BIM a Technology or Something More?

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Abstract
The implementation of Building Information Modelling (BIM) is revolutionizing the construction industry; transitioning from 2D to the nD digital world. Although implementation has increased, there remains confusion towards the term 'BIM'; whether it should be considered a term expressing a form of technology or something more. This may appear as a simple question; however, there remains no definitive definition of BIM which has resulted in a variety of perspectives, influencing different methods of its implementation. This paper investigates current BIM literature that explores its implementation in the industry, in an attempt to shed light on the different perspectives regarding the term. With a better understanding of the term of 'BIM', organizations will be better equipped with understanding how it should be managed when integrated into their construction projects.

Keywords
Building Information Modeling, BIM, Construction, Technology

1. Introduction

Implementing new technology may appear an obvious solution to improve efficiency; however; the construction industry has often been considered 'slow when it comes to adopting and utilizing technological solutions'(Burrus, 2016). Companies may be reluctant to implement new technology for a number of factors, such as but not limited to; lack of demand from cliental, cost to invest new software/hardware, requirement of training and new personnel, and/or poor interoperability with team members involved with the construction project (McGraw-Hill, 2012). That being said, in recent years, Building Information Modelling (BIM) has been drawing attention to potentially revolutionize the Architecture, Engineering and Construction (AEC) Industry from 2D into the digital 3D world (Arayici et al., 2011). BIM is not a new concept, first arising in the 1980's; however, it is not till the recent decade has it built traction in AEC industry (Eastman, Teicholz, Sacks, & Liston, 2011). McGraw-Hill (2012) reported an overall growth in the level of adoption in America, moving from a 28% industry wide adoption in 2007, surging to 71% in 2012, signifying the growing attention and traction towards BIM implementation.

First traditionally utilized in the design phase by architects, successful BIM projects have generated interest for other construction stakeholders to implement BIM into their own organizations. Although there is increasing level of BIM application, there remains confusion regarding its implementation which has potentially limited its adoption. For instance; what exactly is BIM? It is clear a digital model is associated

with BIM (i.e. the BIM model); however, it is the 'information' linked to the model that transitions a standard 3D building model to the BIM model. With the integration of information, now arises the complexity of BIM. With the capacities associated with BIM, is it a typical new technology to be implemented in the industry or must it be viewed as something more. It is important to understand where BIM fits in these two categories, as it influences the method it is implemented in the project. This paper aims to investigate current BIM literature that explores its implementation in the industry, in an attempt to shed light on the different perspectives in effort to provide the most effective scheme in which it should be utilized. With a better understanding of the term, organizations will be better equipped and prepared in regards to managing BIM in their construction projects.

2. Methodology

Within this study a series of BIM literature were reviewed, dissecting a number of papers in which have explored and investigated BIM implementation with preference towards utilization in the construction phase. Papers reviewed, were collected through the database 'Scopus' in which utilized the keywords 'Building Information Modelling, Building Information Modeling, BIM and Construction'. Over 1000 papers were generated from this search, sorted both by 'date' and 'cited by'. Given the significant generation of papers; papers were filtered on the basis of reviewing their abstracts and introductions, with the selection process of identifying papers on the basis of providing alternatives perspectives towards the use of 'BIM'. These different perspectives structure the paper to investigate 'typical' views of BIM implementation, establishing key discussion points to promote effective utilization in the industry.

3. Definitions

Although the introduction of BIM implementation is as early as the 1980s, there remains no definitive definition regarding the term 'BIM', which has prompted confusion to how it should be perceived.

Table 1. Building Information Modelling Definitions

Organization	Definition
The Associated General Contractors of America (AGC, 2009)	"Building Information Modeling is the development and use of a computer software model to simulate the construction and operation of a facility"
US National Building Information Model Standard Project Committee (NBIMS, 2010)	"Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition"
The Hong Kong Institute Building Information Modelling (HKIBIM, 2009)	"Building Information Modeling (BIM) is the process of generating and managing building data during its life cycle... The process produces the Building Information Model, which encompasses building geometry, spatial relationships, geographic information, and quantities and properties of building components"
National Building Information Modelling Initiative (NBI, 2012)	"Building information modelling is a process of representing building and infrastructure over its whole life cycle from planning, design, construction, operations, maintenance and recycling"

