2021

Analysing BIM implementation in the Egyptian construction industry

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Received 14 July 2020
Revised 4 January 2021
4 April 2021
16 May 2021
23 June 2021
Accepted 24 August 2021

Abstract

Purpose – This research is built up upon exploring the concepts of building information modeling (BIM) adoption and strategy formulation with the aim to develop a strategy for implementing BIM in the Egyptian construction industry.

Design/methodology/approach – The development of the BIM implementation strategy was based on two pillars, namely the literature review and results of the survey questionnaire and interviews. First, the review of literature helped investigating the BIM challenges and international strategies developed to implement BIM worldwide.

Findings – The research presented recommendations to assist policymakers in Egypt to facilitate BIM implementation.

Originality/value – Although multiple frameworks have been proposed to aid in BIM implementation, a practical strategy to implement BIM in Egypt is still lacking. Moreover, current market scale studies neglect nonsoftware aspects of BIM adoption, do not identify market gaps or reflect market-specific criteria. As such, it cannot be used by policymakers to facilitate BIM diffusion.

Keywords Construction industry, BIM implementation, BIM diffusion, Developing countries, Macro adoption

Paper type Research paper

1. Introduction

Building information modeling (BIM) is considered an improved process to the traditional life cycle phases of construction facilities. It combines a facility's virtual aspects, systems and concepts into a single 3D environment throughout the project life cycle. This provides different stakeholders with the opportunity to inquire, simulate and monitor needed activities during the whole lifecycle of the project. A broad range of applications are available to simulate time, cost, constructability and activity sequences that are supported by BIM (Gerges *et al.*, 2017). BIM provides better management of information, enhanced collaboration and coordination, better stakeholder engagement as well as better decision-making. As nations realize the value of BIM, its adoption rates are increasing (Hore *et al.*, 2017). This reflects the increasing popularity of BIM implementation in both public and private projects in the industry worldwide due to its promising benefits and quality results. With the different levels of BIM implantation journeys, developed countries have engaged in developing various BIM standards ranging from conceptual to platform-specific; yet, developing countries are still lagging (Bui *et al.*, 2016; Walasek and Barszcz, 2017; Oraee *et al.*, 2017; Ezcan *et al.*, 2013; Khodeir and Nessim, 2017; Cao *et al.*, 2017; Mehran, 2016). Unsatisfactory rates of BIM adoption in developing countries ranged between 10 and 25% with a limited BIM uses, such as 3D coordination, design authoring and clash detection, which represents a very limited application within the whole supply chain. Furthermore, (Bui *et al.*, 2016) reported that 80% of organizations are neither using BIM nor involved in its adoption. Although multiple frameworks have been proposed to aid in BIM implementation, a practical strategy to implement BIM in Egypt is still lacking. Moreover, current market scale studies neglect nonsoftware aspects of BIM adoption, do not identify market gaps or reflect market-specific

Engineering, Construction and Architectural Management

0969-9988
DOI 10.1108/ECAM-07-2020-0523

criteria, and it cannot be used by policymakers to facilitate BIM diffusion (Bui *et al.*, 2016; Sistani and Rezaei, 2012).

The need for this research has been emphasized in recent publications, which encouraged the use of BIM worldwide and in Egypt to enhance the whole industry performance. With the aim of exploiting this opportunity, Egypt needs to adopt a new digital design and construction culture. Hence, BIM is essential as its implementation in the Egyptian construction industry cannot be achieved at one step; shifting to new and more advanced digital models requires new information technology (IT) skills, as well as new coordination and collaboration processes. This is in addition to the required investment in technology infrastructure and software purchases. All this can lead to a state of uncertainty to industry stakeholders as well as clients. Thus, the BIM implementation strategy developed by this research enables decision makers to respond to the industry-specific needs. It aims to develop a strategy to fulfill the mission of adopting BIM in the construction industry in Egypt.

2. Literature review

2.1 BIM adoption challenges

Researchers argued that the most challenging aspect when implementing a new IT system is not technical related but human related. Factors which lead to a weakened implementation include lack of user awareness, poor management and resistance to change culture (Ezcan *et al.*, 2013; Russell and Hoag, 2004). This was also supported by Ezcan *et al.* (Ezcan *et al.*, 2013) findings which indicated that technical issues such as complex software and presented benefits had low and insignificant relation to adoption rates. Moreover, industry unwillingness to change and having a shortage in experience and knowledgeable BIM practitioners or educators adds to the challenge and slows the adoption rates (Smith, 2014).

Additionally, Saka and Chan (Saka and Chan, 2019) reported that the main challenges for BIM adoption in Africa were people/process-related barriers followed by technology-related barriers and economic-related barriers. The study listed lack of training, lack of awareness, lack of demand, contractual uncertainty, lack of skilled personnel, lack of government support, lack of collaboration, lack of management support and resistance to changes are all part of human-related factors. The economic-related factors are lack of investment, high cost of implementation, lack of clear BIM benefits evaluation, initial implementation impends and productivity. And finally, interoperability, lack of BIM standards, inadequate infrastructure, legal risk and insufficient technical knowledge are the technology barriers. Another study by (Reza Hosseini, 2018) argues that lack of proof for financial benefits to organizations, specifically small and medium-sized enterprises (SMEs), can be a major obstacle towards adoption. Furthermore, lack of research and development also hinders information and communication technology implementation (Khodeir and Nessim, 2017).

