CONSTRUCTION EDUCATION REQUIREMENTS FOR ACHIEVING LEVEL 2 AND 3 BIM

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ABSTRACT

The Architecture Engineering Construction (AEC) Industry is well noted for its fragmented nature, leading to several flaws in communication and information processing, which have led to a proliferation of adversarial relationships amongst project participants, thereby affecting the integrity of design information throughout the project life cycle. Likewise, Construction Education is bedevilled by multitudinous issues due to its practice-based, interdisciplinary nature of the industry, its professional and institutional history, and its evolving context and composition. These challenges have influenced the purpose of construction as well as the requirements or strategies needed to achieve it. The purpose of this paper is to examine the nature of Construction Education and learning requirements for successful training and implementation of Level 2 (with the aid of a process map) and also of Level 3, to meeting the ever-changing nature of the AEC industry. This process map seeks to identify the educational requirements for existing industry practitioners and for fresh graduates entering into the industry. In order to achieve this aim, a case study methodology was adopted using semi-structured interviews with BIM experts in purposively selected organisations in the UK, which were further analysed using single case narrative and cross-case synthesis techniques. The BIM sub-processes at each project phase of the construction process were extracted from the interviews conducted. Then the process map linking all the BIM activities in the project was developed. In conclusion, the process map formalises the knowledge and skills set required to successfully implement Level 2 and 3 BIM, facilitating project collaboration, communication flow and agreement amongst project participants on construction processes throughout the project lifecycle. The finding of this research are highly aligned with the seminal literature which argued that new skills required for the creation and management of a BIM model fall into the three categories of technological tools, organisational processes, and project team roles and responsibilities, and that these three skill sets contribute to the success of the entire BIM project and adoption in any organisation.

Keywords: Construction Education, Learning Requirements, BIM Learning Outcomes, Level 2 BIM, Level 3 BIM, UK AEC Industry.

1. INTRODUCTION – THE NEED FOR CONSTRUCTION EDUCATION

The Architecture Engineering Construction (AEC) industry is well noted for its fragmented nature, leading to several documented flaws in communication and information processing (Latham, 1994; Egan, 1998). These flaws have led to a proliferation of adversarial relationships amongst project participants (Forcade et al., 2007; Gudiene et al., 2013), thereby affecting the integrity of design information throughout the project life cycle (Cera et al., 2002; Fruchter, 1998). Business organisations such as AEC organisations are constantly reinventing ways of thriving in a highly competitive business environment.

In a similar vein, construction education is bedevilled by multitudinous issues due to its practice-based, interdisciplinary nature of the industry, its professional and institutional history, and its evolving context and composition. These challenges have influenced the purpose of construction as well as the requirements or strategies needed to achieve it. One of the key drivers of change in construction education practice is the advent of BIM and other aspects of digital construction, which has essentially transformed every segment of the AEC industry, including the roles, responsibilities and inter-relationships between the players acting in the construction world.

According to Camps (2008), the same concepts that seek to transform the AEC industry are also beckoning for change in educational strategies in the academia; and that academic institutions play an essential role in the overall success of BIM implementation in the entire AEC industry. Camps (2008) also stressed that for professionals to be capable of doing more in less time, construction education has to become more efficient in training students who eventually become those professionals. Adding that, for a large-scale integrated practice to be attainable within the AEC industry, adoption of BIM education in the classroom must come first. In accordance to these, the purpose of this research was to examine the nature of construction education and learning requirements for successful training and implementation of Level 2 (with the aid of a process map), to meeting the ever-changing nature of the AEC industry.

2. LITERATURE REVIEW

2.1 Current State of Building Information Modelling Education

BIM enables educators, professionals, and students alike, to explore projects more in-depth than ever before because a single model can be used to produce construction documents, examine constructability, estimate project cost, investigate building performance, and build physical models with the aid of state-of-the-art prototyping (Camps, 2008). According to Camps (2008), much of the industry still operates a paper-based management system steeped in a 2D paradigm, suggesting that BIM educators need to examine this matrix closely, and break out of the mould. Kymmell (2008) posits that most barriers to the uptake of BIM in the academic curriculum are due to: a lack of understanding of the BIM process, instability to use the required BIM tools for specific BIM tasks, and circumstantial issues such as the conduciveness of the environment, participants of the process, experience of the teaching faculty, training budget, etc. However, Hietanen and Drogemuller (2008) highlighted that the barriers relating to a lack of understanding of the BIM process demand greater attention than the others because, in their view, an understanding of the idea is more essential than the mastery of the required tool.

