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Solutions for Effective Diffusion of BIM for BIM late adopters: Case study of UAE AEC industry

Despite the vast success of the United Arab Emirates (UAE) in developing residential, commercial facilities and infrastructure; the track record of the country's Architecture, Engineering, and Construction (AEC) industry is somewhat different with overwhelming evidence of poor performance. Albeit the promising nature of the UAE's AEC industry, that sought to embrace the latest technologies, the research revealed that, BIM is not yet widely utilised. The UAE was selected as a case study due to the diversity of its local AEC industry, whereby the AEC market has attracted contractors, consultants, suppliers from across the globe. This research adopted a mixed methodological approach using both quantitative and qualitative data collection methods to gather data from BIM users and non-users. The research investigated the perceived benefits and challenges of adopting BIM and the impact of short and long-term initiatives that can be deployed to drive the effective diffusion of BIM. The study found that there is irrefutable evidence of a lack of impetus to generate interest in BIM from an industry that has in fact undermined the pace of BIM adoption. This paper offers a set of practical recommendations not only for the government to accelerate the transition to BIM, but also to BIM late adopters.

Keywords: BIM late adopters, BIM mandate, BIM challenges, BIM diffusion

Introduction

Over the last two decades, substantial evidence has been collated which corroborates that BIM is a revolutionary technology and an effective process management tool that has effectively changed the way in that construction projects are conceived, designed, constructed, operated and maintained (Azhar 2011; Eastman et al. 2011; Okakpu et al. 2020). In this context, AEC executives and professionals believe that BIM is the optimal viable solution to address the recognised problems within the construction industry (Bosch-Sijtsema et al. 2017). Accordingly, the use of BIM has witnessed a tremendous surge in the last few years, markedly within developed countries (Elhendawi et al. 2020).

This robust belief in BIM's potential capacity to improve the performance of the construction industry has resulted in several governments such as Finland, UK, Sweden and Singapore to impose BIM as a compulsory requirement in its AEC projects (Mihindu and Arayici 2008; Bosch-Sijtsema et al. 2017).

Conversely, the UAE AEC is witnessing a limited diffusion of BIM, whereby, the Dubai Municipality (DM) is the only government authority that has officially mandated BIM as a compulsory requirement for specific projects within its AEC projects (DM 2013). This initiative is supposed to result in an increase in the diffusion of BIM based on various case studies for the companies who have successfully embraced BIM, not only in Dubai but also nationwide.

However, the status of BIM in the UAE shows contrary evidence with the debilitated diffusion of BIM in its construction industry. Consequently, the construction industry in UAE still suffers from abundant problems resulting in challenges such as a lack of collaboration (Marketline 2016), substandard quality and ineffective communication (AL Mousli and El-Sayegh 2016), in addition to cost and time overruns (Mpofu et al. 2017).

According to Zaneldin (2005) and Mpofu et al., (2017), almost all construction projects in UAE suffer from cost and time overruns. Therefore, the construction industry with its current problems cannot provide optimal benefits to the UAE, which accordingly impedes the governments' ability to realise its aspired developmental agenda (Mohammad and Sidaway 2012).

Indeed, the UAE construction industry has reached an unparalleled position during the last twenty years, which has created a paradigm-shift for the UAE in general and Dubai specifically, as one of the most rapidly growing cities worldwide (Graebner 2014). However, the poor diffusion of BIM in the UAE AEC industry imposes a puzzling

question concerning “*the challenges that diminish the wide diffusion of BIM in UAE AEC industry*”.

The aim of this paper is to propose a framework that would facilitate the effective diffusion of BIM in the UAE AEC industry. The research objective is to investigate how users and non-users of BIM perceive the benefits and challenges that have hindered the effective diffusion of BIM in the UAE.

Advocate for BIM implementation

BIM is a revolutionary technology and management tool that involves the development and use of “a computer software model to simulate the construction and operation of a facility”. The result is a data-rich model, object-oriented, intelligent, and parametric digital representation of the facility. The BIM model enables appropriate analysis for generating information that can be used to make decisions that improve the process of delivering a facility (Okakpu et al. 2020).

Indeed, developed countries have pioneered the implementation of BIM, wherein the use of BIM enabled them to bridge the majority of the recognised AEC performance gaps (Eadie et al. 2013). According to Jin et al., (2017), the global movement of BIM is spreading from the developed countries to the developing countries. However, the AEC industry in many developing countries is still in its developmental stage, and therefore requires a more collective effort to attain the benefits of BIM (Mehran 2016). In order to understand the approaches in adopting BIM, the following section discusses the different models of BIM adoption.

BIM adoption models

Moore (2003a) depicted the technology adoption lifecycle using a Bell-shaped model. Figure 1 has been customised to classify adopters of BIM, in accordance with Moore's model.

[Figure 1]

Figure 1 shows that BIM adopters can be classified within five categories based on the period from when the model is released to adoption for different audiences, and as such this classification follows the concepts developed by Moore (2003a) and Ruikar et al. (2005).

BIM Innovators: this group consist of the technology enthusiasts who adopt the latest technology once launched and before others; they are acutely aware of the latest technology and closely follow updates about new products and services, this group tend to represent approximately 4% of the whole industry.

BIM Early adaptors: this group are the visionaries who adopt the emerged technology after compelling analysis confirms its suitability and evaluation of its pros and cons has been conducted, this group usually represent 15% of the industry.

BIM Early majority: this group represent the pragmatists who take more time to evaluate the implications of the technology on others before adopting it within their business. Their primary interest is responding and adapting to market changes, and this is more important to them than the technology itself. They tend to adopt the technology as a mandatory choice to ensure business sustainability and this group represent approximately 33% of the entire industry.

BIM Late majority: this group has a conservative attitude to any emerged technology, and they are often pessimistic about the technological ability of adding value

to their business. However, they will use the technology but only under duress, they represent approximately 33% of the industry.

BIM Laggards: this group simply does not believe in technology and are satisfied and happy with their traditional and established ‘way of doing things.’ They are not ready to adopt any technology. They consider adoption of new technology as a risk that must be avoided, and this group represents approximately 15% of the industry. In this context, Omar (2015) claimed that *BIM late adopters* are those who adopt BIM beyond 2012 which are classified as “BIM late majority” according to figure 1.