Researchers suggested that efforts made to transfer BIM standards to the developing countries cause additional pressure as it is considered a foreign concept. These transferred standers require tailoring to match the country's regulations and requirements, since the nature of developing countries is totally different than developed countries (Khodeir and Nessim, 2017; Miettinen and Paavola, 2014). Other challenges which contribute to the low adoption rates in developing countries are related to its social, economic and technological characteristics, such as IT-literate practitioners and lack of national implementation strategies (Bui *et al.*, 2016; Jellings, 2010; Olawumi *et al.*, 2017). Jung and Lee (2015) reported Middle East countries, Africa and South America, to still be in the early adoption phases; the percentage of organizations currently using or planning on using BIM is as low as 20% (Gerges *et al.*, 2017). Moreover, lack of knowledge on BIM is noticed where professionals consider BIM as just an advance AutoCAD tool.

Although Egypt was found to have the highest number of BIM publications, followed by Nigeria and South Africa, research highlighted that implementation rates and awareness rates are not matching, since high level of awareness did not translate to high level of adoption; this could be explained by the faced challenges. Another study conducted in Egypt by (Elyamany, 2016) reported that only 48% of respondents used BIM for 2D and 3D modeling. More than half of the respondents, 79%, believed that the government is not providing enough support to BIM adoption. Moreover, 70% believed that the construction industry is not clear enough on the application of BIM. One more study conducted by (Othman *et al.*, 2018), surveyed 42 respondents, reported that BIM diffusion in Egypt is rising, yet it was detected that there is still low understanding of the aspects of BIM implementation. The research highlighted some factors that contributed to this, such as lack of proper training on software, processes and technology as well as lack of proper knowledge of BIM aspects and resistance to change.

The study further presented that 80% of respondents have less than two years of experience in working with BIM, and only 20% have been using BIM between two and five years. Furthermore, results showed that 10% of respondents have learned BIM through home courses, 45% were self-taught and 45% learned it in university. Perhaps the most critical results reported were that 29% of respondents stated that they were not sure about what BIM could be defined as, 32% reported that they believed it is a piece of modeling software and 17% reported that they believed it is a network-based integration.

This also matched results found by (Elyamany, 2016) as the highest percentage, 35%, of respondents were hesitant about the main concepts of BIM. Furthermore, only 29% reported their knowledge about BIM implementation aspects, 24% reported that they are not knowledgeable and 47% reported that they were not sure (Othman *et al.*, 2018). These results highlight a critical challenge as most of respondents lacked the basic awareness and knowledge about BIM which hinders its adoption and presents an obstacle that require attention to assure successful implantation. On the other hand, 91% of respondents hear more about BIM these days, and 95% of the respondents reported that they believed that BIM is the future of project information. Moreover, 70% agreed that BIM help in achieving strong buildings (Elyamany, 2016).

2.2 BIM implementation strategies

Previous research highlighted some recommendations that can aid in overcoming challenges of BIM implementation in developing countries such as developing specific strategies to address the different nature of developing countries. The BIM process has to match the daily activities performed (Cao *et al.*, 2017; Bui *et al.*, 2016; Son *et al.*, 2015; Dong and Martin, 2017), and an active support from the government is essential (Gholizadeh, 2018; Jellings, 2010). Walasek and Barszcz (2017) suggested that new communication strategy is needed once the adoption rates increase. The strategy needs to focus less on the scarcity and shift to focus on social proof to speed up the adoption. Further recommendations were stated by (Hamma-Adama and Kouider, 2019) such as mandating BIM use to help speed up the adoption and lessen education and training challenges. The research also recommended incorporate different diffusion dynamics to help in the process. Accordingly, increasing awareness to BIM benefits would help changing the stakeholder's perception, which will aid in the implementation. Furthermore, (Matarneh and Hamed, 2017) argued that industry practitioners and academic organizations should work together to develop a program that matches the industry practices and processes. Moreover, for BIM to be adopted in developing countries, a demand needs to be found from clients and contractors as well as support from government (Bui *et al.*, 2016; Sistani and Rezaei, 2012).

Since governments are the most benefited client from BIM implementation, governments become active in promoting BIM applications using different policies and initiatives. These

different strategies can be categorized into three main approaches: a government-driven approach, an industry-driven approach and a mixed approach. The government-driven approach is based on the issuance of a series of policies or mandates that pushes the industry to adopt BIM applications.

Research highlighted the notable impact of a government-driven mandating as a driver force for BIM implementation in countries such as UK, Netherlands, China, South Korea, Japan and Singapore. The industry-driven approach reflects an active industry where the applications of BIM are widely spread by the industry, such as the case in the USA. The mixed approach is a mixture between both approaches, which is incorporated by most countries (Yang and Chou, 2018). Nevertheless, (Tuckwood, 2016) argued that developing legalization is a long-delayed process; mandates, on the other hand, provides a better alternative. Mandates create a demand and motivation for people to adopt BIM without the need for issuing legalization.

