ARCHITECTURAL TECHNOLOGY AND THE BIM ACRONYM: 2

Reviewing evolving paradigms for BIM implementation among SMEs

T. KOUIDER, J.J.G. PATERSON
Scott Sutherland School of Architecture and Built Environment, RGU
Email address: t.kouider@rgu.ac.uk
Urbahnstudio Ltd + BIM 4SME
Email address: urbahnstudio@gmail.com

Abstract
Among Small and Medium Sized Enterprises (SMEs) (EC, 2013) in particular, the UK Government's ambitions regarding BIM uptake and diffusion across the construction sector may be tempered by a realpolitik shaped in part by interactions between the industry, Higher Education (HE) and professional practice. That premise also has a global perspective. (Rooney, 2014) In September 2013, Education for the Built Environment (E4BE) was constituted as a strategic UK built environment sector group by the Construction Industry Council (CIC) and Construction Industry Training Board (CITB). E4BE's strategic remit was to encourage professional institutions to extend their engagement with HE in collaboration with other stakeholders to add value to Higher Education's contribution to industry. Also to support HE providers in meeting future industry needs by working with stakeholders in a more integrated way and with employers faced with addressing skill challenges for new entrants and recalibrating/reskilling the existing workforce. A key strand of E4BE's activity is BIM. Building from a previous study and making reference to E4BE's brief, the paper will explore work in progress on defining and developing what the authors have previously described as an *evolutionary* paradigm for engagement with BIM by educators, practitioners and industry. The paper will also report on and appraise progress within the architectural technology discipline making reference to aspects of education, professional practice and drivers for the effective implementation of integrated and effective Level 2 BIM practice in the field.

Keywords: BIM, SMEs, micro-SMEs, evolution, architectural technologist

1. Introduction

This discussion has evolved from an earlier discourse (Kouider & Paterson, 2013) which offered the view that engagement with Level 2 BIM may present significant challenges for the UK construction supply chain's families of small organisations. Also for diverse professional body interests to act consensually in driving what may be regarded as step change in workplace practice. Plus for academic institutions in managing and updating content of built environment academic qualifications which feed and support the industry's demand for skilled and forward thinking graduates.

As an agent for change, the UK Government's aspiration for economic growth outlined in the Construction 2025 strategic document is for an industry that is "efficient and technologically advanced". (HMG, 2013) To what extent, can that vision be delivered on by the 300,000 or so small organisations representing the majority stakeholders in UK construction's constituency?. In June 2014, the Construction Industry Council's Education for the Built Environment Group (E4BE) met to focus on the Government's Construction 2025 strategy and discuss what the stakeholders' (CIC members, academia & industry) priority activities should be for the next 12 months in order to deliver its vision for the future. (CICa, 2014)

It has been suggested that key to addressing these perceived challenges is the UK industry's will, impetus and agility to migrate from document dominated to information-centric digital environments; the latter with the potential to harness the power of information technologies to facilitate greater efficiencies in the delivery of whole-life data for buildings and infrastructure. (Richards, 2010) But, as Bronwyn & Khan (2002) have argued that the contribution of technological innovation to economic growth can only be realized when and if new technologies are widely diffused and used. Also, as Robinson (2009) has noted, technological evolution predicated on change to work practices and/or cultures may diffuse at different rates among populations and/or peer groups (Fig. 1)
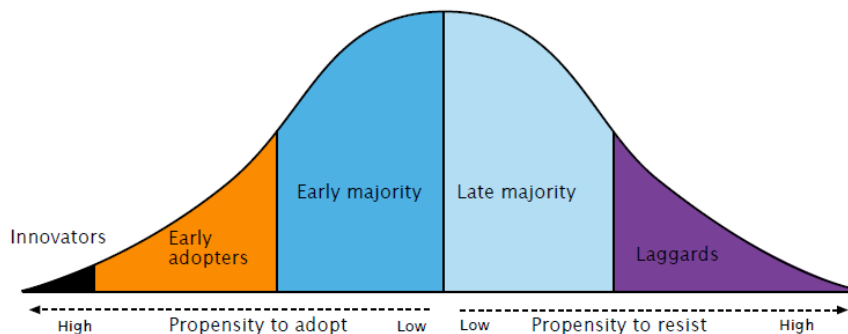
Figure 1. Diffusion of innovations (After Robinson, 2009)

