PREPARING TO WORK IN LEVEL 2 BIM: AN INNOVATIVE APPROACH TO A TRAINING AND EDUCATIONAL NEED

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The well-known (probably the best known) objective of the UK Government's 2011 Construction Strategy was for 'fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016'. This deadline has passed, and a number of reports have followed, commenting on how far the construction industry has progressed in its response. It is clear that some organisations consider themselves to be well-advanced in terms of their digital capabilities, whilst others lag behind. What should be remembered though, is that meeting this objective is not only about the software capabilities of individuals and their firms, but about BIM collaboration within projects. The paper outlines an innovative training offering that prepares project teams for working in such an environment. Virtual Project is a structured 3-day course that offers, to senior and middle management, the experience of multi-disciplinary collaboration, exploring as the '8 pillars' of guidance for working at Level 2 BIM and experiencing some of the available technology for the design, construction and operation of built assets. Case studies are presented that illustrate the development of Virtual Project and responses from the participants, and the outcomes are mapped against the UK Government's Learning Outcomes Framework, as well as the published work of the BIM Academic Forum. There are reflections on the challenges encountered, such as running the course overseas, and opportunities, such as its delivery in an e-learning environment.

Keywords: Common Data Environment, Level 2 BIM training, Simulation, Virtual Project

INTRODUCTION

The mandate for BIM in the UK Government's 2011 Construction Strategy required 'fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016'.

The official 'go-live' for the mandate was the 4th April 2016, and in the NBS 2016 survey, completed just before the date, Richard Waterhouse, the CEO of NBS and RIBA Enterprises, commented that 'in some ways we are well set' (NBS, 2016: 3). This was based on the finding that of the c.1,000 respondents (of whom around 40% are Architects and 60% other AEC professionals) 54% were 'aware of and currently

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using BIM' and 67% of these claim that their adoption of BIM had been successful. However, by contrast, in late 2015 a survey of firms in the building services engineering sector reported that that only 16% considered themselves 'fully ready' to use BIM on projects, and 27% were 'not ready at all' (CIBSE, 2015).

It is clear that some organisations consider themselves to be well-advanced in terms of their digital capabilities; others lag behind. What should be remembered though, is that meeting the Government Mandate is not about the software (or other) capabilities of individuals and their firms, but about 'fully collaborative BIM' within projects. In fact, there is much scepticism in the press and social media about whether any project has yet achieved Level 2 BIM. For example, one commentator observed,

> I would question whether any project is actually achieving Level 2 BIM, because many of the standards have only recently been finalised and there is no reliable way to demonstrate what Level 2 is. (BIM+, 2015)

For firms that are committed it appears eminently feasible to acquire the technical knowledge required to work digitally. However, getting the experience of working collaboratively in a common data environment is more problematic. BIM Level 2 standards have been provided but there appears to be a lack of opportunities for project teams to gain experience, in a safe environment, of their actual use.

Additionally, there is an educational requirement for universities to meet what Lee et al. (2013: 266) describe as the 'explosion in the use of BIM' and fill the gap , identified in the USA by Wu and Issa (2013), 'between the rapid growth of the BIM-related job market and … students [who] to commit to a BIM-oriented career path'.

In the UK, attempts have been made to design frameworks for BIM education and training, setting out appropriate content, timing and means of delivery. Notable examples are the BIM Task Group's *BIM Learning Outcomes Framework* (BIM Task Group, 2012) and the work of the BIM Academic Forum itself (e.g. Underwood et al., 2013 and Underwood and Ayoade, 2015).

PROJECT-BASED LEARNING

Project-based learning, particularly where it is interactive and focused on problem-solving, has been recognised as a valuable alternative to traditional means of education and training in design-based and collaborative disciplines such as the Built Environment (Fruchter et al., 2007). Although 'on the job learning' is a valuable part of personal development, when it comes to extensive and structured experiential learning the use of simulated projects (as opposed to real ones) is normally preferred: simulated projects are cheaper, less risky and easier to control and manipulate than their real-world counterparts.