Hadzaman *et al.* (2015) conducted strategic analysis elements in Malaysia BIM roadmap pillars based on the lesson learnt from Australia, Singapore and Hong Kong roadmaps. These roadmaps were selected due to their recorded performance in BIM adoption. BIM adoption in Australia is steered by public organizations and is following a timeline approach for the strategy implementation where stakeholders are motivated to adhere to the dates established. Yet, the Australian strategy does not include any incentives plan for adopters. As for Singapore, the strategy is more focused on the development in the facility management sector. The strategy takes into account the collaboration means, research and development as well as obstacles and productivity measures. Moreover, the strategy is focused on the design for manufacturing and assembly which matches the government goal by 2020 to establish a technologically advanced industry with competent workforce. The Hong Kong strategy on the other hand does not include a clear timeline for implementation goals, yet it focuses on communicating BIM adoption benefits and providing incentives to adopters. Additionally, the strategy incorporates communicating adoption risk management as well as global competitiveness.

Literature review investigated BIM adoption challenges in different location around the globe, yet human-related factors were found to have a great influence on the adoption. These factors included, and not limited to, lack of awareness and resistance to change. Furthermore, it was concluded that awareness levels and adoption rates are not related since high awareness levels does not translate in high adoption. Thus, improving awareness only should not be the only strategy followed. Successful implementation strategies were found to respond to human-related challenges through the different channels and industry players. Furthermore, strategies presented have stressed on the importance of responding to each country's nature and culture emphasizing on the importance of government role in speeding up the adoption. In the next section, BIM adoption challenges and opportunities are discussed to provide bases for formulating the strategy to respond to the countries' specific nature and challenges.

2.3 Research gap

Although efforts are directed towards providing finances and developing an agenda to respond for the Egyptian national demands, there is a need to establish a construction sector mechanism. Research highlighted the increasing interest in adopting BIM globally since it presented a huge potential in overcoming the industry challenges as well as facilitating project execution and operation. This atmosphere created a highly competitive environment where countries compete to implement it in order to reduce its expenses and grasp the potential benefits. The adoption rate in the Middle East/North Africa (MENA) region is still slow, which puts it at a huge risk of not catching up. Moreover, there is lack of empirical studies on adoption and implementation of BIM in African AEC. In the case of Egypt,

although research recommends the implementation of BIM to overcome current challenges and meet national demands, there is a lack of a clear strategy to do so. Thus, there is a need for a tailored strategy, which facilitates BIM adoption within the Egyptian industry.

3. Research methodology

The research involves conducting in-depth literature scanning of BIM implementation challenges and different strategies adopted worldwide for BIM implementation. In total, two macro-adoption models were used to conduct the study which are *diffusion areas* and *diffusion responsibilities*. Data collection is achieved through an online survey, which was developed by BIMe initiative and was hosted on the BIMexcellence.org website. The research adopted this survey to conduct the analysis. A purposive sampling technique is used in this research as one of the types of nonprobability sampling for both quantitative and qualitative samples. The purposive sample could be referred to as judgment sampling and is considered a form on nonprobability and nonrandom sampling methods. In this method, people who are knowledgeable of the needed information were approached. Therefore, the sample used in this research had a strong relation to the investigation. Participants have applicable work experience in BIM and are actively involved in different BIM related activities. Second, semi-structured interviews were developed and conducted; information is gathered and categorized into themes and sub-themes to perform content analysis.

4. Data collection

Data collection is divided into two parts which are (1) analysis of the survey questionnaire questions and (2) development of structured interviews with subject matter experts. The analysis of the survey questionnaire questions considers two macro- adoption models (Section 5) to provide an in-depth explanation to the macro-adoption dynamics in Egypt. Respondents were selected based on using expert nonprobability sampling method. The purpose of the questionnaire was to investigate the levels and dynamics of BIM diffusion in Egypt. The total number of responses for *diffusion areas* and *diffusion responsibilities* models are 38 and 30, respectively. Since the size of the population is unknown, the author depended on previous similar study conducted to decide on the sample size (Kassem and Succar, 2017). The estimated time for completing the survey is 30 min. Mean values were calculated for each model.

The second part includes the development of structured interviews with subject matter experts, mainly targeting policymakers, to provide more in-depth understanding to the current situation of BIM diffusion in Egypt. Expert nonprobability sampling method was adopted to get a comprehensive and in-depth understanding of the studied topic. This part focuses on assessing the current BIM diffusion status form the point of view of policymakers and industry associates. Furthermore, the results were checked with questionnaire findings. The research follows the method of content analysis in which results were classified into themes and sub-themes to provide quantifiable and comparable data (Langos, 2014). A total number of five interviews were conducted.

For clarification, the research focuses on the market diffusion dynamics and not individual organizations or projects. In this study, diffusion represents the spread of the process/technology within a population and not within an organization.

5. Questionnaire results

5.1 BIM diffusion models

The first model, named *diffusion areas*, provides nine areas of BIM diffusion. These areas are the result of intersection of the three BIM fields, namely, technology, process and policy, and three

BIM capability stages, namely, modeling, collaboration and integration. The model clarifies how BIM field types (technology, process and policy) interact with BIM capability stages (modeling, collaboration and integration) to generate nine areas for targeted BIM diffusion analysis and BIM diffusion planning (Succar and Kassem, 2015). The study results show irregular diffusion rates, as shown in Figure 1, *modeling technology* appears to be the most mature area with 61%, followed by 50% for *modeling process* and 40% for *collaboration technology*. This is further illustrated in Figure 2 showing that modeling capabilities are higher with ranking of 5.6 followed by 4.2 for collaboration capabilities and 3.2 for integration capabilities. These values were calculated by adding the mean values for the three categories in each capability.