The status of BIM in the UAE

On 18 November 2013, DM mandated BIM as a compulsory requisite for specific building projects, but only in the Dubai emirate. The mandate became effective as of 1st January 2014 via circular No. 196, that was issued to all developers, contractors, and consultants (DM 2013). A subsequent circular, No. 207 issued on 23 July 2015, broadened the implementation of BIM in Dubai. The later circular mandated BIM for buildings that exceed 20 stories instead of 40, for buildings with a total area that exceeds 200,000 ft² instead of 400,000 ft², for all the governmental projects, for any specialised project such as Universities, hospitals, and the alike and for any project designed by a foreign consultant/designer.

Recently at the BIM Middle East 2020 conference & Expo, the DM declared their intention for integrating BIM with Geographic Information System (GIS) system. This initiative will allow all DM customers to submit their applications as e-submissions, which lends itself for these submissions to be automatically checked. This initiative will potentially reduce the time in reviewing applications, save resources, boost customer satisfaction, and ultimately speed up the process and reduce the time required to acquire the No Objection Certificate (NOC) for construction projects. Although, BIM is

mandated by DM in the emirate of Dubai, the vast majority of construction organisations are still following the traditional CAD approaches (i.e. non-BIM). Road and Transport Authority (RTA) is one organisation deemed the most committed public authority for their implementation of BIM in all their projects. On the other hand, other public organisations such as Dubai Electricity and Water Authority (DEWA) have implemented BIM only in their new headquarter 'Al-Sheraa Building'.

Although, the other emirates such as Abu Dhabi do not officially mandate BIM, a number of organisations in Abu Dhabi have strongly committed themselves to implementing BIM in their projects. For example, Abu Dhabi Airports Company (ADAC) has adopted BIM for their iconic project Abu Dhabi International Airport Midfield Terminal. Also, Miral and SeaWorld Parks & Entertainment utilised BIM in their project SeaWorld Abu Dhabi. Anecdotal evidence shows that there are no high-profile projects adopting BIM in the other Emirates (Sharjah, Ras Al-Khaimah, Ajman, Umm al-Quwain and Fujairah).

Consequently, the overall adoption of BIM in the UAE is modest, and it is cautiously adopted based on the individual companies' intrinsic drive for evolution (Mehran 2016).

Due to the scarcity of published research investigating the challenges of adopting BIM in the UAE, this research has investigated the various challenges facing organisations in their journey of adopting BIM. The following section details the salient challenges during the transition from non-BIM to BIM aggregated from various construction industries including developed countries.

The prominent challenges for BIM adoption

There is a great deal of consensus amongst researchers and construction industry professionals that, the implementation of BIM is fraught with challenges (Azhar 2011;

Arayici et al. 2012; Elhendawi et al. 2020). Several researchers such as Omar (2015), Ahuja et al., (2020), Shehzad et al., (2020) and Okakpu et al. (2020) have categorised the challenges that hinder BIM adoption in the AEC industry, and the most prominent and common categories found to be technical, financial, socio-cultural, skills-based and contractual. These five categories have been customised to suit the case study as following:

Management challenges

This is related to the organisation's lack of the *know-how* required to switch to BIM (Rezgui et al. 2013), in addition to the lack of top management support and commitment in favour of adopting BIM (Azhar et al. 2012; Shehzad et al. 2020).

Furthermore, resistance to converting to BIM is recognised as one of the most critical management challenges (Arayici et al. 2011; Okakpu et al. 2020). Traditionally, switching to BIM changes most of the daily processes and procedures, which often requires changing the workflow, roles and responsibilities. Consequently, some positions within the organisation may lose their level of importance and influence, whilst new job roles will need to be created and given a high level of eminence, with titles such as BIM champion, BIM manager and BIM specialist (Migilinskas et al. 2013).

Undeniably, the challenges associated with managing the process of switching from non-BIM to BIM are critical; particularly those interlinked with top management who have the power and authority to decide the future of their organisations. This is chiefly due to their level of authority in that they can bring to an end any potential change initiative that may affect their level of power or future within the organisation.

In practice, the absence of top management commitment to adopt BIM, the whole initiative is doomed to fail from the start (Eastman et al. 2011).

Technical challenges

One of the common obstacles that impedes the implementation of BIM is the lack of skilled resources to operate BIM software, with demand for BIM operators, coordinators, specialists, and managers often more than the available resources (Arayici et al. 2012; Ahuja et al. 2020). Moreover, the BIM model requires rigorous control of inputs, approvals, sharing and archiving, otherwise the BIM federated, coordinated and as-built models are exposed to errors and the liabilities of these errors could be lost (Azhar et al. 2012).

Frequently, the various disciplines within the project tend to use different software and accordingly, the different software interoperability is often a common challenge that hinders the seamless exchange of project information and fact sharing (Eastman et al. 2011; Shehzad et al., 2020).

Level of BIM adoption within the surroundings

Collaboration is at the heart of BIM (Eastman et al. 2011; Okakpu et al. 2020) and therefore, to reap the maximum benefits of BIM, it must be implemented simultaneously throughout the country to accomplish the required level of collaboration amongst all AEC industry players (Ghaffarianhoseini et al. 2017). However, some large companies and the vast majority of Small and Medium Enterprises (SME) are not willing to switch to BIM; primarily as they view the change to BIM as risky or as creating uncertainty (Jones et al. 2005; Okakpu et al. 2020). These organisations deprive potential users from reaping the full benefits of BIM, mainly because they limit communication, terminate the sharing of information, and ultimately create a cumbersome transition to BIM. Indeed, this issue is perceived as one of the most common challenges in countries that offer BIM as an optional choice.

Conversely, many governments have tested and experienced BIM on a small scale and as such have further expanded its use, thus, the promising results of BIM

encouraged those governments to adopt requisite policy mandating the use of BIM within their AEC industry (Rogers et al. 2015). This policy has proven its value as illustrated by those governments who opted to make the implementation of BIM optional, whereby they are suffering from a low level of BIM adoption (Eadie et al. 2013). Accordingly, the absence of a government and/or client mandate for BIM as a compulsory component is recognised as one of the most paramount drawbacks that hinder BIM utilisation.

