FINDINGS

The majority of respondents were male (86.0%, n=43) with 11 years AEC working experience (calculated using mean scores), practicing in construction management roles (76%, n=38) for large contractors employing over 250 employees (68%, n=34) in middle management positions (38%, n=19).

54% (n=27) of respondents confirmed that they had received some kind of BIM education and/or training compared with 46.0% (n=23) who had not. 68.0% (n=34) of respondents confirmed that they were aware of, and understood the Level 2 BIM mandate; whereas 26.0% (n=13) were not aware, and 6.0% (n=3) were aware but did not understand it. Focusing only on the sub-set of respondents who were aware of the Level 2 BIM mandate, a minority (27.0%) believed the industry would be ready, with the majority (73.0%) believing that it would not.

Using inferential statistics, associations were tested between the receipt of BIM education/training received and the awareness, understanding and use of BIM [T1-3]. This part of the research was designed using categorical variables in order for the following Chi-Square tests of associations:

T1: *Level of BIM education/training compared against BIM awareness.*

T2: *Level of BIM education/training compared against BIM understanding.*

T3: *Level of BIM education/training compared against BIM use.*

In each test, all 50 cases were usable, but conditions for Chi-Square (X^2) were not met due to some cells having expected counts of less than 5, therefore Fisher's Exact Tests were used. In each test appropriate null (H_0) and alternative (H_A) hypotheses were formulated, and results of each test showed that the null (H_0) could be rejected in favour of the alternative.

T1 gave a Fishers statistic of .000 and interrogation of data produced in the cross-tabulation about this relationship appears suggest that receipt of BIM education/training means that respondents were likely to profess themselves as 'fully aware of BIM' in contrast to respondents who had not received BIM education/training (*Note: the researchers are unable to account for the reasoning of the sole respondent who has identified that they have received some BIM education or training but has also advised that they are 'not aware of BIM'*).

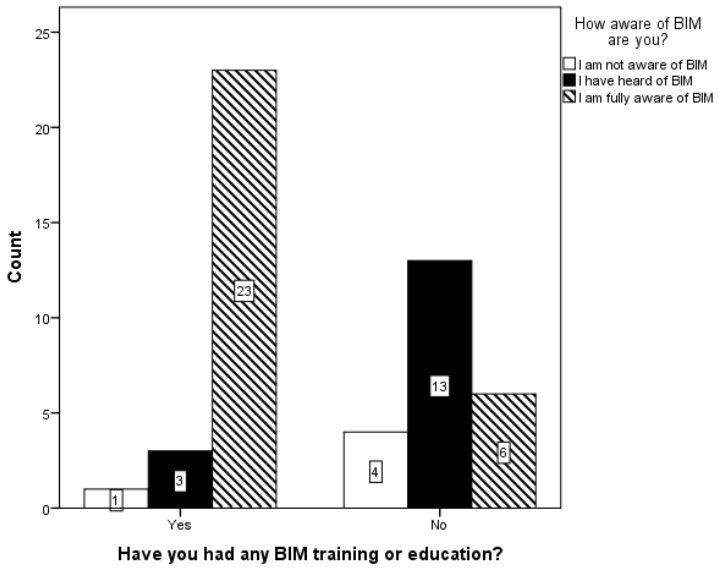

Figure 1: Levels of BIM education/training compared against BIM awareness

T2 gave a Fishers statistic of .003 and interrogation of data produced in the cross-tabulation about this relationship again, appears to suggest that receipt of BIM education/training means that respondents were likely to perceive themselves as having a high degree of BIM understanding.

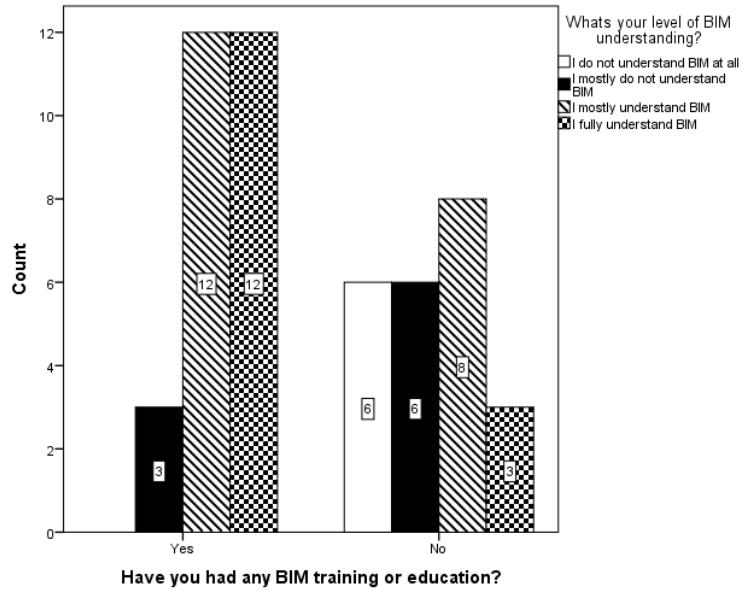

Figure 2: Levels of BIM education/training compared against BIM understanding

T3 gave a Fishers statistic of .001 and interrogation of data produced in the cross-tabulation about this relationship appears to suggest that while receipt of BIM