The second model, named *diffusion responsibilities*, classifies nine industry stakeholders who are/can be involved in the diffusion of BIM within the industry. The model further categorizes the nine stakeholders into the three BIM fields, namely, *technology*, *process* and *policy* (Succar and Kassem, 2015). The model helps in identifying stakeholders' involvement, which is essential when developing the national BIM plan. Survey results show that *technology developers*, followed by *communities of practice* and *educational institutions,* are the stakeholders with highest impact on the diffusion of BIM. This indicates the unbalanced role among the involved eight stakeholders (Kassem and Succar, 2017). The results reveal the existing role of *technology developers* and *educational institutions* in BIM adoption and present an opportunity for development in regard to policymakers' area (see Figure 3). Respondents were further requested to expand their responses to get more in-depth understanding. One response was received and confirms the low contribution of stakeholders in Egypt and specifically highlights the low contribution of policymakers. The response confirms the efforts currently taking place to develop the code of practice.

5.2 Models verification

5.2.1 Participants evaluation. In order to verify the understanding, representation and usefulness of each mode, experts who participated in the questionnaire were requested to rate

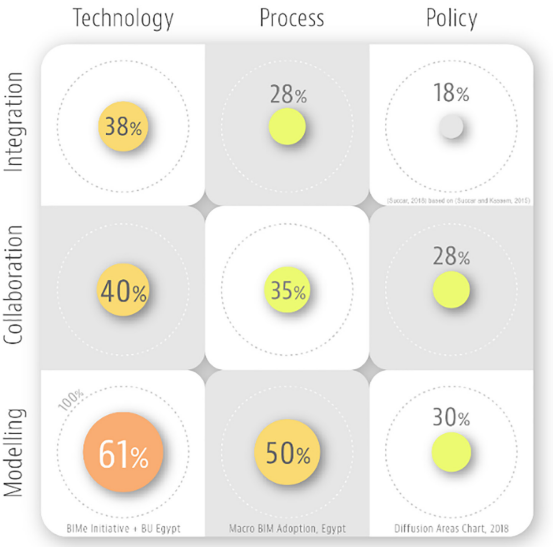

Figure 1.
Study result–diffusion dynamics in Egypt

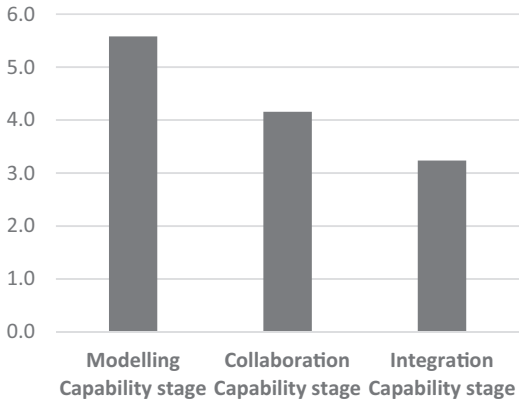

Figure 2.
Capabilities ranking

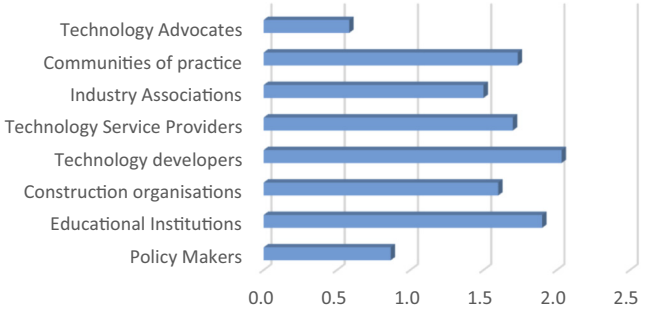

Figure 3.
Diffusion responsibilities

each model for three aspects, namely, clarity, accuracy and usefulness. This verification is important where "clarity" verification indicates if participants well-understood the models, "accuracy "verification assures that each model represents its intended concepts and "usefulness" verification indicates if the models achieve their intended purpose (Succar and Kassem, 2015). Table 1 lists the ratings of each model, highlighting highest result for each in bold. These values were calculated by measuring the mean value of the ratings provided by the respondents. Respondents were provided five values to pick from, namely, *low* (0), *medium-low* (1), *medium* (2), *medium-high* (3) and *high* (4). After the mean was calculated for each model, percentages were concluded and presented in the table. All three aspects, clarity, accuracy and usefulness, were rated as medium and medium-high.

5.2.2 Experts interviews. Each question that was asked in the interview is associated with an analysis of its intended aim and results of the interviews. Findings of the interviews are illustrated in Figures 4–6. According to the interview findings, 60% of the participants are aware that efforts are in place to develop a BIM code in Egypt. Out of five respondents, four responded that the highest challenge for BIM adoption in Egypt is "lack of BIM Awareness and knowledge" followed by "resistance to change", "lack of regulations" and "lack of client demand" ranked by 2 out of 5. Also, three out of five respondents rated government and educational institutions to be the main drivers or champions that could facilitate BIM adoption in Egypt. Furthermore, respondents agreed that providing incentives and spreading awareness would be the best strategies for promoting a wide spread of BIM in Egypt.

