

Rethinking the Build Process for BIM Adoption

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Abstract

Collaborative working and integrated project delivery (IPD) are considered to be pivotal for the UK Built Environment Sector to rise up to the important challenges, such as reducing carbon emissions and cost, whilst delivering better value to the client. Considerable work remains to be done after nearly 1.5 decades since Egan listed them among the five key drivers of change. Innovating through integration and advocating change remain amongst the Government's top priorities for the sector to respond to the five-low carbon challenges, and thus to reduce costs by between 10% and 30%.

Building Information Modelling (BIM) is currently hailed as a solution that will eventually make collaborative working a reality. There is a strong push in the UK for the industry to adopt BIM but very limited appreciation of the issues that need to be resolved, e.g. cultural, procedural, contractual and process-related. Technological solutions to this problem exist but they need to be creatively combined to facilitate true collaboration between disparate project stakeholders who are often reluctant to share innovative solutions due to contractual relationships and Intellectual Property.

This paper focuses on improving the processes to design and deliver standardised schools in the UK by developing a novel approach to IPD through collaborative working and learning from project experience (collaborative BIM- cBIM). This is achieved by utilising the power of BIM, and emerging techniques and technologies. First a review of the current processes is undertaken to identify how IPD of standardised designs should be lead, planned and implemented. Second, emerging tools and technologies that can support this novel approach to procurement, design, and delivery are identified. The paper concludes with suggestions to develop an initial framework for cBIM which details the processes and protocols that should be embedded in project teams to make IPD a reality.

Keywords: collaborative BIM, Project, Standardised Schools.

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1. Background

Climate Change and the resultant need to drastically reduce carbon emissions across the Globe, had long been acknowledged as key challenges to industries before the unprecedented global economic crisis started to overwhelm major economies in 2008. As a result, every industry has been forced to re-think its processes and practices to deliver efficiently. The UK Construction Industry, the efficiency of which was identified as being critically important for the UK economy in the Government's Plan for Growth published in March 2011, is no exception.

The UK Built Environment Sector faces a number of important challenges such as reducing carbon emissions and cost, whilst delivering better value to the client. There has been a plethora of initiatives to encourage the industry to take action to rise up to these and other key challenges such as low productivity. Collaborative working & IPD have long been regarded as solutions. However, "lack of progress in implementing the recommendations [of these initiatives], and pessimism about the future outlook for change" were identified as issues in the latest industry review (Wolstenholme, 2009).

BIM is currently hailed as a solution that will eventually make collaborative working a reality. The UK Government has recently announced that BIM will be compulsory on all public sector projects from 2016 (Morrell, 2011). The Ministry of Justice announced in April 2011 that contractors on its framework must use it by the middle of 2013. Therefore, there is a strong push for the industry to adopt BIM but very limited appreciation of the issues that need to be resolved, e.g. cultural, procedural, contractual, process-related, so that BIM becomes the vehicle for collaboration. Technological solutions to this problem exist but they need to be creatively combined to facilitate true collaboration between disparate project stakeholders who are often reluctant to share innovative solutions due to contractual relationships and Intellectual Property. To gain insights about BIM and IPD, it is important understand how other countries have implemented them. The Scandinavian countries have been noted for being technologically advanced with highly educated population and large public sectors (Jensen and Jóhannesson, 2013). Therefore, an overview of BIM and IDP practices Finland and Denmark will be undertaken in the ensuing section.

2. BIM Penetration: Scandinavia vs UK

In 2007, a survey conducted by Kiviniemi (2007) revealed that the usage of BIM and Industry Foundation Classes (IFC) compliant applications stood at 33%. The same study revealed that 93% and nearly 60% of architects and engineers respectively, used BIM in some parts of their projects. So, many pilot studies demonstrating the benefits of BIM have been conducted in Finland. Results from these studies have been used in developing mandatory BIM requirements since the end of 2007. A survey by Kiviniemi et al. in 2008 reported that 50% of architects, 29% of clients and 40% of engineers used BIM for some parts of their projects in 2008. In January 2007, Denmark launched an initiative called "Det Digitale Byggeri" meaning Digital Construction for mandatory use of BIM in government projects. While these countries have already established BIM mandatory requirements, the UK's first

BIM mandatory requirements will come into force in 2016 (Morrell, 2011), nearly 9 years later.

