BAF
BIM Academic Forum

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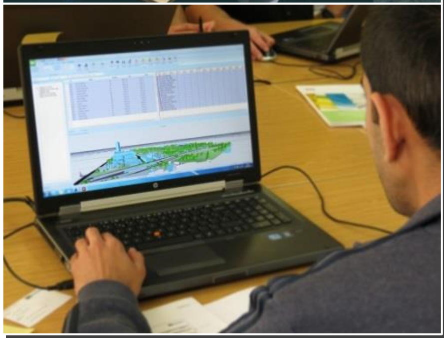
Current Position and Associated Challenges of BIM Education in UK Higher Education



The Higher Education Academy STEM

BiM Building Information Modelling (BIM) Task Group

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CURRENT POSITION AND ASSOCIATED CHALLENGES OF BIM EDUCATION IN UK HIGHER EDUCATION

This study is supported by the BIM Task Group and the Higher Education Academy, and conducted by the BIM Academic Forum.

BIM Academic Forum

With the HM Government's 2011 Construction Strategy now gathering momentum the necessity for an informed and equipped workforce becomes a growing priority. Alongside this is the requirement on all HEI's to respond to the changing need across industry, and although many programmes have begun to recognise this, the need for guidance and consistency has also come into focus. The BIM Academic Forum (BAF) is a group of representatives from a large number of UK universities and the BIM Task Group, which was established in late 2011 to respond to this need and to promote the academic aspects of BIM.

BAF operates under the following values and principles:

VISION

To foster integrated collaborative working on projects over the lifecycle of the asset through academic involvement and enhancement of BIM.

MISSION

To create a dynamic group to develop and promote the training, learning and research aspects of BIM through strong collaboration and co-operation.

OBJECTIVES

- focus on and elevate the training and learning and research aspects of BIM;
- collective promotion of BIM (expand wider market not extend own market);
- establish open medium for communication thus sharing knowledge, experience, case studies, views, etc.;
- collaboration for joint activities and research projects;
- collective voice in both teaching and learning and research matters, so to contribute to policy issues, funding priorities and agenda setting;
- attempt to minimise duplication and create standard practices while celebrating diversity.

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EXECUTIVE SUMMARY

In May 2011 the Cabinet Office published the Government Construction Strategy, announcing the Government's intention to require collaborative 3D BIM (with all project and asset information, documentation and data being digital) on its projects by 2016. Together with industry the UK Government has set out on a four year programme to reduce capital expenditure and the carbon burden from the construction and operation of the built environment by 20% through a modernisation of the sector. Such proposed transformation of the construction sector has significant implications for Built Environment education providers in ensuring they meet the demands required of future professionals. To this end, this study assessed the current position and associated challenges along with perspectives of BIM education in UK HE through surveys targeted at BIM-related Academic networks across the UK. Key areas focused on included:

- The Definition of staff resource
- State of BIM in HEI (Higher Education Institutions).
- BIM adoption Strategy
- BIM awareness and associated issues
- Generation implications

Findings from the study indicated a nuanced appraisal of BIM readiness in UK HEIs. There are clear distinctions between the category of top performers and low performers concerning investigated concepts with clear defining parameters. However the disconnect between these two tiers exists in a state of inertia that is counterproductive to the overall strategic role/contributions of HEIs to the ongoing BIM digital revolution.

A BIM assessment matrix was developed from the key investigated issues. This represents an update to the optimum requirements for BIM teaching among HEIs in the UK. This update mapped additional crucial strategic considerations concerning BIM in HEIs.

SUMMARY OF FINDINGS

- There is clearly a huge disconnect between built environment disciplines. Despite average/infused to high embedded levels for BIM related disciplines, this has not reflected on neither the BIM maturity levels, BIM policy awareness nor the consistency expected for the appropriation of BIM components (People, Process and Technology).
- There is no correlation between software adoption and generation categories. The implication for software vendors is not absolute as for now, however it is apparent that BIM software adoption in HEIs is dominated by the trio of Revit (Arch, struct, MEP), Autodesk Naviswork and Sketch Up., with limited choice variability.
- At the cutting edge where BIM is fully embedded into majority of the programmes/modules, architecture maintains a significant edge over all other Built Environment disciplines. Moreover, similar cutting edge levels of BIM delivery are most common at Undergraduate Level 6 (NQF) /Level 10 (SCQF). On taking the entire Built Environment disciplines into consideration there are overall low levels for BIM maturity awareness.
- HEIs are largely underperforming with generally low levels of engagement with industry. This might have further severe consequence on the Level 2 BIM targets for 2016, as the study identified links between the low levels of both direct and indirect external involvement with industry and perceived low BIM maturity levels.
- Despite the general level of support for the importance of BIM-related accreditation criteria of courses in academic institutions, the level of conviction for actual change is however not evident.
- About 40% still consider themselves not adequately informed on BIM and the UK government implementation strategy. This high level of detachment remains a setback.
- The pattern of responses to certain BIM strategic considerations, particularly in the aspects concerning ambitious and proactive Intended Learning Outcomes (ILO), practical inclination of curriculum developments, cost implications, and specialised ILO were closely associated with the age of respondents (i.e. generation category). Unsurprisingly, the Pre-war generation category

(considered digital immigrants of having adopted digital technology as adults and gained proficiency but interact with it in a fundamentally different way and therefore remain immigrants in contrast with digital natives who have grown up with digital technology and therefore have no meaningful memory of life without it, having become fluent in it) appeared to show more scepticism, perhaps restraint in their responses concerning the aforementioned considerations.

FOREWORD

As we move towards a digitized built environment we are rapidly having to reassess education against the backdrop of a digital future. Academia will need to quickly adapt to radical changes in educational needs focusing on reimagined professions that are more integrated and driven by data intelligence. Generation Y (born between 1980 and 2000) will expect to be equipped with new hard and soft skills that will allow them to rapidly create, manage and analyse data as part of their core ability.

The work of the BIM academic forum (BAF) is helping to shape this agenda and the draft BAF report looking at the current position and associated issues of BIM education in UK Higher Education is an important milestone in realising this goal. The BIM Task Group takes this opportunity to thank the BAF members for their commitment to the level 2 programme and imbuing its components within their respective programmes.

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BACKGROUND

Information regarding BIM adoption strategy in the UK has been garnering attention in the contemporary built environment discourse for a while now. In going forward, BIM development should be coordinated in tandem with built environment requirements which traditionally build upon a creative and collaborative process based on a knowledge intensive and generative framework (Berente, et al., 2010). The UK Government's approach has been broad based, focused mostly on deriving significant improvements in cost, value and carbon performance. This however, lacks specificity; hence developing an informed and equipped workforce remains an ever growing priority (Wolstenholme, et al., 2009). Huge strides are being made in this regard, particularly in areas concerning the amount of support available for BIM implementation through UK standard/guides etc. as being developed through the UK BIM Task Group. However, to achieve an efficient alignment of BIM UK targets with the built environment, inherent obstacles clogging the flow of seamless interaction between the numerous built environment workplaces and Higher Education Intuitions (HEI) has to be identified and tackled to systematically overcome what appear to be evolving challenges. To achieve these goals, a proactive and co-ordinated HEI response towards embedding BIM in their academic development framework needs to be facilitated. To this effect this study's investigation has focused on the following key areas:

- How providers in teaching and training and learning respond/react to the inception of BIM learning and training in HEIs.
- 'Attitude' and predisposition within the existing built environment professional workforce.
- Unravelling areas of concern for HEIs in BIM adoption.
- The need for an appropriate updated assessment matrix of BIM readiness among individual HEI stakeholders.

AIM AND OBJECTIVES OF THE STUDY

In order to unravel areas of concern for HEIs in BIM adoption, identification of factors that influence attitudes, perception and behavioural inclinations inherent in HEIs is considered crucial (Clarke, 2008). Therefore, this study aims to: 'Investigate the current position and associated challenges of BIM education in higher education.'

To achieve this aim, the study adopted the following objectives;

1. Understanding BIM requirements and development from an industry and higher education perspective.
2. Explore the aforementioned issues regarding the current position and associated challenges of BIM education in UK HE as identified from literature through workshop consultations and interviews.
3. Identify key indicators required to investigate the current position and associated challenges of BIM education in UK HE.
4. Update/develop the BIM Teaching/Training Impact Matrix (BTIM) for HEIs.

EMBEDDING BIM IN THE EDUCATION FRAMEWORK: IMPLICATIONS FOR HEIs AND INDUSTRY

In May 2011 the Cabinet Office published the Government Construction Strategy, announcing intentions to require collaborative 3D BIM (with all project and asset information, documentation and data being digital) on its projects by 2016. Together with industry, the UK Government had set out on a four year programme to reduce capital expenditure and the carbon burden from the construction and operation of the built environment by 20% through the modernisation of the sector.

Such proposed transformation of the construction sector has significant implications for Built Environment education providers in ensuring they meet the demands required of future professionals. In order to address these implications, the BIM Academic Forum (BAF) was set up with the aim of creating a dynamic collaborative group to enhance and promote teaching and learning together with the research aspects of BIM, therefore serving as a conduit between industry demands and BIM education in HEIs.

According to BAF (2013), the core learning outcomes for levels 4, 5, 6 (undergraduate) and 7 (postgraduate) contents (Appendix A) are expected to be 'BIM aware', 'BIM focused', and 'BIM enabled'. This is designed to facilitate knowledge and understanding, practical skills and transferable skills. These outcomes stand the risk of being hampered if inherent obstacles to HEIs fully embracing BIM are not measured and tackled. This study has carried out related investigations of potential sources of obstacles focused on four key areas and requirements, i.e. up-skilling of staff, industry engagement and HEIs, framework for learning and keeping pace with BIM development in IT and Built Environment-related industries.

Up-skilling of staff

Long before the advent of the UK Government's drive towards BIM adoption, the approach to work and employment has continually experienced shifts, particularly in deskilling, up skilling of workforce (Watson, 2008). Clearly, rigorous debates have rejected the concept of deskilling as a workplace management strategy in favour of up skilling as a strategic response to employee flexibility (choice, discretion, autonomy and so on), particularly during the adoption of, and reaction to new technology/knowledge; see Braverman (1974). To better understand this phenomenon as an incentive to the appropriate BIM strategy, attitude is fundamental, i.e. how stakeholders in teaching and training and learning respond/react to the inception of BIM in HEI. This in particularly becomes an issue when faced with a supposed steep learning and training programme referred to BAF (2013), which poses a challenge to HEIs.

