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Building Information Modelling Benefits-Maturity Relationship from Client Perspective

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Abstract
Much work has focused on improving construction productivity including the use of information and communication technology (ICT) in construction. In particular, Building Information Modelling (BIM) could revolutionise the project process. Also, it is considered by the different construction industry stakeholders as a main driver towards them gaining a considerable savings in project costs. Clients can play a vital role in the implementation process of such technologies but still there is a lack of understanding as to where during the project lifecycle BIM can provide benefits to the client. In this article a new conceptual framework will represent the relationship between BIM application benefits and the client organisation maturity levels. This framework will help the clients to fully understand and monitor the BIM benefits through project life cycle.
Keywords: Client, BIM, Applications, Benefits, Maturity Levels.

1. Introduction

The building sector, as one of the main sectors in the UK construction industry, is facing huge pressure from the government to deal with all the factors likely to affect the demand for building construction (Department for Business Innovation & Skills, July 2013). These factors include some new challenges such as globalisation, demographic changes, demand for green, and sustainable construction (Barton et al., 2013).

At project level, activities are usually divided into purposeful areas, which are completed by different stakeholders (e.g. the client, architects, engineers, and contractors). Regularly, each discipline makes decisions without considering its impact on others (Love, Edwards, Han, & Goh, 2011). All these barriers are causing project delays that directly lead to increasing the amount of time needed to complete the project and/or additional resources are required to complete the project, thus productivity rates decrease and costs rise.

Much work has focused on improving construction productivity including the use of information and communication technology (ICT) in construction (Onyegiri et al, 2011). Building Information Modelling (BIM) as a modern technology, provide examples where designing complex structures requires a high level of coordination between the electrical, mechanical, and structural stakeholders. Other applications such as estimation and planning can be completed in minimal time with a high level of efficiency (Peansupap & Walker, 2005).

In particular, Building Information Modelling (BIM) could revolutionise the project process. Also, it is considered by the different construction industry stakeholders as a main driver towards them gaining a considerable savings in project costs.

Considerable research has stated that as one of the construction stakeholders, clients can lead the innovation to achieve vital benefits from using BIM in their construction projects (Gann and Salter, 2000, Harty, 2005, Kulatunga et al., 2011, Manley, 2006, Miller, 2009). Furthermore, BIM implementation process has been prevented from being more widely accepted across the construction industry by client fears and lack of full understanding of the BIM benefits as well as the requirements that are needed to gather these benefits (Succar, 2010b).

This paper aims to develop a framework which explains the relationship between the Building Information Modelling (BIM) benefits through project life cycle and the desired BIM maturity level from a client's perspective. The paper is organised as follows: Section 1 reviews all BIM applications which support client needs to meet their desired benefits in their construction projects, followed by Section 2 that presents the benefits for each application. Section 3 presents the requirements that need to be met in order to run the application in perfect way. and Section 4 presents the available existing maturity evaluation methods which focus on the client organisation. Section 5 presents the conceptual framework. Finally, Section 6 discusses the initial findings, limitations and future research of the work presented in this paper, and concludes the paper.

2. BIM Applications

The application generally is defined as the act of applying something to a particular purpose or use (TechTerms, October 12, 2008). The applications of BIM have been used in a considerable number of large-scale construction projects, which may cover commercial, industrial real estate, and infrastructure sectors (Sebastian & van Berlo, 2010). Different types of BIM applications could be applied in each project life cycle stage. Some applications were only used in a particular stage, while others extended to be used in different stages. The use of any application mainly will be dependent on what the expected benefits are and also the capability of the users (Hardin, 2011). Each application has different types of benefit that may apply to a certain stage in the project life cycle or sustain as a long-term benefit. In addition to that, each application has requirements that the users need to provide to achieve the desired benefits (Eastman, 2011). From the literature it can be seen that there are 21 main applications which provide benefits for client. These applications were investigated in detail to find their benefits and what their requirements are to work properly.