Despite immense benefits of BIM already noted in these countries, and others, industry experts have often argued that BIM only becomes a vehicle to delivering better value if parties truly collaborate (Wright, 2012). One of the main challenges is to learn how to lead, plan and implement IPD. It is therefore necessary to review and remodel traditional delivery processes so that using BIM at Level 3 of Bew-Richards' BIM Maturity Model, i.e. intelligent BIM (iBIM), becomes a reality. This paper reports on the initial stages of an R&D project which aims to pave the way to iBIM by developing, testing and validating a novel approach (cBIM) to collaborative working and learning from project experience by utilising the power of BIM and emerging techniques & technologies.

cBIM will be developed, tested and validated in the Education Sector in England and Wales. Education is ripe for an innovative approach of this kind because the Government is under very high pressure to provide more school places in an environment where project funds are dwindling. There is a mismatch between the demand for public services and the funds that are available to provide them. Education is one of sectors in which this mismatch is acute. The education sector in England and Wales requires over £12Bn of funding during the three years between 2013 and 2015 in accordance with the Comprehensive Spending Review. In addition, the population growth in major UK conurbations is creating a Primary Place bulge requirement well-beyond the space available in the current school building stock. Local Authorities, which have a statutory duty to educate children of school age, are having to respond by diverting their resources to primary schools. This strategy will lead to a similar problem at secondary level by 2016-2018. The Government forecasts that there will be 4.39 million primary pupils by 2015 (an increase of about 10% on 2011), and this will increase to 4.8m by 2020. In London, 70,000 new permanent primary school places will be needed by 2015, even after 240 classrooms, built in response to rising demand since 2010, come into use this September. Birmingham faces a shortage of 3,000 reception places between now and 2020.

With an increased focus on both capital cost and long-term cost in use, new ways of working are necessary to meet society's need for school places and to work within the restricted budgets and timescales necessary to enable this major building program. Therefore, a significant opportunity exists to overcome these challenges for innovative providers and for forward thinking procurers to collaboratively create a totally new and unique method of building design and procurement that takes learning from major product manufacturing principles and from projects that are already delivered, and applies this to revolutionise the process of delivering built facilities in order to respond to the James Review which suggested standardised building techniques as one of the best ways to deliver low-cost schools (UK DE 2012; Talbot and Francis 2012).

3. The Novel Approach

The aim of this paper is investigate how best to deliver standardised schools in the UK through innovative IPD processes that harness the power of BIM and emerging technologies

for sensing and automated data collection. First a review of the current processes is undertaken to identify how IPD of standardised designs should be lead, planned and implemented. Second, emerging tools and technologies that can support this novel approach to procurement, design, and delivery are identified. The paper concludes with the principles of a framework for cBIM which details the processes and protocols that should be embedded in project teams to make integrative project delivery a reality.

IPD has been an aspiration for the UK construction industry since the mid-1990s but it remains to be one of the top priorities of the Government. Contrary to traditional construction practices which have made the industry notorious for its fragmentation, IPD is an approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all the phases of construction.

Although it is possible to achieve IPD without BIM, it has actually become the most recommended strategies to enhance IPD. Merging IPD and BIM can lead to greater collaboration in terms of procurement and delivery. It should lead to reductions in time, cost, waste and bring about innovative solutions to persistent problems. The complexities and constraints coupled with the high demand, makes IPD undoubtedly one of the best approaches to deliver schools in the UK.

4. Current Approaches to Project Delivery

Standardisation, off-site manufacturing, prefabrication and similar innovative approaches to delivering buildings is another area which provides opportunities to deliver better built facilities. Finnimore (1989) defines standardisation as an early theory in building technology, borrowed from manufacturing industry's attempts to maximise repetition in methods of manufacture in order to enhance economy and precision. The benefits of standardised construction are fast return on investment, health and safety savings, time savings, quality savings, efficiency savings, material savings, fewer defects and fewer mistakes (Ross 2005). Recently, it has been argued that schools can also gain from these benefits in an environment where demand for school places is increasing whilst funding is decreasing (Watson 2012; UK DE 2012; Talbot and Francis 2012).

