The Use of Building Information Modelling (BIM) in Construction: An exploration of current challenges for collaborative construction

استخدام نمذجة معلومات المباني (BIM) في اعمال البناء: استكشاف التحديات الحالية للبناء التعاوني

by

MAEN SABRI

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Dr. Khalid Almarri

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Abstract

The Construction market represents more than 10% of the global economy, and the demand for infrastructure project is increasing due to population increase. Particularly, in the UAE, the construction market is considered one of the best markets compared to other Middle Eastern countries due to the availability of international companies involved in the construction activity. The use of the Building Information Modelling (BIM) technology provides a developed communication system to ensure effective collaboration between all stakeholders when running constructions. This research explores the reasons which prevent the UAE construction market from switching to the collaborative construction approach, by highlighting the current use of BIM in some of the running projects in UAE market. In addition, this research explores the challenges facing BIM users. A quantitative approach was followed, using a survey questionnaire as an instrument. The main result of the study was that the current practice of BIM implementation in UAE construction industry is not strong, and needs improvement in many sections, such as cost estimation according to BIM requirements.

Keywords: collaborative-networked organization; information analysis; social network analysis; complex networks; conceptual modelling; United Arab Emirates.

الملخص

يمثل سوق البناء أكثر من 10% من الاقتصاد العالمي، ومع ازدياد التعداد السكاني، يزداد الطلب على المشاريع الخاصة بالبنية التحتية. في دولة الإمارات العربية المتحدة، بالأخص، يعتبر سوق البناء الأفضل في المنطقة، لمشاركة العديد من الشركات العالمية في مشاريع البناء. تعتبر تكنلوجيا نمذجة معلومات البناء وسيلة فعالة لضمان التعاون بين الشركاء أثناء عمليات البناء. هذا البحث يستطلع الأسباب التي تقف في طريق التحويل إلى استعمال نهج البناء التعاوني في سوق بناء دولة الإمارات العربية المتحدة، من خلال تسليط الضوء على عدة أمثلة من مشاريع تستعمل تكنلوجيا نمذجة معلومات البناء في الدولة. هذا البحث يستطلع أيضاً الصعوبات التي تواجه مستعملي تكنلوجيا نمذجة معلومات. لقد استعلمت طريقة تعداد رقمية، من خلال استعمال دراسة استقصائية كأداة للبحث. أهم استنتاجات هذا البحث تنص على أن الاستعمال الحالي لتكنلوجيا نمذجة المعلومات في سوق بناء دولة الإمارات غير قوي، وبحاجة إلى الدعم من عدة نواحي، أهمها تقدير التكاليف على حسب متطلبات تكنلوجيا نمذجة المعلومات.

الكلمات الرئيسة: نهج البناء التعاوني، تحليل المعلومات، تكنلوجيا نمذجة معلومات، دولة الإمارات العربية المتحدة.

Table of Contents

Copyright and Information to Users III
Abstract IV
Chapter One 1
1.1 Introduction 1
1.1 What is Construction? 1
1.2 The construction Industry 2
1.3 Construction as an economic activity in the global industry 2
1.4 Collaborative construction 2
1.5 Structure of the construction industry 3
1.6 The UAE core view. Location & Economy 4
1.7 The UAE Construction Industry 4
1.8 BIM 5
1.9.1 What is BIM? 5
1.9.2 Why BIM 5
1.9.3 The promise of BIM 6
1.10 Challenges in UAE industry to switch from 2 D models to BIM. 7
1.11 The Problem statement 7
1.10 Aim of the research 9
Chapter Two 10
2.1 Literature review 10
2.2 Theoretical Framework 18
Chapter Three 21
3. Methodology 21
3.1 Study methods 21
3.2 Ethical considerations 22
Chapter Four 23
4.1 Overall Survey 23
4.2 Respondent Profile 23
Chapter Five 41
Discussions and Conclusions 41
5.1 Conclusion 41
5.3 Implications and recommendations 45
5.4 Limitations of the study 45
5.5 Recommendations for Further Research Study 46

REFERENCES 47
Appendix 1 54

List of Tables

Table 3.1 Participant groups 22
Table 4.1 Participants Frequency 23
Table 4.2 Participant profile 24
Table 4.3 Reliability test 25
Table 4.4 Case Processing 25
Table 4.5 Use of BIM in selection of site office location 26
Table 4.6 Analysis of survey results 27
Table 4.7 Correlation between variable- numbers of models 28
Table 4.8 Correlation between variable- preparing 3D presentation 30
Table 4.9 Correlation between variables - clash detection 33
Table 4.10 Correlation between variables-project cost 34
Table 4.11 Correlation between variables-building energy distribution 35
Table 4.12 Correlation between variables-buildings performances 35
Table 4.13 Correlation between variables - checking clashes 36
Table 4.14 Correlation between variables- planning activities 37
Table 4.15 Correlation between variables - simulating the master schedule 37
Table 4.16 Correlation between variables - integration of schedule 38
Table 4.17 Correlation between variables- Offsite Fabrication 38

List of Figures

Figure 1.1 Structure of the construction industry 3
Figure 2.1 The study stages 20
Figure 4.1 The percentage of Quantity Surveyors 24
Figure 4.2 Preparing of 3D presentations of complex structures 29
Figure 4.3 Pearson correlation between coordination of architectural, structural, and MEP services 31

Chapter One

1.1 Introduction

The Construction market is representing more than 10% of the global economy especially in our region as it is considered as developing country and its demands for infrastructure project are increasing due to population increase. In UAE, the construction market is considered one of the best markets comparing to other Middle Eastern countries due to the availability of international companies involved in the construction activity as most of the projects is funded by governments or privet investors in the hospitality projects. However due to the huge demand of fast track projects the quality of the output is still below expectations.

The barriers between the stages of the projects (Concept design, detailed design, construction, and handing over) are the main reasons behind the fragmented and uncoordinated projects output which causes the project time and cost overrun and ultimately client dissatisfaction. Reference to Halloum (2012) study about civil, architecture and construction engineering management development which was introduced in "Third International Conference on Construction in Developing Countries (ICCIDC–III) "90% of infrastructure project in Abu Dhabi are suffering from time and cost overrun.

This research is exploring the reasons which preventing the UAE construction market from switching to the collaborative construction approach, by highlighting the current use of BIM in some of running projects in UAE market and what are the challenges facing the users to have more effective and efficient BIM us

1.1 What is Construction?

Reference to Fernández-Solís, J. L. (2008): Dubois, A., & Gadde, L. E. (2002): Gidado, K. I. (1996) K. (2012): Bee Lan Oo, Derek Drew, Hing-Po Lo, (2007). To answer that question, we will discuss the construction from three different aspects: as a business, economic activity and as a commence.

The construction as a business has a three-dimensional meaning; a commerce, an occupation, and an organization. In the construction activity, you have buying and selling goods in a large scale as the procurement activity is essential activity in the construction market.

The construction market is one of the most activities which requires new employment. It is considered as a hub for job professions. Although it is described as challenging and dynamic environment, it provides a good opportunity for people to design important products and create services professionals.

The project execution is an organized group of people with a purpose to build a clear system of code of conduct between various levels of employment. Through this system roles and responsibilities and communication protocols are clarified to help all stakeholder to achieve the same target.

1.2 The construction Industry

Any national economy requires a Construction Industry, which is needed to design and build new areas in addition to repairing and modifying traditional properties. The construction is a manufacturing industry as its turn the raw material into a finished product, it's a place that allowed mankind to implement their innovation, creativity, knowledge, strength, determination and persistent to control their environment.

1.3 Construction as an economic activity in the global industry

Now days the construction represents more than 10% of the global economy. The global competitiveness and the advance technology have significantly altered the way in which the firms are doing business.

The 'Bon curve' emphasize that countries must relate between the level of constructional activity in their country and their progress in the economic development. Utilizing macroeconomic analysis, various studies tried to model this relationship between constructional level and economic development. However, new paradigms appeared based on Keynesian philosophy, these studies referred to construction as a continuous procedure that supports economy at all phases of development.

1.4 Collaborative construction

Construction is an engineering activity where contributing parties of several specializations are concerned. The success of a construction project is measured by the contributors' ability to make the correct compromises that would maintain the safety, reliability, performance, and cost pertaining to the construction within acceptable standards

Global links and competition caused swift developments in business setting which encourages the companies involved in construction activity to start a collaboration system with other organizations to promote effective communication systems. Collaborative Working (CW) was first introduced by Ren Anumba and Yang, (2013) this term became the buss word to indicate encouraging collaborative and competitive environment to adapt the dynamic nature of construction. In addition, they clarified that when project stakeholders work together, they accomplish a construction product effectively and efficiently. They also identified two main points that enable active CW in construction projects that are human manners and the commercial environment.