Whilst there remain similarities with the definitions listed in Table 1, subtle differences demonstrate there are a variety of perspectives towards the term 'BIM'. Arguments can be made dependent on how one

views each definition; however, from afar judgments on each can be made. The AGC and NBIMS prompt a view that leads towards BIM as a tool or technology; through the form of 'computer software' or 'digital representation', whilst HKIBIM and NBI place emphasis on the use of the word 'process' in their definitions. This paper does not aim to determine which definition is correct; although as there a subtle differences, varying perspectives of BIM affect how it is managed, potentially minimizing the benefits that can be achieved, if mismanaged.

When reviewing the term 'BIM', it is important to understand the definitions of both the terms 'technology' and 'process'. Oxford University Press Dictionary (1998) defines 'technology' as 'Machinery and devices developed from scientific knowledge' and the term 'process' as "a series of actions or steps taken in order to achieve a particular end". It must be noted, that this paper does not argue that 'BIM is not a form of technology' as BIM incorporates a model. It is clear when implementing new technology; traditional processes are to be modified to accommodate. This is no different to implementing BIM technology; however, it can be argued that implementing the term 'BIM' in a construction project, should be perceived more than simply introduction of new software.

4. Just a Technology

BIM has been growing a lot of attention in the construction industry, with the perceived value to automate tasks that have generally been considered either too complex or time consuming if done manually. The exposure of BIM has generated significant levels of interest with practitioners and researchers exploring its alternative uses, expanding past from its 'visual capabilities'.

A comprehensive review conducted by Abanda, Vidalakis et al. (2015) details a vast number of BIM software available, with over 120 application examples commonly utilized in the AEC Industry. Whilst apprising the significant number of common BIM systems available in the market, it identifies a number of aspects to consider before adopting. Interoperability has been seen as the main concern when adopting BIM, signifying a technology standpoint. Abanda, Vidalakis et al. portray BIM as a source of technology, in which place emphasis on the question to answer "Which BIM software should [the organization] use?" Each BIM software have their own use, combined with pros and cons to each, prompting the importance of effective decision of what BIM software should be integrated into the project. Abanda, Vidalakis et al provide knowledge of the different software packages available, in attempt to help resolve the decision making of which BIM software to use.

When moving towards studies which investigate specific capabilities of BIM in the construction phase, the importance of the term BIM as a technology remains a favorable view. Lin, Chang et al. (2016) study, explores BIM technology used to track and manage defects with models through records and photos introducing the term 'BIM-base Defect Management (BIM-DM)'. BIM has been utilized to 'facilitate easy quality inspection', demonstrated in a system process flow-chat. As noted previously, traditional processes are altered to accomdate new technology, which remains the case for the BIM-DM system. The system "integrates web and BIM technologies in the BIM-base Defect Management (BIM-DM) system to illustrate and analyze defect information at the jobsite in real time". Emphasis of 'BIM technologies' demonstrates the perception of the term BIM as a tool to support defect management, rather than integrating an entirely new process.

With the growing concern towards sustainable construction in the industry, the term 'Green BIM' has been introduced, promoting research towards BIM capabilities in assisting towards sustainable design. A literature review conducted by Wong and Zhou (2015) provides an insight of the different implementation of BIM throughout the lifecycle construction projects. The approach in which Wong and Zhou establishes Green BIM as technology with the justification regarding 'Green BIM is considered the use of BIM tools to achieve sustainability and/or improved building performance objectives on a project". The paper discusses a number of different 'BIM tools' that has been implemented to minimize and/or monitor

environmental impacts to influence decision making for sustainable construction. When examining the construction phase of the project, they make a key note as "more attention should be given to the development of a more accurate and comprehensive tool for automatic emission data analysis and visualization". It is worthy to note their inclusion of the results reported by McGraw-Hill, identifying 'the lack of tools' to be an importance consideration for adoption of BIM for energy performance simulations and analysis (26%). Wong and Zhou prompt for the need "to develop a practical BIM tool for green building certification", considering the entire project life cycle. Prodiminate focus has been made through Wong and Zhou's study portrarying the term 'BIM' in relation to a form of technology demonstrating a similar approach to Lin, Chang et al. The use of BIM technology as a tool is promoted in both of these papers to demonstrate how they can facilitate current proccesses.

