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BIM implementation throughout the UK construction project lifecycle: An analysis

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ABSTRACT

Substantial impacts through BIM implementation may be achieved throughout all stages of the construction process. The paper measures BIM use throughout the project lifecycle, confirming BIM is most often used in the early stages with progressively less use in the latter stages. This research demonstrates via 92 responses from a sample of BIM users that collaboration aspects produce the highest positive impact. The process aspects are more important than the software technology. BIM necessitates investment in software and training however, smaller practices can afford it. Stakeholder financial benefits are ranked concluding that clients benefit most financially from BIM followed by Facilities Managers. Despite this, over 70% do not provide a 3D model and Cobie dataset at the conclusion of a project. Identification of Key Performance Indicators currently being used for BIM is provided and findings indicate a lack of industry expertise and training providing an opportunity for education providers.

1. Introduction

Building Information Modelling (BIM) is defined as the process of *generating, storing, managing, exchanging, and sharing building information in an interoperable and reusable way* [59]. It requires the development and use of a computer generated model to simulate the planning, design, construction and operational phases of a project [7]. The BIM Industry Working Group shows that the UK Government believes that its use brings many efficiencies and benefits across the project lifecycle [14]. The paper seeks to measure the impacts of BIM use throughout the project lifecycle. Current literature in the area tends to focus on individual sections of the construction process. Those papers which deal with BIM across the lifecycle do not focus mainly on the financial side of the process. This paper seeks to fill that knowledge gap. The research firstly investigates the different positive impacts of BIM. It analyses and ranks the benefits to determine the significance of the financial aspects. This is followed by an examination of BIM usage at the various lifecycle stages to indicate the frequency of financial savings at each stage of the process currently. The main financial beneficiaries of BIM adoption are determined, followed by the financial impact of a Project Execution Plan. Next the amount and content of information supplied at the end of the project are determined to ascertain the financial impact on future schemes, and Key Performance Metrics used in relation to BIM are ranked to provide a means of measuring the impact of BIM overall. Lastly the reasons for not implementing BIM are examined.

2. Literature relating to BIM

2.1. BIM impacts and outcomes

The BIM Industry Working Group [14] indicates that there are substantial organisational impacts through BIM implementation for all stages of the construction process. Arayici et al. [2] indicate that stakeholder collaboration expands organisational boundaries which enhances the performance of the project organisation during the design and construction process. This collaboration is further supported by Kymmell [45] and BSI [18]. However, a further impact highlighted by Howard and Björk [36] demonstrates the need when implementing BIM, to change business processes in addition to the simple promotion technology. BIM implementation may impact on all the processes within the project organisation and therefore cannot be treated in isolation as a software tool. It therefore may be defined as a process related rather than simply technology and that both approaches require BIM to be managed holistically. Holzer [34] concludes that BIM is a more accurate way of working. As the processes change BIM will reduce waste (materials, resources & cost) through improved designs and construction processes [4]. Nawari [51] attributes one of the successes

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of BIM to creating more sustainable communities. Another key aspect leading to similar improved accuracy, design and construction is 3D visualisation as identified by BIMhub [13] and Bentley [12].

However, to have a successful implementation of BIM processes, all members of the construction team need security of confidential data external and internal to the BIM model. The BIM model can be part of an extranet [19] however, this may lead to legal issues. There is the need to deal with the legal issues through the construction contract in order to reduce this significant risk [16,19,58].

The significance of the cost of implementing BIM in terms of resources and training has been seen to act as a substantial barrier within the construction industry [5,22,26,28,57,60]. Despite the significant cost of implementation BIM will ultimately be driven by clients [26]. Hore et al. [35] suggest that if adoption becomes a requirement then training must be subsidised by the Government to facilitate implementation.

The size of the organisations implementing BIM is a significant factor as it is easier to implement BIM within client or supply side SMEs [2] however it may be beyond the reach of some SMEs due to its cost [43].

This study ranked the various aspects of BIM adoption in order of importance.

2.2. BIM application across the project lifecycle

After analysing the significance of the impacts in the application of BIM the research investigated the use of BIM at the various stages in the construction lifecycle. For the purposes of this research the project lifecycle is defined as encompassing project inception, feasibility, design, construction, handover, operation, maintenance and eventual demolition. Key literature defines the various stages using BIM as feasibility [6,20,32], design [3,6,32], preconstruction (detail design and tender) [3,6,20,28,33], construction [3,7,31,38,60] and operation and management [7,38]. BIM is cited as being useful and providing benefits at these stages however, omitted from the literature is the frequency of use by organisations at each stage of the project lifecycle. This paper seeks to provide empirical evidence from the contracting parties on this issue.