3. BIM Application Benefits

The definition of benefit in general is "an outcome of change which is perceived as a positive by stakeholders" (Bradley, 2010). Stanford University's Centre for Integrated Facilities Engineering highlighted that the main benefit of BIM (cited in CRC Construction Innovation ,2007) reduces the un-budget change up to 40%, increases the cost estimation accuracy up to 3%, reduces time taken to generate a cost estimate up to 80%, increases the contract's value up to 10% and provides up to 7% reduction in the project period. In addition, Holzer (2013) indicated that BIM represents a more accurate way of working. As the processes change, BIM will reduce waste (materials, resources & cost) through improved designs and construction processes (Azhar, 2011).

Clients in particular can achieve worthy benefits on their construction projects by adopting BIM as a process and tool to guide their delivery process to higher quality and performance for a whole building life cycle (Eastman, 2011). BIM changes the methods of design and builds (Yan & Damian, 2008), which leads to reducing the total cost and time as a direct benefit (Love et al., 2013). Y Arayici et al. (2011) concluded that the collaboration among stakeholders will expand the client's organisational boundaries which may lead to increased performance of the project during different stages of the life cycle. BIM can help in creating this new collaborative environment, where all the project stakeholders can sit together and exchange information between themselves in the early stage of the project life cycle. However, the organisation readiness and capability to provide and accept such an environment will have an impact on the expected benefits. This new process of sharing information will provide some direct valuable benefits for the client, specifically full project understanding (Azhar, Khalfan, & Maqsood, 2012; Bryde, Broquetas, & Volm, 2013; Eastman, 2011; Succar, 2009).

Haron (2013) stated that the BIM benefits full understanding by helping the organisations to approach their action plan for BIM implementation to meet their needs. The benefit identification process is critical in nature. Therefore, wide literature has been analysed to identify BIM main benefits as explained in Appendix B. It is difficult to treat each benefit individually because of the interaction between them. For example, applying one or more application might have an impact on project time which subsequently can reduce the project cost.

4. BIM Application Requirements:

Each BIM application needs a set of requirements to ensure that it runs perfectly and thus ensure getting the desired benefits from the application (Penn State, 2012). The failure to provide these requirements or provide a part of it will be reflected directly on the benefits of the application (B. Becerik-Gerber, Jazizadeh, Li, & Calis, 2011). The application requirements are not fixed, but rely entirely on the user. For example, the application used by the designer will differ in their aims and purpose from the contractors. For this research, all BIM application requirements will be investigated with respect to the client as the main beneficiary (Mayo, Giel, & Issa, 2012; Penn State, 2012).

For further clarification, the cost estimate application needs a set of requirements that a client should provide such as, the ability for staff to manipulate the model, having a quality assurance system, defining the best level of detail, defining the role and responsibilities, and selecting the compatible software and hardware (Sabol, 2008b, 2008c). These requirements help clients to evaluate the developed BIM models by different stakeholders during the project life cycle and make sure that all the desired benefits are met. The client capability to provide these requirements will determine the nature and the quality of the benefits that can be expected when using BIM applications (B. Giel & Issa, 2012).

5. BIM Maturity Levels:

It has been approved that information systems and technology represent the main factors in supporting BIM (Haron, 2013; Mayo et al., 2012). Therefore, before starting the process of assessing the BIM maturity level, many studies have looked at how other Information Systems (IS) investments are evaluated (Mayo et al., 2012).
There have been quite a number of methods used to evaluate the BIM implementation maturity in recent years. The various maturity models and scoring systems tend to fall into two basic categories (B. Giel & Issa, 2012; Succar, 2010a). The first category is focused on how to evaluate a particular project against BIM implementation. The second category would take the entire organisation as its target to evaluate against BIM implementation..
At this stage a comparison was made between these three models (Succar 2010, Penn State Matrix 2012, and GPIS 2005) in order to select the elements and categories of the maturity matrix. The selection and adoption of each category were made based on the following criteria:

- The frequency of occurrence among the models reviewed.
- The suitability of the category to be used within the context of client organisations.
- The suitability of the category to be used specifically with the context of BIM implementation.