In the UK sphere, most HEIs have relied on basic training focused on technology and its relative functionality. This might not be sufficient for an effective BIM transition if a phased process that accommodates industry requirement is taking into consideration. Apparently, the phased approach allows time for both HEI and industry to prepare for the development of new standards and training in line with the Government Construction Strategy (Cabinet Office, 2011). These limitations in BIM education have been further highlighted in a BAF (2013) report which found out existing lapses in HEI progress, i.e. current developments in BIM education appear to largely focus on only the most fundamental aspects, which alone is not sufficient to support the knowledge and understanding required by the push for overall BIM adoption.

Industry engagement and HEIs

As technology changes rapidly and diffuses readily, keeping up with the level of sustained investments in education and training will require an adequate educational system, that equips students to become critical players in future waves of innovation. However, leaders in technological innovations such as the UK are projected to experience critical skill shortages in this aspect, due in part to their aging populations and, paradoxically, by an increasing percentage of their population being relatively "well educated": this, according to Oxford Economics (2012), can actually result in a saturation of generic skills that lack specialisation, hence offering less room for meaningful improvement. Furthermore, jobs and required skills are continuously shifting to reflect changes in business, technology and client expectations which require constant upskilling of employees. However, there is bound to be skills gap if HEIs lag behind in filling existing lapses in academic curriculum and learning outcomes. Moreover, amidst dwindling resources, HEIs are expected to be at the forefront of taking advantage of opportunities that exists in BIM training and re-skilling, people planning and designing engagement strategies within the Built Environment industry in the UK (Oxford Economics 2012, cited in The Canadian Chamber of Commerce 2013). Consequently, with this increasing awareness of BIM across the industry, more than ever there is an increasing need for HEIs to face up to these challenges in the aspects of funding, training and research development for the construction sphere.

Framework for Learning

The strategies towards BIM implementation have been focused largely on construction applications such as lean procurement processes; use of whole life, outcome based specifications targeted at encouraging supply chain innovation; applying cost targeted integrated approaches to procurement (Cabinet Office, 2011). To make up for the practical skill demands necessary to fulfil the requirements of these approach, HEIs are already struggling to cope with the subsequent demands for BIM-ready graduates, i.e. those capable of demonstrating discipline specific benefits of BIM within existing skill gap irrespective of targeted industries (BAF, 2013). The training options for learning available to businesses are constantly growing in the UK due to new entrants. Options considered by businesses include, in house, external supplier, either on-site or off-site. The delivery methods are also diverse and constantly evolving, due in a large part to information technology, and the need to build upon a great deal of research into what is most effective, both of which could be costly.

BAF's recommendation involves a measured mix of these formats, resulting in learning outcomes derived through knowledge and understanding, practical skills and transferable skills, with HEIs expected to play a central role in dissemination (Appendix A). Alternative views from an industry perspective argue that an HEI centred training developed by academics and guided by institutional specialisation might no longer be fit for purpose. Critics believe there is limited industry input in terms of checks and balances, because training requirements are usually validated through academic peer review structures, rather than industry driven critique processes/protocols. Other identified constraints include existing inflexibility in HEI course time frames, which makes it difficult for work-based learners, despite derivable benefits such as retention and upskilling of employees, improving staff motivation, and improvement in company competitiveness. However, these benefits appear challenging for HEIs and their inherent traditional course delivery routes (Martin, et al., 2010). More recently, collaborative efforts between BIM Task Group and BAF have resulted in the development of a Learning Outcomes Framework (LOF) that encourages industry's procurement and delivery of training and education courses in order to grow strong capacity and capability of BIM Level 2 in the UK market, underpinned by a consistent learning outcomes definition (Appendix B). The 2015 version of the LOF now accommodates the BIM Level 2 foundation documents and includes academic and industry feedback on its applicability, presentation format, structure, and content. However, it appears that the supposed levels of disconnect between industry and HEI will require evaluation to ensure LOF targets are realised.

KEEPING PACE WITH BIM DEVELOPMENT IN IT AND INDUSTRY

In keeping pace with recent BIM development in industry, HEIs are normally faced with the options of either adapting their existing curricula towards this (Integrated approach) or as a separate standalone arrangement (Sacks & Barak, 2008). On this issue, Wong, et al (2011) suggested that the integrated approach is in line with industry requirements. However, this will require inculcating avenues that cater to new developments in technology or new methods of training delivery to their students. Moreover, Forsythe, et al (2013) suggested the adoption of active and regular collaborative design charrettes with industry, staff and students as a useful tool to facilitate up to date industry involvement. However, a survey by Kiviniemi et al (2008) identified traditional parameters like software choice, upgrading costs and education as major obstacles. Forsyth, et al (2013) also highlighted the crucial need to investigate these soft issues before embarking on significant technological implementations. Moreover, due to the rapidly evolving nature of BIM, adopters (HEI, student and industry), and supposed historical preservationist thinking in HEIs (Davidson & Goldberg, 2010), this study recognised the need for an appraisal of 'attitude' and predispositions towards investigated transition strategies 'for and within' UK HEIs. This would also include technological and accreditation implications.

ATTITUDE TOWARDS BIM IN HEI: CMC/CBL AND GENERATION INFLUENCES

BIM represents a succession to Computer-aided Drafting (CAD) which gained prominence through the 1980's (Wong, et al., 2011). This evolution apparently signifies a paradigm shift in PBL (Problem-based learning and CMC (Computer-Mediated Communication) applications inter-generationally. PBL functions as an approach that emphasise students' learning through active inquiry in groups and integrating their conceptual knowledge with their procedural skills (Gallagher, 1997). Furthermore, this fosters intrinsic motivations and hence encourages questioning and association with and reflection on previously acquired knowledge (Teo & Wong, 2000): an approach of "learn[ing] how to learn" via. "real-life" problems (Boud & Feletti, 1999). Much credence has been given to the effectiveness of PBL, as literature suggests that students consider PBL to be an effective learning method over the lecture format (Antepohl & Herzig, 1999). BIM attributes as an embodiment of a digitally mediated problem based learning model can be associated with the transitional process experienced with the prior advancement of technology in computer-mediated communication (CMC). Likewise BIM allows interaction, collaboration and communication among students through digital medium exchanged dialogue (Lo, 2009). BIM learning compared to CMC and CBL at inception does face significant challenges posed as either conflicting perceptions or physical limitations among intended adopters. This could be due in part to facilities and space; the difficulties involved in finding the time and resources to initiate the appropriate technological support (Ertmer, et al., 1999; Vannatta & Beyerbach, 2000; Parr, 1999). Predicators such as intergenerational disparities in the workplace could also influence technology adoption impacting organisational experiences and perceptions (Macky, et al., 2008).

The impact of generational differences on beliefs and perceptions might be underestimated, however several research have highlighted the significant impacts of having four distinct generation cohorts in the academic workplace as a significant issue facing HEIs (Hannay & Fretwell, 2011; Murray, 2011). Also crucial is the significant implications of how each generation experiences life, including education and work. This could stem from the effects of the social and cultural values of the society within which they mature and by the technologies available (Underwood, 2014). Even more pronounced is how this influences manifest among the 'digital natives', who have grown up with technology, have no meaningful memory of life without it, and have become fluent in it, and 'digital immigrants' who have adopted it as adults; resulting in possible variations in brain structure and thinking patterns (Underwood, 2014; Koutropoulos, 2011; Prensky, 2001).

A report by Ipsos MORI buttressed Rhodes' (1983) view on the impact of generation disparities and the influence of factors such as; external events or a general cultural shift; lifecycle effects; growing older through significant life stages; cohort effects, i.e. where opinions gradually shift over time from one generation to the next (Rhodes, 1983; Duffy, et al., 2013). In order to explore generation impacts, the study also investigated perceptions on associated issues concerning BIM integration in traditional built environment disciplines in HEIs based on the following Ipsos MORI four adult generational classifications:

- The Pre-war Generation (represents those born before 1945)
- The Baby Boomers (represents those born between 1945 and 1965)
- Generation X (represents those born between 1966 and 1979)
- Generation Y (represents those born between 1980 and 2000)

THE SURVEY: CONSULTATIONS

A series of workshops was conducted by the BIM Academic Forum (BAF) which as mentioned earlier was set up with the aim of creating a dynamic collaborative group to enhance and promote teaching and learning together with the research aspects of BIM (BIM Task Group, 2013). Areas addressed during the consultations include the following:

- How stakeholders in teaching, training and learning respond/react to the inception of BIM learning and training in HEIs.
- Unravelling areas of concern for HEIs in BIM adoption.
- Confirming indicators/elements for an updated assessment matrix of BIM readiness among individual HEI stakeholders.
- Identification of factors that influence attitudes, perception and behavioural inclinations inherent in HEIs (Clarke, 2008).

Participants in the consultation include the BAF, which is fully recognised by the UK Government, BIM Task Group, Construction Information Committee (CIC), Constructing Excellence, etc. The forum includes professional and academic representations spread across over 35 UK universities.

THE QUESTIONNAIRE

The questionnaire was informed by data gathered from consultation processes analysed with the intent of identifying areas and issues of concern. As part of the evaluation process; a content analysis of the transcripts of workshop consultations was carried out. This resulted in a concept map comprised of the following thematic clusters and respective evaluation indicators of associated issues regarding BIM education in UK HE:

Defining staff resource

- BIM representation in the Built Environment

State of BIM in HEI

- Assessment of BIM Maturity Levels
- The need for Up-skilling in HEIs: BIM Representation Levels
- BIM Software adoption trends: Implications for CBL/CMC
- BIM Curriculum Incorporation
- Maturity levels of BIM delivery strategy/involvement
- Length of BIM inception: Impact on BIM Maturity Levels

BIM adoption strategy

- Perception of BIM components: Implication of Level of Experience with BIM
- External Engagement Assessment: Implication for BIM Maturity and BIM experience levels
- BIM Transition Strategy (BAF ILO)
- Competition and alternative education providers

BIM awareness and associated issues

- BIM Policy awareness
- BIM and institution accreditation in HEIs
- Understanding the relevance of BIM in overall construction policy development.
- BIM HEI transition strategy

Generation implications

- The recognition levels of the negative impact of premature and unrealistic ILO for BIM in HEIs.
- The recognition levels for more practical and 'industry relevant' BIM assessments, as against the theoretical approach.
- The recognition levels of the cost implications of discipline specific diversification/specialisation of BIM ILO as counter-productive to embedding BIM in HEI curriculum.
- Identification levels of the negative impact of lack of bespoke BIM ILO for different disciplines on employment readiness for industry specific roles.
- The level of understanding of the relevance of BIM in overall construction policy (future perception).