In the UK, the provision of standardised schools has an established track record since the end of the Second World War (Phillipson, 2001). However, other than the traditional project lifecycles (CIOB, 2010), details about processes used in the delivery of standardised schools are sketchy despite a rising number of standardised schools being reported in the country. The Hertfordshire schools programme was an outstanding example of a programme which used standardised and prefabrication technology to meet the local pressures from the expansion of London and the establishment of post war new towns (Hatfield, Hemel Hempstead, Welwyn Garden City, etc.) that were driving the need for schools. In the UK, most projects including standardised schools are often required to use construction lifecycles. Some common lifecycles in the UK have been defined by leading institutions such as Chartered Institute of Buildings, British Standards, British Property Foundations and Royal Institute of British Architects (CIOB, 2010). These lifecycles often adopt a stage-gate

approach to project delivery, where professionals are involved only during the stages when their expertise is deemed necessary, dominates. Furthermore, many project partners still pursue these lifecycles in a linear fashion. The BIM approach is non-linear and provides project partners opportunities to collaborate simultaneously on a project. Therefore, the role of BIM can potentially contribute to reducing industry fragmentation, improving efficiency/effectiveness and fostering interoperability thereby reducing cost and time, and thus supporting IPD. It is considered that the use of BIM can greatly enhance the production of standardised buildings by providing integrated information solutions from the factory to the site. Lu and Korman (2010) argue that the use of modular construction techniques may increase as BIM becomes more prevalent in the construction industry.

4.1 BIM tools

The paradigm of collaboration between project partners using Information and Communication Technology (ICT) to share useful information throughout a project's lifecycle is well-encapsulated in BIM. Currently, BIM is at the centre-stage of almost every single country's construction industry including the UK. It is being hailed as a solution to overcome age old difficulties in communications and information management that have plagued the industry for decades. The contribution of BIM in addressing some of these issues that have remained unattended for far too long has already been noted (Jordani, 2008). However, whereas other industries have succeeded in leveraging significant benefits from BIM solutions, the construction industry has struggled to achieve similar productivity benefits for technological, practical and methodological reasons (Olatunji 2011; Arayici et al. 2012).

Hence, it is imperative to understand the technological, practical and methodological challenges impeding the uptake of BIM so as to provide a way forward for its full-scale adoption. In the ensuing section a review of the different BIM tools is undertaken.

The review criteria were identified with the aim of gaining insights of the benefit and challenges involved in the use of BIM. The main criteria considered are the various domain of activities, e.g. architecture, structures, etc.; the various tools used in the different domains; the different professionals involved such as the designers, engineering and cost consultants. Key aspects of exploiting construction information are interoperability, links of BIM with other tools, construction domain and stages in which the tools can be used, and whether the BIM tools are open source or not. With these criteria set, the most widely used tools established by the UK National Building Specification (NBS, 2013) were reviewed. The BIM tools are Revit, Microstation, Allplan, Bentley Building Suite, AutoCAD, Vectorworks, ArchiCAD, Trimble SketchUp. The summary of the review of these tools are presented in Table 1.

Table 1: Comparison of the common BIM tools in the UK construction industry

	Stage	Domain	Users	Links with other software	Interoperability	Open source
Revit Architecture	Planning and Design	Architecture	Architects and drafters	AutoCAD, Google SketchUP, Excel, ODBC, Google Earth	IFC, gbXML, DWG	No
Revit Structure	Planning and Design Construction	Structure	Structural engineers	Ecotect, Green Building Studio	IFC, DWG	No
Revit MEP	Planning and Design	MEP	Mechanical, Electrical and Plumbing Engineers	Ecotect, Green Building Studio	IFC, DWG	No
ArchiCAD	Planning and Design Construction	Architecture	Architects	Revit	IFC	No
Allplan Architecture	Planning and Design	Architecture (3D design)	Architects and drafters	Google SketchUp, Google Earth, Microstation. 3ds-Max, AutoCAD	IFC, DWG, DXF, PDF	No
Allplan Engineering	Planning and Design Construction	Structures (3D design for structural design)	Structural engineers	Google SketchUp, Google Earth, Microstation. 3ds-Max, AutoCAD	IFC, DWG, DXF, PDF	No
Allplan Facility Management	Operations	Facility Management	Facility managers	Google SketchUp, Google Earth, Microstation. 3ds-Max, AutoCAD	IFC, DWG, DXF, PDF	No
MicroStation	Planning and Design Construction Operation	Architectural Design	Architects, engineers, contractors, planners, GIS professionals	AutoCAD, Google SketchUP, Revit, IES, Google Earth	DWG, DXF, PDF	No
Vectorworks	Planning and Design	Landscape design	Planners and Landscape Architects	Google Earth	DWG, DXF	No
Bentley suite	Planning and Design Construction	Architecture, Structures, MEP	Architects, MEP and Structural Engineers	Google SketchUp	DWG, gbXML, IFC, PDF	No
Trimble SketchUp	Planning and Design	Architectural design	Architects	Google Earth	DWG, DXF	Free for limited version, small fee for complete version