	Degree	Diffusion areas model (%)	Diffusion responsibilities model (%)
Clarity	High	13.1	30.0
	Medium-high	*36.8*	*33.3*
	Medium	*36.8*	26.6
	Medium-low	13.1	2.60
	Low	0	0
Accuracy	High	15.7	20.0
	Medium-high	34.2	23.3
	Medium	*47.3*	*43.3*
	Medium-low	2.60	13.3
	Low	0	0
Usefulness	High	*34.2*	30.0
	Medium-high	18.4	16.6
	Medium	31.5	*50.0*
	Medium-low	13.1	3.33
	Low	2.60	0

Table 1.
Evaluation of macro-BIM adoption models

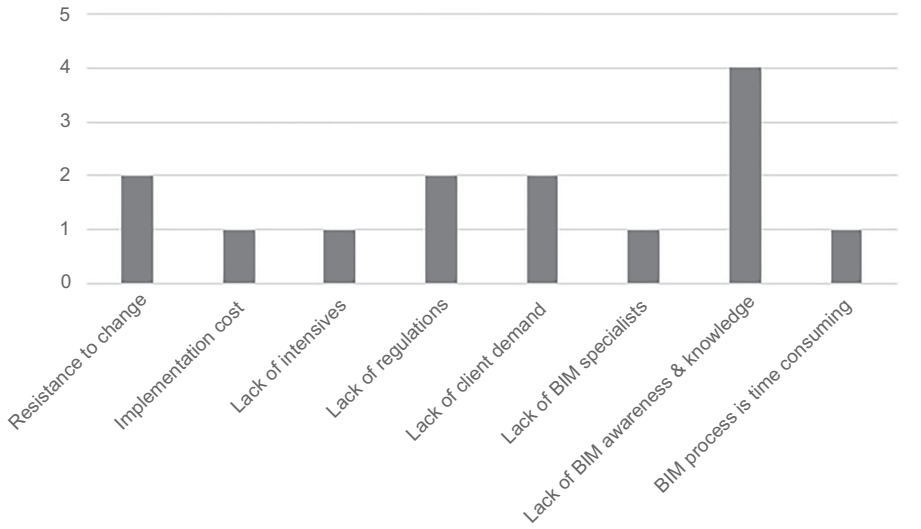

Figure 4.
BIM challenges in Egypt

5.3 Interviews results

In this section, the expert nonprobability sampling method is adopted to get an in-depth understanding of the studied topic. This research method has been developing since early 90s as a qualitative method designed to get an understanding of expert's knowledge in a specific field. This part focuses on assessing the current BIM diffusion status form the point of view of policymakers and industry associates. The interview questions are presented with their intended aim along with a sample of received from the expert's interview comments and results in Appendix.

5.4 Discussion of findings

The analysis of the results highlighted uneven diffusion rates in the Egyptian construction industry. Efforts are being influenced by large and small organization towards BIM

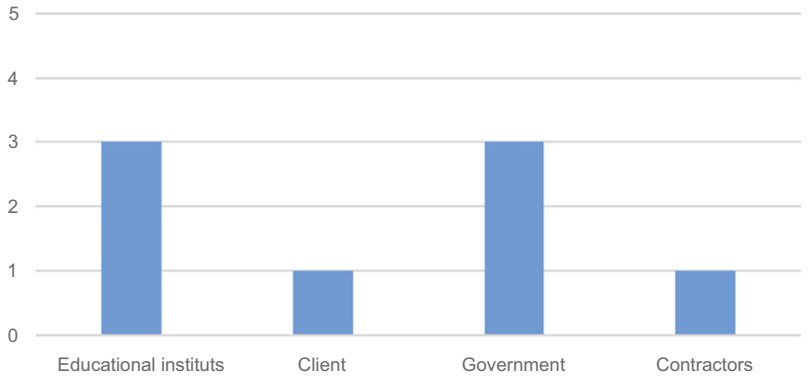

Figure 5.
Main drivers or champions that could facilitate BIM adoption in Egypt

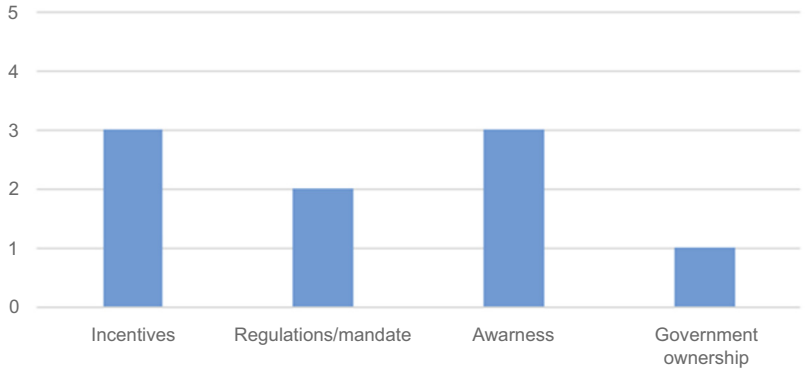

Figure 6.
Proposed strategies for BIM adoption in Egypt

implementation, while the government role remains inactive. The models indicated a great potential since Egypt is more mature when it comes to modeling technologies, which reflects a high-level of intraorganizational maturity, However, more efforts are needed to improve the collaboration processes between organization, interorganizational maturity, *process* as well as *collaboration technology*. These results reflect higher levels of intraorganizational maturity and lower levels of *collaboration processes* and *policies* which are reflected in the low percentages at 18–28% and 30%, resulting in unbalanced distribution of diffusion areas. The unbalanced distribution of diffusion areas would face different adoption challenges compared to countries with well-distributed diffusion across the nine areas (Kassem and Succar, 2017). For Egyptian construction industry, improvement can be achieved by the involvement of the government in the implementation through different mechanisms, such as communicating, engaging and monitoring, to encourage these organizations to collaborate.