Pedagogic researchers have recognised the valuable of ICT in support of project-based learning and the emergence of BIM and its incorporation into academic and professional training curricula has expanded the potential for simulated projects as vehicles for project-based learning (Peterson et al., 2011). An early example is presented by Poerschke et al. (2010: 575) who recount the development in 2008/9 at Pennsylvania State University of a 'Collaborative BIM Studio' that was designed to 'prepare future building professionals for interdisciplinary collaboration'.

This paper outlines an innovative education/training programme that offers project participants the experience of working collaboratively in a simulated Level 2 BIM project using a common data environment. The concept is adaptable for use in

academic education or professional training, and is particularly useful for newly-formed or prospective multidisciplinary project teams.

THE '*VIRTUAL PROJECT'* PROGRAMME

'Virtual Project' (hereafter referred to as 'VP') is the name given to an intensive 3-day course originally developed by BIM Academy . It was designed to allow participants to experience BIM in a real time collaborative environment and to explore the Level 2 BIM project process with none of the risks or costs which can arise on a real project.

The programme can be adapted in a number of ways. These include its use: (i) for multidisciplinary project teams (particularly those that are newly-formed and to some of whose members the use of BIM is new); (ii) for single organisations within the industry (particularly those seeking to adopt BIM and requiring an exposure to the implications of Level 2 working); (iii) for Built Environment students working in a multidisciplinary project; (iv) for single-discipline Built Environment students (e.g. in Architecture, Architectural Technology, Construction Management, Surveying). A selection of applications and example objectives are presented in Table 1, together with the possible adaptations that are made to the VP course in order to accommodate a particular type of participant group.

Table 1: Virtual Project: applications, objectives and adaptations

Programme Application	Example objectives	Programme Adaptation
Multidisciplinary project teams	To simulate the experience of working on a Level 2 BIM project in advance of real project aspirations.	None, other than limited substitution of pre-prepared materials for any absent specialists
Single industry organisations	To expose selected members of the organisation to the implications of Level 2 BIM working	Substitution of significant amounts of pre-prepared materials to compensate for other specialisms
Students working in a multidisciplinary project	As part of an academic programme that includes project-based learning in multi-disciplinary teams	None, other than limited substitution of pre-prepared materials for any absent disciplines
Single-discipline Built Environment students	As part of an academic programme that includes project-based learning within the specialist curriculum	Substitution of significant amounts of pre-prepared materials to compensate for other specialisms

Origins and development of *Virtual Project*

BIM Academy was formed in 2011 as a partnership between Ryder Architecture and Northumbria University with the goal of promoting successful BIM adoption by both industry and academia and supporting all construction disciplines in embracing collaborative working practices through the effective application of BIM.

The conceptual origins of *VP* lay in the successes of BIM Academy in the annual 48-hour Build Earth Live competitions sponsored by Asite to encourage and raise awareness of digital design and construction, cloud-based collaborative working and interoperability. Following BIM Academy's as the Overall Winner of the Build Qatar Live competition of 2012, it was suggested that a similar challenge could be designed to form the basis of an exciting education/training package. The program was piloted in March 2013 and has since been used extensively for industry organisations, project teams and students of Built Environment disciplines. In its earliest form *VP* pre-dated some of the later UK BIM guidance but these were included as they became available. For example, the NBS BIM Toolkit (NBS, 2015) which first appeared during 2015

and is a core component on Level 2 BIM was assimilated and plays a significant role in the content of *VP*. Further development of the core materials took place through a partnership with White Frog Publishing Ltd., a leading producer of technical training material for the AEC industry. November 2015 saw the delivery of the first *VP* course outside the UK, at Beijing Jiaotong University, in China, with subsequent courses hosted by the University of International Business and Economics (Beijing) and Wuhan University.

Content of Virtual Project

The 3-day course follows the pattern of project work stages of the RIBA Digital Plan of Work (RIBA, 2013). This has been adopted by the NBS BIM Toolkit (NBS, 2015) and forms the basis of Figure 14 ('Information delivery – Production) on page 24 of PAS-1192-2 (BSI, 2013). Table 2 illustrates the VP content associated with each of these Stages. The last column ('Content code') allows content to be referenced in subsequent sections of the paper.