THE SURVEY

The questionnaire was sent electronically to academic and professional networks across the UK. Respondents were divided into three major groups; those with Academic, Industry and both Academic and Industry experience in BIM. For a more in-depth analytical and study focus purposes, the groupings were further sub-divided into other categories to develop a profile map of the respondents.

ANALYSIS

A random representation of the target databases was sought, irrespective of location. The questionnaire build up comprised simple and mixed format multiple choices and five point likert scale questions (mostly closed). The survey received a total of 98 responses (65 complete and 33 partial/incomplete). The survey constructs where then analysed with the SPSS software preceded with a measure of internal consistency. A Cronbach's Alpha coefficient of (α=0.901) was obtained from the reliability test, which indicates a high level of internal consistency. Other major techniques adopted include Pearson's Correlation and Multinomial Regression Analysis (MRA) to analyse patterns within study variables.

DEFINING STAFF RESOURCE

This section sets the stage for the data analysis by mapping the strategic profile of the survey responses. This plays a role in BIM strategy development in HEIs, hence help assess readiness, efficiency and upskilling potentials or needs.

Despite the survey receiving a total of 98 responses, 33 were incomplete. A quick analysis was carried out comparing the level of BIM experience existing within both categories. It was observed that 27.3% of respondents with grossly incomplete responses had no experience at all with BIM, compared to just 3.1% for those with complete responses. Therefore, it appears that the likelihood of completing the questionnaire was significantly impacted by the level of BIM experience of the respondent.

BIM representation in the Built Environment

Analysis of the respondents revealed that; 53.8% of the respondents had only academic experience of BIM; while 4.62 % had only industry experience. However, 38.46% of the respondents had both academic and industry experience (Figure 1).

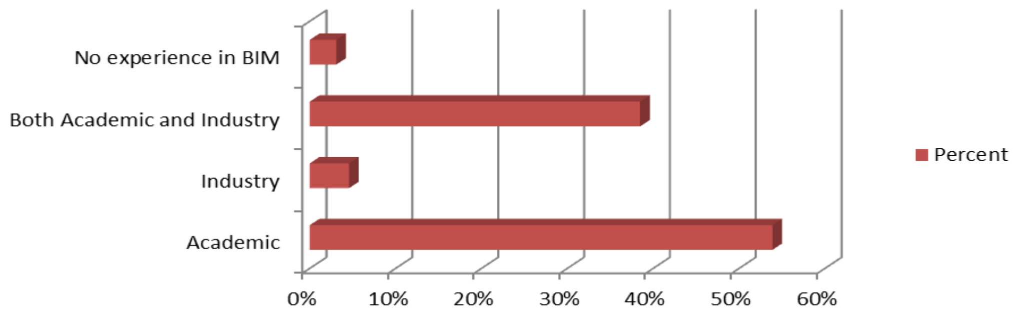


Figure 1: Respondents' BIM experience

Furthermore, 20.0% of responses were researchers, 12.3% lecturers, 38.5% senior lecturers, 4.6% readers, and 20.0% professorial (Figure 2).

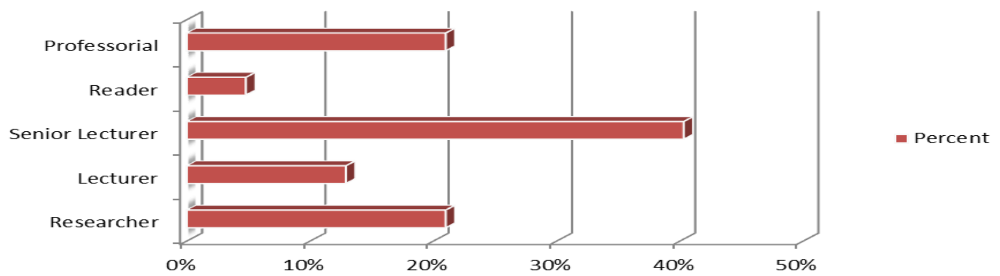


Figure 2: Primary academic position/level

A robust representative sample of respondents was also captured with 50.0% of the respondents being module leaders, 22.6% programme leaders, 6.5% head of directorates, 11.3% head of research centres, while 11.3% are not within these key academic categories.

To assess generation implications an intergenerational distribution of the respondents was also analysed. Interestingly, over 60% of the respondents fall within the 49-68 age categories (Figure 3).

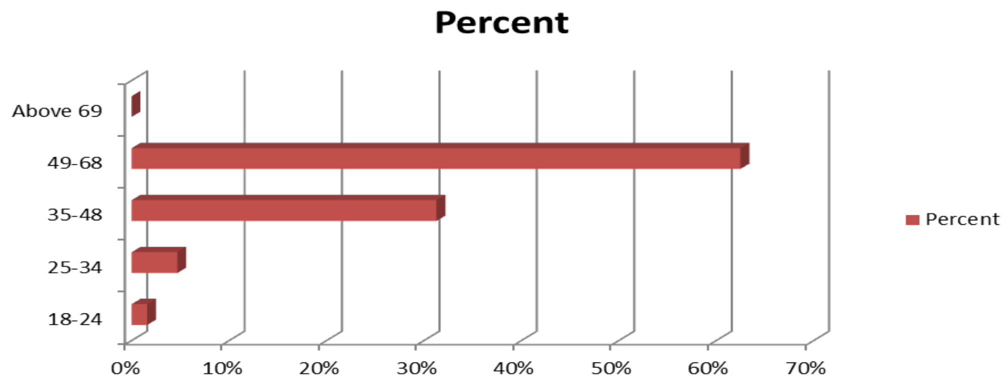


Figure 3: Age Classification of respondents

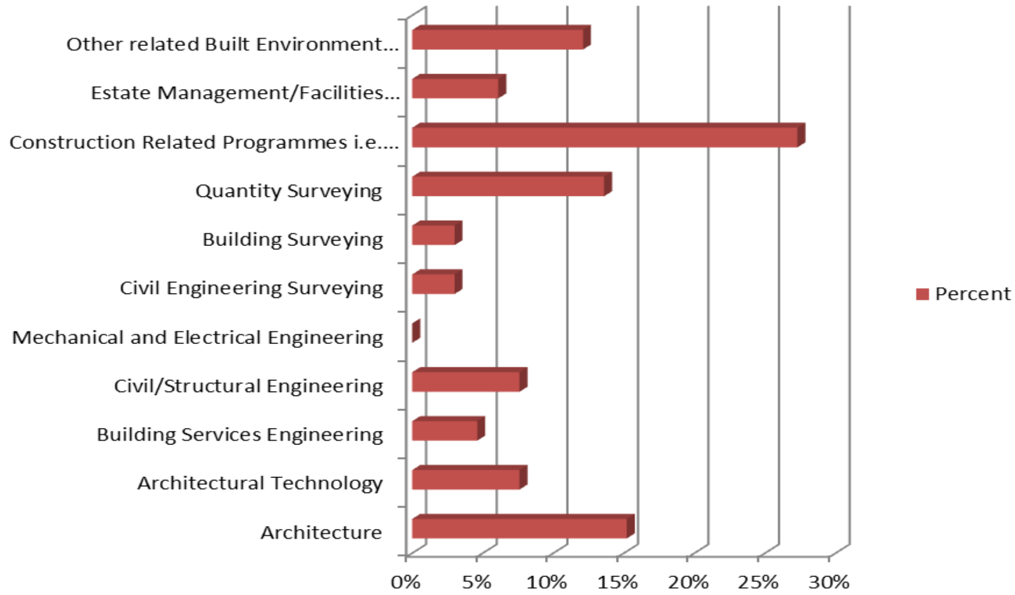


Figure 4: Built environment related disciplines: BIM representation

In regards to BIM representation in the Built Environment, construction and architecture account for over 40% of BIM survey respondents; while Quantity Surveying, Civil Engineering, Building Services and Estate/Facilities Management related disciplines account for 13.6%, 10.6%, 7.6% and 6.1% of the respondents respectively. Other Built Environment related disciplines have a 12.1% representation, comprising disciplines such as Computer Engineering, Sustainability Systems, Planning and Urban Studies, the majority of which had incomplete responses. Moreover, Electrical/Mechanical Engineering had no representation.

STATE OF BIM IN HEI

Findings from this section explored the perceptions of respondents on how they respond/react to BIM learning and training systems in HEIs. This study observed that over 80% of responses have come from individuals with some degree of management responsibilities within built environment disciplines (Figure 4).

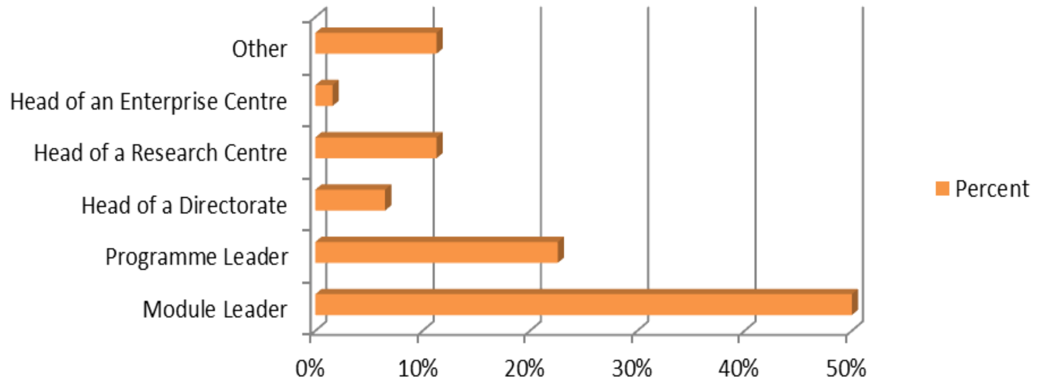


Figure 4: Positions with degrees of management responsibilities

Assessment of BIM Maturity Levels

Perceptions from respondents on their (institutions/departments) BIM maturity levels revealed that the levels of development trends (Figure 5) in the following order; level 1: *Managed CAD in 2 or 3D format,* Level 0: *Unmanaged CAD probably 2D, with paper (or electronic paper) as the most likely data exchange mechanism and then Level 3: Fully open process and data integration enabled by IFC / IFD.*