Azhar, Carlton et al. (2011) provides an overview utilizing BIM technology in relation to the green certification 'Leadership in Energy and Environmental Design (LEED)'. Azhar, Carlton et al refer 'BIM technology' in combination with sustainable design strategies to "potentially change the traditional design practices' with efforts to provide savings in time, cost and environmental implications surrounding construction projects. The study explores if there is a relationship between BIM and LEED rating processes. Software selection carried significant importance, with the decision based on selecting Integrated Environmental Solutions (IES) Virtual Environment (VE) against other software, enforcing
Abanda, Vidalakis et al importance of "what BIM software to use" . To enforce a concept of BIM as a typical 'technology' Azhar, Carlton et al. study demonstrates the importance of understanding the capabilities of the BIM software for energy analysis, calculating the annual energy consumption enabling visualization of the building's energy consumption in early stages of the project. The term BIM is surrounded by the word 'software', favoring the view 'BIM just a technology'. It is through the results extracted from the BIM software (in this case, from Autodesk Revit and IES Virtal Environment) that generate documentations to support 17 LEED credits and 2 prerequisites (worth 38points) which may help documentations directly/indirectly (Azhar, Carlton, Olsen, & Ahmad, 2011). Generating results quicker compared to traditional methods, promote the benefits BIM technology can achieve if implemented into the construction project.

In the quality management model, they Chen and Luo 2014 make a clear statement promoting BIM being "beneficial in the preparation of schedules and estimates, tracking and managing changes, and managing site logistics" in which 'informed decisions". They acknowledge the benefits of BIM technology can provide, with the use of technology storing and capturing data and the benefits this data can provide in management through the analysis of the data. Where they differ to the previous studies in this section, Chen and Luo (2014) propose Product, Organization and Process (POP) definitions in their model to manage BIM in conjunction with their work flow chart. Whilst reviewing their Product Definitions, they make it clear the responsibilities of the BIM model ensuring that "information must be structurally organized and enriched to be detailed enough for effective decision making". From this standpoint, they make it clear the importance towards BIM technology; as it is the core foundation to which support information that will be utilized for effective decision making. If technology support is not available or met, the effective of the proposed workflow will be deemed impractical for quality management.

5. Technology and More

As noted earlier, this paper acknowledges the terms BIM and technology have a strong relationship together; however, there is argument to be made that the term 'BIM' requires a greater level of consideration than purely software capabilities. It is well acknowledged in the industry the capabilities BIM software have in regards to generating outputs; however, researchers and practitioners are beginning to understand there are greater benefits than simply the generation of software outputs.

Shou, Wang et al. (2015) refer to Eastman, Teicholz et al. (2011) regarding "BIM is just not a tool but a process, it is defined as modelling technology and associated set of processes to produce, communicate and

analyses building models". From this notion we can understand that BIM cannot just be considered solely based on the technological output the 'tool' provides; the organization must consider a number of processes to accumulate the benefits it can bring. Shou, Wang et al. 2015 explores the level of BIM implementation in the building and infrastructure industries; providing an insight in the overall utilization in a construction project. Initial listing of the different uses of BIM established throughout the building and infrastructure lifecycle, Shou, Wang et al. 2015 move towards the implementation in case studies. Key mention has been made that researchers are developing new solutions and management methods associated with BIM performance "due to the inadequate capacity of existing BIM tools and platforms".
Acknowledgement has been made of the importance towards improving BIM technology; however, mentioning "BIM describes an activity, not an object". The industry is continuing to adopt BIM, even though there faces technology issues, as they understand the 'term' BIM integrates the process of managing information effectively, not only is it the usage of technology.