Table 2: Virtual Project content for each stage of the RIBA Digital Plan of Work (DPoW)

DPoW Stage	VP Content	Content code
0 Strategy	What is BIM?	0.1
	Case study examples	0.2
1 Brief	Introducing the CDE	1.1
	Project design brief	1.2
	EIRs, AIRs and the NBS BIM Toolkit	1.3
	The BIM Execution Plan	1.4
	Client Information Exchange - COBie	1.5
	COBie data drop at Stage 1	1.6
2 Concept	Initiate design concept (mass) model	2.1
	Environmental – Energy analysis	2.2
	COBie data drop at Stage 2	2.3
3 Definition	Developing the concept (mass) model	3.1
	Cost information	3.2
	Project Strategies (Acoustics, Fire, etc.)	3.3
	Design programme	3.4
	Co-ordination review	3.5
	COBie data drop at Stage 3	3.6
4 Design	Discipline-specific authoring & transmittal	4.1
	Model federation and clash resolution	4.2
	Model validation	4.3
	Design review	4.4
	Publish design data	4.5
	Rendering and visual production	4.6
	COBie data drop at Stage 4	4.7
5 Build & Commission	4D Construction simulation	5.1
	5D Cost modelling	5.2
	5D Quantity take-off	5.3
6 Handover and Closeout	Introduction to BIM in FM	6.1
	COBie data drop at Stage 6	6.2
7 Operation & End of Life	N/A	

The course opens with an initial discussion sessions and examples of BIM case studies to contextualise the whole event. Drawing on the concepts detailed in current BIM documentation (particularly PAS 1192-2) the roles of Common Data Environments (CDEs), Employers Information Requirements (EIRs) and BIM Execution plans

(BEPs) are introduced and the use of Construction Operations Building Information Exchange (COBie) data drops is explained and the first COBie drop is carried out. CDEs are either accessed live or (in cases of poor internet connectivity) simulated by use of a central 'console' computer. From Stage 2 onwards the work is essentially 'hands on' with a range of proprietary software products being made available for delegates' use. VP conforms to BIM Academy's 'software agnostic' philosophy, and the range of possible native platforms is only limited by the logistics of pre-event licence acquisition. However, in practice the tendency is to utilise the products more commonly-used in industry. The NBS BIM Toolkit, which is free-to-use and where real or experimental projects can be readily created, is used throughout and where required, interoperability is enhanced using the open-source xBIM Toolkit (https://github.com/xBimTeam) as a vehicle for handling IFC-based transfers and automating COBie data drops.

MAPPING *VIRTUAL PROJECT* AGAINST BIM LEVEL 2 NEEDS

There have been a number of attempts to classify the knowledge, skills and experience necessary for work successfully at Level 2 BIM. Some, such as the joint report of the Higher Education Academy and BIM Academic Forum (Underwood et al., 2013) were concerned with embedding BIM in built environment HE curricula. Others, such as the UK BIM Task Group's *BIM Learning Outcomes Framework* (BIM Task Group, 2012) were more practice-focused and included the needs of 'institutions … training providers and private educators developing and delivering training courses to professionals in the sector'.

In order to evaluate the comprehensiveness of the VP offering, its elements were mapped against the two aforementioned reports. A visual comparison of VP's performance against each is presented in Tables 3 and 4, below. Because of constraints of space some of the elements of these reports have been abbreviated, but it is hoped that this does not alter their meaning.

VP content mapped against the learning outcomes in the BAF 2013 Report
A comparison between the content of VP and the learning outcomes proposed by the 2013 BAF Report is shown in Table 3. The BAF report made recommendations aimed at different levels of Higher Education in the Built Environment, ranging from Level 4 (year one of undergraduate study) to Level 7 (Masters). Key learning outcomes identified at Levels 4 and 5 were contextual (e.g. 'importance of collaboration' and 'supply chain integration') and although though some (e.g. 'BIM tools and applications') were clearly covered by VP content, the analysis was restricted to the outcomes identified as belonging to Levels 6 and 7.