Another opportunity is observed in the learning and education, champions and driver domains. This indicates the willingness of the Egyptian industry to improve and learn new technologies; however, a clear plan for implementation remains unknown. Policymakers' involvement is relatively low, with no noticed influence, yet technology developers, communities of practice and educational institutions are observed to be with highest influence on the diffusion of BIM. Although governments' role can be very influential when it comes to technology implementation, large organizations and educational institutions appear to be the key to influence the adoption of BIM within the Egyptian industry.

The study concluded that Egypt is relatively mature when it comes to applying modeling technology and processes. It was also apparent that middle-out diffusion is the dominant diffusion dynamic in Egypt. Moreover, it was found out that technology developers, followed by communities of practice and educational institutions, are the stakeholders with highest impact on the diffusion of BIM. This indicates that the most efforts being made are by large organizations or industry associates, followed by efforts from small organizations. Results reflect that government efforts are the lowest in motivating BIM adoption. Since Egypt is classified as a developing country (World Bank, 2017), the government is usually pressured to provide political and economic stability; thus, lower efforts in development are noticed (Othman and Ahmed, 2013). This suggests that private sector and large organizations need to assist the government in implementing new developments such as BIM.

These findings come in line with the interview findings where responses described large organizations as the main drivers to BIM implementations. They explained the reasons for that either to respond to a client need, since they deal with international clients, or to grasp the possible benefits of the implementation such as cost and time savings. Respondents also emphasized the interest of small organizations to catch up and enhance their performance through implementing BIM. However, respondents explained that implementing BIM might be a challenging step for them. Moreover, responses show that large companies may have BIM departments but are not fully used. This highlights the interest of large and small organizations to implement BIM in its projects; however, the implementation is still in its early stages and contains many challenges.

On the other hand, the study revealed lower levels of integration technology and collaboration processes and modeling policy. In addition, government efforts towards implementing BIM were observed to be low. The study suggested developing an incentive governmental strategy to encourage BIM implementation, for example, tax breaks for projects using BIM or even facilitating the building permit process. Finally, lack of having an implementation strategy to assure an organized BIM implementation is problematic; this could be due to improper implementation that can cause more waste and risks, BIM use can become less appealing to engineers since, thus, using the traditional methods would become more appealing. Also, it would be hard to compete in the global market using the traditional methods.

6. Conclusions

There has been an increasing interest in adopting BIM globally due to its huge potential in overcoming the industry challenges as well as facilitating project execution and operation. This atmosphere created a highly competitive environment where countries compete to implement it in order to reduce its expenses and grasp the potential benefits. The adoption rate in the MENA region is still slow, which puts it at a huge risk of not catching up. Moreover, there is a lack of empirical studies on adoption and implementation of BIM. In the case of Egypt, although research recommends the implementation of BIM to overcome current challenges and meet national demands, there is a lack of a clear strategy to do so. Thus, this research develops a strategy which facilitates BIM adoption within the Egyptian industry. The study identified the challenges of BIM implementations in the construction industry, proposed the enablers of BIM implementations and provided a depth investigation about BIM macro-maturity level and diffusion dynamics in Egypt. Moreover, the research identified BIM implementation challenges and enablers within the Egyptian construction industry and developed the BIM implementation strategy in the Egyptian context.

Although this research is limited to the Egyptian construction industry, the adopted methodology could be referred to when reforming other sectors in other countries or Middle East region. Strategies developed by this research provide a long-term sector development plan; thus, it provides a valuable reference for policymakers and stakeholders to develop the

sector and promote economic growth. Government policy and public procurement methods are recommended as powerful tools to support this positive change in the sector. Without this top-down leadership, the sector is likely to continue its under-investment in information technology and to deliver low value for money and mediocre productivity levels. This is especially true for its large and diverse SME sector. Governments and public sector organizations can provide leadership to encourage the sector towards the untapped opportunity of digital and in turn provide better public services and better value for public money.

References

Bui, N., Merschbrock, C. and Munkvold, B. (2016), "A review of Building Information Modelling for construction in developing countries", *Procedia Engineering*, Vol. 164, pp. 487-494.

Cao, D., Li, H., Wang, G. and Huang, T. (2017), "Identifying and contextualising the motivations for BIM implementation in construction projects: an empirical study in China", *International Journal of Project Management*, Vol. 35 No. 4, pp. 658-669.

Dong, R. and Martin, A. (2017), "Research on barriers and government driving force in technological innovation of architecture based on BIM", *Eurasia Journal of Mathematics, Science and Technology Education*, Vol. 13 No. 8, pp. 5757-5763.