Some educational institutions such as Coventry University, California State University (Chico), Pennsylvania State University, to name a few, have overcome some of these hurdles, and are now regarded as leaders in BIM education by perfecting the synergy and coordination of three levels: teachers, curriculum and university (Hietanen and Drogemuller, 2008), achieving remarkable feats in BIM pedagogy. However, Barison and Santos (2010) noted that educational institutions planning to embark on BIM education will encounter many problems; the greatest of which will be institutional, which entails promoting integration within different curriculum aspects and collaborating with other departments or schools to promote integration. This lends credence to Kymmel's (2008) conclusion that Collaboration is a foundational concept to the entire BIM process, which encourages a learning team to become a cohesive team, overcome hurdles, and make progress together.

Many national governments have established BIM as a necessary requirement in the AEC industry (Zeiss, 2013), which has created an urgent need for educators in the industry to train BIM-ready graduates in order to meet industry requirements globally (Rooney, 2014). Hence, Hon et al. (2015) considers it highly imperative for educational institutions to incorporate BIM into their curricula, and also reinforce the capacity of BIM educators to cope with the change, as Sacks and Pikas (2013) found out in their study that a lack of competent BIM educators is an undeniable barrier for incorporating BIM in education.

Hon et al. (2015) conducted a literature review on BIM education dating back to ten years; the outcome of which forms the fundamental basis to identify gaps in current learning and teaching methods, which will help in the adjustment of the modules or curricula. The research reveals that six core aspects of BIM learning and teaching were selected by authors, namely: 1) Essential BIM skills 2) Integration Strategies 3) Teaching Methods 4) Assessment Criteria 5) Assessment Methods, and 6) Critical Success Factors in BIM education. However, Hon et al. (2015), out of the six aspects of BIM learning and teaching, pointed out 3 under-explored areas to be: Assessment Criteria, Assessment Methods, and Critical Success Factors for BIM education.

In conclusion, Sacks and Pikas (2013) emphasised that BIM is a holistic process that must be introduced into curricula in a methodical manner such as being taught as standalone courses or incorporated into existing courses. However, each education provider will have to make decisions of where and how to introduce BIM, with regards to their unique context, policies and strategies.

2.2 Building Information Modelling Level 2 and Level 3

The UK Government's decision to mandate *Level 2 BIM* for publicly procured projects by 2016 appears to address the fragmentation and complexity of the AEC Industry (Latham, 1994; Egan, 1998; Cabinet Office, 2011; Charalambous, et al. 2013). There are signs indicating that many AEC Organisations have come to acknowledge the value in adopting BIM technology, and seeking to define their role within the BIM process (Waterhouse and Philp, 2013). In 2013, the UK Government published another report, Construction 2025, setting out its long-term vision to place UK at the forefront of global construction and market. To drive this vision, the UK Government is willing to invest in smart construction and digital design by investing in people and technology, in collaboration with the AEC Industry. The UK Government and the Industry have successfully developed an effective BIM strategy, and HM Government (2013) reiterates that only through BIM adoption will more sustainable buildings be delivered more quickly and more efficiently, such that lower project costs, lower carbon emissions, faster project delivery and improvement in construction exports are achievable.

Despite the widely acclaimed benefits of *Level 2 BIM*, the most significant change will emerge by the adoption of *Level 3 BIM* (BSI, 2014). Charalambous et al. (2013) affirmed that *Level 3 BIM* represents a paradigm shift in the re-engineering of the process and mindset of the industry. The gap between the current BIM situation in the UK and the 2016 mandate is gradually being bridged as some AEC organisations are nearly attaining the goal, hence the need to take BIM adoption to the next level of maturity, which is 'BIM in the Cloud'.

The BIM Task Group, a Government body that drives BIM implementation on public sector AEC projects across the UK, developed a model called the BIM Maturity Model (BIM Industry Working Group, 2011). According to BIM Task Group (2013), the Maturity Model explains maturity levels with respect to the capacity of the AEC supply chain to manage and exchange project information. The model's application spans a wide spectrum of project scenarios, such that a particular organisation may have several projects operated at different levels of BIM Maturity, which is normal and anticipated, as different organisations attain maturity at different timescales, based on a number of factors.