1.5 Structure of the construction industry

The construction industry is divided into five main sections, Residence, Commercial,

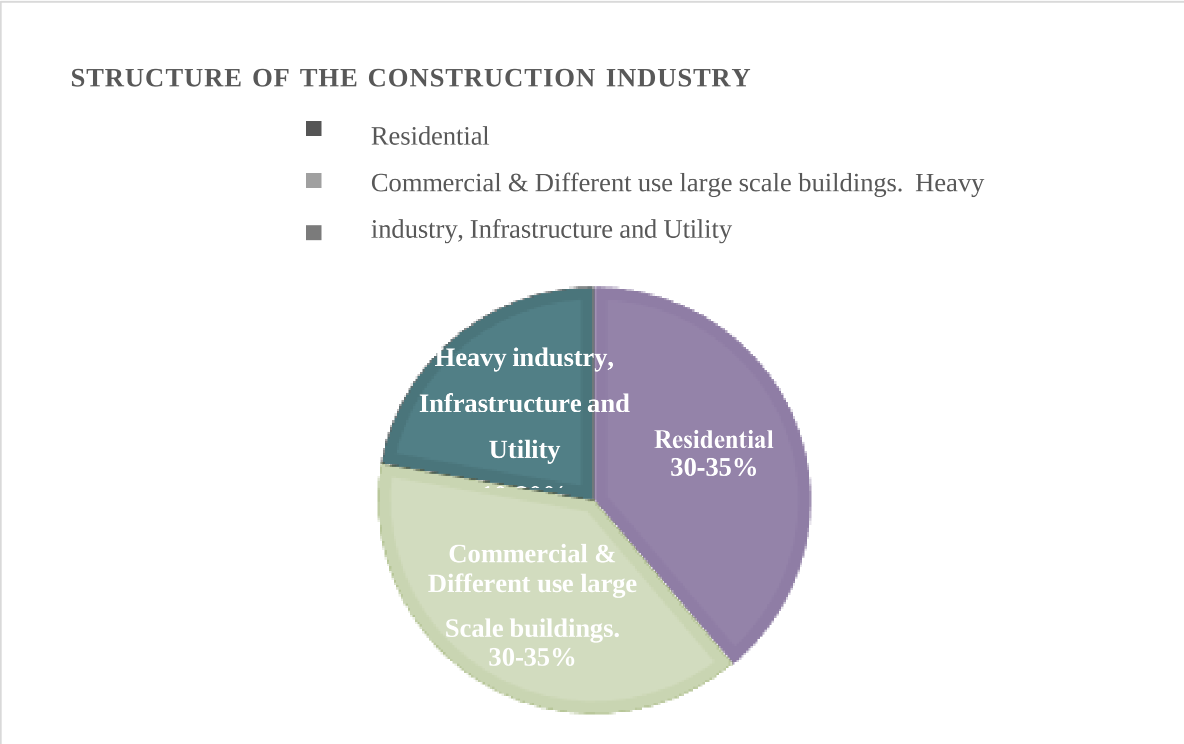

Figure 0.1 Structure of the construction industry

Heavy industry, Infrastructure and Utility projects. Figure 1.1 below is summarizing the percentage for each section.

Residential

Multiple types of the residential buildings which consist of single family houses, individual compounds, and high raise buildings. Normally it's been designed by architects and its constructed by a developer. Globally it's about 30% to 35% of the total industry, Low capital and less technology requirement more privacy oriented.

Commercial & Different use large scale buildings.

Large scale projects like shopping malls, universities, schools, government buildings, hospitals, hotels and office buildings, normally these buildings have multiple owners mostly private designed by Architecture Engineers and having a 30% to 35% of the construction market.

Heavy industry, Infrastructure and Utility

It's about 10% to 20% of the construction market normally designed by specialized engineers mostly owned by government sector very high complexity and using the most advanced technology.

1.6 The UAE core view. Location & Economy

(EC Harris Research| International Focus on United Arab Emirates | Winter 2012 / 2013): AECOM (2013): Kerr et al (2013). The UAE has a central tourism role in the Middle East, and this causes a continuous development of building and construction in the country. Which entails extra developments related to the entertainment field. UAE was recognized as a safe country compared with the instable areas in the Middle East which had a positive impact on the construction market in UAE.

1.7 The UAE Construction Industry

The UAE government's strategy to promote economy advancement is based on investments and diversity. Abu Dhabi and Dubai cities are expanding to accommodate young and growing population. Therefore, both cities are the two dominant emirates in the construction field, which requires more real estate and construction industry application (Maddison, 2013).

Regulation: Building regulation cods in the UAE is derived and implemented by the government's entities in which like Dubai Municipality & Abu Dhabi Municipality and these regulations been updated according to the market requirement and global cods and standards). Maddison, 2013.

Structure: The structure of the UAE construction industry differs between Emirates as in Dubai you will find RERA which greatly involved in finance monitoring of the developers and has a control over the progress of the construction projects. In general, a construction project structure is influenced by the value and the complexity of the project. (Albaloushi and Skitmore, 2008).

Quality of the output: The construction industry in UAE showing progression over other countries in the region due to the involvement of international consultant and project management firms, yet due to the fast trace projects and the huge demand in the construction market the projects are extremely hindered with problems including the separation of design and construction, lack of coordination and integration between the various functional disciplines and poor communication among all projects stake holders. The final product for clients of the construction industry is dissatisfaction with outcomes in many cases and higher costs than necessary. Traditional management approaches tend to dominate the construction industry, with little awareness of alternatives that might lead to better outcomes.

The demand in the construction market has exposed the need of new innovative solutions which can be implemented in different stage of a project. -3663). Performance problems such as cost, and time overrun in most of the large scale and infrastructure project is badly affecting the budget and the timely completion of the projects. The construction industry in the UAE is suffering due to continue slippage in the program and cost overrun, in most of the cases the overrun was due to incomplete and uncoordinated design. (M. Halloum 2012.) Additionally, current 2D design model are not delivering the required innovative solution which can enhance the construction market, hence the BIM technology has been introduced and the use of the BIM in the construction project started to be implemented in very limited areas.

1.8 BIM

1.9.1 What is BIM?

Succar, (2009) defined Building Information Modelling (BIM) as a change in the technological practices within the Architecture, Engineering, Construction and Operations (AECO) industry. On another note, Love et al., (2014) also defined BIM as a new technology- based procedure that aims at developing the design, construction, operation and maintenance methods of an asset.

1.9.2 Why BIM

BIM can create the required innovative solutions to the UAE construction market since one of the most complicated problems in the construction projects is the disconnect between the design stage and the construction stage of the project again the uncertainty created by the owners due to the lack of experience. Succar

(2009) clarified that BIM can help owners choose their end product by lowering construction expenses, reducing bias in work contract adjustments, developed quality of information design, collaborations between project organizations, optimizing benefits of assets throughout their life cycle.

1.9.3 The promise of BIM

The BIM is playing a central role in collaboration construction models. Seeing that the use of the BIM is extended from the conceptual design stage of a project which the responsibility of the owner up to facility management stage which involved the end user of the facility including the designer, contractor, subcontractor & the supplier chain. Hence all these parties' needs be interacting with collaborative approach to reach the satisfactory result expected by the owners.

To the Owners

- BIM can be used as an energy model which will help the owners to select the correct material and equipment for their facilities.
- BIM will enhance the design of the project by detecting all the problems in the design before starting the construction phase which will reduce the time and cost impact of the variations due to the design errors.
- BIM will assist the owners to freeze the budget in early stage of the project which means less complicated finance.
- BIM will give clearer ideas to the owners about their desired product which will limit the variation orders in the construction phase. And many more indirect benefits for the owners which will be discussed in detail in the research

To the contractors

- Some of the direct benefits which can be observed by using the BIM by contractors. The model will assist the contractor to provide more accurate estimation of the project which will reduce the risk and accordingly will reduce the prices of the project.
- The model will minimize the time and cost of the estimation of the project as the BOQs and specification will be available as a data output of the system.
- The model will make the planning and progress monitoring of the project easier and more accurate which will reduce the cost of the project. In addition to several indirect benefits which will be detailed latter.

To the Operator

- By using the develop module the operator can schedule his preventive maintenance program based on the output data from the system.

1.10 Challenges in UAE industry to switch from 2 D models to BIM.

Implementing BIM is involving participant with different specializations, coming from different backgrounds throughout the stages of the project including; the facility management after completion of the project. The structure of the construction market in UAE does not help the collaborative approach which will allow the construction market to implement the BIM.The structure of the construction in UAE is divided in design stage, construction stage, and the hand over stage. (Mehran, 2016)

The regulation and lows in UAE based on the traditional way of construction which enforce barriers between different stages of the project, after design completion you need to have a design NOC from the related authority then you can bring the contractor on bored after issuing the tender documents, however the contractor can join before this stage but this may cause a higher risk of variations due to Authority requirement.

As a contractor, you are not allowed to have an independent design entity. Till this date this considered a conflict of interest by the law. Accordingly, the BIM implementation will be negatively affected the BIM implantation in UAE construction market. Another challenge is to justify to the client the proof of cost saving and proposing the initial investment cost of the new software.

Getting all the required teams from the designers, contractors, subcontractor, and specialist supplier will add an indirect cost to the project as the teams needs to be mobilized as soon as the BIM model been developing. Moreover, all different construction companies need to invest by buying the software and having trained staff who can work on the system efficiently and effectively. (M. Kerr, D. Ryburn, B. McLaren and Z. Or Dentons practicallaw.com/1-519- 3663).

1.11 The Problem statement

While BIM has been attributed with several advantages relating to design integration (Lee et al., 2015) and collaborative construction project approaches) (Ren et al., 2011), its adoption in the UAE has so far faced considerable challenges. We argue that sub-optimal implementation of BIM in the UAE construction industry led either poor performance (or potential of poor performance) in some areas or at least sub-optimal performance. For example, according to (Mehran, 2016), the current practices do not reflect the BIM advantages, and related costs and profitability was not clear with the adoption of BIM in UAE Construction. In addition, (Mehran, 2016) suggest that BIM faces challenges relating to Technology diminution, Organizational diminutions and attitude factor. Following on from this, it may appear that the successful adoption of BIM in the UAE will be considerably challenged for the above reasons. Although being the case, there appears to be a paucity in research that has explored how BIM can be successfully adopted for use by the UAE construction industry although the contrary may be the case in other developed countries. Subsequently, this thesis seeks to undertake a systematic review of the current literature on BIM and in the process evaluate the potential adoption of BIM in the UAE market. This will be achieved through a survey of practitioners and stakeholders in the UAE construction market.