4.2 The Barriers to the uptake of BIM tools

Table 1 provides the basis of discussion of factors inhibiting the uptake of BIM. In addition to the technical barriers in Table 1, non-technical barriers will be examined.

Information exchange and interoperability: Information exchange is crucial in fostering integrated process. Based on Table 1, it emerged that some of the common BIM tools can output information in at least one standard format, e.g. IFC. However, a recent study revealed that most construction professionals have never used most of the exchange protocols (Redmond et al., 2012). Perhaps that justifies why some tools are still very dominant in the BIM market. Without the knowledge of exchange protocols, the tendencies of buying the most common software will most likely prevail.

At which stage should BIM be integrated in projects? Opinions on the applications of BIM processes and tools on various phases of a construction project vary. These variations are generally based on the level of information available with regards to each construction phase. Current belief is that information about the operational phase of a building is widely abundant and well-researched. Also, there is a shift in investigating the implementation BIM at early design stages (Cheung et al., 2012). In Redmond et al. (2012) more diverse views have been expressed. Some respondents adamantly argued for BIM to be implemented in the whole life cycle while others recommended the early design stage.

Web-based or desk-top applications: Despite an overwhelming support and acknowledgement of cloud-based BIM systems supported by the Web (Redmond et al., 2012), many common BIM tools in the UK construction industry are still localised on desktops. All of the tools in Table 1 are desktop-based systems.

Overcoming the technical barriers alone is not sufficient to trigger the uptake of BIM. Other non-technical barriers such as cost, contractual issues, intellectual property, behavioural, cultural are known to hinder the uptake of BIM (Olatunji 2011; Gu and London 2010; Redmond et al. 2012; Yan and Damian 2008; NBS 2013).

Cost: Based on Table 1, most of the BIM tools are not free. In both the UK and the US, cost and human resources are among the major barriers hindering the implementation of BIMs by construction firms (Yan and Damian, 2008). This is particularly worrying given the huge number of SMEs in the construction industry.

Contractual issues with BIM: The openness in sharing construction information in BIM is the fundamental underlying principle of BIM and key in overcoming fragmentation in the industry. However, this “openness” has been considered as a barrier (Redmond et al., 2012). Current construction contracts do not cover information exchange. The lack of Standard BIM contract documents is a barrier to the uptake of BIM (Ashcraft 2008). Thus, issues such as risk allocation, compensation, insurance and dispute resolution common in traditional contract documents cannot be easily dealt with in BIM projects. Ownership and copyright attributions of construction BIM model and/or pieces of a particular aspect of a BIM model still constitute major concerns in BIM managed projects.

The lack of immediate benefits of BIM for designers: The benefits of the adoption of BIM have been acknowledged by academics and construction professionals (Ashcraft 2008; Yan and Damian 2008). However, amongst construction professionals, scepticisms about the level economic benefit in the supply chain exists (Ashcraft ,2008). For the project owner, the benefits are obvious and include design optimisation, fewer construction errors, fewer design coordination issues, increased quality, decrease in cost, shorter delivery times, less coordination and engineering effort and reduced fabrication costs. On the other hand, designers feel less enthusiastic about BIM as they believe its economic benefits are less apparent to them (Ashcraft, 2008). In the conceptual phase of a construction project, the ability to explore various design alternatives using BIM tools leading to greater efficiency and improvement in quality is a major benefit to designers. However, as argued by Ashcraft (2008), unless the designer shares in the economic benefits, the owner, not the designer, reaps the immediate rewards. Yet, it is the designer, not the owner, who must adopt and invest in BIM more than owners (Sebastian, 2010).