NBS (2014) noted that the UK Government acknowledged the fact that the process of moving the AEC Industry to *full* collaborative platform will be a gradual process, with milestones recognised as 'levels', which range from Level 1 to 3. Hence, the BIM Levels of Maturity are expatiated below:

NBS (2014) and DBS (2015b) explain that the *Level 1 BIM* is a combination of 2D for drafting of approval documentation and Production Information, and 3D CAD for concept work. The CAD standards adhere strictly to BS1192:2007; and the Common Data Environment (CDE) often managed by the Contractor, is used to share data electronically. Majority of AEC organisations in the UK are operating at this level, whereby each project participants publish and maintain its own data without any collaboration with other participants.

At the *Level 2 BIM*, NBS (2014), DBS (2015b), and Goulding et al. (2014) maintain that all participants utilise their own 3D CAD models, enabling 2D/3D coordination based on BS1192:2007, but not effectively working from or with a single shareable model. Collaboration is achieved in the way information is exchanged between project participants. For example, design information is exchanged via a common file format, which allows parties to combine the sent data with their own data to facilitate a federated BIM model, and to carry out investigative checks on the model. In essence, the CAD software that each party deploys must be able to export to either of IFC (Industry Foundation Classes) or COBiE (Construction Operations Building Information Exchange) common file formats.

Attainment of the *Level 3 BIM* is seen as the 'holy grail', which symbolises full collaboration between all project parties with the facility of a single, shareable project model, held in a central location. All participants have access to this model and can modify it. The huge benefit is that it eliminates the potential risk of conflicting information. Also known as 'Open BIM', the UK Government has set a target date for public sector adoption by 2025 (HM Government, 2013). Issues pertaining to copyright are going to be resolved through comprehensive appointment of documents and software authorship – read – write permissions; issues pertaining to liability are going to be resolved through shared-risk procurement routes such as partnering, both facilitated by the Construction Industry Council (CIC) BIM Protocol (NBS, 2014; DBS, 2015b).

For the purpose of this paper, Isikdag and Underwood's (2010) definition is most appropriate, defining BIM as the information management process spanning the life cycle of a building, with focus on the collaborative use of semantically rich 3D models. These models contain rich geometric and semantic information about a project, where several views could be extracted from depending on the pressing business need (Goulding et al., 2014). Research has demonstrably shown that BIM is capable of revolutionising the AEC industry as a whole by improving project team collaboration (Gu and London, 2010); enhancing project integration (Woo et al., 2004); easing construction information flow (Ibrahim et al., 2004); enabling better documentation flow (Popov et al., 2006); supporting the facility management phase by decreasing operational cost (Wang et al., 2013); and generating simulation for construction sequencing, planning, clash detection and coordination interfacing (Fisher and Kunz, 2004). The Government task group mandated to drive change agenda in construction in the UK, Constructing Excellence (CE), clamour for the establishment of a framework for BIM adoption. Interviews with AEC organisations revealed that the adoption of BIM is favourable in the sense of the competitive advantage it offers; and the role it plays in enhancing the construction process, and also facilitating an integrated working environment (Dawood and Iqbal, 2010; DBL, 2015a). According to Al-Shammari (2014), the Construction Industry Council (CIC) issued the BIM Protocol which is designed to stimulate collaboration between project parties to support *Level 2 BIM* projects, concluding that the CIC BIM Protocol is inappropriate in dealing with construction contracts involving advanced levels of BIM (beyond *Level 2*), which might undermine its use. Seminal literature, Gu and London (2011); Rezgui et al., (2011); BIM Task Group (2013); and Dassault Systemes

(2014), asserted that this is not likely to occur except project information is simulated and managed throughout all phases of the project life cycle, with the aid of *Level 3 BIM* adoption.

The purpose of this paper is to examine the nature of Construction Education and learning requirements for successful training and implementation of Level 2 and 3 BIM (with the aid of a process map), to meeting the ever-changing nature of the AEC industry.