6. Conceptual Framework

After conducting a rigorous “Literature Review”, twenty one applications were identified as the main factors for the client organisation being motivated to implement BIM in their internal processes to emphasise the project management process. All tangible and intangible benefits were investigated. These benefits were achieved through a BIM application, which it also identified through literature review. These applications will be distributed against the new RIBA project life cycle as shown in appendix A. This distribution will help the client to track their benefits through the project life cycle and examine the entire BIM application requirement through the existing maturity indicators. By following the steps outlined in the conceptual framework as shown in figure (1), all the BIM application requirements and benefits will be spotted. The next step involves classifying the requirements for each application according to the main maturity matrix components. After this, the classified requirements will be distributed against the maturity levels, which are divided into four levels from level one to level four as shown in table (1). By exploring and knowing the relationship between the requirements and benefits, the researcher was able to distribute benefits through the maturity levels as shown in table (2). This conceptual model explains the relationship between the BIM implementation maturity level and the benefits related with it. It also covers all the benefits in the project life cycle which represent the main tangible and intangible benefits that clients can achieve through implementing BIM in their internal organisational system.

7. Framework Benefits and Contribution

This framework will represent the relationship between the BIM maturity level and BIM application benefits for client organisation. This relationship was explained through distrusting the BIM application requirements through the BIM maturity level and also explained the expected benefits for each maturity level with respect to certain applications. This article only focuses on how the BIM application can produce benefits for client organisation.

The following expected benefits can be achieved when a client organisation applies this framework in order to examine their ability to achieve all BIM application benefits in project life cycle.

- The framework will help the client to formulate a clear vision regarding how to build capacity to ensure the achievement of the desired benefits.
- The project management process will gather huge benefits when the client leads the BIM implementation process.
- The framework helps the client to find their actual BIM maturity level and to find out what the expected benefits related with it are.
- The deeper explanation of benefits against BIM maturity level will help the client to select the appropriate maturity level.