Ku and Taiebat (2011) agree with Eastman, Teicholz et al. (2011) as BIM is to consider both "modelling technology and associated set processes to produce, communicate and analyze building models. Ku and Taiebat explore contractor's perspectives of BIM determining a 'shift towards integrated design approach' in which expands the term 'BIM' further than just a 'tool' as it "fundamentally impacts communication…and also changes the way project teams collaborate". Findings have determined that it is not solely technology challenges that face an organization transitioning to BIM in their projects; there must be a consideration towards a number of other factors. When considering the barriers to implementing BIM in new areas, software related issues were considered the third LEAST considered issue out of a total of seven other barriers; others' capability to collaborate, lack of data on Return of Investment, lack of experience and skilled personnel, and cost/time constraints were all aspects that had a greater level of response in regards to barriers. These aspects can appear interrelated towards software related issues; however, they are affected at a larger scale due the integration of new processes, rather than integrating new software/technology.

Referring back to Chen and Luo's POP definitions, the inclusion of Organization and Product definitions demonstrate that the inclusion of BIM cannot solely consider the 'product' when in cooperated in a construction project. Mentions have been made that the "latter (organization-process modelling) is used to construct and simulate the interaction among teams and/or organizations, and their associated responsibility". Acknowledgement is made improving the communication and collaboration channels between stakeholders to support design and construction procedures (i.e. BIM). Without considering effective communication and collaboration, the BIM based model is compromised creating future conflicts. An understanding of identifying who is responsible and the management of quires fall under the organizational template, whilst the process template follows the integration of linking the BIM model to the 'actual construction processes'. Chen and Luo acknowledge the importance of what BIM technology capabilities can provide, from the data that can be stored and generated in models; however, the management that follow through BIM processes cannot be ignored.

Sebastian and Van Berlo (2010) supports the ideology of viewing the term 'BIM' as more than simply its software capabilities, as they attempt to benchmark BIM performance implemented in construction firms in the Netherlands. Rather than establishing BIM as a support tool towards generating data, Sebastian and Van Berlo consider BIM as an important aspect for collaborating in building projects, as they describe
BIM comprising of "collaboration frameworks and technologies for integrating process and object-oriented information" throughout the 'multi-dimensional model'. The combination of both technology and management is surrounded with the concept of BIM by Sebastian and Van Berlo. It is the 'added value of BIM for collaborative processes' that generates the benefits in which BIM has been recognized to achieve, including "more effectiveness, higher efficiency, reduced time and errors, and improved quality". Sebastian and Van Berlo developed an instrument, aimed to provide insight into the performance of BIM in Design, engineering and construction firms, in which is represented through both 'hard' and 'soft' aspects of BIM. The need to review both 'hard' and 'soft' aspects of BIM signify the importance to consider more than simply the technology capabilities of the BIM software. (Sebastian & Van Berlo, 2010) recognize to evaluate the performance of

BIM, a number of aspects are to be considered, breaking them down into 4 different chapters (Chapter 1: Organization and Management; Chapter 2: Mentality and Culture; Chapter 3: Information Structure and Information; and, Chapter 4: Tools and Applications). Chapter 4 focuses on the hardware and software-related KPIs (i.e. BIM technology aspect) whilst the remainder focus on the organization (Chapter1 and 2) and the process of information (chapter 3) recognizing BIM past its technology aspect. Sebastian and Van Berlo support the need to understand the technology background of BIM; however, there must be consideration at an organization level to utilize the full benefits BIM can provide in the project.

6. Discussion

The reviewed studies in this paper, demonstrate the complexity regarding the term 'Building Information Modelling'. There are a number of definitions currently available linked to 'BIM', introducing similar concepts within their statements. Recognition is made regarding the utilization of a model (BIM-model) as a platform for information to be stored and analyzed; yet this is only one factor to consider with BIM implementation. Specific wording regarding available definitions can be interpreted differently; however, there is a general argument that the definitions prompt the need to consider the term 'BIM' in relation to a process. While the BIM definitions demonstrate similarities, the differences have created alternative interpretations towards the term, affecting the manner in which BIM is perceived and implemented. Some have viewed the term BIM more specific towards utilizing BIM as new technology whilst others have recognized a number of organization aspects are to be considered in relation to its implementation.

Typical BIM studies have been reviewed in this paper and as we refer to Table 2, there are arguments made towards associating the term 'BIM' as a technology or something as technology and more. Generally the studies promoting BIM technology have explored the software capabilities to facilitate current practices (Abanda, Vidalakis et al., Lin, Chang et al.), recongize the issues with current software availability which need further improvements or areas for future development (Azhar, Carlton et al., McGraw-Hill, Wong and Zhou). It is clear literature has investigated the benefits of BIM technology implementation can create; generally revolving around the time savings and efficiency created through software capabilities generating outputs automatically.