The earlier paper referred to *evangelical* and *evolutionary* paradigms as perceived agents for diffusion of the BIM message among built environment actors and organisations. In the UK, the evangelical model has been characterised by an implied hegemony embodying zealous enthusiasm for the BIM cause in general combined with advocacy for implementation through the application of specific rulesets. If a carrot and stick analogy was applied, the UK Government's 2016 deadline for the application of Level 2 BIM to centrally procured projects might be regarded as the stick. Exemplars cited to support the evangelical model for collaborative BIM tend to be medium sized to large projects serviced by interdisciplinary design teams, often embodying an information co-ordinator, BIM manager or the like. However there may be significant challenges in testing and validating the evangelical paradigm's effectiveness in the field, particularly in relation to engagement with BIM by the industry's majority stakeholders by numbers; viz the SMEs and micros. Also in determining to what extent the message is permeating across the industry as opposed to drawing from the experiences of targeted organisations and/or professional groups. For example, as the SME section of the 2014 NBS National BIM Report draws almost entirely from the experiences of architects' practices, (NBS, 2014) it may not necessarily represent a pan-discipline perspective.

The authors' interests lie primarily in recording and defining an implied evolutionary model for BIM praxis by observing and tracking cause and effect of drivers for technological change, consequent impacts on work practices and interrelationships with supporting pedagogies. Ongoing enquiries have drawn from literature sources, raw data gathered/collated through student dissertations and personal experiences as academics, and/or practitioners. Plus individual and/or joint engagement with a range of professional bodies and industry organisations including CIAT, RIBA, CIC and BIM4 SME group tasked with disseminating the UK Government's message to small organisations. In the round, the authors have adopted a hybrid methodology in combining, investigative with phenomenological approaches.

This paper will make reference to issues raised by the previous discussion, provide an update from a range of UK industry initiatives including E4BE's brief and strategy, plus the BIM Academic Forum and Higher Education Academy's curriculum. The study will focus on CIAT's constituency including making reference to the 2012 CIAT member BIM survey, and current educational developments. In addition, the findings from an online BIM survey using data provided by CIAT Scotland East membership will be discussed. Also present outcomes from a built environment undergraduate

dissertation which embodies a contemporary snapshot of architectural technology practice.

The authors' overarching intention with the study is to offer a targeted but contemporary view of BIM in the field ranging from strategic industry initiatives, through to activities which engage with built environment SMEs and micros making specific reference to architectural technology.

2. Global Trends; the NATSPEC Survey

NATSPEC is an Australian not for profit organisation with a vision to improve construction quality and productivity through leadership of information. Perhaps significantly, the advisory group is not involved in advocacy or policy development. In October 2013, NATSPEC trawled globally by e-mail for information regarding the current state of BIM education. The summative report (Rooney, 2014) offered a snapshot of the current status of BIM education (including interactions with industry and professional bodies) from a range of destination sources.

From the twelve countries which responded and sampling from contemporary Australian experience, the study identified that the Australian Institute of Architects and Consult Australia had established a BIM working group of industry and academic members in 2011. By 2012, the group had concluded that introducing BIM into academia could be a difficult change process and highlighted a range of challenges including:

- difficulties of introducing a perceived new topic into an already crowded curriculum
- unfamiliarity of academics with BIM and workflows of related technologies
- resistance among some teachers to alter established teaching methods
- inability to bridge the traditional educational silos of AEC and deliver collaborative undergraduate built environment programmes.

20 educational principles were identified including, significantly, the need for professional bodies to engage with universities to develop new collaborative BIM courses or to integrate the principles and technologies of multidisciplinary collaboration into curricula.

Rooney (2014) concluded that the NATSPEC survey results suggested a reluctance towards industry change, a "wait and see approach" among some respondents and a shortage of experienced BIM practitioners inevitably

slowing BIM uptake. Drawing from data received, the predominant focus with contemporary BIM education seemed to be on development of hands-on software skills. The report also noted that education and training for working in collaborative BIM environments using openBIM concepts and the like seemed to be in its infancy.

Ironically, it could be argued in context that strategic and cognitive outcomes are more likely to be effective tools to apply industry leverage than operational capabilities. For example, when questioned on the topic, the director of an Edinburgh architectural practice (Bruce, 2014) noted that graduate skillsets which could enhance and add value to his business were a much higher priority than, for example expertise, in specific BIM authoring software packages.

3. UK Initiatives; Education for the Built Environment (E4BE)

E4BE is a tripartite and strategic grouping representing professional body, Higher Education (HE) and employer interests through CIC and CITB. The alliance was tasked with acting on priorities impacting on the built environment in response to UK Government's 2025 strategy. (CICb, 2014) E4BE's engagement is intended to help shape capability and build capacity in the sector by enabling:

- professional institutions to extend their engagement with higher education in collaboration with other stakeholders so that value is added to what higher education offers to industry
- higher education providers to meet the needs of industry by working with other stakeholders in a more integrated way to satisfy higher education needs given constraints in the sector
- employers to address the need to skill new entrants (including employed, mature entrants and job changers, as well as new young entrants), and re-skill/up-skill/'recalibrate' mature entrants and the existing workforce.