According to Love et al., (2013) to justify the initial cost of implementing BIM we need to analysis the benefit of it as a method to lower construction expenses reduce bias in work contract adjustments, better the quality of information design, facilitate collaboration between project organizations, and optimize benefits of assets throughout their life cycle.

While the benefits from implementing BIM in design and construction phase of the project can be easily evaluated unlike the benefits of the system during the life cycle of the building and the facility management which considered as indirect benefits and need to be proofed for the owners. (Love et al., 2014).

As described above the culture of the construction market is not helping the collaborative construction approach which needed for implementing BIM as the structure of the construction market is divided into 2 stages the design stage and construction stage for implementing BIM a lot of specific input DATA is required from the contractors, subcontractors, and specialist suppliers in design stage. To bring the contractors and suppliers into the project team during design stage will have additional cost to the project due to mobilizing additional resources from the contractors and supplier's firms and it will limit the owner's choices in having better prices during negotiation stage of the project, moreover the authority regulation does not allow the contractor to have a design firms under the same name due to conflict of interest low.

Moreover, there is technical issues like; lack of knowledge by the owner's technical advisers about the BIM capabilities so far, it's been used as a visualization tool or clash dedication tool.

Experience and trained staff, Software technical issues. Lake of collaborative approach in the construction companies within the UAE market and the cost of the switching proses as for some time the companies has to pay double the cost for smooth switching proses. Because of the above reasons is preventing the construction market from switching to the BIM implementation. (Mehran, 2016).

1.10 Aim of the research

The aim of the research is to examine the current practice of BIM implementation in the UAE construction industry, evaluate the effectiveness of each practice and describe how BIM technology could be considered as a tool to assist decision making, potentially serving as an essential factor in conducting a successful construction project (Cao et al., 2015).

In view of a possible gap between technical feasibility and practical adaption this research is trying to highlight the current problems and the suggested solution with reference to the clients and users of the systems.

Chapter Two

2.1 Literature review

2.1.1 The use of BIM in Construction projects

An adverse trend in the construction industry lies within the recurring discontinuities present in the life-cycle of s given project; different stages in the project could be spaced out by long time intervals, halting the progress. All stakeholders need to come together and work in collaboration, including the landlord, designer, contractor and sub contactors. In addition to the providers. However, this is not the case, as stakeholders will not come to work together voluntarily due to the fact every one of the individuals has a different economic interest, driven by their company's benefits, with little interest for other stakeholders' economic benefits. This nature of the disconnection of the construction industry has been considered as a critical factor that results in low productivity, weak performance and uncooperativeness, as stated by (Xue, Shen and Ren, 2010).

The construction industry should learn and take advantage of the advanced technology in delivering project (Forgues and Koskela, 2009). Based on National Construction and management Conference. He emphasized that to improve production efficiency by reducing waste and eliminating non-value activity from the construction proses thus enhance the overall competitiveness of enterprises.

2.1.2 Construction IT and computer aided design (CAD)

Construction projects are increasing in their complexity and difficult to manage (Ajam, Alshawi and Mezher, 2010). One difficulty is the that different stakeholders like financing bodies, Architecture engineers, authorities, Lawyers, contractors and suppliers depend on each other. (Clough et al., 2008). The Computer Aided design CAD have served the industry throughout decades by using 2 D design tools and drawings which has traditionally served as a boundary objective.

2.1.3 ***The limitations of 2D design in construction*** *(focus on information provision required* for design and collaborative work)

Construction is an engineering activity that has various objectives including safety, authenticity, achievement and expenditure. All objectives need to be equally achieved, which would require the partnership of teams with different specializations, who will make many adjustments to their plans to meet unified expectations. Typically, a building design of a building Requires collaboration between various professions including architecture, construction designers, quality assurance and building services, who will work together for a certain period of time to deliver the construction project.

It has been acknowledged that design environment can improve design performance and outcome by allowing collaboration between designers keeping in mind their different backgrounds and varying building Code requirements. This is an important aspect in designers' decision making process in addition to design requirements and constraints.

2.1.4 What is BIM?

Hardin, (2009) defined BIM as “digital representation of the building process to facilitate exchange and interoperability of information in digital format”. Alternative definition by Son, Lee and Kim, (2015) as the technology of producing and handling a parametric model of a building. However, Hardin, (2009) clarified that it is not possible to find one acceptable definition of the BIM, instead it should be studied from different point of views considering the history and the development of the concept that can be defined as “digital representation of a building”. Additional definition as “An object oriented with three-dimensional model of project information to facilitate the interoperability and exchange of information with relevant software application” (M, Reijo, S Paavola 2014 43). The international standards of constructions ISO, (2010) defined BIM as “shared digital representations of physical and functional characteristics of any built object”.

2.1.5 Attributes of BIM (What BIM does and delivers)

BIM is a technology-based procedure that can be used to advance the building progress and efficiency of an assists design, construction, operation and maintenance process (Lee et al., 2015).

Building Information modelling (BIM) refer to a compensation or set of technologies and organizational solutions that are expected to increase inter organizational and specialty collaboration in the construction industry to advance performance, productivity, and the quality of the design, construction, and maintenance of the building. (Miettinen and Paavola, 2014) BIM tools support the modelling of the buildings parameters which introduces a new level of buildings visualizations and simulations of the buildings behaviours, as well as, utilizing efficient management of the project. "BIM is considered as a tool of collaboration (Miettinen and Paavola, 2014). When BIM is used starting from the design stage throughout the project life cycle, new levels of interoperability and collaboration can be achieved. The cooperative use of BIM lowers mistakes in the design and improves the productivity of the construction industry. Accordingly, BIM provides an evolving new paradigm for construction management or "an emerging technological and procedural shift in the Architecture, Engineering and Construction industry" (Succar, 2009).

Cao et al., (2015) suggested a principle way to implement BIM that focuses on creating and communicating project information throughout the project life cycle. Where BIM can be used in budgeting, sustainability studies, clash identification, building schedules and offsite fabrication throughout the project life cycle.

Eastman et al., (2011), Bryde, Broquetas and Volm, (2013) and Giel and Issa, (2013) agreed that if BIM was used properly, it will facilitate effective collaboration during the construction procedures with sustainable benefits of producing less design errors and effective energy utilization.

BIM support and facilitate a digital representation of physical and functional characteristics of a building due to the fact the designer and engineers has evolved from 2 D sketches and traditional specification to a parametric object oriented 3 D models that includes detailed description of the facility or the organization. BIM helps as a hub of information supportive for various application along the design and construction process including cost estimate, energy analyzing and production planning. (1) {Real-time visualization of building information models}

As all the information is available in 3 D modules BIM is used as a real time visualization tool which facilitate a real time communication between the different stakeholders among the project and the engineers which facilitate the evaluations of the design, collaborative demonstrations and walkthroughs. An interactive SD model becomes a common frame of reference visualizing tool during these sessions. Having the same frame supports common understanding for professions from various specialties involved in the project. Architect can explore their design options and engineers can simplify the structure steel to the workers all from the same sources of data. (2).

BIM are used in the existing building to ensure that the performance requirement is fulfilled during building service life.

According to (Biagini et al., 2016) 22 Using BIM in historical building could be a solution due to the fact that renovation projects must maintain the heritage properties if the building, in addition to other expected difficulties during the stages of onsite interventions, the designers must take into consideration a computable solutions that avoids endangering the culture significant of the historical buildings, the traditional methods which based on 2 dimensional drawings and too many paper exchange are time consuming and barely efficient, BIM may present an answer to these problems by creation a 3 D model of the buildings component and link it to variety of information. Reference to a research by (Kim et al., 2016).

BIM can be used to lower the consumption of the fossil fuel in buildings. The most effective way of reducing the buildings energy consumption is the early consideration of energy saving in the design stage, however during late design stages, analyst specialist also conducts building energy analyses. The BIM provide an opportunity to design alternative options for the building and select the best one, nevertheless, this advantage is not utilized in the constructions. Due to the difficulty and expense of building modelling and energy systems. By implementing the BIM technology testing different scenarios with variable data is an easy option and can be conducted in early stage of the design of a project which leads to more efficient energy systems in the buildings. Another potential use of the BIM is the ability to simulate the different scenarios for security and access control system to the buildings by applying different scenarios in the early design stages which will improve the access control administrator kandhak (Sumar et al., 2016).

Volk, Stengel and Schultmann, (2014) explained that although BIM procedures are assured in new constructions, most of the current buildings are not renovated to integrate BIM yet due to ambiguous building conditions and lacking documentation. The research recommended further studies to evaluate current practices in utilizing the BIM and providing a state-of-the art overview for stakeholders to encourage them to incorporate these procedures in the existing projects.

Also, BIM can be used during construction to facilitate the temporary arrangement for construction project like stated in the case study done by (Marzouk and Abubakr, 2016). (Regarding the decision support for the selection of tower crane using the building geometric layout generated by BIM. They stated that the planning processes for tower crane utilization start at very early stage in the construction project, poor selection could incur extra cost or could be the cause of a delay in a construction project, the planning procedure of a tower crane includes selection, positioning and operation, select the suitable tower crane type, adjusting the model, and selecting appropriate number of tower cranes in the ideal location for each. In addition, the use of 4D simulation model to analogue the tower crane operation. For a safe operation of the tower crane, several clash detection scenarios can be presented.

Moreover Wang et al., (2015). Stated that the BIM can be used to support emergency and safety requirement and management procedures in cases of fire. Based on his research BIM can be used in four main models including conservation of equipment, fire exit routes, safety education and fire drill to assess evacuation processes. The conservation of the equipment is achieved online through a web-based program that allows distant administration. Regarding fire exit route planning model BIM is used to assure that the distance of the escape route is acceptable. Fire drill assessment with BIM involves the use of Dynamic simulator to forecast the precise time required for evacuation in case of real fire accident. Finally, the safety education model is about raising awareness of dangerous areas and showing possible escape routes.