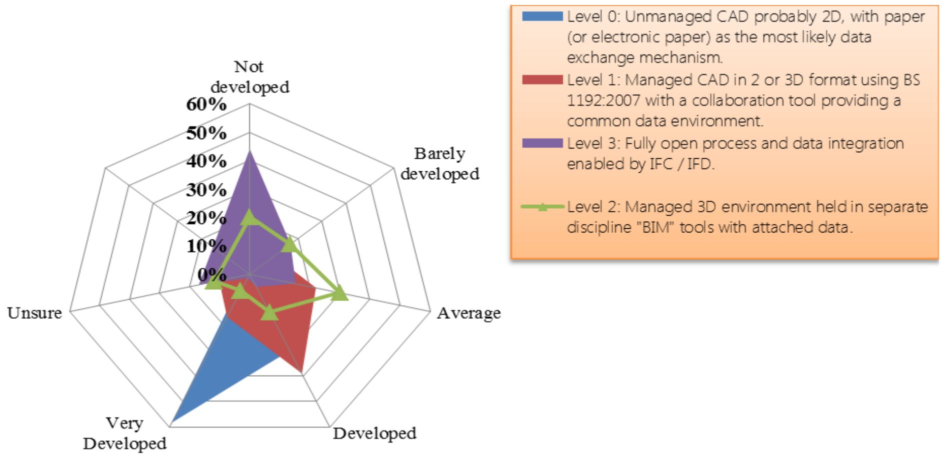


Figure 5: BIM maturity levels

Responses revealed that 66.7 % of respondents expressed average or less than average maturity for BIM Level 2: *Managed 3D environment held in separate discipline "BIM" tools with attached data*, with 36.7% expressing barely matured/not matured levels (Figure 5).

The need for up-skilling in HEIs: BIM representation levels

In order to evaluate built environment staff awareness and exposure to BIM the study measured the level of BIM interest gaps in built environment disciplines.

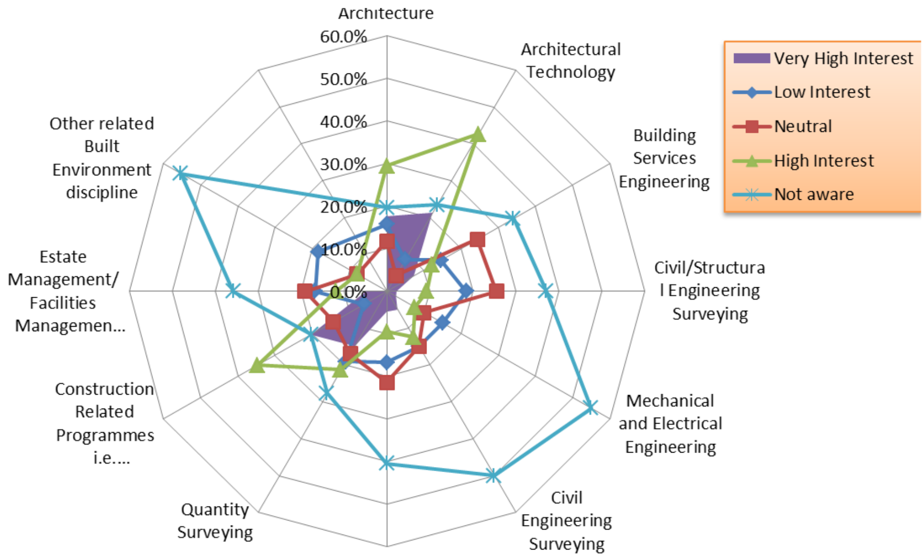


Figure 6: BIM representation levels according to disciplines.

Apart from architecture and construction related disciplines, analysis (Figure 6) indicated overall low levels of interest in BIM incorporation in teaching across built environment related disciplines. 64% and 47% of respondents indicated high levels of BIM representation for architecture and architecture Technology disciplines respectively. Construction, quantity surveying, Estate Management/Property related disciplines/programmes had considerable high interest levels of 55%, 36% and 16.7% respectively. Other built environment disciplines all had less than 20% BIM interest/representation.

BIM Software adoption trends: Implications for CBL/CMC

The study investigated BIM software adoption among respondents to explore CMC challenges in regards to software adoption (Kiviniemi et al, 2008; Woo, 2007). Findings show a 79% rate of adoption/use for Revit (Arch, struct, MEP), followed by both Autodesk Naviswork and Sketch Up with 45.6% and 42.1%, respectively (Figure 7).

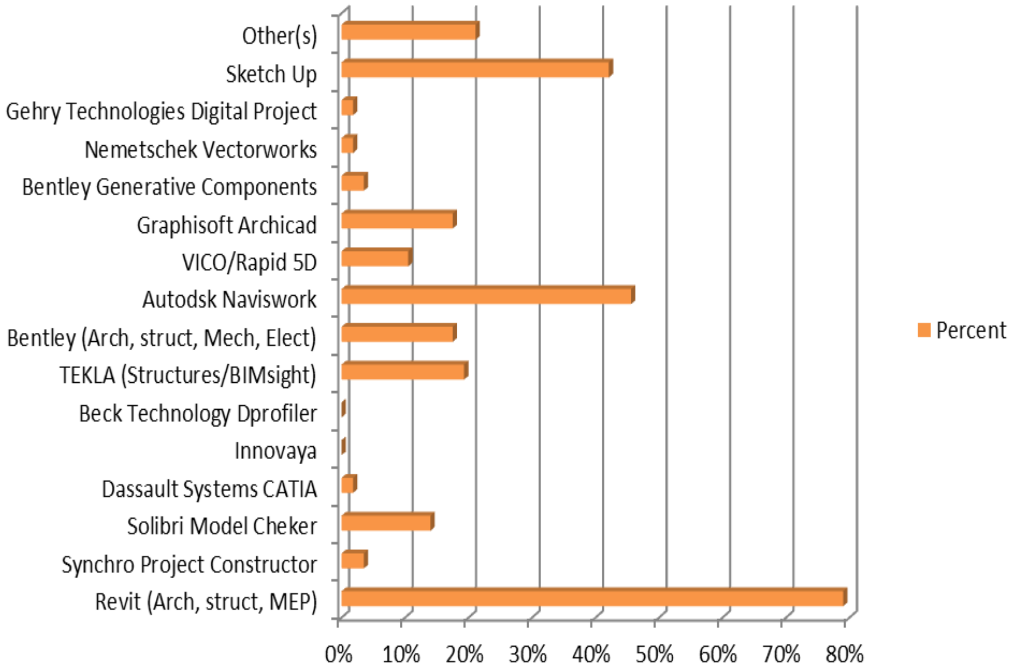


Figure 7: BIM software adoption

BIMMeasure, Causeway BIM Measure, ASTA.IES, CostX, IES, Grasshopper, White Frog training are some not so common platforms adopted for BIM teaching. They all account for about 21% of respondent adoption/use rate. Moreover, there was evidence that users of certain software products (Sychro Project Construct, VICO/Rapide 5D and Nemetschek Vetorworks) disagreed with the notion that the steep learning curves for (staff and students) impair BIM progression in HEIs. This is based upon their significant negative associations ($r (61) = -.308$, $p = .016$; $r (61) = -.279$, $p = .029$; and $r (61) = -.308$, $p = .016$, respectively) with the 'steep learning curves' statement.

BIM curriculum incorporation

An appraisal of the implementation/incorporation strategy for BIM in the HEI curricula is deemed crucial to addressing and understanding issues pertaining to risks that might be encountered when addressing implementation lapses (Forsythe, et al., 2013). It is therefore fundamental to measure BIM curriculum incorporation among individual disciplines.

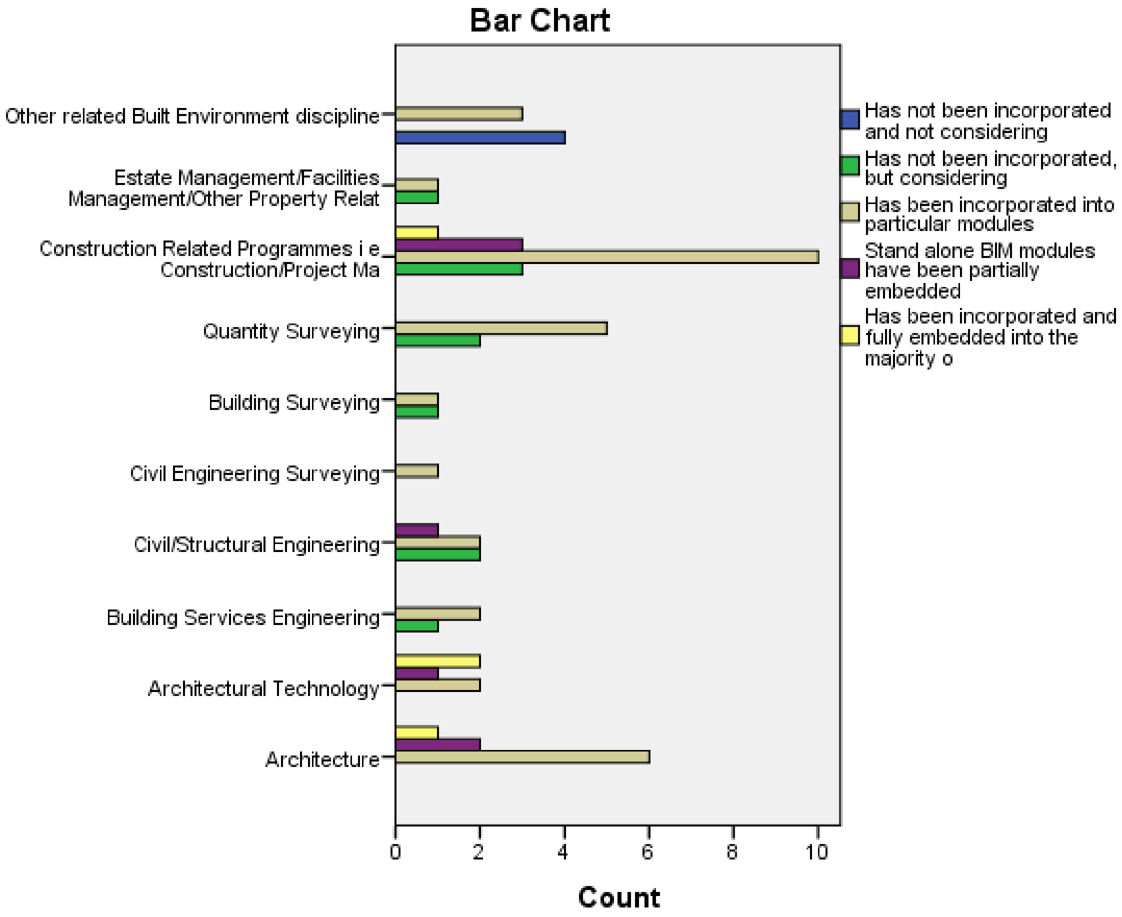


Figure 8: BIM curriculum incorporation

Overall findings here indicated that 24% of programmes are yet to incorporate BIM; of this 6.9% are not considering incorporating BIM. Notably, 57% have incorporated BIM into particular modules. About 20% of programmes have developed standalone BIM modules, however only 13% have partially embedded BIM, while only 7% have fully embedded BIM in majority of their programmes.