education/training results in use of BIM, respondents with no such BIM education or training, were much more likely to have never used BIM in any capacity.

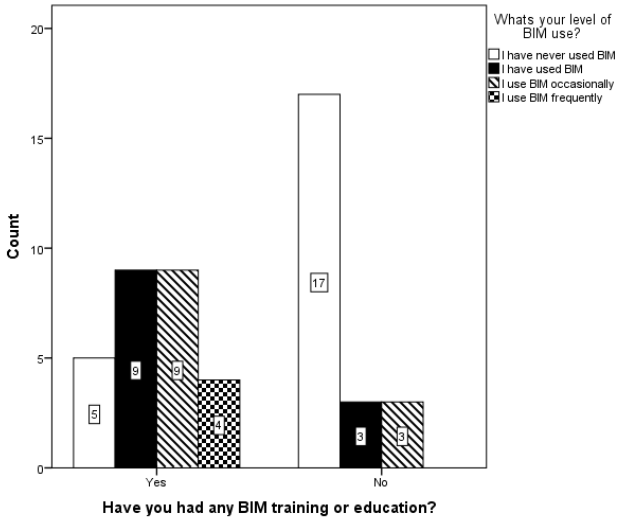

Figure 3: Levels of BIM education/training compared against BIM use

Examination of differences between respondents with and without any BIM education or training then occurred. This first section focuses only on the sub-set of respondents who have received prior BIM education or training.

Sub-set 1: Respondents who had received prior BIM education or training (n=27)

The drivers for such education and training were sought under the categories of '*Compulsory*', '*Optional*' and '*Requested*' (by the individual). The results of this highlighted that in the majority (63.0%) of respondents have accessed training/education because it was compulsory, for 25.9% it was optional but 11.1% had to request it.

The survey was designed to collect data on the quantity of BIM education and/or training received, and identify how such content was being delivered across four broad categories: *company provided training* (White bins)*; company provided education* (White bins with diagonal hatching)*; self-sourced training* (Black bins bins), or *self-sourced education* (Black bins with checker-box hatching).

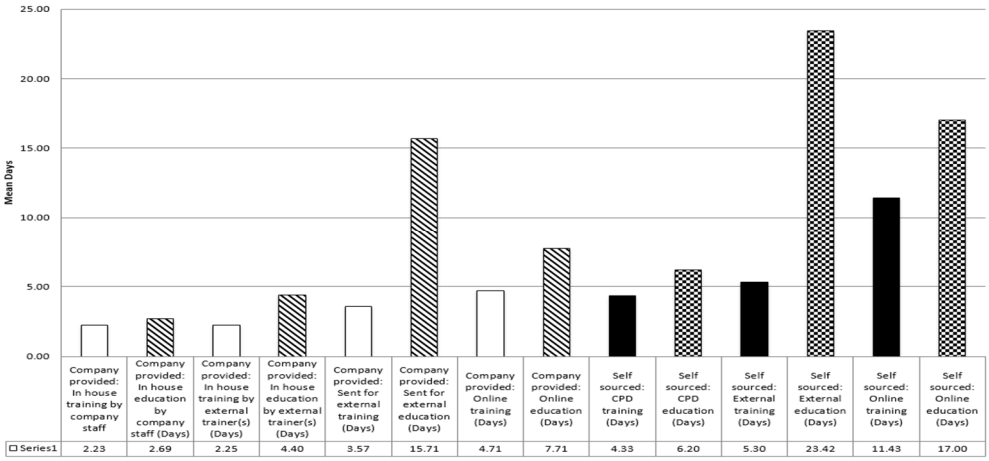

Figure 4: Quantity of training and education received in mean days

Figure 4 illustrates that amongst the sample surveyed, self-sourced 'instruments' (as used in this research as the term to identify the education or training 'mediums' or

'channels') are more prevalent than company provided instruments. The most frequently accessed training instrument was *'Self-sourced: external education'* followed by '*Self-sourced: online education*', and the least frequent identified was *'Company provided: in house training by external trainer(s)'*. Furthermore, these data also show that regardless of the instrument or supplier, BIM education has been more prevalent than the more practical hands-on training.