At the 2013 E4BE BIM workshop in November 2013, CIC Chief Executive Graham Watts emphasised how fundamental BIM is to the UK construction industry's future and the critical role higher education has in ensuring BIM is developed and delivered to assist in hitting strategic industry targets. (E4BE, 2013) Richard Saxon, UK Government BIM Ambassador for Growth argued that BIM can't be taught with no read across disciplines and suggested, for example, 'crash weekends' where students from different disciplines work together solidly on the same multidisciplinary project. He argued that reorganisations in HEIs could position construction and built environment undergraduates away from each other, and with unrelated

disciplines and could 'deepen' silos which would not be helpful to learning what different professions do and how to work across such boundaries deemed fundamental to developing the kind of professional necessary to make BIM a success. It was also noted that a key function of E4BE was to coordinate the fragmented higher education of a fragmented industry, in order to influence policy and practice more coherently. For example, making reference to the Royal Academy of Engineering's single validation system for 39 engineering institutions, it was argued that professional body accreditation is a key building block in the context of HE adopting and embedding BIM into and across built environment academic programmes. To what extent E4BE's evolution and interventions may be influential in disseminating BIM practice across the broad spectrum of UK construction interests remains unclear at this stage.

4. BIM 4SME

BIM 4SME is a pan-discipline industry working group linked to the UK Government BIM Task Group. It is one of a number of BIM 4 communities within UK construction. Membership draws from a range of professional and industry representative interests. Some might argue that status quo is a significant strength in an industry characterised by a diversity of interests. Since 2012 BIM 4SME has developed its remit to:

- Raise awareness of BIM within the SME marketplace
- Ensure SMEs understand the requirements of Level 2 BIM relevant to their role in the supply chain and relative to the Govt data drops
- Demonstrate the value proposition / business benefits to the SME: better efficiency, better information and better decision making
- Make sure the SMEs understand the risks of doing nothing with regards BIM implementation
- Help SMEs get ready for the Level 2 switch over: where they are and what next?
- Produce simple guidance around the BIM process (PAS1992-2 and COBie UK)
- Ensure that guidance is in simple English and matches business needs

To date, BIM 4SME has relied on volunteer effort to disseminate its messages built significantly around perceived benefits of adopting open and collaborative BIM. The group hosts a website specifically targeted towards SMEs and over the last year has run a series of interactive BIM clinics for

practitioners. BIM 4SME could be described as a "push" organisation in that it actively encourages interactions with SME practitioners. BIM 4SMEs LinkedIn page has stimulated online discussion and debate among players. For example, in a recent post, the UK Government's 20% cost saving target has been challenged.

In 2012, The National Federation of Builders (NFB), a core group member of BIM 4SME undertook a national BIM survey of members. (NFB, 2012) 24% of SME respondents said that they did not perceive any business benefits from BIM. While there was a clear view that BIM would become a clear competency, there was also a lag in terms of intentions to understand, plan and invest resources in BIM, particularly among SMEs. These findings were matched by ambivalence with regard to BIM education and training with only10% of SME respondents planning to invest in BIM training, 27% of SMEs waiting for BIM practices to standardise before committing to training and 27% of SMEs were not planning to train at all. These findings resonate in the broader context of the global NATSPEC study. (Rooney, 2014)

5. BIM Academic Forum (BAF)

The BIM Academic Forum (BAF) comprises around 50 faculty members from UK universities and was formed to promote academic aspects of BIM, in particular, a "BIM Academic Framework". (HEA, 2013) BAF's articulated vison was to embed BIM learning within undergraduate and postgraduate Higher Education. BAF's stated vision was to foster integrated collaborative working on projects through academic involvement and enhancement of BIM. The mission articulated in the 2013 HEA report was to create a dynamic group to develop and promote the teaching, learning and research aspects of BIM through collaboration and co-operation. In 2013, following a participatory workshop held at the University of Salford in 2012, BAF published a suite of level learning outcomes for built environment Higher Education. (Fig. 2) Key drivers outlined by the Government BIM Task Group and CIC included:

- one function of the Task Group's role is to create the "intelligent client" as an enabler to ensure that "pull" is balanced with Government's "push"
- part of the BIM journey necessitates behavioural change
- BIM is able to deliver performance predictability for the client and new efficiencies for the supply side
- project lifecycle now being articulated through data drops
- the role of the information manager is now evolving

- the introduction of employer information requirements is seen as a key part of the process
- all aimed at securing the right amount of data at the right time.