2.1.6 BIM as a design Building (Construction) Information Model

The international standards defined (BIM) as: “shared digital representation of physical and functional characteristics of any built object which forms a reliable basis for decisions” [26].and collaborative medium, it is required to share knowledge and experiences in an innovative, cooperative and integrated manner to ensure continuous improvements of the construction bodies in the coming era.

The emerging information technology (IT) offer the construction organization a great opportunity for collaboration work environment, by managing the information systems in the construction industry, (Xue et al., 2012). Modern construction businesses operate in global environment with multiple stakeholder, construction, in collaborative team work process. With successful projects depending on strong communication between owners, architect, engineer, contactors and providers. Which will allow strong collaboration between the teams and eliminate discontinuity problem that face the teams between the project stages. Which is considered an essential factor to promote successful performance of the construction companies (Guo, Li and Skitmore, 2010).

The globalization required construction organization to establish an effective and efficient collaborative working system for sharing information and improving work performance, (Paton, 2002; Erdogan et al, 2008). Additionally, Xue et al., (2012) clarified the importance of information technology in the development of programs and websites that provide online communication to support collaborative work and the exchanging of ideas between all stakeholders involved in the project. Durugbo, (2014) suggested a collaborative network that can be referred to as a method of information modelling. The method includes a system of information structure that enables collaboration between various organizations. The system has two main components the Information structure represented by decision making and a process to evaluate generation of information. Scenarios and case studies from different national corporations are demonstrated and discussed to represent the use of the suggested method and to discourse how the method would be beneficial to improve the control of collaborative network organizations.

"In recent special issues by Journal of Intelligent Manufacturing (JIM, 18 (2007), 5; JIM, 21 (2010), 3), International Journal of Production Research (IJPR, 47 (2009), 17), International Journal of Services and Operations Management (IJSOM, 6 (2010), 3), Produc- tion Planning & Control (PPC, 22 (2011), 5–6), and International Journal of Computer Integrated Manufac- turing (IJCIM, 26 (2013), 1– 2), the emerging discipline of collaborative networks (CNs) has been highlighted as an important area of research for improving the opera- tions of modern firms C.Durgubo 2015"

Camarinha-Matos et al., (2009) clarified that improving the operations in companies requires investing in information modelling that would be applicable to various functions. Fiala (2005) stated that "Information reduces uncertainty in networks". This reduction of uncertainties is useful for the organizations as it minimizes the time spend for alternate discussions due to uncertainties as stated by Also, Sonnenwald, (1996) and Barut, Faisst and Kanet, (2002) stated that the flow of information is important for managing interactions and collaboration activities and companied works for individual designers.

2.1.7 Adoption of BIM – current challenges.

According to, Mehran, (2016) there is three main elements that negatively affect BIM adoption in building industry the first one is related to technology. Particularly, the ability of different applications to operate together, the compatibility of these applications, licensing and quality control of the progress, identification of the design errors and finally the visualization and adhering to BIM protocols. The second factor is an organizational diminution which includes the specialists, BIM professionals, and the support from the senior management and clients, BIM vendors and training by BIM professionals. (Eadie et al., 2013). The third factor as per Won et al., (2013) is the attitude towards learning BIM and willingness to adopt this technology.

The absence of one unified meaning of BIM leads to confusion within the non-BIM professionals. Although building experts have good knowledge related to the BIM benefits. Yet there is no identified list of advantages supported with relevant cost benefits. (Vass,S, 2014). Lack of contractual and legal agreements issues must be legalised and put in form of protocols before having an effective BIM adaption (Arensman and Ozbek, 2012). Lack of user security is a barrier in using BIM freely as the level of design module and the security of information which related to fees and liability issues is to be resolved. (Aibinu and Venkatesh, 2014). Lake of Skiles and lake of training is a big barrier preventing smooth BIM implementation as per (Xu, Feng and Li, 2014). In their Chinese construction industry and its slow BIM implementation,

High cost of initial investment and its costly implementation is a considerable barrier (Love et al., 2014.)

. *"The authors also noted that there is resistance to change upon receiving the BIM model as well as more time spent on the accuracy and checking the model prior to information extraction or updating D. Mehran"*

Cao et al., (2015) stated in their study the barriers preventing effective BIM implementation.

1) BIM use still limited to visualization and clash detection due to the technical issues.

2) Support by clients and owners still limited.

3) The cooperation between different stakeholders in the construction project in China is still inadequate. This is caused by following the traditional delivery methods.
4) The ability to run different BIM applications together requires further development at the technological level, with clear identification of the risky issues.
5) The official limitations of the delivery system that must be reviewed to allow more collaborative activities.
6) Involvement of the clients, owner is limited to design stage.

Investment justification process is not direct and needs to have more justifications and a lot of assumptions to convince the owners and the client the utilization of return on investment due to the fact that the measures dose not accurately reflect the real cost and benefits of BIM implementation (Love et al., 2013).

2.1.8 Challenges adopting technology

The construction industry has a low progress in adoption new technology as there is not Significant changes in traditional business model when introducing new tool to the Industry. (Mc. Graw. 2009). The best way of a technology acceptance is to have it imposed by the clients and owners as part of the contract. Since is not negotiable. (Canada, Quebec 2011). Adoption a technology would require changings in the current practice to achieve better Quality and performance of the buildings (Cerovsek, 2011)

Adoption of a new technology in any industry poses challenges. (Mc Graw report on 2009). With reference to NBS (national building specification) in UK November 2011 (NBS 2012), followed by. A survey to track people attitude towards BIM adoption 90% of users revealed that Significant changing in the current industry practices is required. ((NBS 2012). It's also notice that the Cost is a real barrier to technology adoption especially for small organizations. (NBS 2012).

Building SMART (2010) an organization in Australia conducted a survey research study and concluded that a significant change in the technology adoption is achieved only if the approach of the design and construction team works also changed. (Best practice' project report, an investigation of 'Best Practices' through case studies at regional, national and international levels, November 30, 2011).

According to cooperate research center (CRC) for construction innovation in Australia several challenges related to technology hinder the BIM adoption which mostly is related to organizational variations and changes required in the employment process.

> *"There are some constraints and difficulties of applying IPD. Construction industry firms are accustomed to traditional way of leadership, responsibility and opportunity, and change is generally slow. Absence of standard BIM contract documents and issues in the use of BIM as a collaborative framework are two major obstacles for full adoption. Achieving a value-based procurement approach is a challenge, particularly for the public-sector clients who are limited to evaluate the competitive bids solely based on the low-bid award system. Public institutions and agencies lack the alternatives to restructure their procurement processes to enable the IPD model. Even though new contracts supporting IPD exists, they have not been tested over time, and are not fully proven or even understood in the public procurement e n v i r o n m e n t " [27") (Porwal and Hewage, 2013)*

2.2 Theoretical Framework

In the theoretical framework two main theory will be discussed (i) The spread of Innovation Theory and (ii) The Technology Adoption Model. Innovation spread is a model development by (Rogers) in (1962 to 1995).

2.2.1 The Diffusion of Innovation Theory.

To understand the spread of innovation processes, Roger has developed a frame work theory the ways of representing this including the S curves for representing the process by which attitude and knowledge of an innovation is transmitted through communications channels, time and members of social system are the tow variables considered in Rogers 1995 model the elements included described as: Innovation as an idea in practice or as an objective, communications channels which refer to a massage of innovation been transmitted between individuals. Time, that refers to the time line includes the innovation decision processes and the rate of innovation adoption by the individuals or as a group. And a community of interconnected departments that are involved in solving a problem of one project. This outline is determined by the degree at which the interconnected departments work together to produce innovative product. Different authors followed Roger s adoption spread model provided other scenarios for explaining adoption process including “bass model” Innovation or imitation model in (Roger 1995) which include that the adoption of new a technology depend on two factors Innovations or imitation. Where innovators are driven by their interest to try new technology, regardless of their competitors or number of other users of a new technology. Where imitators are most dependent on the influence of other users of the new technology and they are directly related to the number of the new technology users. In this technology adoption model imitators are considered the innovation diffusion workforce including people who follow the new technology at the beginning or at a late stage. Not considering the time as an important variable. However, the innovators groups are expected to adopt innovation faster.

As a third theory in innovation adoption model is Clude Moore’s complexity and interrelation of various influences on both individuals and organizational rolls in the diffusion of innovation processes in (Roger 1995). (Aranda-Mena and Wakefield, 2006).

2.2.2 The Technology adoption model (TAM)

Melville, Kraemer and Gurbaxani, (2004) justified the significance of having strong information system as it is an essential element to in the organizational life. They specified the benefits of these information systems that would lead to dominance of the organization over all competitors. The investment and implementation would be recognized in various systems including “enterprise- level systems, such as enterprise resource planning (ERP) systems, supply chain management systems, customer relationship management (CRM) systems, and business intelligence systems”.(Melville 2004)

Employees will not put much effort to gain the required benefits from the new systems. In their study they Venkatesh et al., (2008), claim that the two main predictors of individual system use Behavioural objectives and supporting conditions, they introduced that behavioural expectations as early warning that addresses some of the main limitations and provides more clear understanding of system use. They examined the system use in terms of three key conceptualization: duration, frequency, and intensity. They develop a model that employs behavioral intention, supporting conditions, and behavioral expectation as early warning of the three conceptualizations of system use. They argue that each of these three elements play different roles in predicting each of the three conceptualizations of system use. Benbasat and Zmud, (2003) suggest that the usage of the IT should be driven by managerial levels as instruction & along with the required facilities. Yet, they discussed some barriers related to the behavioral intention and facilitating conditions application. They stated that "*Behavioural expectation was introduced as an alternative predictor of system use. The mechanisms through which these three predictors influence the three conceptualizations of system use were theorized and one temporal factor—experience—was identified as a Contingency affecting the predictive validity of these two determinants of system use. The results provided support for the proposed model and highlight the importance of behavioural expectation as a key construct in individual- level technology adoption and use*".(Benbaset 2003).