Of the 25 learning outcomes identified from the 2013 BAF Report, 20 were covered in the content of VP. Four of the five not covered (i.e. 'nature of current industry practice', 'supply chain management', 'change management and cultural gap' and 'masters level thinking') were generic and arguably inappropriate for the present mapping exercise.

The remaining item 'commercial implications – contractual, legal etc.' is an omission that perhaps needs attention in the content of VP.

Table 3: Virtual Project content mapped against BAF Report, 2013

BAF Report, 2013	VP content	Met
Level 6: Process/management: how to deliver projects using BIM	All	✓
Level 6: Process/management: information and data flows	1.1-1.6	✓
Level 6: Process/management: BIM protocols/EIR	1.3	✓
Level 7A: collaborative working & BIM in the built environment	0.1	✓
Level 7A: commercial implications – contractual, legal etc.	-	
Level 7A: de-risking projects through BIM and risk management	0.1	✓
Level 7A: understanding nature of current industry practice	-	
Level 7A: client value – soft landings	1.3	✓
Level 7A: business value – R.o.I / value proposition	0.2	✓
Level 7A: understanding supply chain management	-	
Level 7A: lifecycle management of BIM – asset, performance in use	6.1	✓
Level 7B: ability to evaluate/adopt different platforms & applications	All	✓
Level 7B: protocols/inter-operability/ standards	4.2	✓
Level 7B: capability evaluation	0.1	✓
Level 7B: change in way projects are to be delivered	0.2	✓
Level 7B: visualisation of large data sets	3.5	✓
Level 7B: lean principles and links to BIM	5.1	✓
Level 7B: use of BIM enabled technology e.g. palm devices	0.1, 0.2	✓
Level 7C: project level application	All	✓
Level 7C: cross discipline and team working	All	✓
Level 7C: importance of effective communication and decision making	All	✓
Level 7C: process mapping and BPR	1.4	✓
Level 7C: change management and cultural gap	-	
Level 7C: masters level thinking – strategic/technical/ managerial	-	
Level 7C: ability to assess barriers to BIM at corporate/project levels	0.2	✓

Note that the three categories of the BAF learning outcomes, *Knowledge and understanding*, *Practical skills*, and *Transferable skills* have been coded 7A, 7B and 7C respectively.

VP content mapped against the UK BIM Task Group Learning Outcomes Framework

There are 32 Learning Outcomes in the UK BIM Task Group's Framework. They are classified in three groups. Group 1 (outcomes 1.01 to 1.09) is prefaced by 'Understand what BIM is, the contextual requirement for BIM Level 2 and its connection to the Government Construction Strategy and Industrial Strategy 2025'; Group 2 involves 'Understand[ing] the implications and value proposition of BIM within your organisation'; and Group 3 relates to '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'. Groups 1 and 3 are more pertinent to the objectives of VP, though some of the content of Group 2 is appropriate, therefore all the identified learning outcomes have been included in the

exercise. The comparison revealed that 24 of the 32 learning outcomes were covered in some form by the content of VP.