Making reference to E4BE's remit as it feeds from the Government 2025 strategy, , the extent to which BAF can usefully develop without cross-pollination with industry is open to question, other than as a pure academic and research related forum. Many built environment undergraduate academic programmes are professional body accredited; RIBA, CIAT, CIOB, RICS and others. Invariably course validation and periodic re-accreditation involves dialogue with industry partners in shaping syllabus content and development. It could be argued that interactions between the academic realm and construction UK are of fundamental importance in developing holistic strategies to drive the BIM agenda forward.

Level	Knowledge and understanding	Practical skills	Transferable skills
	Undergraduate		
4	• importance of collaboration • the business of BIM	Introduction to technology used across disciplines	BIM as a process/technology/people/policy
5	• BIM concepts – construction processes • stakeholders' business drivers • supply chain integration	• use of visual representations • BIM tools and applications • attributes of a BIM system	• value, lifecycle and sustainability • 'software as service' platforms for projects • collaborative working • communincation within inter-disciplinary teams
6	• BIM across the disciplines • contractual and legal frameworks/regulation • people/change management	Technical know how: • structures and materials • sustainability	Process/management: • how to deliver projects using BIM • information and data flows • BIM protocols/EIR
	Postgraduate		
7	• 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	• demonstrate ability to adopt different platforms • critically judge/evaluate various BIM tools/applications • protocols/inter-operability/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	• 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

Figure 2. BIM academic level learning outcomes (HEA, 2013)

6. Chartered Institute of Architectural Technologists (CIAT)

In October, 2010 the West Yorkshire Lifelong Learning Network (WYLLN, 2010) recorded 46 organisations with common interests in built environment education and training in the UK. Clearly, these organisations address a diverse range of professional activities. Drawing from the experiences of just one professional body, an April 2014 trawl of CIAT's accredited undergraduate degrees in Architectural Technology (Page, 2014) revealed that while some universities have already introduced BIM into the curriculum as a course specific subject, others are using BIM as a lever to encourage broader and deeper interactions between built environment disciplines. For example, one respondent noted that for a final year multidisciplinary project involving 250 students, the overriding objective was "to develop the course placing equal importance on students experiencing both the people aspects of collaboration as well as the technical skills, with no bias towards either". As an additional sounding board, the 2014 QAA draft consultation paper (QAA, 2014) on a revised subject benchmark statement for Architectural Technology made reference to BIM (section 4.2) without any specific detail and/or qualification

Following on from a 2012 CIAT UK BIM survey (Saxon, 2013) CIAT Scotland East members were polled on BIM (including the underpinning BS1192-2007 standard) during September 2014. From a group, comprising predominantly SME and micro constituents, the purpose of the online survey was to ascertain to what extent members:

- have an awareness of the use and management of digital information in the workplace
- are managing digital data in a structured and organised way
- are following the industry standard for file management and collaborative working
- are using BIM or would like to develop an understanding of BIM principles/practice

Data received from respondents recorded that:

- 85% were storing/managing project files digitally
- 85% either not aware of BS1192-2007 or have never used it
- 96% were working collaboratively
- 77% using online sources for information sharing
- 55% were currently using parametric authoring software
- 77% thought BIM and/or elements relevant to AT practice
- 70% considered "lack of knowledge" barrier to BIM implementation

Unlike some UK built environment professional bodies, CIOB, RICS and ICE, CIAT does not offer a publicly accessible BIM portal although there is a members section of CIAT's website dedicated to information on BIM. 66% of respondents to the Scotland East survey recorded that they had not accessed the BIM tab of the CIAT website

7. Case Study 1

The live practice based case study was developed by an architectural technology student between 2013/2014. The investigation was embedded into an undergraduate dissertation while the student was employed as a technician by a North East of Scotland architectural design consultancy. The micro SME (EC, 2013) organisation which was staffed by 2 architectural technologists and 4 technicians developed architectural project work using 2D CAD authoring software which represented a second generation migration from manual drawing from the late 1990s. The company's portfolio ranged from domestic extensions and new builds through residential and commercial developments. The student's methodology embodied a literature search and an investigative commentary which recorded the third generation transition from 2D CAD drafting towards the use of BIM authoring software.