Cost overrun, and program slippage have long has negatively affected the construction industry causing all kind of performance problems and have forced participants to explore new ideas to stream line the design and construction activity in the projects. (Smyth, 2010). Figure below presents the main stages in this study.

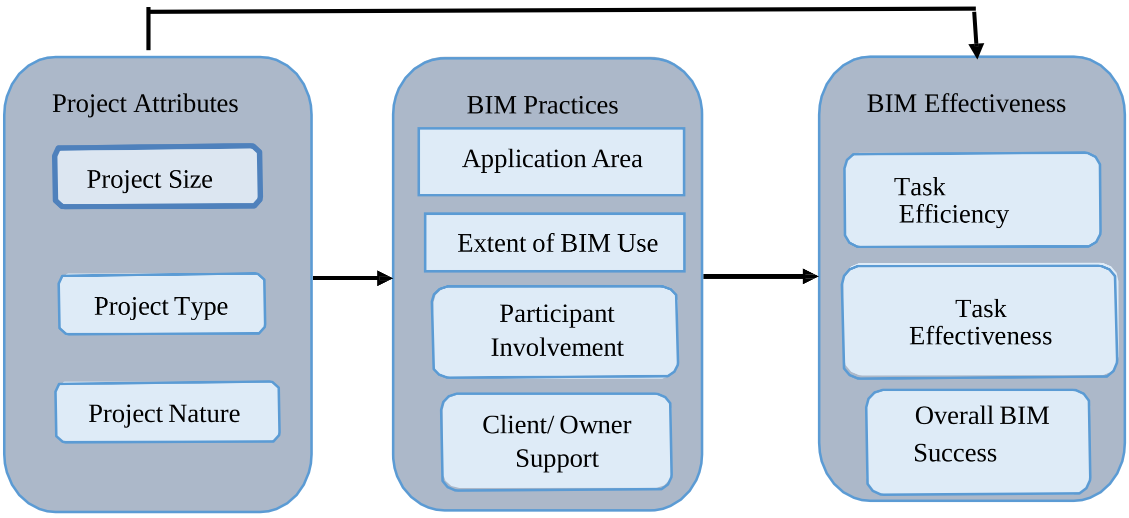

Figure 0.1 The study stages

Three projects are investigated in the United Arab Emirates. Variables are divided into three main categories Project attributes, BIM practices and BIM effectiveness. Project attributes including project size, project type and project nature are investigated through observation, where data are collected from a modified questionnaire. Finally, the BIM Effectiveness is determined utilizing a survey adopted from Coa, et al (2015) who conducted a similar study in China.

Chapter Three

3. Methodology

This chapter aims at explaining the methodology and the study approach. Main points explained are the site, sampling method, study context, the questionnaire tool and ethical consideration during the project implementation. In addition, a description of how the study meets validity and reliability requirements.

3.1 Study methods

This study represents non-experimental quantitative approach that utilizes a survey as a research instrument.

3.1.1 Context

The research is undertaken in the United Arab Emirates, particularly in Dubai and Abu Dhabi. In Specific all projects studied are characterized as large complex projects belongs to public sector, required at least 5 years duration to be completed. Such as Abu Dhabi Mid-field air terminal project, Lover museum, & Maktoum airport.

3.1.2 Study instrument

- ***Survey***

This is a cross sectional study implemented through a survey in which the opinion of a large group regarding an issue is investigated at once. The survey is adopted from a study done in China by Cao, el at (2015) It is composed of two sections; the first section concentrates on the roles of the key project participants involved. The second section investigated the perceptions of the respondents regarding the effectiveness of BIM usage in the surveyed projects. The survey is distributed to the participants by hard copy they will fill the questioner 50 form where distributed for each project.

Appendix 1: actual questionnaire (survey)

3.1.3 Participants

Participants consisted of two groups the clients and the contractors. From the client site participants included design engineers and owner representatives. From the contractor side the project managers and BIM modular. The method of choosing operators was based on purposeful sampling (Creswell 2009). As each participant is selected based on their role in the project.

Project	Engineering design	Owner representatives	BIM modular

Table 0.1 Participant groups

3.2 Ethical considerations

The researcher was granted official permission from all the project management and owners of the surveyed project. The anonymity and confidentiality of the information was granted for all participants and the data collected will be used for the academic research purposes only.

Chapter Four

Results and Data Analysis

This chapter aims to present the results of the current research regarding building information modelling (BIM) in UAE constructions. Data collected from the survey results including the respondents' demographic information, current practices in the industry, and the descriptive and inferential statistical analysis. Descriptive analysis considered in this research is the mean, frequency and standard deviation. Inferential statistics included correlations between different variables in this study.

4.1 Overall Survey

50 sets of questionnaires were distributed to three groups; clients, contractors and consultants. The clients group participants included design engineers and owner representatives. From the contractor group; project managers and BIM modeler, only 37 sets (74%) of responses were collected back.

4.2 Respondent Profile

4.2.1 Organizational

Out of the 37 sets of questionnaires, most of the respondents were BIM modelers (28%) followed by BIM coordinators (17%). Then comes BIM Leads with (14%), other participants take percentage around 6% to 2.8% as BIM architects, BIM engineers and technicians, as shown in Table 4.1.

Participant	Frequency	%
BIM Arch.	3	5.7
BIM Head	2	5.7
BIM Eng.	1	2.8
BIM Mod.	1	2.8
BIM Mod.	10	28
BIM lead	5	14
Engineer	2	5.7
BIM coor.	6	17
MEP Drau	1	2. 8
Technical	1	2. 8
MEP proj.	1	2. 8
Mechanic	2	5.7

Table 0.1: Participants Frequency

As for the Survey distributed on consultants and contractors; the percentage of contractor's responds was more than that of consultants. The survey was mostly distributed to contractors at 88%, while the consultants was at 8.3%. Some of the respondent's surveys didn't determine the company type at 8.3%. The gender of respondents is divided to be 83.6% for male, and 16.4% female as shows in Table 4.2 below.

Gender	Percent %
Male	83.6
Female	16.4

Table 0.2 Participant profile

4.2.2 Individual

The percentage of Quantity Surveyors who responded to the survey was (27.2%). The majority of the respondents had 5 to 9 years working experience (30.7%). Additionally, their education backgrounds were Bachelor/Degree holders (22.6%), while those with more than 15 years' experience take around 19.5%, As shown in the figure below.

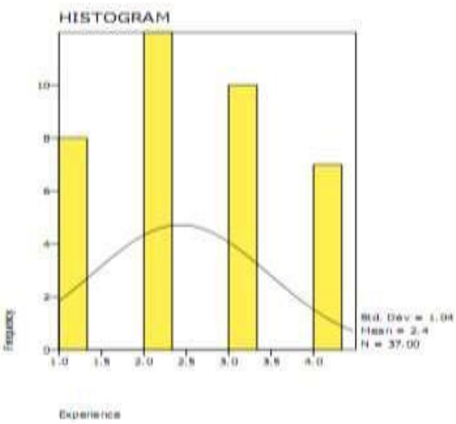

Figure 0.1 The percentage of Quantity Surveyors

4.2.3 Current Practice of the Industry

As for companies' level of technological knowledge in the construction industry it was found that 92 % of organization's employees have basic Microsoft office software skills, 77.4% have AutoCAD skills but only 8.6% are using Revit 32 Architectural software and it is the for same the Primavera software. As can be seen from the table below for the ICT tools usage 66% of the respondents are using it for designing tasks and 59.1% use it for measuring tasks. However, 29.5% of these respondents are not using the ICT tools for communication purposes.

4.4 Questionnaire Analysis

Reliability Test and case processing

The survey covered 13 points; the reliability test was performed to establish the integrity of the data. It stated that results cannot be accepted if the Cronbach's Alpha coefficient is less than 0.60. As can be seen in Table 4.3, the results displayed that all 13 issues have around 0.6 values which makes them authentic.

Reliability Statistics	Number of Issue	Percent %
Cronbach"s Alpha	13	0.6

Table 0.3 Reliability test

After case processing performed the results shows that there are of respond survey excluded from study, to modify the valid respond survey to be more than 89% from all respond survey, as shown in Table 4.4

Case processing Results	Number	Percent %
Case Valid	33	89.19%
Case Exclude	4	10.81
Total	37	100 %

Table 0.4 Case Processing

In this study survey there are 13 issues asked about. After analysis of responds, using SPSS the Mean rank, minimum and maximum value, and correlation between each variable and other was calculated and later showed each issue respond results and its correlation with the other 12 issues because the issue correlate with its self in 1 value.

The proposed hypothesis and data analysis will be evaluated and then decided if it's true or false. Through the descriptive analysis, when asked about using of BIM during the selection of the site office's location and the related Logistics the majority of answers was that there isn't any use of BIM in the selection of the site location reaching 43% of the responds, followed by participants who don't know if there's any use of BIM in selection of location and related logistics reaching around 35%, while just 8 participants agree that there is real use of BIM during the selection of the site location. The Mean for these variables (Logistics) is 2.35, with deviation 1.36. As shown in below Table 4.5

Valid cases = 37; cases with missing value(s) = 7.