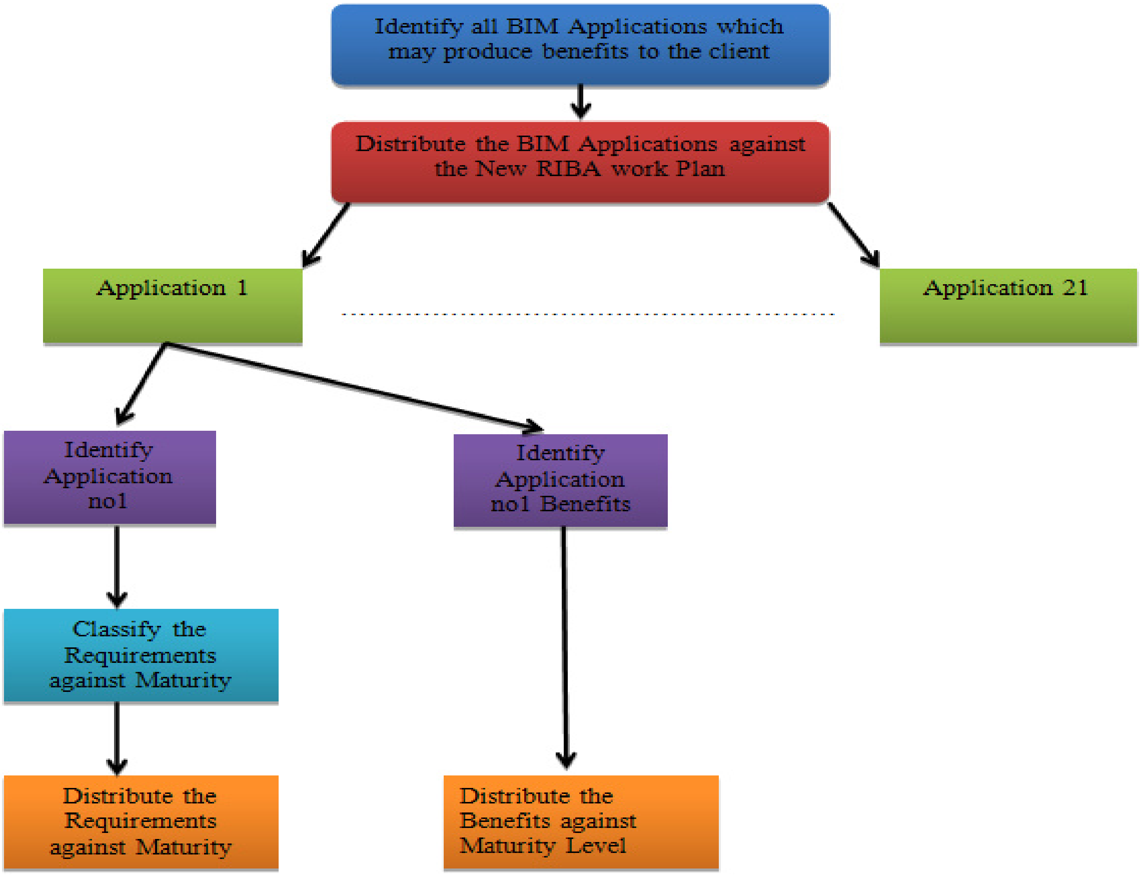

Figure 1. The Conceptual Framework.

Table 1. The distribution of BIM application requirements through maturity levels.

No	BIM Application	Requirements	Expected Design Benefits Logical Construction Benefits Logical In-Use Benefits	Definite Design Benefits Expected Construction Benefits Logical In-Use Benefits	Definite Design Benefits Definite Construction Benefits Expected In-Use Benefits	Definite Design Benefits Definite Construction Benefits Definite In-Use Benefits
			L1	L2	L3	L4
1	Any Application	Environment	All the requirements that are needed to gather the level of benefits listed above will be explained here.	All the requirements that are needed to gather the level of benefits listed above will be explained here.	All the requirements that are needed to gather the level of benefits listed above will be explained here.	All the requirements that are needed to gather the level of benefits listed above will be explained here.
		People				
		Process				
		IT system				

Table 2. The distribution of BIM Application benefits through maturity levels.

No	BIM Application	Expected Design Benefits Logical Construction Benefits Logical In-Use Benefits	Definite Design Benefits Expected Construction Benefits Logical In-Use Benefits	Definite Design Benefits Definite Construction Benefits Expected In-Use Benefits	Definite Design Benefits Definite Construction Benefits Definite In-Use Benefits
		L1	L2	L3	L4
1	Any Application	All the expected benefits at this level will be explained here.	All the expected benefits at this level will be explained here.	All the expected benefits at this level will be explained here.	All the expected benefits at this level will be explained here.

8. Conclusion and Future work.

The authors have presented the new framework which explains the relationship between the BIM maturity level and the benefits related with it. The results of this study are summarised as follows.

- The authors have developed a methodology for finding twenty one BIM applications which support the construction project management process.
- All the twenty one BIM applications requirements and benefits were spotted through the literature review.
- All the available existing maturity methods were investigated in order to find the best BIM maturity components which related specifically to the client.
- The authors have suggested a framework which explains the relationship between the BIM maturity level and the benefits which are related to it. Client organisations can use this framework to evaluate their maturity and their benefits. These results provide the opportunity for the client to change the existing BIM implementation plan.

This study has some limitations and opportunities for future studies. Firstly, this paper represents only a conceptual framework, with actual data needing to be collected to validate this framework. Secondly, the focus of this study has been limited to client organisations only. Future studies can examine the effect of client organisation type on the BIM application use. In addition to that apply this framework on other stakeholders like define firms, contactors, and operation & maintenance companies.

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This paper will represent part of the author's work as a PHD student in Salford University, Built Environment School.

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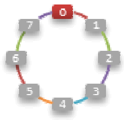
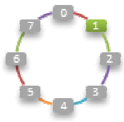
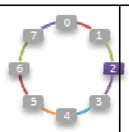
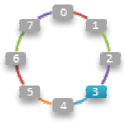
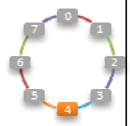
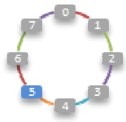
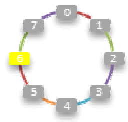
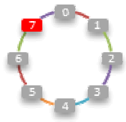
Appendix A