Table 4: Virtual Project content mapped against UK BIM Task Group LOF

UK BIM Task Group Learning Outcomes Framework	VP content	Met
1.01 Background and the need for collaborative working	0.1	✓
1.02 Value of whole life approach	6.1	✓
1.03 The concept of (Government) Soft Landings	6.1	✓
1.04 Roles and responsibilities of supply chain members and clients	1.2, 1.3, 1.4,	✓
1.05 External context for BIM, global, national, standards etc.	1.3, 1.4	✓
1.06 Core and extended suite of BIM Level 2 standards	1.3, 1.4	✓
1.07 Barriers to successful BIM Level 2 and conditions for success	0.2	✓
1.08 Value of high quality data and principles of data management	4.1, 4.3	✓
1.09 Key vulnerability issues/controls required for assets security	-	
2.01 Implementation implications for introduction of BIM Level 2	0.2	✓
2.02 Organisational change management considerations	0.2	✓
2.03 Assessment of organisation and supply chain (e.g. PAS91)	-	
2.04 Interoperability requirements of Level 2 BIM	4.1	✓
2.05 Importance for business process review/improvement	-	
2.06 Legal and commercial implementation implications	-	
2.07 The value, benefits and cost of BIM Level 2	0.1	✓
2.08 Relationship between Design & Construction and FM	6.1	✓
2.09 Potential security threats and need for risk management	-	
3.01 The purposes for information in the capital and asset phase	1.3	✓
3.02 Requirements for collaborative information exchange	1.5 and All	✓
3.03 Roles and responsibilities of supply chain members and clients	1.3	✓
3.04 BIM PLQs, EIRs, AIRs and collaborative information exchange	1.3, 1.5	✓
3.05 BIM Execution Plan	1.4	✓
3.06 Digital delivery of information (COBie, DPoW etc.)	1.3,1.5, 1.6	✓
3.07 Project Information Models & Asset Information Models (AIM)	1.1, 1.2,1.3	✓
3.08 A Common Data Environment (CDE)	1.1	✓
3.09 Implications of Level 2 BIM in relation to project team working	All	✓
3.10 Level 2 BIM to benefit decision-making for design management	3.4, 3.5, 4.4	✓
3.11 Technologies and methods	All	✓
3.12 Contractual interventions required to support BIM Level 2	-	
3.13 Ownership of information and related issues of IP and insurances	-	
3.14 Requirements for security policies, processes and procedures	-	

Four of the 8 omissions were in Group 2 (see above for a discussion of its relevance). Examination of the remainder suggested two major areas of exception. The first relates to issues of security. These were: *1.09 Key vulnerability issues/controls required for assets security, 2.09 Potential security threats and need for risk*

management, and *3.14 Requirements for security policies, processes and procedures.* The second are concerned commercial and contractual matters (including insurance and liability) and the specific items were: *2.03 Assessment of organisation and supply chain (e.g. PAS91), 2.06 Legal and commercial implementation implications, 3.12 Contractual interventions required to support BIM Level 2,* and *3.13 Ownership of information and related issues of IP and insurances.* The single remaining learning outcomes not covered by VP was *2.05 Importance for business process review/improvement,* which is arguably outside its scope.

SUMMARY, CONCLUSIONS AND PROJECTIONS

Virtual Project is an example of BIM-supported of project-based learning where BIM technology is both a *means* (to develop skills in collaborative working and structured information exchange) and an *end* (for those seeking to understand BIM and the implications of BIM Level 2 working). By working in a multidisciplinary team over three days with guidance from experienced practitioners, participants will experience the benefits of BIM tools and processes. To-date, the VP programme has been appreciated by students and industry practitioners alike, and the recent ventures outside the UK have been well received.

The programme is now relatively well-developed and robust. It encompasses most of the learning outcomes set by academia and industry. There is a need for keeping materials current, and for absorbing the growing pool of experience from projects utilising BIM. There are, also, as has been noted above, minor shortfalls in coverage (i.e. issues of security, and contractual / insurance / legal issues) that may require incorporating into the programme's elements.

In the aspirational 'Digital Built Britain' report (which draws upon a number of UK Government Strategies for the Economy) one of the five underpinning objectives for the success of these strategies is 'An effective education and change management programme to enable the industry to develop necessary skills and new ways of working' (HM Government, 2015:14). It could be argued that the VP programme is certainly a contribution to this. The report goes on to say 'The Universities, FE Colleges and professional bodies that deliver much of the construction industry's training today are becoming aware of the changes that are taking place and of the need for new ways of providing people with the skills they will need to find fulfilling careers in Digital Built Britain. This awareness needs to be developed into a debate about the industry's future needs for skills and training and the best way of providing it whether through changes to existing courses or the introduction of new forms of online training supported by CPD.' (HM Government, 2015:29). Again, it is argued that the VP programme is an example of what is required.

Although VP has, to-date, been confined to co-located physical workshops, the developers are examining the possibilities of casting VP in an online gaming environment with distribution through end-user license agreements and hosted by experienced moderators, who fulfil the role of the workshop tutors.

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