Variable	N	Mean	Std Dev	Minimum	Maximum
Gender	37	1.19	.40	1.00	2.00
Experience	37	2.43	1.04	1.00	4.00
Company Type	33	2.09	.29	2.00	3.00
logistics	37	2.35	1.36	1.00	4.00
Options	35	2.40	1.40	1.00	4.00
3D	36	2.03	1.08	1.00	4.00
coordination	37	2.86	.92	1.00	4.00
Cost	37	1.62	.92	1.00	4.00
Energy	37	1.19	.52	1.00	3.00
Performance	37	1.97	1.17	1.00	4.00
Clash detection	37	3.59	.64	1.00	4.00
System Design	37	2.41	1.26	1.00	4.00
Schedule	36	2.00	1.07	1.00	4.00
Quantity	37	2.35	1.16	1.00	4.00
Resources	37	1.68	1.13	1.00	4.00
Offsite Fabrication	37	1.76	1.12	1.00	4.00

Table 0.5 Use of BIM in selection of site office location

Correlation between these variables and others according to the analysis of survey results, as shown in Table 4.6 there aren't very strong correlations with these variables. But there is a strong positive relation with the number of Models was prepared for the same Project (BIM2) to be 0.52 in Pearson correlation. There is a moderate negative relation between this variable and 3D (BIM3) variable to be -0.38 and with cost variable (BIM5) to be -0.33, and with (BIM6), there are modest negative relation between logistics and coordination (BIM4) to be -0.16, and with energy variable (BIM6) to be - 0.14, and with Offsite Fabrication variable (CS6) is to be - 0.13, and negative modest relation with schedule variable (CS3) to be -.29, and positive modest relation with Quantity (CS4) to be 0.13.

There is a negative moderate relation with logistics and performance (BIM7) to be -0.41. There is a negative week relation between this variable and clash detection (CS1) to be -0.09and system design (CS2) to be -0.10, and positive week relation with resources variable (CS5) to be 0.04.

Variables	Pearson Correlation	N
	Sig.(2tailed)	
Logistics	1.00	37
Options	.52	35
	.001	
3D	-.38	36

	.023	
Coordination	-.16	37
	.340	
Cost	-.33	37
	.043	
Energy	-.14	37
	.421	
Performance	-.41	37
	0.11	
Clash	-.09	37
Detection	.610	37
System Design	-.10	37
	.548	
Schedule	-.29	36
	.084	
Quantity	.13	37
	.440	
Resources	.04	37
	.814	
Offsite	-0.13	37
Fabrication	0.460	

Table 0.6 Analysis of survey results

When asking about the numbers of Models were prepared for the same Project the majority of responds was divided between one model to seek 40.5 % and more than three models to seek 39%, the respond answer percent 13.8 whose prepared two models, with just 1 responds answers that he prepared three models to be around 2.7% which can help us in determine the state of this variables, about Mean value was 2.40 with 1.4 deviation. About correlation between this variable and others according analysis of survey results, as shows in Table 4.7 there aren't very strong correlation with these variables. But there is strong positive relation with logistic variable (BIM1) to be 0.52 in Pearson correlation, and negative strong relation with cost variables (BIM5) to be equal -0.52. There is a moderate negative relation between this variable and 3D (BIM3) variable to be -0.33 and with clash detection variable positive moderate relation (CS1) to be 0.38 there are modest negative relation between option and system design (CS2) and also with variables performance (BIM7) to be -0.13, and with resource variable (CS5) to be - 0.15, and with Offsite Fabrication variable (CS6) there are positive weak relation to be 0.01, also with variables energy (BIM6) to be equal.05 and with variable (BIM4) to be 0.06, in addition there are negative modest relation with schedule variable (CS3) to be -.28, and positive modest relation with Quantity (CS4) to be 0.20

Variables	Pearson Correlation	N
	Sig.(2tailed)	
Logistics	0.52	36
	.001	
Options	1.00	35
3D	-.33	34
	.59	
Coordination	0.06	35
	0.726	
Cost	-.52	35
	.043	
Energy	.05	35
	.786	
Performance	-.13	35
	.448	
Clash	.38	35
Detection	.023	
System Design	-.13	35
	.450	
Schedule	-.28	34
	.107	
Quantity	.20	35
	.261	
Resources	.15	35
	.402	
Offsite	-0.01	35
Fabrication	0.932	

Table 0.7 Correlation between variable- numbers of Models

About being involved in preparing 3D presentation of a complex structure to non-professionals the majority of answer 56% was yes, they involved Around 44 % answers no they aren’t involved, the frequency of involving in preparing 3D presentation was 19% involving just for one time, 25% percent for more than three times, 11% percent for involving every month, with Mean equal 2.03 and 1.08 deviation. As shown in following Figure 4.2.

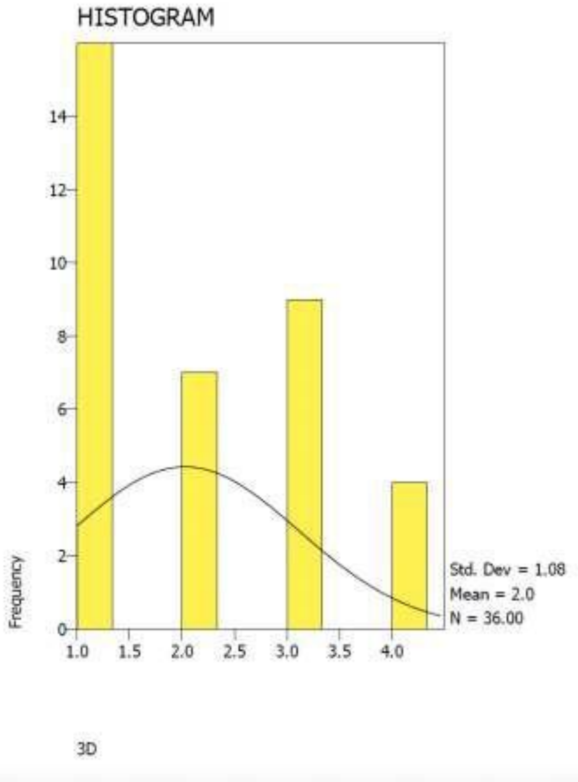

Figure 0.2 Preparing of 3D presentations of complex structures

About correlation between this variable and others according analysis of survey results, as shows in Table 4.7 there aren't very strong correlation with these variables.

But there is a strong positive relation with cost variable (BIM5) to be 0.55 in Pearson correlation, and with performance variable (BIM7) to be 0.61

There is a moderate positive relation between this variable and coordination (BIM4) variable to be 0.35 and with logistic variable and logistic variable (BIM1) also to be - 0.38, and option variable (BIM2) to be -0.33 there are modest positive relation between option and system design (CS2) to be 0.32, and schedule variable (CS3) to be .45.

There is positive weak relation with variables energy (BIM6) to be 0.1, and positive modest relation with Quantity (CS4) to be 0.17, and with clash detection variable (CS1) to be 0.17, and with resource (CS5) to be 0.12 and with Offsite Fabrication (CS6) to be 0.18 as shown in Table 4.8 below.

Variables	Pearson Correlation	N
	Sig.(2tailed)	
Logistics	-.38	36
	.023	
Options	-.33	34
	.59	
3D	1.00	36
Coordination	0.35	36
	0.038	
Cost	-.55	36
	.001	
Energy	.10	36
	.580	
Performance	0.61	36
	.000	
Clash	.18	36
Detection	.294	
System Design	0.32	36
	.054	
Schedule	0.45	35
	.007	
Quantity	.17	36
	.317	
Resources	0.12	36
	.475	
Offsite	0.18	36
Fabrication	0.290	

Table 0.8 Correlation between variable- preparing 3D presentation

When asking about involving in the design coordination of architectural, structural, and MEP services the answer was strongly involve with around 91.7% percent, the involving percent was mostly when changes occurs in 50 % percent, 25 % of respond survey answers that they involved regularly every month in the design coordination, just 16.6 answers they are involved once in the beginning of the design phase, the percent of they aren’t involve in the design coordination is equal to 8.3, with Mean 2.86 and 0.92 deviation, with extreme moderate correlation with checks clashes variable (CS1) with Pearson correlation equal to 0.52. As shown in following figure 4.3.

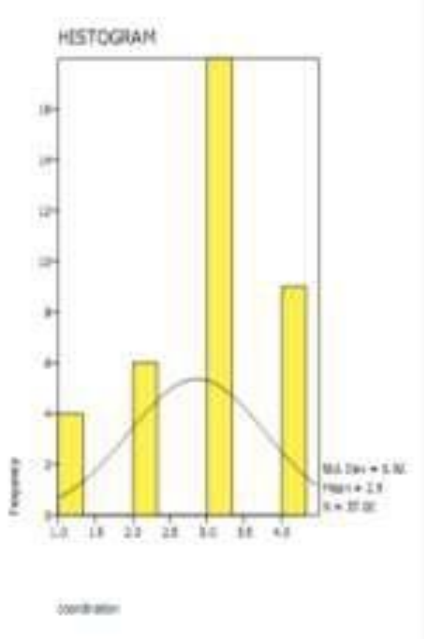

Figure 0.3 Pearson correlation between coordination of architectural, structural, and MEP services

Results about involving in project cost estimation in the design stage was they aren’t involved with 61.1%, the involved team specially when a change occurred it was 13.8 percent, 19.4 was the percent of involving answers at the beginning of design stage, just around 6% percent was involved regularly in cost estimation, with Mean 1.62 and 0.92 deviation.

There isn’t new correlation related to this variable, just correlation mentioned above with previously variables.