In addition to quantity of training/education, the survey was also designed to assess respondents' perceptions of the quality of the training/education that they had received to assess which instruments are considered to provide better levels of training/education. To measure this, 5-point Likert scales were used with response options being: (1) Awful; (2) Poor (3) Average (4) Good, and (5) Excellent.

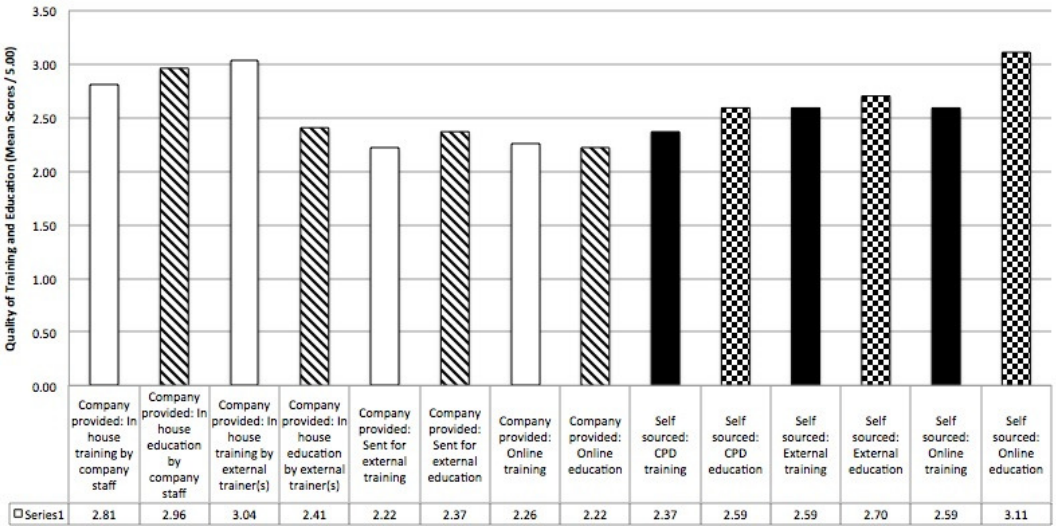

Figure 5: Quality of training and education received

This time there was no clear trend. Although the instrument that provides the highest quality was seen to be '*Self-sourced: Online education*' (3.11 / 5.00), it was followed by '*Company provided: training in-house,* (which is delivered) *by external trainers'* (3.04). The joint poorest performing instruments are highlighted as being '*Company provided: online education'* and '*Company provided: sent for external education*' (both 2.22 / 5.00).

With these results established, this subset of respondents were also asked whether their level of BIM training/education was sufficient or they would like more in the future. The results from this found that the majority (88.9%) would like access to further training and education, with only 11.1% feeling the training they have had was sufficient.

Notable qualitative comments provided by respondents that have undertaken BIM training or education also focussed on issues of quality and quantity:

> After receiving the BIM training provided by the company, I feel that the industry as a whole will not be ready to use BIM because of people's mind-sets and [there is] not enough training going on …. Not enough people are aware of what BIM has to offer… (Respondent 32)

> The only training I have received is a very basic BIM awareness course providing an overview of the governments targets and how BIM can further the construction industry. (Respondent 34)

Sub-set 2: Respondents who had not received prior BIM education or training (n=23)

The majority of this subset of the sample (91.3%) advised they have not had the opportunity to take any BIM training or education with only a minority (8.7%) being offered it, but opting out of receiving any.

In order to understand the attitudes towards BIM training and education amongst those that have not received either, respondents were asked whether they would consider requesting training or education from their employer or if they source their own outside of work. In this subset, there was a clear preference amongst the respondents that they would rather request training/education from their employer than self-source (73.9%). This was supported by the following qualitative data obtained from within this sub-set of respondents:

> If BIM is essential for my job role I would expect my employer to provide training, just like I need a mobile phone or a laptop (Respondent 17)
>
> Investment in training, needs to come from the top and currently isn't (Respondent 31).

These respondents were asked to rate the instruments that were their preferences for BIM training. Responses were collected using a 5-point Likert scale with the following options being available: (1) Definitely would not attend; (2) Would only attend if it was compulsory (3) Unlikely/Indifferent attendance (4) Likely to attend, and (5) Definitely would attend. The mean results from this are provided below in Figure 6 which indicates again, a trend that company provided instruments are more likely to be attended by respondents who have not yet received any BIM training.