Elyamany, A. (2016), "Current practices of building information modelling in Egypt", *International Journal of Engineering Management and Economics*, Vol. 6 No. 1, pp. 59-71.

Ezcan, V., Isikdag, U. and Goulding, J. (2013), "BIM and off-site manufacturing: recent research and opportunities", *19th CIB World Building Congress*, Brisbane, Australia.

Gerges, M., Austin, S., Mayouf, M., Ahiakwo, O., Jaeger, M., Saad, A. and El Gohary, T. (2017), "An investigation into the implementation of building information modeling in the Middle East", *Journal of Information Technology in Construction*, Vol. 22 No. 1, pp. 1-15.

Gholizadeh, P.E.B.A.G.P. (2018), "Diffusion of building information modeling functions in the construction industry", *Journal of Management in Engineering*, Vol. 34 No. 2, 04017060.

Hadzaman, N., Takim, R. and Nawawi, A. (2015), "BIM roadmap strategic implementation plan: lesson learnt from Australia, Singapore and Hong Kong", *Proceedings of 31st Annual ARCOM Conference*, pp. 611-620, s.l.

Hamma-Adama, M. and Kouider, T. (2019), "Comparative analysis of BIM adoption efforts by developed countries as precedent for new adopter countries", *Current Journal of Applied Science and Technology*, Vol. 36 No. 2, pp. 1-15.

Hore, A., McAuley, B., West, R., Kassem, M. and Kuang, S. (2017), "Ireland's BIM macro adoption study: establishing Ireland's BIM maturity", *Proceedings of the 3rd CitA BIM Gathering*, Dublin, 23rd, pp. 32-40.

Jellings, J. (2010), "BuildingSMART ME: bringing BIM to the Middle East", *Journal of Building Information Modeling*, Spring 2010, pp. 36-38.

Jung, W. and Lee, G. (2015), "The status of BIM adoption on six continents", *International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering*, Vol. 9 No. 5, pp. 444-448.

Kassem, M. and Succar, B. (2017), "Macro BIM adoption: comparative market analysis", *Automation in Construction*, Vol. 81, pp. 286-299.

Khodeir, L. and Nessim, A. (2017), "BIM2BEM integrated approach: examining status of the adoption of building information modelling and building energy models in Egyptian architectural firms", *Ain Shams Engineering Journal*.

Langos, S. (2014), "Athens as an international tourism destination: an empirical investigation to the city's imagery and the role of local DMO's", MSc in Marketing Management, University of Derby, Athens.

Matarneh, R.T. and Hamed, S.A. (2017), "Exploring the adoption of building information modeling (BIM) in the Jordanian construction industry", *Journal of Architectural Engineering Technology*, Vol. 6 No. 1, p. 189.

Mehran, D. (2016), "Exploring the adoption of BIM in the UAE construction industry for AEC firms", *Procedia Engineering*, Vol. 145, pp. 1110-1118.

Miettinen, R. and Paavola, S. (2014), "Beyond the BIM utopia: approaches to the development and implementation of building information modeling", *Automation in Construction*, Vol. 43, pp. 84-91.

Olawumi, T., Chan, D. and Wong, J. (2017), "Evolution in the intellectual structure of BIM research: a bibliometric analysis", *Journal of Civil Engineering and Management*, Vol. 23 No. 8, pp. 1060-1081.

Oraee, M., Hosseini, M.R., Papadonikolaki, E., Palliyaguru, R. and Arashpour, M. (2017), "Collaboration in BIM-based construction networks: a bibliometric-qualitative literature review", *International Journal of Project Management*, Vol. 35 No. 7, pp. 1288-1301.

Othman, E. and Ahmed, A. (2013), "Challenges of mega construction projects in developing countries", *Organization, Technology and Management in Construction: An International Journal*, Vol. 5 No. 1, pp. 730-746.

Othman, M., Elbeltagi, E. and Hassan, M. (2018), *BIM Implementation within the Egyptian AEC Industry*, Aswan, Egypt, s.n.

Reza Hosseini, M.P.E.E.D.P.E.A.O.M. (2018), "Roadmap to mature BIM use in Australian SMEs: competitive dynamics perspective", *Journal of Management in Engineering*, Vol. 34 No. 5.

Russell, D. and Hoag, A. (2004), "People and information technology in the supply chain: social and organizational influences on adoption", *International Journal of Physical Distribution and Logistics Management*, Vol. 34 No. 2, pp. 102-122.

Saka, A. and Chan, D. (2019), "A global taxonomic review and analysis of the development of BIM research between 2006 and 2017", *Construction Innovation*, Vol. 17 No. 3, pp. 1471-4175.

Sistani, N. and Rezaei, A. (2012), "BIM implementation in developing countries", *10th International Congress on Advances in Civil Engineering*, 17-19 October, s.l.

Smith, P. (2014), "BIM implementation–global strategies", *Procedia Engineering*, Vol. 85, pp. 482-492.

Son, H., Lee, S. and Kim, C. (2015), "What drives the adoption of building information modeling in design organizations? An empirical investigation of the antecedents affecting architects' behavioral intentions", *Automation in Construction*, Vol. 49, pp. 92-99.

Succar, B. and Kassem, M. (2015), "Macro-BIM adoption: conceptual structures", *Automation in Construction*, Vol. 57, pp. 64-79.