Related to variable 6 (BIM6) involving in building energy distribution and consumption simulations the answer was there aren’t involving in 86% percent, there aren’t any regular involvement in building energy distribution in responded survey, but the percent of involving happened when changes occurs was 5.5%, around 8.3% percent they involved in building energy distribution at the beginning of the design phase, with Mean 1.19 and 0.52 deviation value, there aren’t any strong or moderate correlation with this variables.

About involving in buildings other performances; such as lighting, acoustics, ventilation, and air flow simulations the majority answer was they aren't involved in building other performance in 51.4% percent, followed by 25% percent for involving in building other performance when their changes occurs, then around 13% percent to regularly involve, finally 11.1% percent to involving at the beginning of design stage with 1.97 Mean And 1.17 as deviation.

About correlation between this variable and others according analysis of survey results, as shows in table 4.8 there aren't very strong correlation with this variable.

But there is a strong positive relation with clash detection variable (CS1) to be 0.52 in Pearson correlation, and with performance variable (BIM7) to be 0.61

There is a moderate positive relation between this variable and coordination (BIM4) variable to be 0.35 and with logistic variable and logistic variable (BIM6) also to be - 0.30, there are modest positive relation between option and schedule variable (CS3) to be .46. There is a positive weak relation with variables cost (BIM5) to be 0.1,

and positive modest relation with performance variable (BIM7) to be 0.26, and system design (CS2) to be 0.22, resource (CS5) to be 0.20, and with Quantity (CS4) there are negative weak relation to be -0.06 and positive with Offsite Fabrication (CS6) to be 0.10.

Variables	**Pearson Correlation**	**N**
	Sig.(2tailed)	
Logistics	-.16	37
	.340	
Options	.06	35
	.726	
3D	0.35	36
	0.038	
Coordination	1.00	36
	0.038	
Cost	.10	37
	.549	
Energy	.30	37
	.076	

Performance	0.26	37
	.126	
Clash	.52	37
Detection	.001	
System Design	0.22	37
	.196	
Schedule	0.46	36
	.005	
Quantity	-0.06	37
	.731	
Resources	0.20	37
	.242	
Offsite	0.10	37
Fabrication	0.545	

Table 0.9 Correlation between variables - clash detection

Relating about project cost estimation in the design stage and according to the correlation between this variable and other variable, as the analysis shows in Table 4.9, there isn't any strong relation, but there is a positive moderate relation between this variable and system.

Design (CS2) to be 0.35. and with schedule (CS3) to be 0.32, and there is a positive modest relation with energy variable(BIM6) to be 0.27, and with performance variable (BIM7) to be 0.30, there is a positive week relation with variable clash detection (CS1) to be 0.02, and with variable resources (CS5) to be 0.7.

There is a negative weak relation between this variable and quantity variable (CS4) to be -0.05, and with Offsite Fabrication (CS6) to be -0.09.

Variables	**Pearson Correlation**	**N**
	Sig.(2tailed)	
Energy	0.27	37
	.106	
Performance	0.30	37
	.072	

Clash	0.02	37
Detection	.929	
System Design	0.26	37
	.116	
Schedule	-0.10	36
	.554	
Quantity	0.12	37
	.489	
Resources	.11	37
	.527	
Offsite	0.08	37
Fabrication	0.630	

Table 0.10 Correlation between variables-project cost

Relating about building energy distribution and consumption simulations according to the correlation between this variable and others variables, as analysis shows below in table 4.10, there isn't any very strong relation, , but there is a positive modest relation between this variable and system design (CS2) to be 0.26, and with performance variable (BIM7) to be .19.

And with variable resources (CS5) to be 0.11, also with quantity variable (CS4) to be 0.12, there is a negative week relation between this variable and with schedule (CS3) to be - 0.10, and clash detection (CS1) to be -0.10.

Variables	Pearson Correlation	N
	Sig.(2tailed)	
Performance	0.19	37
	.254	
Clash	-0.10	37
Detection	.569	
System Design	0.35	37
	.033	
Schedule	0.32	36
	.060	
Quantity	-.05	37

Variables	Pearson Correlation	N
	.751	
Resources	.07	37
	.701	
Offsite	-0.09	37
Fabrication	0.589	

Table 0.11Correlation between variables building energy distribution

Relating about buildings other performances; such as lighting, acoustics, ventilation, and air flow simulations, according to the correlation between this variable and other variables, as analysis shows below in Table 4.11, there isn't any very strong relation but there is a positive moderate relation between this variable and with schedule (CS3) to be 0.50, and with and with variable resources (CS5) to be 0.41, in addition with Offsite Fabrication (CS6) to be 0.36.

There is a positive modest relation with this variable and all of clash detection (CS1) to be 0.13, and with system design (CS2) to be 0.23, and finally with quantity variable (CS4) to be 0.29,

Variables	Pearson Correlation	N
	Sig.(2tailed)	
Clash	0.13	37
Detection	.433	
System Design	0.23	37
	.162	
Schedule	0.50	36
	.002	
Quantity	0.29	37
	.077	
Resources	.41	37
	.011	
Offsite	0.36	37
Fabrication	0.030	

Table 0.12 Correlation between variables buildings performances

When asking about checking clashes among services prior to construction the answers was in majority shows that's checking clashes performed regularly in 63% percent, with Mean 3.59 and .64 deviation according correlation between checking clashes among services prior to construction variable and others variables, as analysis shows below in table 4.12, there aren't any very strong relation, or strong one else, but there are positive modest relation between this variable and with schedule (CS3) to be 0.12, and with this variable and with variable resources (CS5) weak relation to be 0.01, in addition with Offsite Fabrication (CS6) to be 0.09, and finally with quantity variable (CS4) to be 0.09.

There is positive modest relation with this variable and with system design (CS2) to be 0.28.

Variables	**Pearson Correlation**	**N**
	Sig.(2tailed)	
System Design	0.28	37
	.097	
Schedule	0.12	36
	.470	
Quantity	0.08	37
	.619	
Resources	.01	37
	.976	
Offsite	0.09	37
Fabrication	0.592	

Table 0.13 Correlation between variables - checking clashes

About involving in any planning activity prior to construction the answers were divided to involving in change occurs in 33% percent and 38% for there aren't any involves in planning activity based on the correlation between planning activity prior to construction variable and others variables, as analysis shows below in table 4.13, there isn't any very strong relation, but there is a positive moderate relation between this variable and with schedule (CS3) to be 0.43, and with this variable and with variable resources (CS5) modest relation to be 0.29, in addition with Offsite Fabrication (CS6) to be 0.13, and finally with quantity variable (CS4) to be 0.22.

Variables	Pearson Correlation	N
	Sig.(2tailed)	
Schedule	0.43	36
	.009	
Quantity	0.22	37
	.184	
Resources	.29	37
	.081	
Offsite	0.13	37
Fabrication	0.437	

Table 0.14 Correlation between variables- planning activities

Related to simulating the master schedule involvement and the sequence of work the majority of answers didn't reflect involvement 41% percent, with Mean value equal to 2 and deviation 1.07. the correlation between this variable and the other variables is presented in Table 4.14 , there isn't any very strong relation, but there are positive moderate relation between this variable and the schedule (CS4) to be 0.37, and with this variable and with variable resources (CS5) moderate relation to be 0.56, in addition with Offsite Fabrication (CS6) to be 0.29 there are modest.

Variables	Pearson Correlation	N
	Sig.(2tailed)	
Quantity	0.37	36
	.029	
Resources	.56	36
	.000	
Offsite	0.29	36
Fabrication	0.092	

Table 0.15 Correlation between variables - simulating the master schedule

66% of the responses reflected that the quantity takes off and the estimated cost is known, while only 33% of the answer reflected that this information was not known during the construction stage about the correlation with other values according SPSS result that appears in Table 4.15, there isn't any very strong or strong relation, but there is a positive moderate relation between the quantity take off and the cost estimate during the construction stage variable and with variable resources (CS5) to be 0.53, in addition with Offsite Fabrication (CS6) to be 0.11 there are positive modest relation.

Variables	Pearson Correlation	N
	Sig.(2tailed)	
Resources	.53	36
	.001	
Offsite	0.11	36
Fabrication	0.514	

Table 0.16 Correlation between variables - integration of schedule

About involving in the integration of schedule and onsite information, to manage the storage and procurement process of project materials and equipment, most of the answers were that they weren't involved in the site resources in 69%, Mean value is 1.68 and deviation is 1.13. Related to question about producing any prefabrication components that were used in the project the results in survey were 65% percent they aren't producing any prefabrication components The Mean value is 1.76 and the deviation is 1.12.

There is a positive modest relation between integration of schedule and onsite information, to manage the storage and procurement process of project materials and equipment variable and with variable Offsite Fabrication (CS6) to be 0.22 as shown in Table 4.17.

Variables	Pearson Correlation	N
	Sig.(2tailed)	
Offsite	0.22	36
Fabrication	0.187	

Table 0.17 Correlation between variables- Offsite Fabrication

Hypothesis 1: BIM areas in UAE construction industry

According to the above information, which show all of results analysis and the correlation between variables, it's appear that there isn't wide area of using BIM in UAE construction industry related to planning and design phases. Which mean that the hypothesis was wrong and there are really demands to improve and increase the involving BIM uses in construction industry specially planning and design phase.

Hypothesis 2 Potential Factors That Could Accelerate Adoption of BIM in UAE. The descriptive analysis results have shown that there are many factors will impact the implementation BIM in UAE construction industry, about factor that's appear logistics factors is one of effected factor in BIM, to encourage and support using BIM in UAE Company must use BIM during the selection of the site office's location and the related Logistics, also doing the quantity take off and the cost estimating during the construction stage will affect logistic factor.