The study recorded several "pull" factors potentially driving a gradual migration towards Level 2 BIM from within the company:

- in an ultra-competitive local marketplace, an organisation will be ahead of the curve with workplace practice
- in the context of a small practice, the student's academic experience seemed to represent a significant driver for change by raising BIM awareness within the company
- the organisation acknowledging that BIM is not a procurement instrument imposed by Government and adoption may simply represent current and/or future best practice for SMEs and micros
- a sensitivity within the company that information management using 2D CAD drafting packages was becoming problematic
- documentation and detailing necessary to achieve statutory compliance was leading to increased workloads
- laborious creation, sometimes duplication and input of information using 2D CAD was creating pressures and project delays when deadlines were missed.

Perceived challenges deemed to inhibit organisational "push" towards Level 2 BIM included:

- in terms of first steps, balancing the servicing of ongoing workload with development of BIM authoring skills was envisaged to be a hurdle
- the organisation's business model was dominated by projects using traditional construction typologies. Not judged to be a good fit with default object families resident in authoring software. It is not clear why the organisation committed to Autodesk Revit as a BIM authoring package
- balancing perceived advantages in upskilling to lonely BIM, compared to more radical engagement with collaborative BIM. In that context, a survey was carried out among co-disciplines in the locality. (Fig. 3)

Consultant/ contractor	Knowledge of BIM	Current BIM status/ Experience of system	Future BIM involvement
Structural/Civil Engineer	aware	Not utilised/slight experience	Actively investigating use
Mechanical and Electrical Engineer	aware	Early stages of implementation	Actively implementing
Quantity Surveyor	aware	Not utilised/no experience	None planned
Main contractor	aware	Not utilised/experienced on builds	None planned - reluctance to adopt

Figure 3. Record of co-disciplines BIM knowledge/engagement (James, 2014)

The practice devised a self-help strategy initially involving one afternoon per week for two technicians being allocated to familiarisation with the Revit BIM authoring package. That exercise ran in parallel with live projects which continued to be developed using 2D CAD. It is interesting to compare that approach with the idea of "BIM training" being offered by commercial organisations, an oncost which might represent a significant oncost for a small organisation. Also in noting that BIM 4 SMEs online training packages have received limited take-up by the industry to pose the hypothetical question, should migration to Level 2 BIM be within the capabilities of even the smallest organisation?

To date, the information database potential of the BIM authoring package has not been tapped significantly by the practice but, for example, two previously discrete workflows have been harmonised by embodying predictive energy modelling and analysis input/output into the BIM model using Autodesk Green Building Studio and the ubiquitous gbXML file protocol. Plus of course, in outlining the formative stages of migration towards Level 2 BIM, the practice has not yet tackled the key process

protocols, in particular PAS1192-2 and the underpinning BS1192-2007. But it is a start, a short but useful a record in the raw of a micro organisation's will to embody change, embark on a BIM journey and a precursor to a more fundamental review into how data is generated and managed in an holistic way within the organisation.

8. Case Study 2

This hypothetical study which shadowed a live building project represents work in progress by BIMicro, a networking group of four CIAT practitioners active in central Scotland. The current investigation sits within a larger project *BIM toolkit* and builds from previous work presented to the ICAT 13 conference.

The profile of BIMicro participants ranges from a BIM manager with a specialist BIM support organisation, through a sole practitioner, (previously CAD manager) doing lonely BIM using Nemetschek Vectorworks, a researcher and an architectural technologist, also running a solo practice and with no prior BIM experience. Through discussion, scenario review and critique the aim of BIMicro's dialogue has been to unpick and demystify entry level BIM and to propose a toolkit appropriate to micro-SME practices. A key objective was to feedback to a wider education and practice group drawn from within the CIAT community. Also engage that peer group in dialogue which interacted with data gathered from the September 2014 CIAT Scotland East BIM survey.