Maturity levels of BIM delivery strategy/involvement: Implications for CMC/CBL

- Analysis carried out on the 'discipline specific BIM materials' (developed/delivered/involved) in a teaching capacity within respective education levels revealed that most activity occurred within (Figure 9):
- Undergraduate Level 4 (NQF)/Level 8 (SCQF) (20% *Lecture type delivery of BIM*).
- Undergraduate Level 5 (NQF)/Level 9 (SCQF) (31% *Hands on teaching of BIM software in computer labs in addition to lecture type delivery materials*).

- Postgraduate Level 7 (NQF)/Level 11 (SCQF) (23% *Lecture type delivery of BIM*).

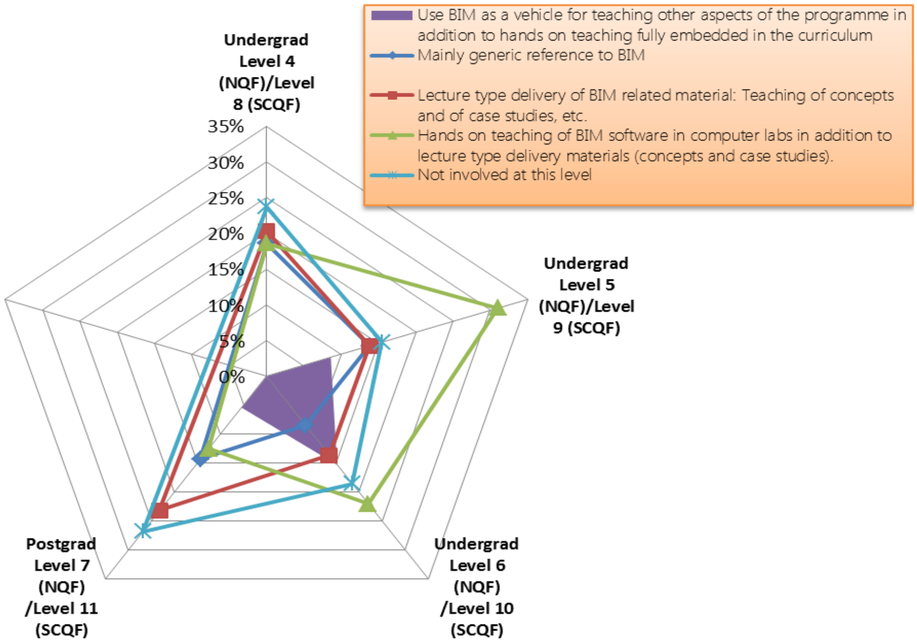


Figure 9: Maturity levels of BIM delivery strategy

At the cutting edge levels of BIM delivery, most of the activity is centred on 'Undergraduate Level 6 (NQF) /Level 10 (SCQF)' where 15% *Use BIM as a vehicle for teaching other aspects of the programme in addition to hands on teaching fully embedded in the curriculum*. Implications for CMC/CBL identified a significant negative correlation between the maturity level of individual BIM involvement at Postgraduate Level 7 (NQF)/Level 11 (SCQF) and the 'steep learning curve barrier' indicator, Pearson's r (54) = -.302, p = .026. Therefore, at Postgraduate Level 7 (NQF)/Level 11 (SCQF), the 'steep learning curve' is likely to be perceived more as a barrier the less the maturity level of individuals' involvoment with BIM, and vice-versa.

Length of BIM inception: Impact on BIM maturity levels

Findings here revealed that about 53% of HEIs/departments have engaged BIM academically for up to 3years. Moreover, 12% of HEIs have engaged BIM academically for at least 3 to 6 years, while 7% and 3% have been engaged with BIM in academic capacity for not less than 6 years and more than 10 years, respectively.

Implications on BIM development identified a significant positive correlation between the length of BIM inception and BIM Maturity Levels, particularly at Level

2, Pearson's r (57) = .308, p = .020; and Level 0, Pearson's r (57) = .262, p = .049. Therefore, the longer the length of time since BIM inception the more developed the maturity for levels 0 and 2.

BIM ADOPTION STRATEGY

In order to keep pace with the industry developments, Wong, et al (2011) suggested that the integrated approach is in line with industry requirements, hence suitable to stay abreast of recent developments. However, this will require inculcating avenues that cater to new developments in technology or new methods of project delivery to their students. Moreover, Forsythe et al (2013), suggested the active/regular collaborative design charrettes with industry, staff and students as a useful tool to facilitate up to date industry involvement. None of these will be possible without improved levels of external engagement and the general understanding of fundamental BIM components. These areas and more were further explored in the next section.

Perception of BIM components: Implication of Level of Experience with BIM

Results here (Figure 10) are generated mean of the perceived importance for each BIM component. The following mean scores were generated in descending order (Max: 5 and Min: 1); People (3.58); Information (3.25); Technology (3.19); Process (2.80). See (Figure 11) for distribution.

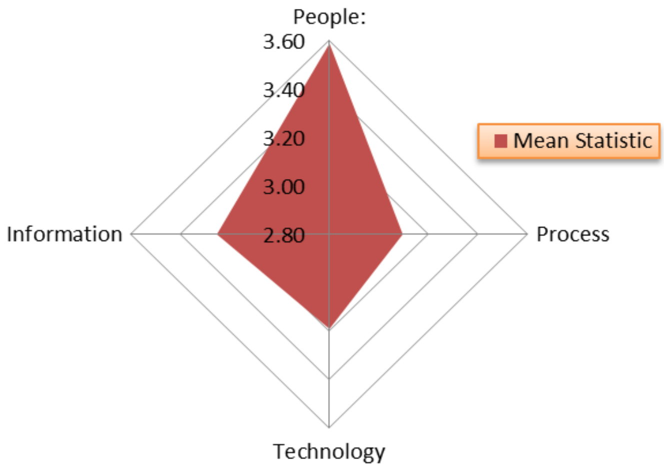


Figure 10: Perception of BIM components

Moreover, there were significant correlations between the level of BIM experience and the level of importance of the technological component of BIM, (Pearson's r (57) = .262, p = .049). This correlation was not significant for the other components.

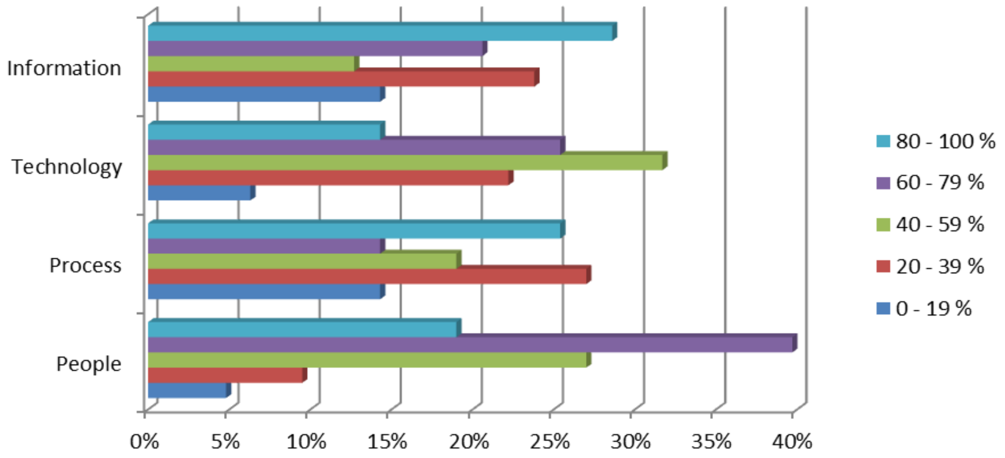


Figure 11: BIM components distribution

External engagement assessment: Implication for BIM maturity and BIM experience levels

The study measured HEI engagement levels with industry in the development and delivery of BIM related materials. Results indicated that there is a low level of engagement with industry either indirect or direct. 62% and 67% of respondents indicated less than high levels of industry direct and indirect external engagement in their BIM curriculum development, respectively (Figure 12). Moreover, there were significant positive correlations between the levels of direct and indirect external industry engagement and the level of development of BIM maturity levels:

- Direct External Engagement and Level 1 BIM, [Pearson's r (57) = .318, p = .016].
- Direct External Engagement and Level 2 BIM, [Pearson's r (57) = .541, p = .000].
- Direct External Engagement and Level 3 BIM, [Pearson's r (57) = .322, p = .015].
- Indirect External Engagement and Level 1 BIM, [Pearson's r (57) = .335, p = .011].
- Indirect External Engagement and Level 2 BIM, [Pearson's r (57) = .489, p = .000].

- Indirect External Engagement and Level 3 BIM, [Pearson's r (57) = .263, p = .048].