3. RESEARCH METHODOLOGY

Interview method was adopted for this research for the following reasons: in-depth information was easily obtainable; there was greater flexibility than the questionnaire method to rephrase questions for better clarity and information; non-response of interviewees was much lower, hence cases were controlled more easily; the interviewer had access to additional information about the interviewee's personal information and work environment that may greatly enrich the interpretation of results (Kothari, 2004). A case study design was adopted for this study because the focus of the research is to answer the "how" and "why" questions, and to cover contextual conditions relevant to the phenomenon in question (Yin, 2009). A multiple-case study was adopted for this research to enable the researcher to explore differences between and within cases. For this research work, a literal replication of 2 cases was required to achieve similar research outcomes (based on literature review) and to achieve a greater degree of certainty and validation of the research study. The target population for this research work are companies involved in architecture, engineering, project management, and construction, and who have had involvements in BIM project environments. The choice of respondents in these organisations was made in gathering relevant data because these BIM Experts were directly involved in the supply chain for the delivery of BIM-driven projects across the UK. The respondents were drawn from Construction Organisations in the North West and Central London regions of England. Since, it is practically impossible to collect data from all construction organisations or all professionals; the non-probabilistic sampling technique was used, also known as deliberate or purposive sampling. Hence, a sampling size of 2 Case Studies was purposively selected in the North West and Central London regions of England, which were later used to represent the research findings for the United Kingdom. Data was collected for this research via two main approaches namely, fieldwork and desk study. Fieldwork research involved gathering data from primary sources of data, in the form of case studies, questionnaires, action research, etc. Desk study research involved gathering data from an extensive review of literature such as textbooks, journals, conference proceedings, online materials, etc.

4. RESULTS

This section presents the case studies of Level 2 BIM adoption through the project phases of a construction development. A process map was derived from the case study interviews, and illustrated below in Fig. 1. The two case studies are presented below, followed by the process map. The section is presented according to the construction project phases, and Case Study 1 is coded as CS1, while Case Study 2 is coded as CS2.

4.1 *Level 2 BIM* Adoption at the Preparation Phase

CS1 does not implement BIM at the Preparation phase because it is a Construction Management organisation that usually takes up projects at the Construction phase and not at the Preparation phase. The CS2 respondent noted that the first thing the organisation does in the Preparation phase of BIM implementation is to hold an introductory BIM Project Execution Planning (BIM PEP or BEP) session comprising the key stakeholders contributing to the project depending on what stage the project is at. The planning sessions set out the project direction, project scope from BIM perspective. In CS2, BIM objectives are confirmed at the Preparation phase. CS2 pointed out that stakeholder roles and responsibility matrix is crucial in the Preparation phase in terms of who is going to be the point of contact for each task and information role. CS2 also discussed how stakeholders collaborate and coordinate information across the project so as to deliver the project outcome for the Client. Inputs like file exchange formats, classification standards, specification standards, etc., are used to enhance BIM project delivery and check project status. CS2 agrees with LR's BIM core activity, which includes definition of BIM inputs and outputs or deliverables, and extent of post-occupancy assessment (RIBA, 2012; Klaschka, 2014).

4.2 *Level 2 BIM* Adoption at the Design Phase

CS1 comes in at Stage 3 of the PAS 1192, which is the design phase. They implement the BIM PEP for post-contract obligation of the project, which is synonymous with the commencement of a BIM pre-start meeting on the agreement of BIM PEP and BIM Change Control Protocols. In CS1, designers draw up their models (architectural, structural, mechanical, electrical and plumbing) and upload into the Common Data Environment (CDE). CS1 reveals that there is a coordination review meeting, in which errors and clashes are discussed and resolved. For CS1, update contract 2D drawings are extracted from the 3D models, which are used for contract information and actual construction on site.

The CS2 respondent revealed that when their organisation receive design models at any stage, they need to understand if they are useful; they need to ask if the customer has provided any Employer's Information Requirement, or if the Customer has prescribed a BIM protocol, or if the Client has started the BIM PEP already. CS2 respondent affirmed that information needs to be transferred seamlessly through the project phases, stressing that it is complicated transferring knowledge and information, and ensuring every project participant is carried along; that is why the Common Data Environment is crucial for effective collaboration. CS2 respondent also pointed out that once they take up the Design and Build responsibility, they employ the designers (on behalf of the Client) and drive the design process to deliver the output.