Financial challenges

Implementation of BIM requires significant capital investment especially at the early stages, which is unaffordable for a majority of SME's. This is compounded with the requirement to train staff or hire an experienced BIM workforce that entails additional expenditure (Bryde et al. 2013; Magill et al., 2020). Moreover, experience shows that, additional costs are accrued for the resources needed in planning, implementing, evaluating and organising the integration of the new system into the organisation (Migilinskas et al. 2013; Okakpu et al. 2020). Emphatically, funding obligations significantly contribute to SMEs disinclination in adopting BIM, and accordingly, an organisation's financial situation can provide a challenge for switching to BIM, specifically for SMEs'.

Contract procurement approaches

Traditional contract procurement approaches are still dominant in the AEC industry, which creates obstacles for optimal collaboration, and consequently the greatest benefits of BIM cannot be attained. Hardin (2009) claimed that BIM does not fit well with the fragmented Design, Bid and Built (DBB) procurement approach. Various practical experiences asserted that, the DBB model creates barriers for BIM (Eadie et al. 2014). Subsequently, there is a crucial need to change from the traditional

contract procurement approach to a more integrated procurement strategy (Hardin 2009; Love et al. 2014). Within this context, Migilinskas et al. (2013) suggested Construction Management at Risk (CM@R) or Design and Built (DB) as the most suitable approaches for BIM projects. However, several researchers and professional executives affirmed that, the most suitable contract approach for BIM is the Integrated Project Delivery (IPD) (Zhang and Hu 2018).

The American Institute of Architects, AIA (2007) defined IPD as a “project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimise project results, increase the value of the project for the owner, reduce waste, and maximise efficiency through phases of design, fabrication and construction”. Clearly, there is a mutual synergy between BIM and IPD, whereby, BIM and IPD foster the collaboration for optimising efficiency of the construction project from inception until demolishing (AIA 2007; Love et al. 2014). However, IPD suffers from a global lukewarm adoption (Kahvandi et al. 2017). Obviously, stimulating adoption of BIM entails a paradigm-shift in contract procurement approaches.

Ownership of the BIM model

Ownership of BIM’s final model to some extent is arguably still a disputable issue, whereby the Intellectual Property Right (IPR) of the BIM model is usually claimed by the engineering disciplines and the client. Whereby, clients assume they have paid the various engineering disciplines to develop the BIM model and therefore, clients consider themselves as the legal owner of the BIM model. However, those engineering disciplines who have developed the BIM model are deprived from what

they consider themselves have the rights to reuse what they have developed (Azhar et al. 2012; Eadie et al. 2014).

Poor contractual terms and an absence of BIM project standards that clarify the ownership of BIM final model have led many researchers to consider IPR of BIM model as one of the vague sovereigns (Azhar et al. 2012; Migilinskas et al. 2013; Chien et al. 2014; Eadie et al. 2014).

Obviously, the literature review presented the most prominent challenges based on the lesson learned from BIM early adopters. These lessons highly benefited organisations and the AEC industry to address the recognised challenges to ease and facilitate the transition to BIM.

The following section introduces the research methodology, wherein, successful adoption of BIM in the UAE entails an appropriate grasp of the challenges and obstacles that organisations face in switching to BIM. Furthermore, participants share their insights and offer their views of practical solutions for the effective diffusion of BIM incorporating the recognised challenges within the UAE AEC industry.

Methodology

In order to develop practical solutions that enable the effective diffusion of BIM in the UAE AEC industry, it was critical to examine the perception of BIM users and non-users towards the challenges of BIM. Authors sought to generalise the findings inferred from the UAE to a broader context to recommend effective diffusion of BIM for BIM late adopters. In particular for those countries are still in the embarking stage of BIM adoption and experiencing resistance to the diffusion of BIM.

To that end, authors collected the data via a quantitative approach based-structured questionnaire, the selected approach viewed as the most suitable for the collection of the maximum number of responses.

To test the accuracy, suitability, appropriateness, and comprehensibility of the formulated questions, in addition to testing the language used and clarity in the presentation of the questionnaire; a pilot survey was sent to 10 randomly selected participants. Subsequently, the constructive comments received from the participants of the pilot survey assisted the authors to refine the questionnaire and to develop the final version.

The final version of the questionnaire was administered via email to a randomly selected 362 organisations (i.e. contractors/subcontractors, architects, clients, suppliers etc.). These organisations were picked from the directory of Emirati Society of Engineers, which includes all AEC organisations in the UAE. The questionnaire was available from 28th November 2014 until 2nd March 2015. Furthermore, to examine the impact of DM BIM mandate on the Dubai AEC industry, another round of data collection was conducted 58 months later with the distribution of the same questionnaire from June 2020 to September 2020, which was sent to the same 362 organisations in the 2015 survey. The responses were collected anonymously via Qualtrics survey platform and were then analysed statistically.

The survey consisted of four sections; section 1 concerning the respondent's personal information such as profession, years of experience, academic qualifications, location, geographical origin of the organisation, awareness of BIM, and whether the organisation was a BIM user or non-user, etc. Section 2 measured the respondent's BIM knowledge and views based on their experience, in addition to their insight into the future of BIM in UAE. In section 3, participants were asked to rate to what extent they agree or disagree with each of the perceived benefits of BIM with regards to the collaboration that BIM offers and to what extent BIM enables time and cost savings. They were also asked about the role of BIM in developing error-free design, increasing

productivity and ROI for the organisation and the whole industry, and additionally the benefits that BIM offers with regards to sustainability, safety, logistic plans, quality, FM performance and documentation. In section 4 respondents were asked about the challenges that can deter the implementation of BIM in UAE, such as issues surrounding know-how, lack of top management commitment in adopting BIM, clients/owners not imposing BIM as a compulsory requirement, and resistance to change. In addition, they were asked about the impact of the insufficient BIM expertise in UAE, the absence of unified BIM standards and the funding required for BIM adoption. Furthermore, they were asked to propose practical solutions for the effective diffusion of BIM in the UAE. The questionnaire adopted five-point Likert scale ranging from 1 to 5, where 5 means ‘extremely significant’, and 1 ‘not at all significant’.