The selected project was a sub £100k new build single space studio for a textile artist located in the Scottish Borders. The real world design and construction project was developed by a sole practitioner architectural technologist in using SketchUp as a 3D conceptual design tool, in association with 2D CAD drawings for project development, statutory approvals and construction. The BIMicro team constructed a widget for the project in Revit BIM authoring software (Fig. 4) at LOD 200 (BIMForum, 2013) and tested the model for ease of manipulation and basic data extraction by non-Revit users through export using the IFC file protocol to a range of free to use industry viewers including Solibri, Tekla BIMsight and xBIM Xplorer, (Fig. 5) the open-source tool developed by the BIM Academy co-founded by Northumbria University and Ryder Architecture in 2010.
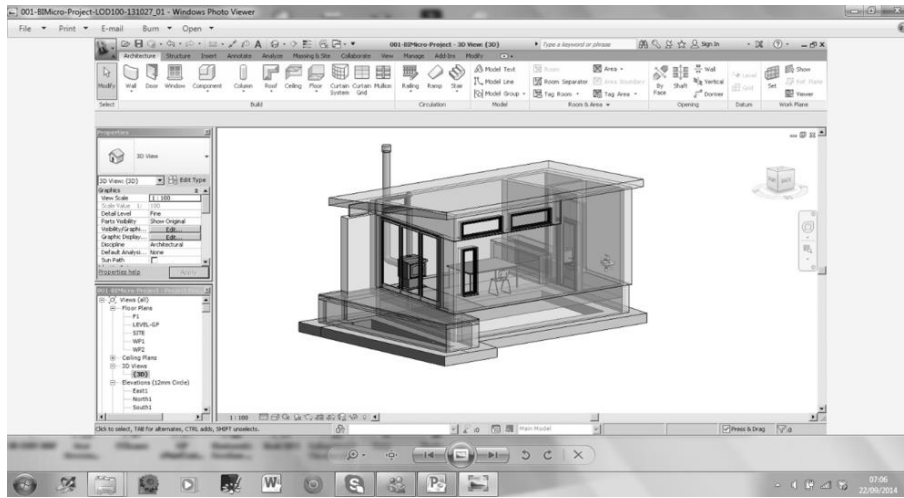
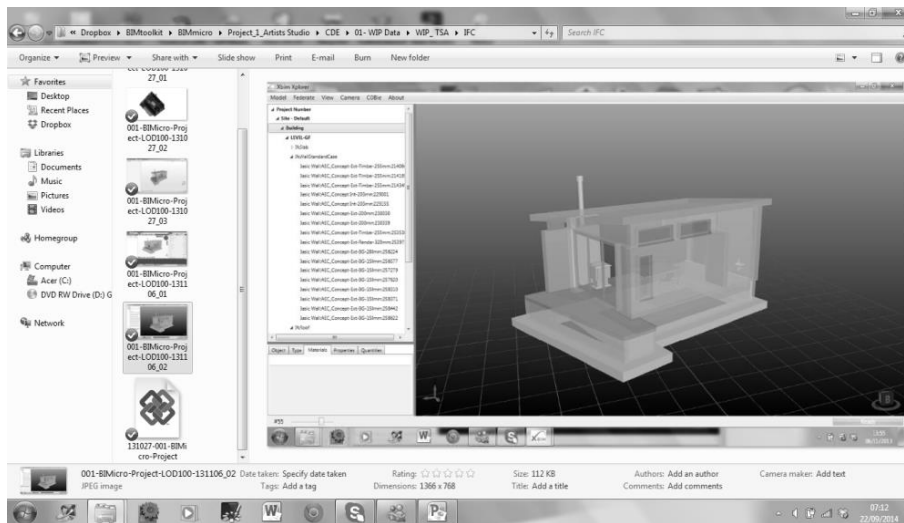*Figure 4.* Artist studio modelled in BIM authoring software

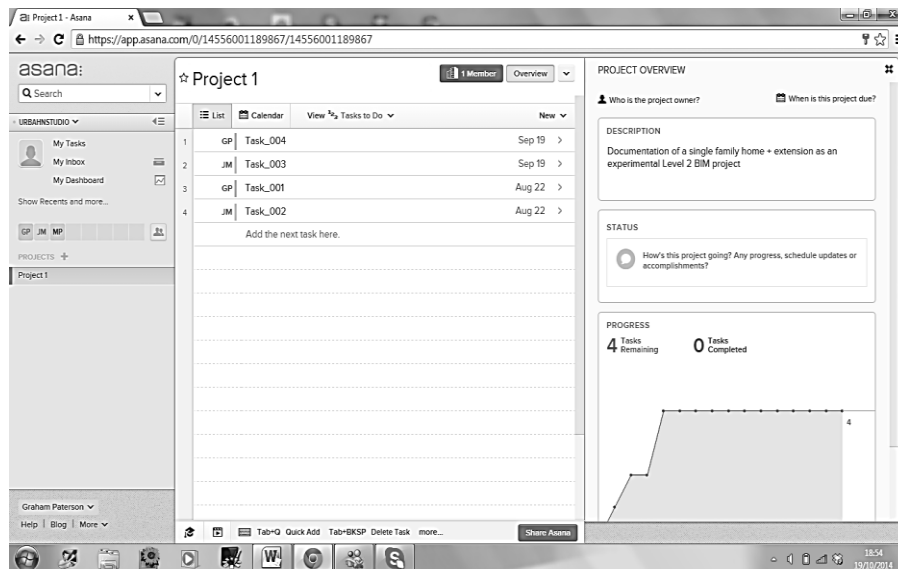*Figure 5.* Artist's studio viewed for teamworking using xBIM Xplorer