4.3 *Level 2 BIM* Adoption at the Construction Phase

CS1 emphasised the use of Hand-held Field BIM device to review 2D drawings and 3D models on the construction site. The device is used to check if a physical item or element has been properly installed on site; working in conjunction with the office desktop to highlight and mark up drawings or aspects of models. CS1 and CS2 use the *Synchro* app for 4D visualisation to upload a model and visualise the time sequence of construction activities on site. CS1 and CS2 also use the *Cost X* app for quantification of building elements. In CS1, the BIM tools are used to model a building (then all the different models are federated together), and several meetings are held to discuss how the models will be installed and erected on site. After the construction of the building, CS1 confirms that the 3D model is handed over to the Client at completion. CS2 respondent confirmed that the use of BIM model for the fabrication of building components starts early in Stage 5 of the RIBA Plan of Work to maximise the benefit. Standardisation of the fabrication in terms of design, manufacture and assembly can be optimised using *object libraries.* CS2 confirms the use of BIM to discover design errors and omissions before actual construction; in the sense that BIM increases right first time delivery, by reducing defects and issues of coordination. It enables the firm to visualise several scenarios and mitigate risks before the model is actually built on site. CS2 confirms that it uses BIM to integrate design and construction planning. Also, CS2 uses BIM to integrate procurement strategy with design and construction. CS2 employs BIM to implement lean construction methods by delivering lean process across the full project lifecycle. CS2 also coordinates and releases BIM models at end of construction by producing the native model file and asset information file for release. On the use of BIM to clarify and resolve design queries as they emerge, CS2 confirmed that it could coordinate design and report data queries within minutes, rather than wait for 28 days of approval of a design query when one is made, which has a positive impact on project cost and schedule.

4.4 *Level 2 BIM* Adoption at the Use/Operational Phase

Given that CS1 does not feature in the operational phase of BIM implementation, it does not use 6D or FM models. However, CS2 engages in the operational phase of BIM implementation. It runs a PAS 1192 – Part3 compliant process in line with the ISO 55001. CS2 affirms that BIM has reduced complexity such that they only need to maintain a 3D model environment linking it to an FM system so as to remain updated; this is how CS2 plans maintenance and react to maintenance issues at commissioning and handover. On the question of integrating BIM models with Facility Operation and Management System, CS2 stressed that only one or two contractors have been able to integrate BIM models with Facility Operation and Management System at any level, since different customer expectations mean different requirements. So CS2 is a work-in-progress as they try to do this properly in line with their internal asset management system. On the question of issuing Facility Management BIM model data as modifications in asset, CS2 explained that, in practice, the model data can only be maintained within the CAFM system, not within the BIM model. CS2 respondent further explained that one cannot use the BIM model to manage an asset, unless the native BIM model file is hosted on the CAFM system with hyperlinks to navigate through it.