The survey aimed to collect data from two groups BIM users (group “A”) and BIM non-users (group “B”), these two groups were classified based on a short survey aimed to recognise the organisation speciality (i.e. contractor, consultant, owner, etc.) and whether they are BIM users or non-users and the most common challenges that hinder the implementation of BIM in the UAE AEC industry. Pursuant to the data analysis of this short survey, respondents were classified as BIM users and non-users.

Ultimately, the final questionnaire was distributed equally to 181 organisations from each group. Although, the 2015 survey was sent to 362 organisations, there were 71 (19.6%) returned responses, of which the uncompleted responses equated to 14 (19.7%) of the returned responses. Accordingly, there were 57 (15.75%) valid responses from the overall tested sample.

The subsequent data collection that was conducted in 2020 and that examined the impact of the BIM mandated by DM, resulted in almost the same level of participation and feedback, where 44 responses were received, which represented 14.5%

of the tested sample. Above all, the 2020 and 2015 surveys were identical which were administered and sent to the same organisations.

Surprisingly, there were nuances between the respondents' views in the 2015 survey and the later survey in 2020. Indeed, this unequivocally reflects organisations' aversion to utilise BIM in UAE despite the followed strategy to induce organisations to adopt BIM, rendering this strategy unsuccessful.

Undoubtedly, this aversion of adopting BIM warrants prompt actions to solicit organisations to utilise BIM in their AEC business.

Figures 2a and 2b depict the organisations involved in 2015 survey, and figures 3a and 3b show organisations involved in 2020 survey. The received responses are shown in table 1.

[Figure 2a] [Figure 2b]

[Figure 3a] [Figure 3b]

[Table 1]

Results and discussion

The collected responses shown that 98% heard about or had adopted BIM, whereby, 80% of BIM users are based in Dubai and 20% are in Abu Dhabi. However, the other five emirates are hardly using BIM.

Despite the 98% that had heard of BIM, only 65% of them are BIM users whilst 35% are BIM non-users. The analysed data demonstrated that 95% of big and medium size organisations are fully aware about the benefits of BIM, however 82% of small size organisations are not aware about the BIM benefits and had just heard about BIM and they are neither willing to investigate nor adopt BIM. Indeed, due to absence of mandating policies for BIM adoption, these organisations are not willing to realise the benefits of BIM, they are just satisfied with their legacy performance.

Although, 65% of the organisations questioned are BIM users, 93% of them utilised BIM only partially (as 3D modelling for clash detection or material take-off) but not as an all-encompassing system.

Seemingly, the current practices of BIM users in UAE focus on responding to specific requirements, overlooking most of the benefits that BIM offers.

Evidently, the low level of BIM adoption is intrinsically linked with organisations' lack of awareness about the real benefits that BIM offers and/or the short termism view in respect to the level of investment required. Additionally, BIM non-users claimed, they are not committed in switching to BIM, as not all their stakeholders are using BIM.

Unsurprisingly, the overwhelming majority of BIM non-users expressed their readiness to adopt BIM once the government dictates BIM as a compulsory requirement in construction projects. This unequivocally supports the key reasons for organisational reluctance in utilising BIM, whereas these organisations strongly believe that the benefits of BIM will only be reaped when BIM is simultaneously adopted. According to Gbadegesin et al. (2020) the success of any initiative is significantly influenced by collective action. Cao et al. (2015) asserted that, the responsibility of BIM diffusion is incumbent on the government. Accordingly, several governments have used their authority and power to mandate BIM such as, the USA (US-GSA, 2008), Hong Kong (Wong et al. 2009), the UK (UK Cabinet office, 2011), and Singapore (BCA 2010). In this context, 76% of respondents believe that BIM will eventually dominate, "*BIM will mandate whether we love or hate*".

Table 2 shows that, 91% of local organisations are BIM non-users; however, 100% of the international organisations are BIM users albeit with differing levels of

maturity. Undoubtedly, the international organisations have acquired BIM experience in their home country and further utilised and developed it in UAE.

The following table shows organisations' nationality and their BIM experience measured in two categories less than or equal to five years and more than five years.

[Table 2]

To analyse the collected data, a quantitative approach was utilised, adopting the standard method of ranking to compare numerically, the perceptions of the two groups (BIM users and non-users) towards the challenges of BIM. Moreover, the Ranking Agreement Factor (RAF) was used for measuring the level of agreement between the two groups to depict the significance of the challenges in the UAE AEC industry.

The Relative Importance Index (RII) was used to rank each attribute considered a challenge for the two groups "A" and "B". The comparison between the two groups was illustrated in a radar shape to show the differences in a weighted format, which represented the level of agreement and disagreement between the two groups.

Then, RAF was developed between groups "A" and "B" to unify the ranking. Whereby, the closer the RAF is to zero, reflects the high level of agreement between the two groups.

BIM users and non-user' views of the challenges that hinder BIM implementation in UAE

Table 3 shows that group "B" considered implementation of BIM more challenging with a record of 0.8025 of average RII against 0.755 for group "A".

[Table 3]

In order to compare groups "A" and "B" views of the challenges that hinder the implementation of BIM in UAE, figure 3 demonstrates their degree of agreement and disagreement.

[Figure 4]

The radar shape illustrates a close understanding and agreement from both groups towards the management challenges (i.e. *resistance to change, significant changes in workflow, and traditional practices in project procurement*)

However, disagreements between the two groups are noticeable for the surrounding challenges (*not all stakeholders are using BIM and owner/client did not ask to use BIM*). Obviously, these factors explain the reasons and drivers that create the reluctance of BIM non-users to implement BIM.

Moreover, the other notable disagreement between the two groups is in relation to the financial challenges of BIM (*high cost of BIM*). Typically, the implementation of BIM requires a significant investment specifically at the onset of the BIM transition journey, which is often unaffordable to a majority of SMEs. The data analysis manifested that 98% of the SMEs are BIM non-users, mainly because they cannot afford the financial requirement of a BIM initiative. However, the majority of BIM users are large multi-national organisations with robust financial resources.

The two groups considered the most critical challenge that hinders the implementation of BIM in UAE AEC industry is “*resistance to change*” from both the organisation and the industry alike with the highest score of **0.9029**. This result is supported by the studies conducted by Arayici et al. (2011) and Eadie et al. (2014) who recognised *resistance to change* and *lack of flexibility* as the most critical factors that preclude the adoption of BIM in the UK.