Tuckwood, B. (2016), "A BIM mandate", available at: http://www.tuckwood.co.uk/blog/a-bim-m.htm (accessed 25 August 2018).

Walasek, D. and Barszcz, A. (2017), "Analysis of the adoption rate of building information modeling [BIM] and its return on investment [ROI]", *Procedia Engineering*, Vol. 172, pp. 1227-1234.

World Bank (2017), "World Bank country and lending groups", available at: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (accessed 18 May 2018).

Yang, J. and Chou, H. (2018), "Mixed approach to government BIM implementation policy: an empirical study of Taiwan", *Journal of Building Engineering*, Vol. 20, pp. 337-343.

Appendix

Q1: Are there any regulatory BIM framework currently being used/developed you are aware of?

Aim: This question aims to assess awareness of respondents towards BIM updates as well as clarify whether there are any frameworks are being used or developed

Results: The results indicate (see Figure A1)
40% of respondents confirm that they are not aware of any framework is being used
60% of respondents mention that there are efforts to establish a code of practice

Q2: Does the government have any identified BIM objectives or milestones? If yes, how is it measured or benchmarked? If no, why?

Aim: This question aims to assess the government contribution to BIM implementation. Moreover, it helps identify any plans or objectives being communicated by the government

Results: 100% of respondents confirm that they are not aware of any plan being communicated by the government to them
Respondents indicate that the reason are due to the current economic situation in the country, the government has no experience in modern technology and the lack of government knowledge and ownership

Q3: What are the major challenges for BIM implementation in Egypt?

Aim: This question aims to identify the main challenges that hinder the BIM implementation in Egypt from the point of view of experts

Results: This was an open-ended question. Figure A2 illustrates the ratings of each mentioned challenge. These barriers were extracted from the respondent's answers and were categorized based on each barrier
Results show that the most voted barriers are lack of BIM awareness and knowledge followed by resistance to change, lack of regulations and lack of client demand

Q4: Who are the main "drivers or champions" that could facilitate BIM adoption?

Aim: This question aims to identify the stakeholders who have the biggest influence on implementing BIM in Egypt

Results: This was an open-ended question. Figure 5 illustrates the ratings of each mentioned driver challenge. These drivers were extracted from the respondent's answers and were categorized based on each driver
Results show that educational institutes and government are seen to be the most influential champions

Q5: In your opinion, what strategies could be proposed to encourage the adoption of BIM in Egypt?

Aim: This question aims to understand the best suited strategies that are suggested by experts to facilitate the implementation process

Results: This was an open-ended question. Figure 6 illustrates the ratings of each mentioned strategy. These strategies were extracted from the respondent's answers and were categorized based on each category
Results show that spreading awareness about BIM benefits as well as providing incentives are the most proposed strategies

Q6: From your opinion, what could be examples for incentives?

Aim: This question aims to identify practical incentive methods to motivate industry players to adopt BIM in order to develop a realistic BIM national implementation plan

Results: This was an open-ended question; a list of responses is as shown

- GPRS provides extra points in sustainability for using BIM
- The insurance and revision process, which is now mandatory on most buildings in Egypt can be the mean to offer an incentive for people who use BIM model
- Tax breaks or tax extensions for people who use BIM
- To be taught to undergraduates
- People has to understand its savings benefits such in efforts, time and coordination

Table A1.
Interviews analysis

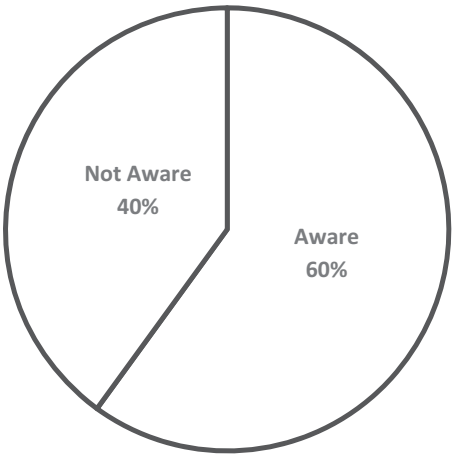

Figure A1.
Awareness of participants of any framework being developed

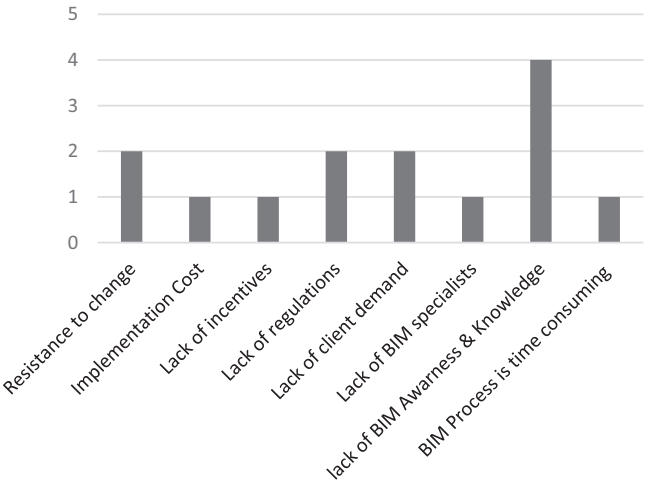

Figure A2.
BIM challenges in Egypt

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