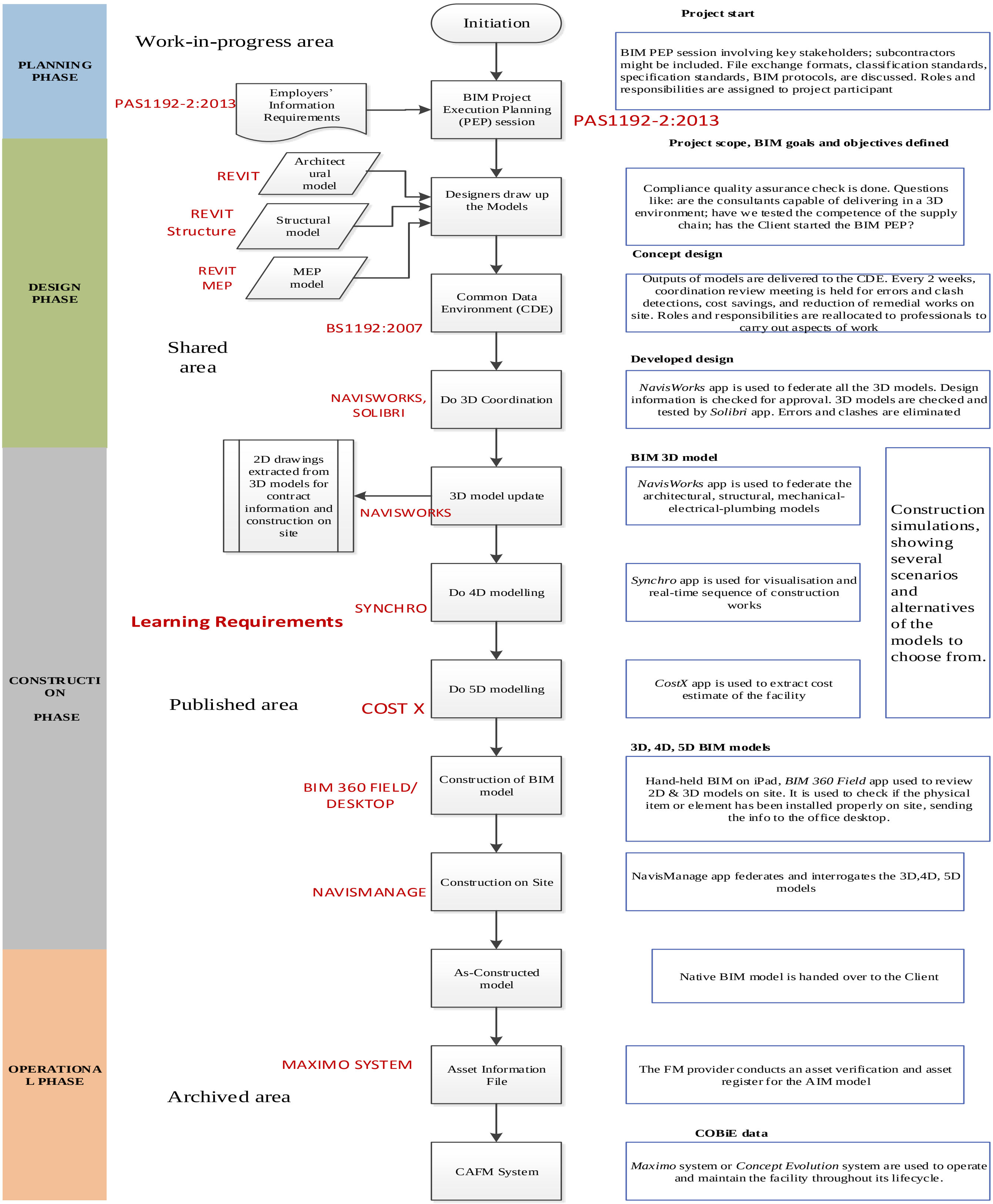

Fig. 1. Process Map Showing Level 2 Adoption through the Project Phases (Ojo, 2014)

5. DISCUSSIONS

The BIM functions or sub-processes at each project phases of the construction process were highlighted from the interviews. Then the generic process map above linking all the BIM activities in the project was developed. The information outputs at the end of each project stage were illustrated in the process map. The information inputs feeding into the BIM functions at the project phases were also examined from the interviews and illustrated in the Process Map.

In conclusion, the Process Map is one of the most appropriate ways to represent research findings in a process understandable to people working in an organisation, facilitating communication flow and agreement on construction processes. The Process Map above in Fig. 1 formalises the Learning Requirements for the adoption of *Level 2 BIM* in academic curricula.

5.1 Learning Requirements for Level 2 BIM Adoption at the Planning Phase

Kymmell (2008) defines learner as people who require training to learn and implement BIM processes such as students, educators and professionals. The following skills and knowledge are essential requirements for the training and implementation of Level 2 BIM in the industry:

1. The need to learn and understand the use of BIM Execution Plan (BEP) Guide, which is the starting point for BIM implementation.
2. The need to hold a collaborative BIM Execution Planning session with all stakeholders, clarifying project purpose, benefits, implications of BIM on project, stakeholder roles and responsibility matrix, file exchange formats, classification standards, specification standards, etc., to be used for the BIM lifecycle of the project.
3. The need to learn and familiarise oneself with the PAS 1192-2:2013 (The Specification for Information Management for the Capital/Delivery Phase of Construction Projects using BIM, which specifies the requirements for achieving Level 2 BIM.
4. The PAS 1192-2:2013 proposes the creation of a BEP, which is used to manage the delivery of the project. Hence, learners should recognise and understand the critical steps to BIM Execution Planning in accordance with PAS 1192-2:2013.
5. The need for learners to understand the role of a supplier (as PAS 1192 defines it – a provider of services or goods either directly to the employer or to another supplier) because the pre-contract BEP is prepared by suppliers, trying to map out their approach, capability to meet the Employer's Information Requirements (EIR).
6. The need for learners to understand the role of a supplier in meeting or responding to the EIR with the Pre-Contract BEP.
7. The need for learners to know and understand the role of a supplier in submitting a Post-Contract BIM Execution Plan, to the Client confirming his capabilities, including a Master Information Delivery Plan (MIDP).
8. The need for learners to appreciate what an MIDP is, and how project information is to be controlled and managed using the right protocols and procedures for each stage as the project proceeds (RIBA, 2012; Klaschka, 2014; Sinclair and Eynon, 2013, BIM Task Group, 2013b).