The second critical factor that constrains the implementation of BIM in UAE is “*inadequate support to the change from the top management*” which has a score of **0.8906**.

However, according to Eadie et al. (2014) this factor was found to be the least constraint in the UK. Mainly due to a mandate triggered in 2011 by the UK government compelling top management to commit to BIM adoption, as otherwise their sustainability in the market is not guaranteed.

Ostensibly, the DM's BIM mandate did not produce enough pressure on the market to create the sufficient impact for mandating BIM and this is basically due to the poor follow-up system for ensuring implementation of the DM's mandate, whereby, until writing this research DM is still accepting drawings in the conventional CAD format (AutoCAD and MicroStation) alongside BIM models.

Undoubtedly, both groups of BIM users and non-users considered "*management challenges*" as the cornerstone for successful implementation of BIM in the UAE AEC industry.

On the other hand, a majority of participants consider the government and clients as primarily responsible for imposing BIM as a compulsory requirement in construction projects. Respondents have also emphasised that there should be a gradual adoption of BIM, in other words a reasonable duration should be allowed for organisations to prepare for the impending and revolutionary changes that will inevitably materialise in switching to BIM. Moreover, consideration should be given to introducing real-life case studies of organisations who have successfully adopted BIM to support the reluctant organisations to adopt BIM.

The quantitative approach offered statistical analysis that enabled the recognition and prioritisation of the attributes pertaining to the challenges precluding the implementation of BIM in UAE. However, to acquire a deeper and more comprehensive understanding of these attributes a qualitative approach was further adopted. This approach included semi-structured questionnaire, which was pre-

prepared, and in-depth interviews that were conducted with six experts in UAE AEC industry in addition to two academics. Interviews were conducted in April 2015 and repeated in October 2020 with the same participants.

Each interview was conducted separately over an average period of 45 minutes; participants answered five open questions concerning their perception towards the challenges which hinder the adoption of BIM in UAE. Consideration was also given to what are the most effective solutions for BIM diffusion in UAE, the impact of DM mandate and the lessons learned from their BIM experience.

The interviews involved three professionals, of which two represented the main contractors (BIM manager and project manager) along with a client representative, and they all comprised of BIM users in the UAE. The participants confirmed that the majority of the UAE AEC players are not aware about the real benefits of BIM. However, they are fully aware that, implementation of BIM is not an easy task, and therefore, many organisations are reluctant to take the decision to utilise BIM. This finding is supported by Shehzad et al. (2020) who claimed that adoption of BIM is a complex process. Clearly, there is an exceptional consensus amongst the participants, whereby they considered using BIM as indispensable, mainly due to the global tendency of the AEC industry. This global tendency towards BIM adoption was the main driver that steered them to utilise BIM. Although, the interviewees admitted that they have utilised BIM partially, however, they have expressed their frustration as BIM users, chiefly caused by other stakeholders who are not using BIM. BIM users feel this situation detracts the collaborative benefits that BIM offers.

On the other hand, the client representative mentioned, they are reluctant to dictate BIM as a compulsory requirement in their projects, due to the risk of losing the services of many contractors, subcontractors, and consultants. Moreover, all the

participants dismissed the duration designated by DM of just 43 calendar days, for organisations to switch to BIM was unachievable and as such many organisations were unable to consider this mandate sincerely. Consequently, some organisations have responded fraudulently to DM BIM mandate by hiring BIM modellers to develop 3D models only for DM approval, whilst maintaining their business-as-usual model. Participants claimed that DM has undermined their mandate, as DM did not set out standards that ensure pertinent compliance of the BIM mandate. In their study, Mehran (2016) and Ahuja et al. (2020) considered a lack of BIM standards as the most critical factor that constrains the implementation of BIM. Likewise, Azhar et al. (2012) classified the risks and barriers in implementing BIM into two categories, process-related risks, and technology-related risks. The study claimed that the most critical risk under the latter category is the lack of BIM standards and protocols.

In this context and as a response to the question “*What are the solutions to mandate BIM in the UAE AEC industry?*” all participants affirmed that, the only way to effectively diffuse BIM in the UAE lies with the federal government who should issue a compulsory mandate of BIM in the UAE AEC industry. In this context, Enshassi et al. (2016) and Ghaffarianhoseini et al. (2017) counted a lack of client demands to use BIM as one of the most critical obstacles in BIM utilisation. Accordingly, client demand plays a pivotal role in mandating BIM and accelerating its utilisation (Aibinu and Venkatesh 2012). In their study, Bosch-Sijtsema et al. (2017) refers to the low demand in using BIM as frequently due to the client’s poor BIM knowledge and expertise.

The research also interviewed BIM non-users from contractors (general manager and project manager), and a client representative. Participants exposed a modest understanding of the benefits of BIM and confirmed that their BIM knowledge originated from training sessions offered by BIM software developers who often

interlinked BIM to their software. Participants ultimately developed a serious misunderstanding of BIM as they considered BIM as just an advanced software that develops the construction drawings in 3D view instead of 2D. Enshassi et al. (2016) claimed that there is a pressing demand for an improved awareness and understanding of BIM across the construction industry. In order to bridge the gap in BIM knowledge, participants have proposed collaboration between the government, BIM institutions and leading companies to contribute to raising the AEC industry awareness of BIM, and hence to deliver an effective strategy for the diffusion of BIM. This finding concurs with the findings derived from the participants of the survey analysis.

Furthermore, the participants proposed solution corresponds with the proposition from Chien et al. (2014) and Ahuja et al. (2020), who have argued that the government should develop and sponsor education programmes for the industry to enable a factual and genuine understanding about BIM. These education programmes should be introduced alongside an overview of lessons that have been learnt based on real case studies to highlight the appropriate and effective methods for BIM implementation.

The general manager explained that BIM requires substantial investment and costs such as hiring new professionals, and a radical restructuring of the organisation. Consequently, the company will not utilise BIM unless it is a prerequisite for tendering or included as a condition of the contract.

Moreover, the third interviewee represented one of the leading local companies in Dubai expressed his company's readiness to utilise BIM provided that, the whole AEC industry adopts BIM; otherwise, the use of BIM is rendered "useless".