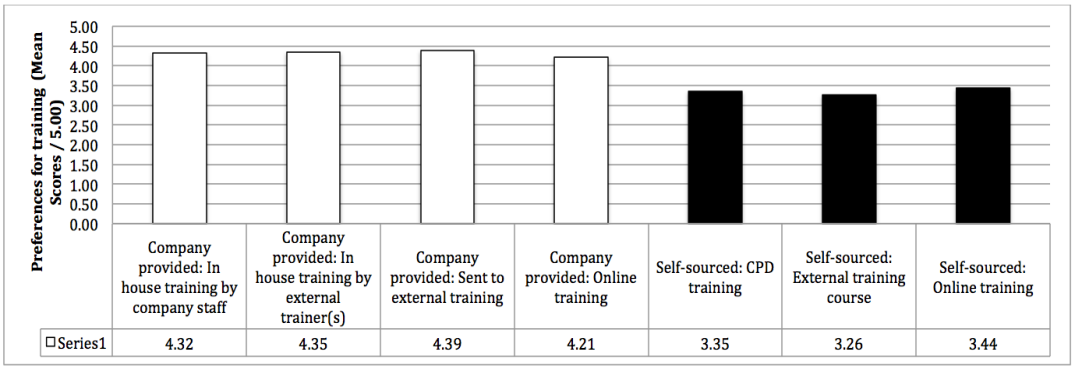

Figure 6: Preferences toward BIM training instruments (Sub-set 2)

DISCUSSION

Adequate and appropriate training and education in relation to BIM has been identified as one of the major recent challenges to the AEC profession (Azhar, 2011; Becerik-Gerber and Kensek, 2009) which is considered to require considerable investment (Eadie et al., 2013; Gledson, 2016). The aim of this research was to create a snapshot of the status, scale and suitability of such BIM training and education prior to the Government mandated Level 2 BIM deadline. In this regard, results identify that research participants largely believe the responses of their own employer organisations to have been lacking in terms of supply of relevant 'internal' BIM training and education material. In addition, respondents have identified a variability in quality of such material across both internal and external channels.

Whilst the Government mandate (HM Government, 2011) acted as a mechanism to incentivize BIM innovation adoption among the construction market, true lessons that

could be learned from initial BIM adopter projects and translated into successful training and education programmes have not always been not made widely available or readily disseminated (either to maintain a competitive advantage, or in cases of failure to protect from any damage to company PR). A maturing market should now follow the Level 2 deadline, and organizations who have spent the 5 years since the 2011 Construction Strategy observing and learning may now be better placed to emerge with more developed education and training solutions (Eadie et al., in particular noted the potential for HEI providers in this area). Later adopters of BIM (the 'second movers') who have not developed any in-house education or training may well benefit from now engaging with such external providers. However, whether these organizations do see fit to capitalize on such opportunities and make efforts to formalize knowledge capture and knowledge management processes around BIM training and education remains to be seen.

CONCLUSION

This study found a relationship between recipients of BIM training and education and levels of BIM understanding, awareness and use. Those who have had BIM training or education are positive about BIM, but also believe that the quantity of education and training that they have personally received is not adequate, and that across the industry there has been low levels of training and education. Despite the fact that companies should be taking a pro-active approach to training and educating their staff to equip them with the skills necessary for successful exploitation of BIM implementation, the data reveal that in this sample, the majority of BIM training and education has been self-sourced by pro-active individuals rather than organisations. In contrast, individuals who have had no education or training about BIM fully expect their employers to provide this. For much of this study aspects of education and training have effectively been grouped together, but the analysis of the results from the sample surveyed highlight that education about BIM appears to be more prevalent than the practical hands-on BIM training required by construction management practitioners.

There are however, several limitations in undertaking such survey research, particularly employing such sampling methods. Data collected via survey can be lacking both in detail and depth. The method only allows one opportunity to collect data and as such does not afford for probing or prompting of respondents to dig deeper in order to collect additional data (Bryman, 2015). However, the nature of the research instrument used means that survey research can be replicated, and in this instance where the measures used are stable, this means that this work is repeatable. Because of the immediacy of the government BIM Mandate; and its impact upon the demand for training and education needs, it is difficult to predict if the same responses would be received and should such an opportunity for research ever be undertaken again in future, at suitable time intervals following the 2016 deadline it would be interesting to compare and contrast the two sets of results, although it is important to note that in terms of external validity, because of the combined purposive/snowball sampling technique used, the results cannot be considered generalizable.

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