 Stage 0	 Stage 1	 Stage 2	 Stage3	 Stage 4	 Stage 5	 Stage 6	 Stage 7
Appraisal	Design Brief	Concept Design	Design Development	Technical Design	Construction	Handover	In use
		Existing Condition Modelling					
		Cost Estimating					
		Phase Planning					
		Design Authority					
		Design Review					
			Engineering Analysis				
			Lighting Analysis				
			Energy Analysis				
		Sustainability Evaluation					
		Code Validation					
		3D Coordination					
			Construction System Design				
					Site utilization Planning		
					Digital Fabrication		
					3D control and Planning		
						Record Model	
							Building (Preventative) Maintenance Scheduling
							Building Systems Analysis
							Asset Management
							Space Management and Tracking
							Disaster Planning

Appendix B

No	Application	Description	Requirements	Benefits	References
1	Existing condition modelling	This application helps the project team to create the 3D model containing the entire external environment which surrounded the proposed project.	The staff are able to manipulate navigate, and review a 3D model. Familiarity with Building Information Model authoring tools. Familiarity of 3D laser scanning tools. Familiarity of conventional surveying tools and equipment. Ability to determine what is the optimum level of detail which may able to add "value" to the project. Ability to select the appropriate software to create the site-linked BIM model.	Increase the efficiency and accuracy of existing conditions documentation and representation. Help in future modelling and 3D design coordination. Provides an accurate representation and visualisation of work that has been put into place. Real-time quantity verification for accounting cost estimation purposes. Disaster Planning. Time Saving Utility Design.	• (John M. Russo, 2012) • (Wang, 2011) • (Arayici and Hamilton, 2005) • (Construction, 2012) • (Penn State, 2012) • (Becerik-Gerber et al., 2012) • (UK BIM Standarded, 2012) • (Smart market Report 2012) • (Reddy, 2012) • (Eastman, 2011)
2	Cost Estimating	This application will help to produce accurate quantity take-off and cost estimate through all project life cycle stages. The cost effect due to any changes can be seen directly from this application.	Software and hardware (all the software must be compatible between the entire project participant which will help to communicate in easy way and change the documents between each other's). Quality assurance system to check design deliverables. Roles and responsibilities. Level of development (LOD) Collaboration. Ability to define specific design modelling deliverables.	Accurate estimate material quantities and generate real-time revisions if needed. Stay within budget constraints while the design progresses Better visualization for project element that must be estimate. Provide accurate cost information to project stakeholders will help to enhance decision making process. Focus on more value adding activities in estimating (identifying construction assemblies, generating pricing and factoring risks) which are essential for high-quality estimates Exploring different design options and concepts within the owner's budget Saving estimate process time and allowing project team to focus on more important issues which may increase project quality.	• (BuildLACCD, 2009) • (The U.S. Department of Veterans Affairs (VA) Office of Construction & Facilities Management (CFM), 2010) • (UK BIM Standarded, 2012) • (Pennanen, Ballard, & Haahtela, 2011) • (Sabol, 2008d) • (Sabol, 2008b) • (Construction, 2012) • (Penn State, 2012) • (A. A. Becerik-Gerber, Burcin et al., 2012) • (UK BIM Standarded, 2012) • (Smart market Report 2012) • (Reddy, 2012) • (Eastman, 2011)
3	Phase Planning	This application will add the 4D (Time) to 3D model. Effective and accurate project process planning by using this application help the project stakeholders to full understanding the project consequences.	Project planning team must be familiar with construction project scheduling and general construction process. Project planning team are able to manipulate navigate, and review a 3D model and all 4D software. Hardware and all 4D software.	Produce full understanding of the phasing schedule to all project stakeholders. Produce dynamic project plan which will be affected by any change happened in project during any phase through project life cycle. Identification of schedule, sequencing or phasing issues More readily constructible, operable and maintainable project Monitor procurement status of project materials Increased productivity and decreased waste on job sites by create optimum project construction plan. Exploring different design options and concepts within the owner's expected handover time.	• (Sulankivi, Kähkönen, Mäkelä, & Kiviniemi, 2010) • (J. Zhang & Hu, 2011) • (Saini, 2013) • (Godawa, 2012) • (Construction, 2012) • (Penn State, 2012) • (A. A. Becerik-Gerber, Burcin et al., 2012) • (UK BIM Standarded, 2012) • (Smart market Report 2012) • (Reddy, 2012) • (Eastman, 2011)

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