Figure 6. Asana free to use cloud hosted teamworking

At this stage, with the proviso that limited outcomes to date represent work in progress, the team have proposed that in underpinning a collaborative approach to data sharing and exchange, an entry level BIM project toolkit for a micro-SME design organisation would consist of:

- cloud hosted common data environment accessible to all team members; e.g. Dropbox freeware
- online teamworking environment; e.g. Asana freeware
- protocol for structured file sharing and collaboration BS1192-2007
- process model RIBA plan of Work 2013
- project specific BIM protocol based on PAS 1192-2
- BIM documentation, for example CIC exemplars
- parametric authoring software
- model viewing freeware; Tekla, Solibri, xBIM Xplorer etc

From these eight elements of the toolkit, applying the caveat that cloud hosted freeware may set a limit on storage capacity; seven were free at the point of use.

In developing a first steps approach towards Level 2 BIM, assimilating an understanding of the structure, content and application of BS1192-2007 is seen as a priority and necessary first step. Delivery on that imperative may be challenging for small practice, a suggestion validated to some extent by

the Scotland East BIM survey results which recorded that 85% of respondents had either never heard of the British Standard for development, organisation and management of digital data for built environment or had never used it.

All be it both snapshots represent work in progress, industry studies 1 and 2 have suggested very different perspectives in developing a first steps approach towards Level 2 BIM. Making reference to Case Study 1, the BIM authoring software was being trialled essentially as a medium to continue to produce orthographic drawings for design and construction drawings. In essence, embodying the same formal language, syntax and semantics (Kiviniemi & Fischer, 2009) as were embedded in previous 2D CAD worksets; different generator, same output.

Case Study 2 introduced and highlighted the primacy of establishing formal and wide ranging protocols to facilitate the development of a structured and controlled environment for engaging with Level 2 BIM. BS1192-2007 was referenced as a key enabling tool. In that theoretical context, the significance of 3D modelling and 2D drawing output is subsumed by higher level objectives targeted towards efficient data management, a broad spectrum including object geometry, metadata and GIS. As a by-product of that perceived step change in work practice, the formal language, syntax and semantics of design, construction and post occupancy phases (legacy) have necessarily been reinvented. It is that shift of priorities which micro-SMEs may find most challenging in stepping up to the mark, both within organisations (lonely BIM) and in embracing new methodologies for teamworking using digital media.

9. Conclusions

This paper has developed from an earlier discussion which addressed challenges facing built environment SMEs and micros in engaging with Level 2 BIM. The investigation has selected and reviewed a number of specific instances, relating to BIM push/pull factors, education, industry organisations and professional bodies. These range from a global snapshot, through national professional and educational initiatives to the specifics of Higher Education and practice associated with the architectural technology discipline. The focus has been on the SME sector which the literature has suggested represents a majority interest by numbers in UK construction.

With the significant caveat that the data reviewed represents a very narrow slice of activity among built environment professionals and their representative bodies in the UK, the paper has attempted to develop the premise of an evolutionary paradigm for BIM engagement, by drawing from observations in the field.

The authors have presented the view that while clearly there may be work in progress, as of November 2014, there is little extant evidence that the Government's 2016 BIM target is impacting significantly on the 300,000 or so SMEs and micros making up the UK construction supply chain. To unpick and analyse the topic in greater depth which would require much higher levels of data collection and analysis than has been viable within this study. Perhaps most significantly though, despite E4BE's strategic purpose, there is little sign that professional and other industry bodies are pulling together to assimilate the step change in work practices embodied in BIM.

At the micro-SME level, even reviewing the narrowest of experiences viz a single micro organisation's first steps towards embarking on the BIM journey has flushed out an empathy with Mervyn Richard's assertion that a key enabler is the will to of organisations to migrate from document dominated to information-centric digital environments. Does that observation constitute validation; certainly not at this stage.

Migrating from a 2D CAD environment towards Level 2 BIM may involve at least three significant phases. Firstly instigating change within the organisation itself, in particular acclimatisation with an unfamiliar syntax for generating, manipulating and sharing construction information and secondly, diffusing the effects of that change across industry partners including clients. Thirdly, getting to grips with the deeper complexities of digital data management. Does the microcosmic frame of reference presented represent a broader industry status quo? On the evidence available to the authors, it's just not possible to say at this juncture. Drawing out meaningful data on cause and effect including interactions between people, process and technology demands further research with a closer focus on the needs and aspirations of the SME and micro built environment community.