This claim is virtually mirrored by Eadie et al., (2014) and Bosch-Sijtsema et al., (2017) in their study, whereby they asserted that the "lack of supply chain buy-in/our partners do not use BIM" is the second most critical factor which impacts the

implementation of BIM in the UK. Accordingly, engaging SMEs and providing them with the incentives should be a priority to reap the full benefits of BIM.

Additionally, a serious concern about the lack of collective BIM standards that replicates the nature of UAE AEC industry, was raised by the two academics. They have proposed that, the solution for soliciting SMEs to invest in BIM is incumbent upon the government who should develop and publish BIM execution guides and subsidise BIM training programs. This proposed diffusion model is aligned with Singapore's successful strategy of BIM diffusion, the Singapore Building and Construction Authority (SBCA) fully subsidised BIM training programs to assist organisations to educate their employees, with the goal of SBCA being to enable the BIM mandate by 2015 (Lin et al. 2017).

Moreover, the academics suggested, the UAE ministry of higher education can play a pivotal role by instructing the universities to include BIM in their undergraduate and postgraduate programmes. This will contribute to disseminating factual knowledge of BIM. According to Khosrowshahi and Arayici (2012) education and training are of paramount importance to enable the implementation of BIM.

Limitations

The main limitation of this study is the size of its sample. Although data collection targeted 362 organisations, only 57 responses were collected in 2015, and similarly, only 44 responses were collected in 2020 survey. Therefore, future research could target a larger sample to provide greater confidence in the results.

Conclusion

BIM is rapidly growing and is expected to be mandated globally and expeditiously within the AEC industry. This study reported that although 65% of organisations in UAE are using BIM, 93% of those organisations are using BIM as a 3D

model for clash detection and acquiring DM building permits. Since the DM BIM mandate, Dubai ranked first out of all the seven emirates for using BIM with 80% of BIM users against 20% in Abu Dhabi. However, the other five emirates are hardly using BIM. The poor following up of BIM within DM has resulted in many firms overlooking adoption of BIM or at best, they are only using it for object-based modelling.

Notably, 94.5% of BIM users are from international organisations whilst only 5.5% are represented by national organisations.

Surprisingly, 82% of the small sized organisations did not understand the material benefits that BIM offers; a misunderstanding that derived from free seminars and presentations offered to the industry players by BIM software vendors. Some suppliers introduced BIM as software to increase sales turnover. Consequently, most of BIM non-users, and in particular SMEs, are perplexed by BIM and do not know how to switch to using BIM.

Ultimately, the research findings enhanced the understanding of the challenges that deter the effective diffusion of BIM in UAE. Whereby, the critical challenges in the UAE AEC industry are pertaining to the *resistance to change and lack of support from the top management* to drive change in adopting BIM. Furthermore, the absence of the federal UAE BIM mandate and standards have impeded the diffusion of BIM.

The study results showed that 93% of BIM non-users in UAE are ready to adopt BIM once it is legislated to become a compulsory requirement. Likewise, due to the few incentives offered by the UAE federal government to mandate BIM, the implementation of BIM as a comprehensive system is almost non-existent. Anecdotal evidence suggests that full BIM implementation can only be found in flagship projects such as the Midfield Terminal building- Abu Dhabi international airport and Expo route 2020 in Dubai.

The study offered solid evidence of the encouraging signs for a fast and effective diffusion of BIM in UAE, which could be achieved by offering stimulus packages to SMEs to successfully implement BIM. These indications of success stemmed from the flexibility of the UAE construction sector, whereby most of the big international AEC organisations create considerable opportunities for sharing their BIM best practices. In addition, 76% of industry practitioners in the UAE AEC believe that BIM will be eventually mandated, not only in the UAE but also globally; “*BIM is mandating love it or hate it*”.

To accelerate the laborious progressive conversion to BIM, particularly for late adopters of BIM, this study proposed the following solutions for the effective diffusion of BIM in long-term and short-term packages.

Long-term solution: The government should include BIM within the engineering undergraduate and postgraduate modules within a timely manner; this will provide a large proportion of AEC workforce with authentic BIM knowledge. This savvy generation will be the catalyst for the change and with the ability to react and drive development of BIM processes and techniques.

Short-term solution: the government should promote and sponsor training programs in collaboration with academic institutions. Once the level of BIM awareness has successfully infiltrated the community within the AEC industry, the government should mandate BIM as a compulsory requirement. Simultaneously, the government should furnish the industry with comprehensive BIM standards, in addition to a BIM transition roadmap to clarify and assist organisations in their BIM transition journey.

Moreover, SMEs are generally unable to afford the significant financial outlay required at the onset in the transition to BIM, and accordingly, the government should

fully or partially subsidise these costs for those organisations. The government could retrieve these funds via monthly instalments or as a levy on a long-term basis.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Figures