Incompatibility of BIM information with Standard Methods of Measurement: A major use of BIM is the measurement of quantities. BIM measurement could potentially change current measurement practices. A classic example is the need to filter quantity measurement output so that it complies with Standard Methods of Measurements. The existence of many different standard methods of measurement further exacerbates this challenge. For example, in the UK building and civil engineering works are managed by the Standard Methods of Measurement (SMM7) or New Rules of Measurements (NRM) and Civil Engineering Standard Method of Measurement (CESMM3) respectively.

The changing roles and responsibilities: The application of BIM to support cross-disciplinary, knowledge-intensive and multi-faceted projects opens new dimensions in the roles and responsibilities of actors in the construction industry. The relationships between the various actors are likely to change. While new roles with special responsibilities and skills (e.g. Model manager, BIM analyst, BIM modeller, BIM facilitator, etc.) will emerge (Sebastian 2011; Barison and Santos 2010), there is an anxiety that some actors (e.g. quantity surveyors) will lose their roles.

Procurement challenges: Current procurement methodologies are ill-suited for the rolling out of BIM in the construction industry. The majority of current procurement methodologies limit the participation of various actors right from the early stages of construction. For BIM integration to be a success there is a need to involve all construction team members including contractors and sub-contractors from the early stages. In addition to the sustainability dimension, BIM and procurement processes constitute the three pillars that will drive the way forward for IPD. These three inter-related issues were strongly echoed in the UK Government Construction Strategy, published in May 2011(GCS, 2011).

5. Preliminary framework for the delivery of standardised schools

In sections 1 and 2 we have argued how IPD and BIM systems can be used in delivering standardised schools. As long as the challenges in deploying BIM persist the benefits from rolling IPD and BIM systems will hardly ever be realised. It is no wonder that experts from

the construction industry have suggested that IT researchers should align with construction practitioners when developing and proposing IT solutions (Gu and London, 2012). This suggests construction industry problems require wider participatory approaches not only from construction professionals but also from other industries working collaboratively in developing innovative solutions. Furthermore, in an industry where almost all projects are handled in multi-disciplinary and multi-organisational terms, the lack of clarity on roles, responsibilities and distribution of benefits in adopting the BIM approach is an important inhibiting factor (Holzer, 2007). Therefore, the challenge in the development of an IPD and BIM solution in delivering standardised schools is multi-dimensional requiring the sourcing, harnessing and using skills of actors both within and without the industry and using them in delivering standardised schools using IPD and BIM approach.

The methodology adopted in this study consists of a literature review, workshops, interviews and case studies. The literature review focuses on different projects that have been delivered through IPD in the UK. This will lead to the establishment of potential factors and decision points to be considered in the development of a framework for the delivery of standardised schools using IPD. We will also conduct a detailed analysis of construction project life cycles (CIOB, 2010) with the view of identifying opportunities and phases where BIM and sustainability can be integrated. Procurement methods are also currently being reviewed for potential recommendations to accommodate IPD and BIM. We are currently exploring BIM Overlay framework developed by RIBA (Sinclair, 2012). Based on these reviews a preliminary framework for delivering standardised schools using IPD has been designed and presented in Figure 1.