2.3. The financial benefits of BIM to the parties involved

Previous research suggests that financial benefits can be achieved through BIM adoption. Jardim-Goncalves and Grilo [39] analyse the savings by company size. Two-thirds of BIM users have reported a positive return on investment on their overall investment in BIM [50]. The BIM Industry Working group [14] indicates that the financial savings can be achieved over all the stages of the project lifecycle. Akcamete et al. [1] indicate that operation and maintenance of the building, the role of the Facilities Managers, equates to 60% of the overall costs of the project. They further suggest that great financial gains can be achieved by targeting this aspect of a project. Furneaux and Kivvits [27] indicate that substantial cost savings through the increased interoperability of the BIM software could result in clients and building users/occupants/operators saving up to two thirds of the overall $15.8 billion per year spent in Australia. Again substantial savings can be achieved in BIM as consultants can produce fully worked up drawings at "half time at half cost" [60]. Contractors and Specialist Contractors demonstrated a reduction of 1%–2% of cost of Mechanical, Electrical and Plumbing Engineering (MEP) systems on a large size healthcare project [42]. Suppliers also benefit from more accurate costs and additional specifications [30]. In addition to the construction industry benefitting in relation to costs, Software Vendors are also shown to have a large return on investment from BIM implementation [10]. However, while the literature is specific on the cost benefits of BIM implementation it does not indicate which of the disciplines benefits most or rank the cost benefits by discipline.

2.4. Project Execution Plan use for BIM projects

The implementation of BIM throughout the project lifecycle is normally laid down in a BIM Project Execution Plan (PEP) [48]. The BIM PEP identifies where the maximum benefits of BIM can be achieved during the planning, design, construction and operational phases of a project [48]. This plan provides an overall programme to ensure that all organisations in the design and construction teams are fully cognisant of their responsibilities connected to BIM implementation in the project workflow. Once the plan is created the progress against this plan is monitored to gain the maximum benefits from BIM. It is a critical success factor in the management of BIM to deliver higher levels of project performance.

2.5. BIM information supplied at the end of the project

Although the Construction, Design and Management (CDM) regulations in the UK specify that as built drawings are provided at the end of the contract, Huber et al. [37] suggest that in the majority of cases this contains as-designed information rather than as-built information. Goedert and Meadati [29] suggest that this information is traditionally supplied as 2D information only. However, with the advent of BIM they further suggest that to develop a 3D as-built model was currently more time consuming than traditional 2D as-built however, it could be supplied [29]. Tang et al. [56] demonstrate how a Multi-Disciplinary BIM Model (MDM) can be used for as-built purposes. From BIM stage 2 individual disciplinary BIM models within each discipline provided separately may be supplied at commissioning and handover [55]. East and Brodt [25] demonstrate the rationale supporting the efficiencies achieved through an additional Facilities Management (FM) Dataset being provided at the end of the construction phase using the example of Cobie. However, current use of these methods in construction is not well documented.

2.6. BIM KPI/metric measurement

The full benefits of BIM need to be measured over the lifecycle of the project to ensure that continual improvement can be achieved. Luu et al. [47] identify performance measurement as an essential element of efficiency. Generally in construction the headline Key Performance Indicators (KPIs) identified by Kagioglou et al. [40] are employed. The use of KPIs allows schemes to be benchmarked against similar schemes to identify standards in the national performance of the construction industry and identify areas for improvement [40]. Constructing Excellence [21] further demonstrates that KPIs can facilitate systematic performance improvement and specify the following list for the construction industry:

1. Client satisfaction — product;
2. Client satisfaction — service;
3. Defects;
4. Predictability — cost;
5. Predictability — time;
6. Profitability;
7. Productivity;
8. Safety;
9. Construction — cost;
10. Construction — time.

While these KPIs are general they may also be applied to BIM. However, prior to using the headline KPIs it is imperative that research identifies what industry is currently measuring. Kagioglou et al. [40] state that Key Performance Indicators are defined as an amalgamation of various measures however it is yet to be determined what these measures for BIM are. Targeted improvements can only be made when the performance of BIM projects are clearly evaluated. Yuan et al. [61] state that KPIs generally allow comparison between the actual and