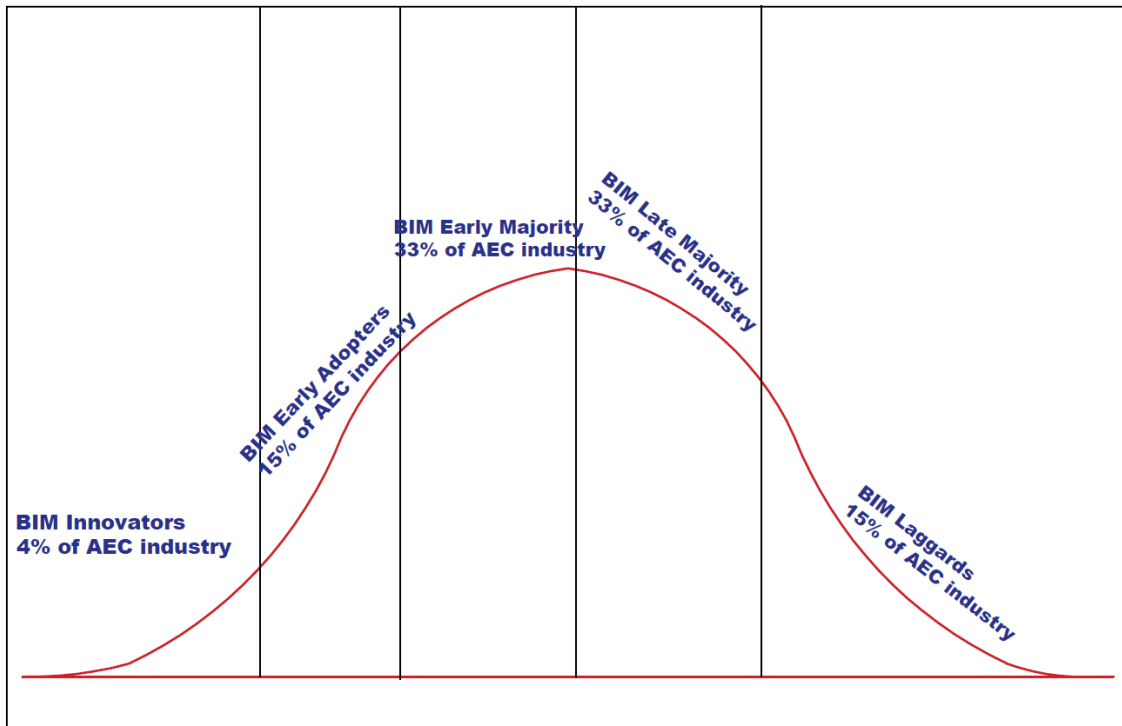


Figure 1: Customised BIM adoption model derived from (Moore 2003a) and (Ruikar et al., 2005) models

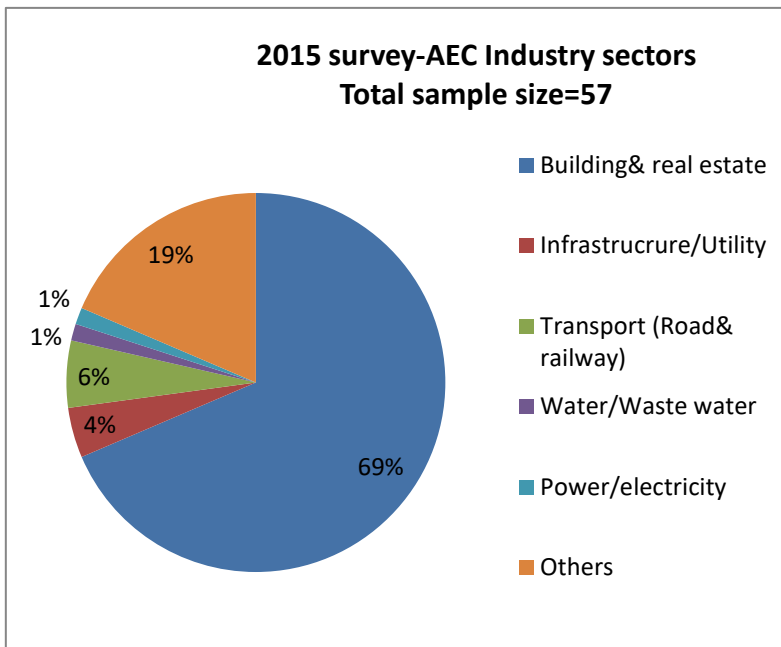


Figure 2a: the organisations based on their AEC industry sectors, 2015 survey.

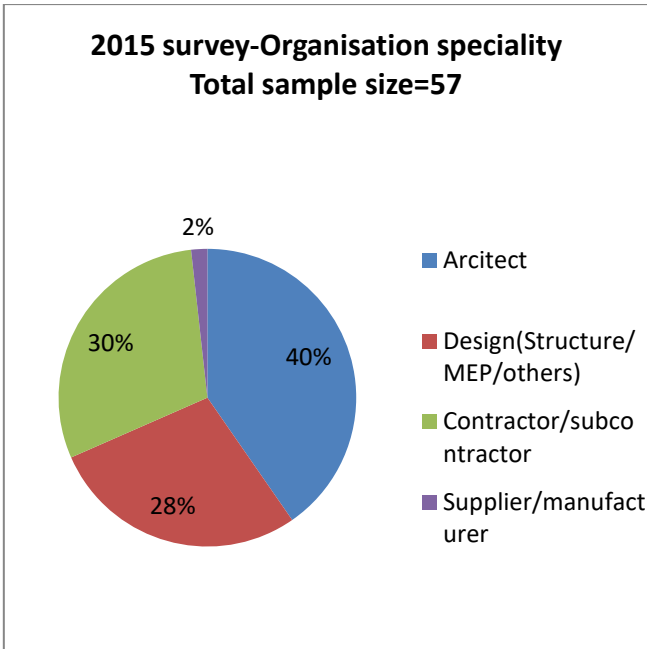


Figure 2b: the organisations classified based on their specialty, 2015 survey.

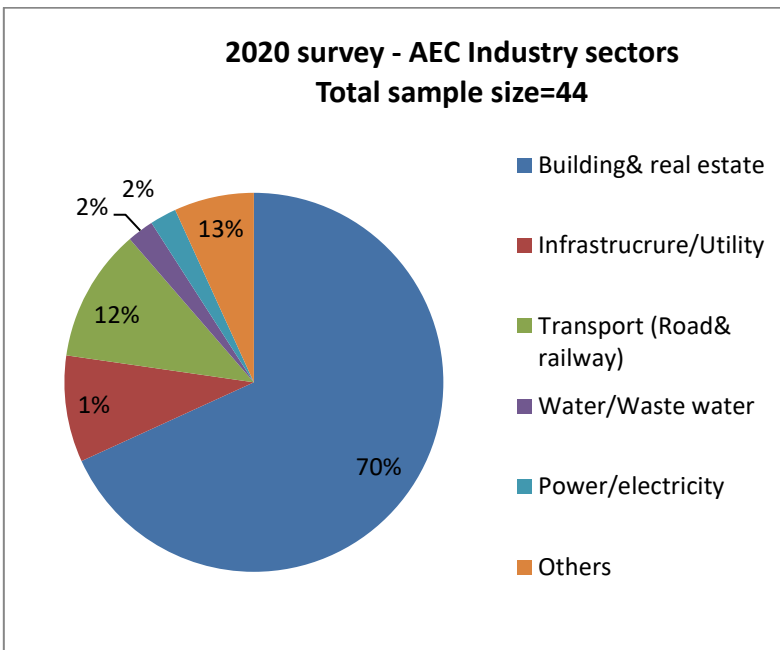


Figure 3a: the organisations based on their AEC industry sectors, 2020 survey.