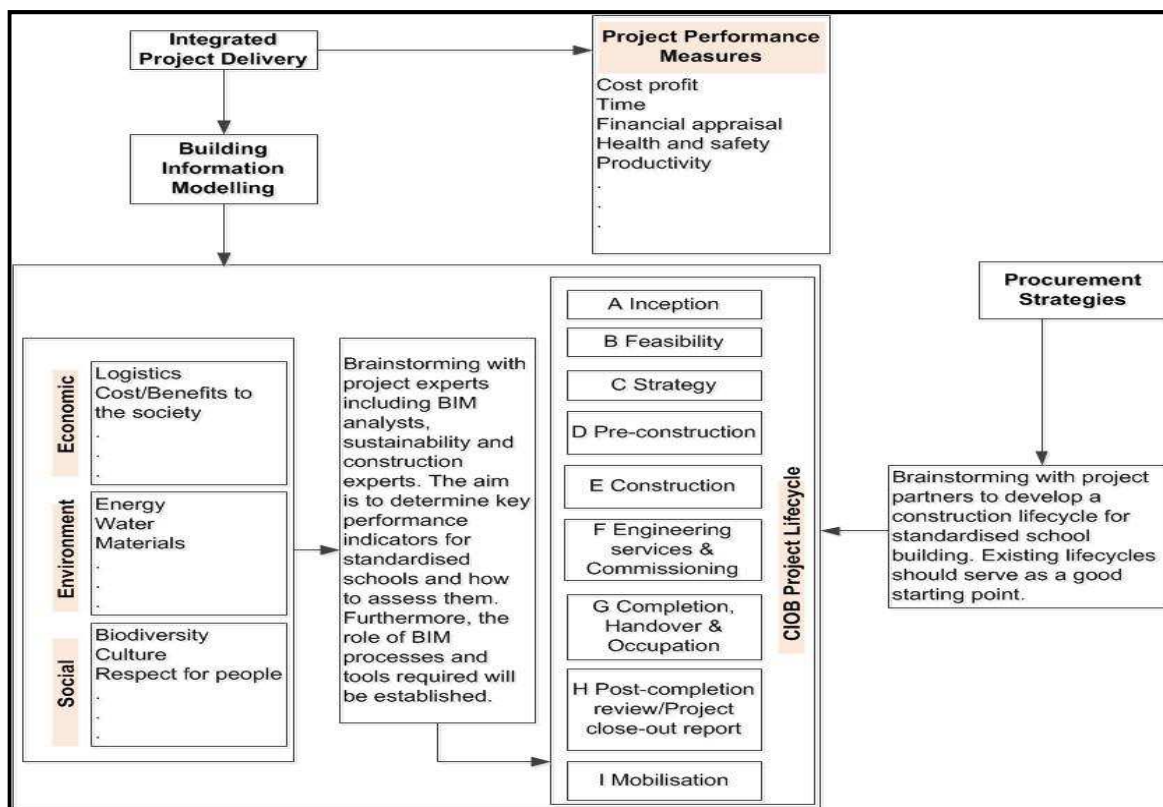


Figure 1: Preliminary IPD/BIM framework for the delivery of standardised schools

Given the novelty of the domain, a series of workshops will be organised and opinion of experts developing standardised buildings in the UK will be sampled and used in developing and validating the preliminary framework. A pilot Sandpit event will be organized for key members of the supply-chain who will use the enhanced BIM for real-time collaborative working in our first live project. A focus group will be held at the end of this event to provide a preliminary evaluation of this new approach, which will be used to further refine the processes.

The project kick-off meeting for our second live project will be a Sandpit. Supply-chain members will attend the event which will provide a “safe play” environment to critically review alternative options and to evaluate the effect of different design and construction alternatives on project performance using the collaborative BIM (cBIM) that will have been developed earlier on in the R&D project. BIM will also give them access to previous project knowledge to improve the product and the process. One example is to generate work packages using the information kept in the recycled BIM in order to evaluate and optimize them according to performance targets such as cost. Attendees will start evaluating this novel approach to collaboratively working so that it can be benchmarked against current approaches to designing and delivering schools using standardised designs.

6. Discussion and conclusion

In this paper we have reviewed the literature on IPD and BIM. We noted that IPD can be achieved without BIM; however BIM can be used to facilitate IPD. Thus, as discussed in most literature, BIM is currently being considered as a vehicle to achieve IPD. To gain an insight of the BIM tools, the most widely used ones in the UK were examined. It emerged from the review that despite the widely popularised benefits of BIM there exist enormous challenges to overcome before many project actors can fully embrace BIM. The challenges were grouped into two main categories. First the technical challenges related to nature of the BIM technologies and secondly non-technical related to the human and industry practices. The challenges constitute part of a wider range of issues that should be overcome for IPD to be implemented in projects. With this in perspective, we proposed an approach to develop a framework for the delivery of standardised schools in the UK. The five components of the proposed framework are BIM technology, sustainability considerations, actors or people, processes (i.e. procurement and project life cycles) and project performance measures.

The BIM technology is about the constituents of BIM technologies and processes that can be used in managing a construction project. In particular in collaboration with our project partners, the most appropriate BIM technologies and processes that can be used in managing standardised school information will be established. The sustainability component will be about the different sustainability issues needed to be included in the development of a standardised school. The set of sustainability indicators will be established through brainstorming with our project partners. The use of BIM in managing construction information requires new roles. These are people related issues. With regards to standardised schools, new roles and relationships within the project teams will be mapped out. New processes, particularly in terms of procurement and construction lifecycles will need to be developed in

order to support IPD. Project performance measure, the last component, will be used to identify the project efficiencies (or otherwise) that can be achieved by using cBIM.

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