The term 'technology' is often established with 'BIM'; however, there are studies which investigated the benefits further than simply software capabilities to facilitate current processes. BIM is now not only considered technology, as researchers and practitioners are becoming more aware that the inclusion of BIM in their project requires attention in a number of areas.. Whilst it is important to ensure software capabilities are met, an organization must be aware of the alterations to the entire project process is monitored and managed effectively. The term BIM is often linked to changing the communication and collaboration channels in the project (Ku and Taiebat); as the exchange of information, between stakeholders, is altered to ensure for effective decision making (Eastman, Teicholz et al.). Within these communication and collaboration changes, follows organizational change, both from cooperate and cultural standpoint.

To fully utilize BIM, software capabilities are only one aspect of many to consider. Literature is recognizing the term 'BIM' refers to the integration of both technology and management tools in conjunction to promote greater levels of efficiency in the AEC industry. Technology promotes the ability of 'BIM-based' software to automate analysis tasks, saving significant amount of time compared to traditional methods. To ensure the software is utilized to its full potential, effective communication and collaboration must be established which recognizes the importance of considering management changes when integrating the term 'BIM' into the organization or construction project.

Table 2: Summary of Arguments from Literature Explored

BIM as a Technology	BIM as a Technology and More
"the development and use of a software"(AGC)	"modelling technology and associated set processes" (Eastman, Teicholz et al.)
Over 120 BIM software application available (Abanda, Vidalakis et al.)	"BIM is just not a tool but a process" (Eastman, Teicholz et al.)
"which BIM software should the [organization] use?" (Abanda, Vidalakis et al.)	"BIM describes an activity, not an object" (Shou, Wang et al.)
BIM technology to track and manage defects (Lin, Chang et al.)	"fundamentally impacts communication…and also changes to the way project teams collaborate" (Ku and Taiebat)
"more attention should be given to the development of a more accurate and comprehensive tool" (Wong and Zhou)	Software issues had the third least response towards barriers influencing BIM implementation (Ku and Taiebat)
'lack of tools' affecting level of BIM adoption (McGraw-Hill, C.)	"Organization and Product Modelling is used to construction and simulate the interaction among teams" (Chen and Luo)
BIM software/technology capabilities to generate documents to support green certification (Azhar, Carlton et al.)	Process and Organization definitions to help manage the implementation of BIM to support quality management (Chen and Luo)
Product definitions needed to ensure effective use of the model can be established (Chen and Luo)	BIM comprising of "collaboration frameworks and technologies for integrating process and object-oriented information" (Sebastian and Van Berlo)

7. Conclusion and Future Research

With the growing attention and utilization towards Building Information in the industry, it is becoming ever so important to be able to define what the term of BIM truly is. Research has explored BIM technology in detail, specifically to the BIM model and analysis tools; acknowledging the visuals and analysis capabilities to automate traditional tasks. With technology forever improving as time continues, so are the capabilities of BIM software and therefore its uses in the industry. However, viewing BIM as purely a technology tool is limiting or potentially undermining the true benefits it can bring to an organization. Researchers are beginning to understand that BIM cannot be treated solely as new form software implemented in the project. Introducing the term of BIM into the organization/construction project, brings changes not only in regards to learning a new program or software but changes to the organization itself. Consideration must be made regarding the changes on how information is processed and managed, the alteration to communication and collaboration channels, acknowledging organization role changes as well other aspects regarding the organization itself (e.g. cultural changes from 2D to 3D). Researchers are becoming aware that these aspects are to be considered when integrating BIM into their project; acknowledging the term 'BIM' goes further than simply the usage of software.

As this paper reviews literature available from previous studies, it would be deemed appropriate to conduct future interviews and/or questionnaires addressing the perception practitioners have towards the term 'Building Information Modelling'. Direct questions can be discussed exploring the aspects considered in this paper, in attempt to establish any trends regarding the term 'BIM' in the construction industry.

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