References

BIMForum, 2013, *Level of Development Specification*. [online] Available at:
   http://bimforum.org/wp-content/uploads/2013/08/2013-LOD-Specification.pdf
   [accessed 20.10.2014]
BRUCE, G., 2014, in conversation with the authors.
BRONWYN H H., KAHN, B., 2002, "Adoption of New Technology", in *New Economy Handbook*, Jones, Derek C., (ed.) Academic Press, Cambridge. [online] Available at:
   http://eml.berkeley.edu/~bhhall/papers/HallKhan03%20diffusion.pdf
   [accessed 19.10.2014]
CIC, 2014a, *CIC Education for the Built Environment Group*, Construction Industry Council, London. [online] Available at:
   http://cic.org.uk/news/article.php?s=2014-06-10-cic-education-for-the-built-environment-e4be-group

[accessed 19.10.2014]

CIC, 2014b, *E4BE Group*, Construction Industry Council, London. [online] Available at:
http://cic.org.uk/networks-and-committees/e4begroup.php
[accessed 19.10.2014]

E4BE, 2013, *BIM: Higher Education and Growth*, report of workshop held at CIC, London, 5 November, [online] Available at:
http://cic.org.uk/networks-and-committees/e4begroup.php
[accessed 19.10.2014]

EC, 2013. What is an SME?, European Commission, Enterprise and Industry. [online] Available at:
http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/sme-definition/
[accessed 19.10.2014]

HEA, 2013. *Embedding Building Information Modelling (BIM) within the taught curriculum.* [online] Available at:
http://www.heacademy.ac.uk/resources/detail/disciplines/built-   environment/BIM-June2013
[accessed 30.06.2013]

HM Government, 2013, *Construction 2025, Industrial Strategy: government and industry in partnership,* Her Majesty's Government, London. [online] Available at:
http://www.gov.uk/government/uploads/system/uploads/attachment_data/file/210099/bis-13-955-construction-2025-industrial-strategy.pdf
[accessed 19.10.2014]

JAMES M., 2014, "An analysis of the potential benefits through continued adaption of building information modelling into an SME", unpublished undergraduate dissertation, Scott Sutherland School of Architecture and Built Environment, The Robert Gordon University, Aberdeen

KIVINIEMI A., FISCHER M., 2009, "Potential obstacles to using BIM in design", in *Collaborative Construction Information Management*, Shen GQ., Brandon, P., Baldwin A., (eds.) Spon Research, London.

KOUIDER T., PATERSON J.J.G., 2013. "Architectural Technology and the BIM Acronym", in *Architectural Technology: the Defining Features*, conference proceedings of the 4th International Congress of Architectural Technology, Sheffield Hallam University, Sheffield. [online] Available at:
http://archtechcongress.com/DownloadableContentHandler.ashx?mediaId=d35daabc-d251-4643-8194-429a225255a1
[accessed 19.10.2014]

NBS, 2012. *National BIM Report 2014*, National Building Specification, Newcastle. [online] Available at:
http://www.thenbs.com/topics/bim/articles/nbs-national-bim-report-2014.asp
[accessed 19.10.14]

NFB, 2012. *BIM: ready or not?*, National Federation of Builders, Crawley. [online] Available at:
http://www.builders.org.uk/resources/nfb/000/318/333/NFB_BIM_Survey_BIM-ready_or_not.pdf
[accessed 03.09.2013]

PAGE T., 2014, unpublished output from BIM e-mail survey by e-mail of CIAT HE accredited centres in Architectural Technology.

QUALITY ASSURANCE AGENCY, 2014, *Architectural Technology, draft for consultation*, QAA, Gloucester. [online] Available at:

http://www.qaa.ac.uk/en/Publications/Documents/SBS-consultation-architectural.pdf

[accessed 19.10.2014]

RICHARDS M., 2010, *Building Information Management, A Standard Framework and Guide to* BS1192, BSI Group, London.

ROBINSON L., 2009, "A Summary of Diffusion of Innovations", in Enabling Change. [online] Available at:

http://www.enablingchange.com.au/Summary_Diffusion_Theory.pdf

[accessed 19.10.2014]

ROONEY K., 2014. *BIM Education-Global Summary Report-2013*, Construction Information Systems Ltd, Sydney. [online] Available at:

http://bim.natspec.org/

[accessed 19.10.2014]

SAXON R., 2013, *Growth Through BIM*, Construction Industry Council, London.

WEST YORKSHIRE LIFELONG LEARNING NETWORK, 2010, *A Guide to Professional Institutions Within Construction and the Built Environment Secto*r, WYLLN. [online] Available at:

http://www.lcb.ac.uk/pdfs/WYLLN.pdf

[accessed 19.10.2014]