5.2 Learning Requirements for Level 2 BIM Adoption at the Design Phase

The following skills and knowledge are required to be provided through educational providers and institutions:

1. The skill to implement the MIDP during the post-contract obligation of the project is required.
2. The authoring skills needed to create architectural, structural, mechanical electrical plumbing (MEP) models are required learning for all BIM students, professionals and educators.
3. Capability of learners to deliver in a 3D environment.
4. Collaborative skills of consolidating all models together.
5. An overview of the Common Data Environment (CDE) using BS 1192:2007 as a guide foe effective collaboration.
6. The skill required to federate all the 3D models, architectural, structural, MEP, etc., with the use of NavisWorks app, facilitating BIM model sharing to enhance evaluation.
7. The skill required to check for clash detections of the 3D models with the aid of *Solibri* app, in a coordination meeting where clashes and errors are dicussed and resolved (RIBA, 2012; Klaschka, 2014; Sinclair and Eynon, 2013, BIM Task Group, 2013b).

5.3 Learning Requirements for Level 2 BIM Adoption at the Construction Phase

The following skills and knowledge are mandatory requirements for the education and implementation of Level 2 BIM in the industry:

1. The learner needs to be skilled in the use of applications such as *Synchro* app, for visualization and real-time sequencing of construction works, showing several scenarios and alternatives of the models to choose from.
2. The learner needs to be skilled in the use of applications such as *CostX* app, for quantification of building elements and cost estimate of the facility.
3. The learner needs to be skilled in the use of applications such as the Autodesk *BIM360 Field* app to monitor and review 2D and 3D models on site, and transmit the information to the office desktop.
8. The learner needs to upskill in the use of applications such as *NavisManage* to federate, coordinate and interrogate the 3D, 4D, 5D models for optimized project delivery on site (RIBA, 2012; Klaschka, 2014; Sinclair and Eynon, 2013, BIM Task Group, 2013b).

5.4 Learning Requirements for Level 2 BIM Adoption at the Operational Phase

There is a need to learn and understand the PAS 1192-Part 3 in conjunction with ISO 55001 to better appreciate BIM adoption at the use or operational phase. When the native model or as-constructed model is handed over to the Client, the *Maximo system* is used to operate and maintain the construction facility throughout its lifecycle. (RIBA, 2012; Klaschka, 2014; Sinclair and Eynon, 2013, BIM Task Group, 2013b).

5.5 Learning Requirements for Level 3 BIM Adoption

Looking ahead, the widespread adoption of Level 3 in the near-future will necessitate the following skills and knowledge for incorporation into academic curricula and industry at large. There will be a need for an awareness of the following:

1. Industry Foundation Classes (Data Definitions)
2. Integration and Standards supporting the Internet of Things
3. Unified Modelling Language Tools, to provide simplified technical and user data user access.
4. Model View Definitions
5. Process Definitions
6. Dictionaries and Ontologies
7. Data and transaction provenance.
8. Geospatial specific open data considerations
9. Internationalisation tools, etc. (HM Government, 2015).

6. CONCLUSION

Construction Education is bedevilled by multitudinous issues due to its practice-based, interdisciplinary nature of the industry, its professional and institutional history, and its evolving context and composition. These challenges have influenced the purpose of construction as well as the requirements or strategies needed to achieve it. It has been emphasised that BIM is a holistic process that must be introduced into curricula in a methodical manner such as being taught as standalone courses or incorporated into existing courses. However, each education provider will have to make decisions of where and how to introduce BIM, with regards to their unique context, policies and strategies. The purpose of this paper was to examine the nature of Construction Education and learning requirements for successful training and implementation of Level 2 and 3 BIM, to meeting the ever-changing nature of the AEC industry. A process map was deployed to illustrate the skill sets and knowledge required for the adoption of Level 2 and 3 BIM for students, educators and industry practitioners. These skills and knowledge can be used to formulate BIM-focused curricula to produce BIM-ready graduates and meet the needs of the AEC industry in the United Kingdom.

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