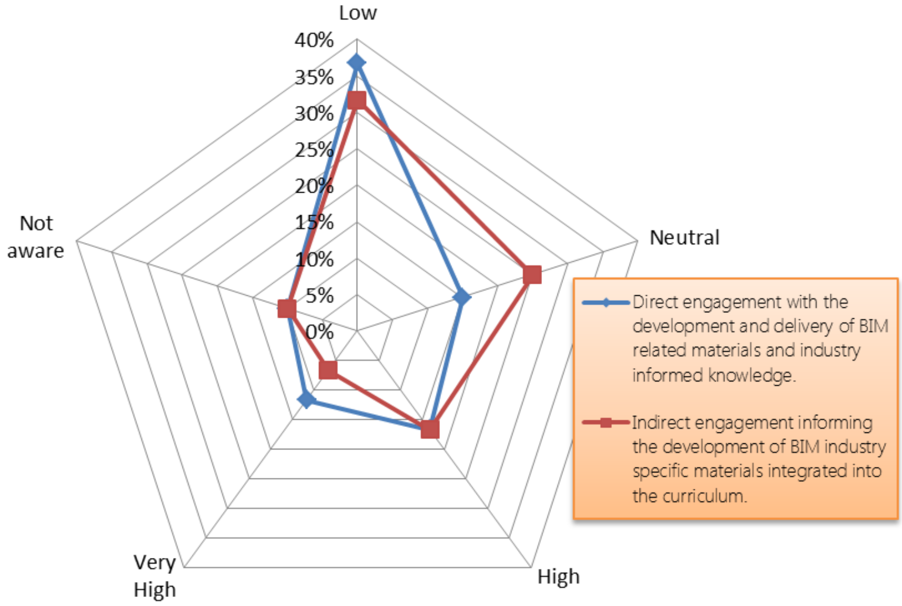


Figure 12: External engagement levels

There were also significant positive correlations between direct and indirect external engagement and BIM inception duration, bearing in mind the following findings on the duration period BIM has been taught for and the corresponding percentage representations: 1 to 3 years, 53%; less than 1 year 19%; 3 to 6 years, 12%; 6 to 10 years, 7% and more than 10 years, about 3%. However, about 7% indicated that BIM is not taught all in their HEIs.

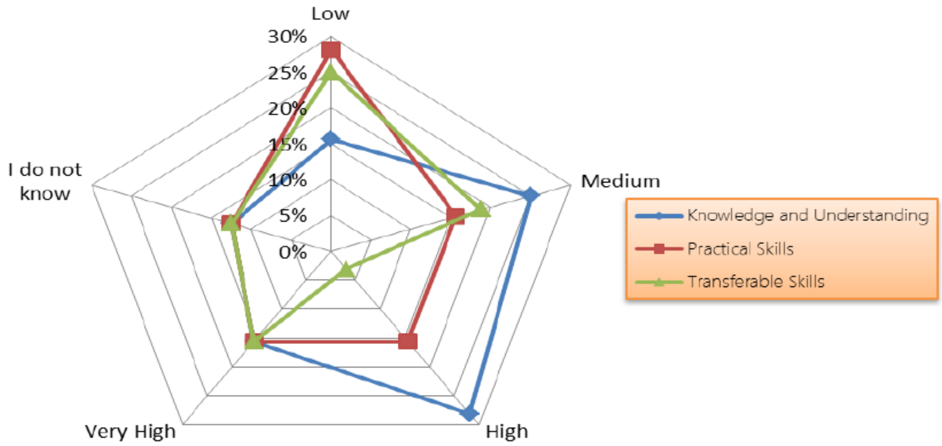
- Direct Engagement and BIM inception duration, [Pearson's r (57) = .361, p = .006].
- Indirect Engagement and BIM inception duration, [Pearson's r (57) = .345, p = .009].

Implications of these significant positive correlations show that the higher the levels of both direct and indirect external involvement with industry, the higher the level of perceived development of BIM levels 1, 2 and 3. Similarly, it appears that the longer the BIM inception, the higher the levels of both external and internal industry engagement/involvement in BIM curriculum development.

Also worth pointing out is the strong statistical relationship between external and internal industry engagement in curriculum development, [Pearson's r (60) = .904, p = .000].

BIM transition strategy (BAF ILO)

In regards to the level of embeddness achieved with key BAF ILO in curriculum development and delivery, results indicated a combined medium to very high adoption levels of 69% for the knowledge and understanding ILO (Figure 13).



***Knowledge and Understanding**: Collaboration, BIM Concepts, Stakeholder Business Drivers, Legal Frameworks, Commercial Implications, Industry Practice, Life Cycle and Supply Chain Management.*

***Practical Skills**: Technology use across disciplines, Attributes of BIM system, BIM Tools and applications, Ability to adopt different platforms, Protocols/Interoperability/ Standards, Visualisation of large datasets, Use of BIM enabled technology.*

***Transferable Skills**: BIM as a process tech/people/policy, Sustainability, Interdisciplinary communication, How to deliver projects using BIM, Process Mapping/ Business Process Re-engineering (BPR), Ability to assess barriers at various levels.*

Figure 13: BIM transition strategy: BAF ILO levels of adoption

This subsequently declines in the case of practical skills and transferable skills ILO; results indicated 47% and 37.5% medium to very high adoption levels respectively. 19%, 41% and 50% of respondents reported low levels of embediness for knowledge and understanding, practical skills and transferable skills, respectively. Notably, a significant 12.5% of respondents were not aware of the level of embediness for these key BAF ILO

Generation influences investigated identified a significant weak positive correlation between generation classification and the perception of the level of BAF ILO incorporation into HEI curriculum development, Pearson's $r(32) = .374$, $p = .035$.

Competition and alternative education providers

Results here indicated that a majority 66% of respondents agree that HEIs are failing to keep pace with BIM skill requirement and industry knowledge demands; hence are faced with the risk of alternative educational providers and/or 'industry delivered in-house BIM education' usurping their traditional roles in graduate skill development/training.

However, there was a significant negative correlation between generation classification and the level of agreement to the aforementioned notion, [Pearson's r (61) = -.296, p = .021]. This might imply that that younger respondents are more likely to agree with this notion and vice versa.

BIM AWARENESS AND ASSOCIATED ISSUES

The first part of this section analysed the general level of awareness of BIM associated issues, whereas analysis carried out at the latter part focused on the respondents' four adult generational classifications and their implications on research specific BIM perceptions.

BIM Policy awareness: The role of BAF in BIM

Despite BAF's role as an academic networking platform for BIM, and the fact that 40% of the study's respondents still consider themselves not adequately informed on BIM, 44% of respondents were unaware of BAF or its activities. Considering that the targeted sampling method employed by this study ensured robust representation of academics in HEI, only 56% of respondents considered themselves aware of BAF. Furthermore, awareness of BAF's BIM ILO strategy was claimed by 44% of respondents. However, 80% see the role of BIM networks like BAF as crucial to informing professional bodies on strategic accreditation criteria for HEIs.

BIM and institution accreditation in HEIs

In regards to the impact of expediting the build up towards accrediting BIM courses in HEIs by key institution stakeholders, hence eliminating engagement barriers. Barriers investigated such as perceptions of the level of difficulty involved in engaging with professional institutions to help address new requirements and demands in discipline specific accreditation revealed that a majority (68%) of the respondents agree on the severity of these barriers, with a minority (15%) disagreeing.

On the issue of accreditation benefits to the overall BIM strategy in HEIs, a majority (80%) agree that BIM related accreditation criteria in academic institutions is important for improving overall student enrolment and graduate employability in the UK construction industry.

Understanding the relevance of BIM in overall construction policy development

Respondents were asked if 'BIM is just a fad and at some period in the future will disappear'. Only 6% thought this, though a further 35% did not not view the future of BIM positively. A majority (65%) however, perceived BIM positively in regards to its present and future relevance.

Similarly, 60% of the respondents believe that embedding BIM into HEI curriculum would signify a paradigm shift in the way built environment education is delivered. Of the remaining 40% who disagreed with this, only 13% were in outright disagreement. Finally, 80% of respondents thought that embedding BIM in HEI built environment curriculum is crucial to attaining headline targets for the 2025 Government construction strategy. On the contrary, 21% of respondents disagreed.

BIM HEI transition strategy

The survey explored the transitional strategy that should be adopted by HEIs in response to industry demand for embedding BIM within the curriculum. Respondents were asked whether to follow and change reactively, track change with industry at equal pace or proactively push and lead change. At the Undergraduate level 4, 5, 6 (NQF)/Level 8, 9, 10 (SCQF), 27% would rather adopt a more cautious approach, that is follow and change reactively, while 29% chose to track change with industry at equal pace. Also, 44% would rather adopt a more aggressive/assertive approach; that is proactively push and lead change. For the Postgraduate level 7 (NQF)/Level 11 (SCQF), there was a 50/50 split among those that would rather adopt a more cautious approach, i.e. to follow and change reactively, or to track change with industry at equal pace, and those that will rather adopt a more aggressive/assertive approach that is proactively push and lead change.

GENERATION IMPLICATIONS

Multinomial Regression Analysis (MLA) was used to explore associations between the age of respondents and their perception of BIM strategic considerations. These include:

- The recognition levels of the respondent to the negative impact of premature and unrealistic ILO for BIM in HEIs

- The recognition levels for more practical and 'industry relevant' BIM assessments, as against the theoretical approach.
- The recognition levels of the cost implications of discipline specific diversification/specialisation of BIM ILO as counter-productive to embedding BIM in HEI curriculum.
- Identification levels of the negative impact of lack of bespoke BIM ILO for different disciplines on employment readiness for industry specific roles.
- The level of understanding the relevance of BIM in overall construction policy (future perception).

Results showed that higher levels of perception of the aforementioned BIM strategic considerations are likely to be associated with Generation X, Y or Baby Boomer categories than the Pre-war generation category.

See the other strategic considerations (BIM associated issues) (Table 1) for further reference to their importance as measured by the mean score of survey responses on a scale of 1 to 5.