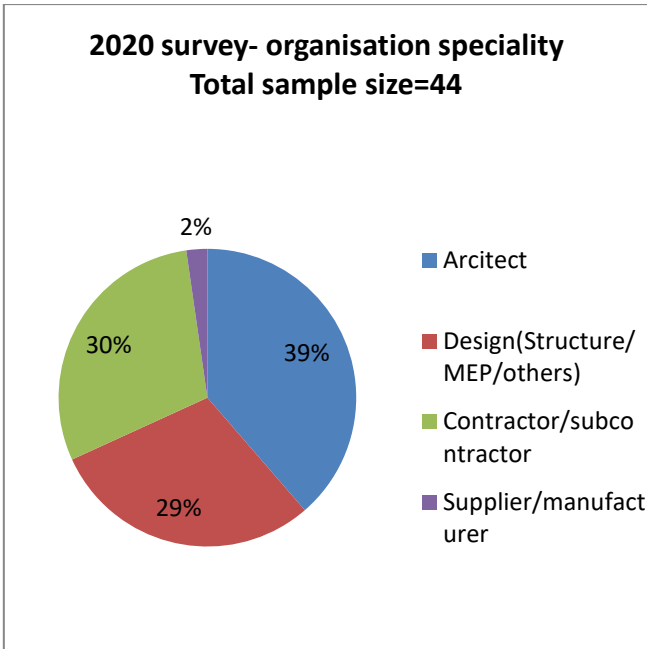


Figure 3b: the organisations classified based on their specialty, 2020 survey.

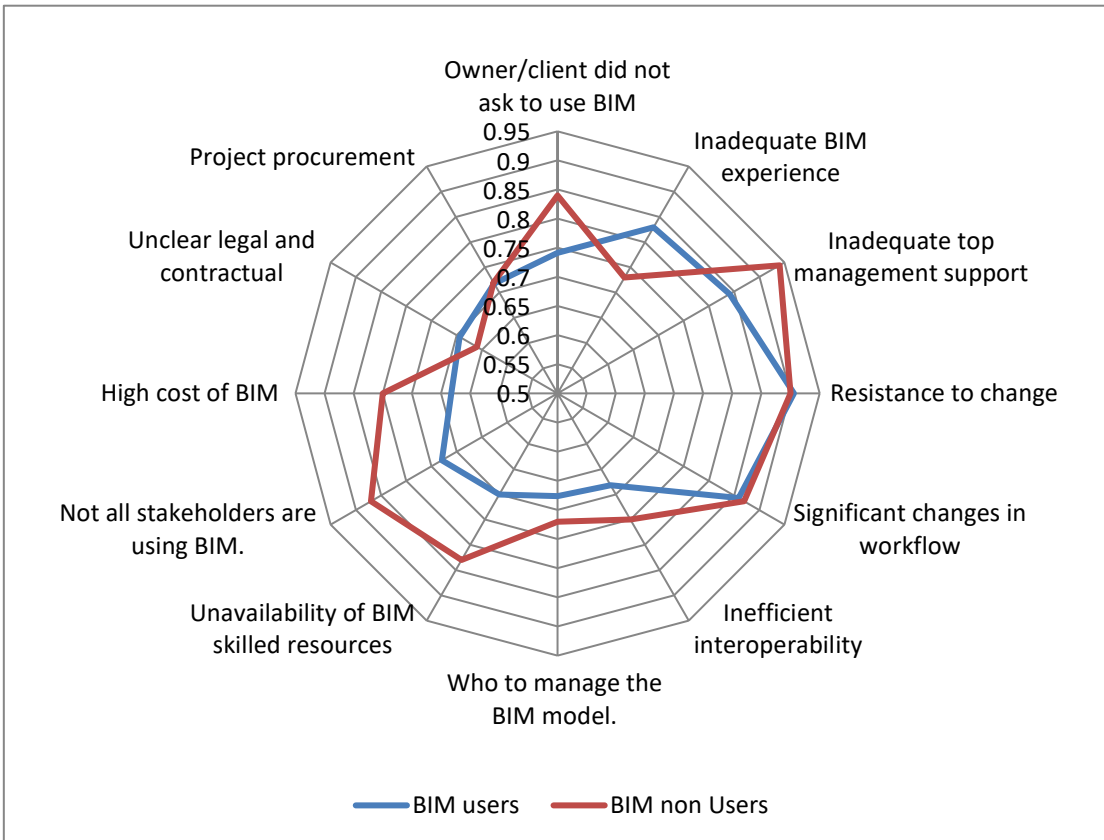


Figure 4: the challenges hinder the implementation of BIM in UAE

Tables

Table 1. the number of valid responses in 2015 and 2020 surveys according to their location in the UAE

Emirate	Data collected in	Abu Dhabi	Dubai	Sharjah	Ras al Khaimah	The remaining three emirates	Total number of participants
Number of valid responses	2015	20	32	4	1	0	57
Number of valid responses	2020	15	25	3	1	0	44

Table 2: organisations' nationality and their BIM experience measured in years.

Status of BIM	International organisations working in the UAE AEC market	National organisations working in the UAE AEC market
BIM non-users	0%	35%
BIM users		
1-5 (years)	100%	3.5%
More than 5 years	0%	0%

Table 3: Ranking the recognised BIM challenges that hindering implementation of BIM in the UAE AEC industry.

Sr.	Challenges and obstacles	RII BIM users	RII BIM non- users	Aver. RII	Rank
1	Resistance to change.	0.9058	0.90	0.9029	1
2	Inadequate top management support.	0.8412	0.94	0.8906	2
3	Significant changes in workflow.	0.8588	0.87	0.8644	3
4	Owner/client did not ask to use BIM.	0.7412	0.84	0.7906	4
5	Inadequate BIM experience.	0.8294	0.73	0.7797	5

6	Not all stakeholders are using BIM.	0.6822	0.87	0.7761	6
7	Unavailability of BIM skilled resources.	0.7	0.83	0.765	7
8	High cost of BIM.	0.6824	0.8	0.7412	8
9	Inefficient interoperability.	0.7294	0.75	0.7397	9
10	Project procurement.	0.7176	0.72	0.7188	10
11	Who to manage the BIM model?	0.6764	0.72	0.6982	11
12	Unclear legal and contractual issues.	0.694	0.66	0.677	12