BIM ASSOCIATED ISSUES: STRATEGIC CONSIDERATIONS	N	Mean
Relevance of BAF ILO targets to industry/professional institutions in regards to BIM accreditation criteria	57	3.75
Difficulty involved in engaging with professional institutions towards discipline specific accreditation of BIM courses	59	3.69
Need for the prioritisation of tackling engagement difficulty with professional institutions	59	3.90
Importance of BIM networks such as the BAF- informing professional bodies on strategic accreditation criteria for HEIs	59	4.03
BIM related accreditation criteria of courses and the improvement of overall student enrolment/graduate employability in the UK construction industry	59	4.02
Difficulty accommodating adequate BIM learning contents due to already full curriculum contents	61	2.98
Limited student study time and low level of receptivity to BIM learning	61	3.39
High financial implications associated with BIM software purchases and the need for extra investment	61	3.23
Impact of availability of free BIM software licences to students as a feasible and sustainable strategy in tackling cost implications	61	3.80
Investment in bespoke/specific hands on BIM education for industry employees	61	3.70
Level of Prematurity- inculcating full BIM education in HEI curriculum	61	2.85
Channelling more resources into improving the curriculum of traditional disciplines rather than embedding BIM.	60	2.97
Gradual funding transition based on necessity or practical industry needs/demand	60	3.65
Issue of 'steep learning curves' for both academic staff and students presents behavioural barriers to BIM in HEI	61	4.07
The relevance of BIM in particular area(s) of teaching	61	4.02
Negative impact of premature and unrealistic Intended Learning Outcomes (ILO)	59	3.66
The inconsistencies between a push towards software innovations and traditional software adopted in teaching is detrimental to BIM acceptability in HEI	60	3.62
More practical and 'industry relevant' BIM assessments, as against the theoretical approach	59	3.80
The regularisation of BIM curriculum and ILO in HEI across the Higher Education (HE) sector, through knowledge sharing platforms like the BAF	60	3.38
Identifying low levels of understanding of BIM among staff as a barrier to embedding BIM in HEI curriculum	61	4.25
Contradictory relationship between traditional built environment education and embedding BIM into the curriculum	60	3.50
Recognising conflicting approaches and ILO requirements among different built environment disciplines as barriers to effective BIM transition in HEIs	58	3.67
The importance of core education component, multidisciplinary knowledge/requirements operational at every stage of an asset life cycle in embedding BIM into HEI curriculum	59	4.14
The need for collaboration and engagement among inter disciplinary staff is essential for enabling cohesion in built environment ILO and curriculum	60	3.98
Identifying the negative impact of lack of bespoke BIM ILO for different disciplines on employment readiness for industry specific roles	60	3.27
Recognising the cost implications of discipline specific diversification/specialisation of BIM ILO as counter-productive to embedding BIM in HEI curriculum	60	3.52
The need for potential availability of innovation research and consultancy funds as mitigating drivers/enablers for BIM ILO diversification/specialisation in HEIs	60	3.75
The impact of existing political will and stakeholder efforts on the emergence of new/potential BIM inclined industry roles/jobs	60	3.90
The impact of poor performance of HEIs in keeping pace with BIM skill requirement and the risk of alternative educational providers usurping traditional HEI roles.	61	3.72

Mean score. Min: 1 & Max: 5

Table 1: Strategic considerations: BIM associated issues

DISCUSSION

BIM matrix: Strategic considerations

A BIM assessment matrix (Figure 14) was developed from the issues investigated in the study. This represents an update to the optimum requirements for BIM teaching among HEIs in the UK (Williams & Lees, 2009). Besides the teaching context, this update has also mapped additional crucial strategic considerations concerning BIM in HEIs. Building up from the study's analysis implications for the findings were deductively interpreted then used to populate the matrix chart accordingly.

Defining staff resource

Considering the construction life cycle, an efficient BIM transition strategy in HEI can be improved with an integrated framework that encompasses every discipline in the built environment. This is crucial because it ensures consistency within HEIs/curriculum as an integral component of the construction value chain, hence improves collaborative networks throughout the construction life cycle. This consistency however, was not reflected in the response patterns because despite the survey receiving a total of 98 responses, 33 were incomplete. Therefore, it appears that the likelihood of completing the questionnaire was significantly impacted by the level of BIM experience of the respondent, which clearly was varied. This inconsistency appears to be manifest in the assessment of *BIM Maturity Levels* as indicators identified by this study in respect to HEIs contribution towards transforming the construction industry to operate at Level 2 BIM by 2016, which appears to be hampered. Therefore, there is clearly a significant disconnect between built environment disciplines. Despite "average/infused" to "high embedded" levels of appropriate BIM-related disciplines among respondents, this is not reflected on neither the BIM maturity levels, BIM policy awareness or the consistency expected for the appropriation of BIM components as shown in the BIM assessment matrix (Figure 14).

BTIM	CURRENT POSITION OF BIM IN HEI ELEMENTS	ASSESSMENT PARAMETERS/ELEMENTS	Absent/ Very Low	Aaware/ Low	Infused/ Average	Embedded/ High Very High
Structure	**BIM Awareness**	BIM policy awareness		X		
		BIM and institution accreditation		X		
		Relevance of BIM in construction			X	
		BIM HEI Transition strategy			X	
	State of BIM in HEI	Assessment of BIM maturity levels		X		
		Need for upskilling				X
		Software adoption trends (choice variability)	X			
		BIM curriculum incorporation		X		
		Maturity levels of BIM delivery			X	
		Length of BIM inception		X		
Staff	**Defining Staff Resource**	Staff academic position				X
		Built environment BIM representation			X	
		Age classification				X
Infrastructure and curriculum research gap	**BIM Adoption Strategy**	Perception of BIM components (consistency)	X			
		External engagement assessment	X			
		BIM transition strategy (BAF ILO)		X		
		Competition and alternative providers				X
	Generation Implications (Strategic Considerations)	The recognition levels of the impact of premature and unrealistic BIM ILO				X
		The recognition levels for more practical and 'industry relevant' BIM assessments				X
		The recognition levels of the cost implications of discipline specific specialisation of BIM ILO				X
		Identification levels of the negative impact of lack of bespoke BIM ILO on employment readiness				X
		The level of understanding the relevance of BIM in overall construction policy (future perception)			X	

Figure 14: BIM assessment matrix: Strategic considerations

On the issue of software competency, while Sychro Project Construct, Nemetschek Vetorworks, VICO/Rapide 5D were found to have low rates of adoption, it appears that the relative ease of use by this group of respondents might have influenced their perceptions on the ‘steep learning curve impediment’ to embedding BIM in HEIs. Despite literature suggesting generation impact on CBL/CMC, this study found no correlation between software adoption and age of respondent (generation categories). While the implication for software vendors is not validated within this current study, factors other than generation category appear to have influenced software choice such as ‘ease of use’ as referenced earlier. Each particular BIM software has its unique set of pros and cons, e.g. effectiveness of available annotation plug-ins to address compatibility lapses. However, it is apparent that BIM software adoption in HEI is dominated by the trio of Autodesk’s Revit (Arch, struct, MEP) and Navisworks, and Trimble’s Sketch Up, with limited choice variability. This trend could be the result of the level of existing interoperability between software from different vendors, hence impeding software adoption choice among users along with competition and innovation among vendors.

BIM Adoption strategy and the state of BIM in HEIs

A breakdown of these statistics in line with individual disciplines revealed that the trio of architecture, construction and quantity surveying lead among those that have at least incorporated BIM into particular modules, although construction and architecture lead with larger margins, with construction holding a slight lead over architecture. However, at the cutting edge where BIM is fully embedded into majority of the programmes/modules, architecture maintains a significant edge over all others. Moreover, similar cutting edge levels of BIM delivery are most common at Undergraduate Level 6 (NQF) /Level 10 (SCQF). On taking the entire Built Environment disciplines into consideration there are low awareness levels for BIM maturity.

Implications for BIM level 2 targets show that the more inclined a respondent is to disagree with the notion that the steep learning curve for (staff and students) impairs BIM progression/development in HEIs then the more mature is their involvement in BIM delivery. Therefore, it is apparent that the more the exposure to actual practical BIM engagement, the more unlikely the steep learning curve for BIM is perceived as impairment. Hence, the need for training and upskilling particularly at matured levels becomes even more relevant to attaining Level 2 BIM targets for the UK by 2016.

It is important to point out that the length of duration of BIM inception in HEI does influence BIM maturity levels as reflected by the study findings. Therefore, the longer the time since BIM inception in a HEI, the more the likelihood of meeting Level 2 BIM HEI targets for the UK. This leaves HEIs with two options of either developing gradually with time, or intensifying the push towards an expedited strategy for those ranking low in BIM maturity levels. Perhaps in due time even low performing institutions will catch up. This will be dependent on the condition that issues raised by this study such as the lack of consistency in the understanding of the degree of BIM components required during adoption are remedied in a way that is not counterproductive to individual HEI goals.

On external engagement assessment and its implication for BIM Maturity and experience level, evidence suggests that, although broader industry awareness and appreciation of BIM is still largely in its infancy, larger leading contracting and consultancy firms have already embraced the benefits of BIM and most have a BIM strategy. For the smaller players, recent developments in this area include the BIM4SME group aimed at the Small and Medium Enterprises (SME) mainly found in tiers two and three in the supply chain (specialist contractors and sub-subcontractors). HEIs however are becoming less and less involved at these levels. The opportunities at these micro levels cannot be underestimated within the overall BIM network; however, how HEIs also respond here is most crucial. Unfortunately, this study found that HEIs are largely underperforming and have low levels of engagement with industry (see the BIM Matrix). This might have more severe consequence for the Level 2 BIM targets for 2016, as the study identified links between the low levels of both direct and indirect external involvement with industry and perceived low BIM maturity levels.

Regarding the issue of BAF's role in ensuring Level 2 BIM targets for HEIs is centred on ILO developed to enhance and promote teaching and learning together with the research aspects of BIM. This study found that there are generation implications for perceptions of the BIM ILO in curriculum building particular for the 'knowledge and understanding component'. The older the respondent the more the tendency to perceive higher levels of BAF ILO incorporation into the curriculum. This study did not however take into consideration individual contributions to BAF ILO incorporation. However, it is worth noting that 80% of respondents for this study occupy managerial positions in HEIs, (hence the high/embedded levels for academic position on the BIM matrix). Therefore, the more likely that they might have been involved in some form of curriculum development and decision making that may have influenced this finding. Generation implications were also observable in regards to competition and alternative education providers. This might not absolutely imply a less competitive drive among older respondents, perhaps a little complacency? However, an overwhelming majority agree with this notion.

BIM awareness, associated issues and generation implications

Expectedly, the issue of accreditation benefits to the overall BIM strategy in HEIs was largely seen as positive. Despite an overwhelming level of support for the importance of BIM related accreditation criteria of courses in academic institutions, the level of conviction for actual change is however debateable. This is evidenced by the high degree of uncertainty/pessimism among respondents in regards to the prospect of BIM in the long term, as majority of respondents would rather adopt a more cautious approach that is follow and change reactively, as opposed to proactively pushing and leading change, hence the average/diffused levels on the BIM Matrix. With the rapidly evolving BIM policy landscape and the need for a more aggressive approach to leading change, it is important that HEIs and the industry workforce keep abreast with developments in the BIM sphere. Considering the high level of representation of academics among the respondents, about 40% still consider themselves not adequately informed on BIM and the UK government implementation strategy (see the BIM awareness element on the BIM Matrix). This high level of detachment remains a setback for embedding BIM. Mitigating this skill and information dearth would require improved level of awareness and access to information sources such as the BIM Task Group to facilitate the transmission of up to date knowledge on BIM policy, standards and processes. Moreover, consultations with BAF and BIM4SME working group can also help foster open innovation and collaboration with top performing HEIs and their respective local Regional BIM Hubs, and of course local SMEs and communities.

The multinomial logistic regression model developed provided sufficient evidence that the pattern of responses to certain BIM strategic considerations, particularly in the aspects concerning ambitious/proactive ILO, practical inclination of curriculum developments, cost implications and specialised ILO were closely associated with the age of respondent. Not surprisingly, the Pre-war generation category appeared to show more scepticism, perhaps restraint in their responses concerning the aforementioned considerations. This further confirms existing studies on the impact of generational differences on beliefs/perceptions within the distinct generation cohorts in the academic workplace (Hannay & Fretwell, 2011; Murray, 2011). Apparently, this differential pattern would similarly apply to the dual categorisation of digital immigrants and natives (Underwood, 2014; Koutropoulos, 2011; Prensky, 2001).

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APPENDIX A: BIM ACADEMIC FORUM LEARNING OUTCOMES

LEVEL	Undergraduate			Postgraduate
	4	5	6	7
Knowledge & Understanding	▪ Importance of collaboration. ▪ The business of BIM.	▪ BIM concepts – construction processes. ▪ Stakeholders' business drivers. ▪ Supply chain integration.	▪ BIM across the disciplines. ▪ Contractual and legal frameworks/regulation. ▪ Peoplechange management.	▪ Collaborative working, BIM, information management and its application in the built environment. ▪ Commercial implications – contractual/legal, etc. ▪ De-risking projects through BIM and risk management. ▪ Understanding nature of current industry practice. ▪ Client value – soft landings. ▪ Business value – RoI /value proposition. ▪ Understanding supply chain management. ▪ Lifecycle management of BIM – asset, performance in use, etc.
Practical Skills	▪ Introduction to technology used across disciplines.	▪ Use of visual representations. ▪ BIM tools and applications. ▪ Attributes of a BIM system.	▪ Technical know how. ▪ Structures and materials. ▪ Sustainability.	▪ Demonstrate ability to adopt different platforms. ▪ Critically judge/evaluate various BIM tools applications. ▪ Protocols/interoperability/standards. ▪ Capability evaluation. ▪ Change in way projects are to be delivered. ▪ Visualisation of large data sets. ▪ Lean principles and links to BIM. ▪ Use of BIM enabled technology, e.g. palm devices.
Transferable Skills	▪ BIM as a process/ technology/people/policy.	▪ Value, lifecycle and sustainability. ▪ 'Software-as-a-service' platforms for projects. ▪ Collaborative working. ▪ Communincation within interdisciplinary teams.	▪ Process/management. ▪ How to deliver projects using BIM. ▪ Information and data flows. ▪ BIM protocols/EIR.	▪ Project level application. ▪ Cross discipline and team working. ▪ Importance of effective communication and decision making – human interaction! ▪ Process mapping and BPR. ▪ Change management and cultural gap. ▪ Masters level thinking – strategic/technical/ managerial. ▪ Ability to assess barriers to BIM at various levels, e.g. corporate/project.

APPENDIX B: BIM TASK GROUP LEARNING OUTCOMES FRAMEWORK

1	Understand what BIM is, the contextual requirement for BIM Level 2 and its connection to the Government Construction Strategy and Industrial Strategy 2025; including an understanding of:			
1.01	* Background and the need for collaborative working (removing waste, errors and poor quality/incomplete information)			
1.02	* The value of whole life and whole estate approach rather than capital-led and single asset			
1.03	* The concept of Soft Landings / Government Soft Landings (GSL)			
1.04	* Roles and responsibilities of the supply chain members and clients as part of BIM Level 2 delivery (cultural / behavioural)			
1.05	* External context for BIM, global, national, standards and support communities			
1.06	* Core and extended suite of standards, documents and deliverables describing BIM Level 2			
1.07	* Barriers to successful adoption of BIM Level 2 and how to create the conditions for success			
1.08	* The value of high quality data and the principles of data management			
1.09	* The key vulnerability issues and nature of controls required to enable the trustworthiness and security of digitally built assets			
2	Understand the implications and value proposition of BIM within your organisation; including an understanding of:			
2.01	* Implementation implications for the introduction of BIM Level 2 on your organisation and supply chain (e.g. training, management processes and systems)			
2.02	* Organisational change management considerations in context of the introduction of BIM Level 2			
2.03	* Assessment of capability of your organisation and your supply chain (e.g. standard methods of assessment PAS91 Table 8)			
2.04	* Technical, technology and interoperability requirements of Level 2 BIM (Information Management / CDE, model-based design and analysis)			
2.05	* The importance of Level 2 BIM as a driver for business process review and improvement			
2.06	* Legal and commercial implementation implications for the introduction of BIM Level 2 on your organisation and supply chain (e.g. commercial stakeholders)			
2.07	* The value, benefits and investment associated with BIM Level 2			
2.08	* How BIM supports the relationship between Design & Construction and Facilities & Asset Management			
2.09	* The potential security threats to built and information assets, and the need for the development of an appropriate and proportionate security risk management approach			
3	Understand the requirement for the management and exchange of information between supply chain members and clients as described in the 1192 suite of standards and PAS55 / ISO 55000; including an understanding of:			
3.01	* The purposes for information in the capital and asset phase			
3.02	* Requirements for the exchange of information between supply chain members in a collaborative manner as described in PAS1192-2: 2013 & PAS1192.3: 2014 and provided in conjunction with BS1192:2007			
3.03	* Roles and responsibilities of the supply chain members and clients of BIM Level 2 and the implications on Scopes of Services			
3.04	* BIM Plain Language Questions, Employers Information Requirements (EIR), Organisation Information Requirements, Asset Information Requirements and the exchange of information between supply chain and client in a collaborative manner in context of PAS1192.2: 2013 and PAS1192.3:2014			
3.05	* BIM Execution Plan (BEP) in context of PAS1192.2:2013 - the related concepts, purpose and implementation principles			
3.06	* Digital delivery of information between supply chain members and with clients in context of BS1192-4:2014(COBie), Digital Plan of Work (DPoW) and classification systems			
3.07	* The Concept, purpose and implementation principles of Project Information Models (PIM) & Asset Information Models (AIM) and the relationship and interchange between them			
3.08	* A Common Data Environment (CDE) as described in the 1192 suite of standards			
3.09	* The implications of Level 2 BIM in relation to project team working methods as described in BS1192 :2007			
3.10	* The way in which Level 2 BIM can be adopted to benefit decision-making for design management			
3.11	* Technologies and methods for creating, using and maintaining structured information			
3.12	* Contractual interventions required to support BIM Level 2 and the implications on exiting forms of contract			
3.13	* Ownership of information and related issues of IP and copyright, insurances and potential liabilities			
3.14	* Requirements for security-minded policies, processes and procedures which address specific security threats or combinations of threats in a consistent and holistic manner			

APPENDIX C: BIM ACADEMIC FORUM MEMBERS

Zulfikar Adamu	University of Loughborough
Abdullahi Ahmed	Coventry University
Zeeshan Aziz	University of Salford
Nooshin Akrami	University of Bolton
Anas Bataw	University of Manchester
Tim Bennett	College of Estate Management
Mark Bew	BIM Task Group
Avril Behan	Dublin Institute of Technology
Paula Bleanch	Northumbria University
Anne Boner	Letterkenny Institute of Technology
Ezekiel Chinyio	University of Wolverhampton
David Comiskey	University of Ulster
Nashwan Dawood	Teesside University
Peter Demian	University of Loughborough
Eleanor Driver	Letterkenny Institute of Technology
Ray Elysee	Huddersfield University
John Forde	University of Salford
Rob Garvey	University of Westminster
Barry Gledson	Northumbria University
Jack Goulding	University of Central Lancashire
David Greenwood	Northumbria University
Michael Greenwood	University of Greenwich
Howard Griffin	Kent University
John Harrington	Leeds Metropolitan University
Peter George Haywood	London South Bank University
David Heesom	University of Wolverhampton
Aidan Hoggard	University of Sheffield
Anthony Holeness	Arts University Bournemouth
Georgios Kapoqiannis	Coventry University
Mohamad Kassem	Teesside University
Anthony Kelly	University of Greenwich
Farzad Khosrowshahi	Leeds Beckett University
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Tahar Koudier	Robert Gordon University
Bimal Kumar	Glasgow Caledonian University
Richard Laing	Robert Gordon University
Richard Lane	BIM Task Group
Geoff Levermore	University of Manchester

Steve Lockley	Northumbria University
Priti Lodhia	The College of Estates Management (Reading)
Meenakshi Mandhar	University of Lincoln
Energy Maradza	University of Reading
Ramesh Marasini	Southampton Solent University
Diane Marsh	Liverpool John Moores
George Martin	University of Coventry
Malachy Mathews	Dublin Institute of Technology
Adam Matthews	Autodesk
Marie May	Sheffield Hallam University
Mark McKane	University of Ulster
Danny McGough	Coventry University
Benachir Medjdoub	Nottigham Trent University
Jim O'Connor	Galway Mayo Institute of Technology
Geoff Olner	Sheffield Hallam University
David Philp	BIM Task Group
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Aimie Rimmington	Nottingham Trent University
Kirti Ruilkar	University of Loughborough
Noha Saleeb	Middlesex University
Mark Shelbourn	University of the West of England
Bhavna Solanki	Nottingham Trent University
Paul Stephenson	Sheffield Hallam University
Josheph Tah	Oxford Brookes University
Jim Tennant	Leeds Metropolitan University
Patrik Thornhill	University of West of England
Antony Thorpe	University of Loughborough
Jason Underwood (Chair)	University of Salford
Ben Wallbank	Graphisoft
Norman Watts	Sheffield Hallam University
Jennifer Whyte	University of Reading
Aled Williams	HEA Academy/College of Estate Management
Tom Workman	Blackpool & The Fylde College

The BIM Academic Forum aims to foster integrated collaborative working over the lifecycle of the asset through academic enhancement of BIM

A BAF survey of the current position and associated challenges of BIM education in UK Higher Education

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