Finical factor has strongly affect to accelerate adoption of BIM in UAE, using BIM maybe will require more costs and expenses in the starts, at beginning you must pay to get the advantages of BIM using n construction industry.

Another factor will be affected is to increase involving in design coordination of architectural, structural, and MEP services, and involving in the integration of schedule and onsite information, to manage the storage and procurement process of project materials and equipment, that's will be working to enhance using BIM in construction industry in professional way to make change in its results.

Based on the above the hypothesis there are many potential factors that could accelerate adoption of BIM construction industry in UAE was right and these factors need to enhance in implementation in UAE market.

There are more than these factors that were not included in this survey study like economic and technological factors, which effect strongly in BIM using and implementation in UAE.

Hypothesis 3 Barriers of Implementing BIM in Local Construction Industry

Descriptive analysis reflected that one of the barriers of implementing BIM in local construction, is the lack of BIM in the architectural and structural design coordination, considering the frequency and consistency of BIM involvement.

A second barrier is BIM involvement in a 3D presentation of a complex structure to non- professionals the third barrier appeared in this research study is the involvement in project cost estimation in the design stage considering the frequency and consistency of involvement, the study shows that the most of the participants are not involved in this issue which causes barrier. Involving in building energy distribution and consumption simulations and other factors such as lighting, acoustics, ventilation, and air flow simulations, are other barriers that must be reduced or stopped, to increase the using of BIM in UAE construction industry.

Hypothesis4 Simulating the master schedule and the sequence of work will enhance *BIM implementation*

Through the descriptive analysis and all the correlations mentioned above, the results show that 41% of the participants are not involving BIM in simulating the master schedule and the sequence of work which means that more than 55% are involved yet, only 13% are involved regularly, the lack of BIM implementation in UAE can be explained by lower involvement in simulating, which supports the corrective of this hypothesis and leads a way to ensure that the simulating will reflect with better impact on BIM implementation in the construction industry.

Others Descriptive Analysis

For the category of working experience more than 15 years, most of the participants agreed that they aren't involved in many steps that must be followed to implement BIM.

The results showed that this group of respondents had limited experience in data exchange between different organizations and even these exchanges were only 2D drawing. The results also clarified that they have faced a problem in the interoperability when they tried to communicate information within the company. For the item asking about the cost "We will include the relevant cost in our bid if BIM is mandated" it was achieved by the category of 5 to 9 years working experience while majority of the category of 1 to 4 years of experience, agreed that their organization has the required framework to establish and support the implementation of BIM.

The group of respondents with less than one-year experience scored the least mean rank for all items except for the one stated "We will include the relevant cost in our bid if BIM is mandated" which have also recorded high score by the group of respondents with 10 to 15 years of experience.

Chapter Five

Discussions and Conclusions

5.1 Conclusion

5.1.1 Chapter Overview

This chapters aims to summarize the study and present the final findings. In the summary the main purpose and the four-main hypotheses that were suggested at the beginning of the research are related to the methodology, results and the conclusion. The main findings that are presented include the current understanding of the BIM concept in the UAE, and the implications and recommendations of this research study.

5.1.2 Summary of study

The aim of the research is to examine the current practice of BIM implementation in UAE construction industry and assesses how different practices alter their effectiveness. And to expose the fact that the BIM technology is principally employed as a visualization tool and how it is implemented is significantly associated with project characteristics. (Cao et al., 2015)

In view of a possible gab between technical feasibility and practical adaption this research is trying to highlight the current problems and the suggested solution with reference to the clients and users of the systems.
According to the study results and finding which shows that the current practice of BIM implementation in UAE construction industry is not strong and need improvement in many section like cost estimation accord BIM requirements, Selection of the site office’s location considering BIM, and design coordination of architectural, structural, and MEP services and many other section.

In addition, the construction industry need to reduce the gap between technical issue and practical adoption, company must involve the BIM team more and regularly in cost estimation or in building energy distribution and consumption simulations and other performance simulation such as lighting, acoustics, ventilation, and air flow or involving more in simulating the master schedule and the sequence of work.

This study concluded that BIM is used in limited areas, there aren't wide using in planning or design phases (hypothesis 1), there is a lack of using BIM especially in contractors' segment which creates the majority of our study sample. There are many potential factors that could accelerate adoption of implementation BIM in construction industry in UAE such as economic factor, financial and social one.

The company, contractors and consultant should contribute and encourage BIM implementation according believing and patient in the benefit and outcome will return to their works and projects, they must touch the difference between implementing BIM and the projects before that step. In addition, decision maker before working to approve on pay and make investment need to know well the return of investment and the revenue of this investment, government and economic society must working to support and encourage the BIM Implementation by providing facilities and performing awareness and feasibility studies.

Related to Barriers of Implementing BIM in UAE Construction Industry (hypothesis 3) are summarized in lack of coordination between companies and contractors and consultant and the lack of involving the team in necessary procedures and phase which will reflect with many of mistakes and defects in work, which will reduce the interest of parties to implement BIM in local construction industry.

To ensure a good implementing of BIM in UAE construction industry all required procedures to this step should be gathered made available and valid, also ensuring that performed continues and be as a part of the work. Simulating the master schedule and the sequence of work will enhance BIM implementation (Hypothesis 4)

According the results in this study which shows that there is a high involvement in simulating the master schedule and the sequence of work but not in regular times, the lack of implement BIM in UAE is caused due to low involvement in simulating, which support the corrective of this hypothesis and lead way to ensure that the simulating will reflect with better impact to implement BIM in construction industry. The results of this research study imply significant changes to the current practices throughout all the stages of the construction projects. The main finding emphasizes the importance of the design stage which would require raising the level of the design professionals and stimulate their commitment to produce efficient designs that would reduce the waste throughout project stages. Accordingly, professional development for the designers is an essential requirement to improve their design capabilities.

Collaboration between various professions involved in the design process is required for approximately 237 design mangers. They are required to improve their skills in the fundamental design task in addition to the adequate information related to the project operations including the ability to predict the materials required and designing out wastes.

The main goal of the designers should be to align the construction design with the standard material provided. Particularly, this is a key factor required for the projects that do not need materials that are previously manufactured.

The results of this study reflected weak collaboration between project organizations and the disconnection between the project stages. The results imply the importance of the involvement all the stakeholders in the design stage.

The use of BIM to apply the integrated design process and achieve collaboration between different involved professions would develop the construction industry and minimize the waste through design processes. Attention should be given to the procurement plans and policies to minimize the construction wastes.

Although the suppliers are not considered internal stakeholders of any project, consideration to their role and better communication with them have an essential impact on minimizing waste. This is promoted when they provide the materials pre-cut, appropriate and classified materials.

This agreement with the suppliers would involve two processes that were proved to prevent material waste the back scheme and JIT delivery. One of the major findings of this research is related to the use of the prefabricated material. Following this method is known to reduce the waste products in the constructions. The finding of this research study also revealed that the use of this construction technique would reduce a significant amount of the produced waste.

The prefabricated materials warrantee that raw material is produced offsite and assembled in the site. This would prevent waste-inducing practices such as offcuts. However, Chen et al, (2010) clarified that the prefabrication techniques are expensive and cannot be implemented in all projects. An alternative option would be the application of collaboration with suppliers through the procurement route.

The results of this study suggest that further communication with the suppliers and better system to share information with all stakeholders can help minimize waste generation. Utilization of this system will also ensure that all professions participate to decrease wastes and efficiently use time and money to produce projects with competent quality.

5.1.3 The BIM concept

The Building Information Modelling has many advantages over the traditional 2D technology. An improved collaborative work process can be accomplished when better information in construction is achieved. Through these procedures the work in AEC-project will be streamlined and accordingly enhance productivity.

Productivity development is not the only outcome after BIM implementation at the project level, but also the use of BIM at a smaller scale by each worker involved in the project would achieve many other smaller benefits.

The implementation of BIM should not be a goal by itself. On the contrary, the use of this technology should promote valuable difference in the project procedures to make them well organized and effective. Consequently, the companies should determine the main goal behind using this valuable tool, before starting to plan how to use this technology. Many challenges hinder the appropriate adoption of BIM, each challenge cannot be treated in isolation of the others to encourage broader scale of BIM adoption. That would promote a significant change in the construction industry and cause huge consequences on the projects' design and implementation. The number of projects that adopted this computer technology is still limited (59). Therefore, more work is to be done in order to identify how these new processes affect the industry business models.

Technical support requirement is considered a challenge that must be addressed before the BIM adoption. Another big challenge that must be dealt with is the workers readiness. Professional Development for all staff members who will use this technology is required. BIM application will cause significant changes in the roles and responsibilities of different individuals working together in a project.

5.3 Implications and recommendations

The results in this research study have emphasized the findings in the previous papers regarding the identification of the challenges that are expected after BIM adoption.

Hence, the government can use the research results related to challenges that hinder BIM adoption as an outline to draft a policy to promote it. For instance, the implementation of the BIM in other countries provided good examples on the benefits that are expected, which can be the benchmarks used to introduce BIM strongly in the local industry.

The results of this research study have some implications on the academic research body. Researchers can develop policies and outlines to introduce BIM in the local constructional industry. They can align their policies with the International Alliance for Interoperability (IAI) standards.

There is a lack in implement BIM in construction phase like planning, design and also in executive phase, the results show that every variable has independent behaviour and results which mean we need to create integration in al construction phase as initialized implementation of BIM in construction industry.

In we need to perform awareness for all clients, contractors and consultant to shows and explain why we need to implement BIM in UAE construction industry, what are the advantages and results for this step, how we will manage this implementation to reduce as we can the added expenses which required to implement BIM, and how it will return to construction industry with benefits and profit.

5.4 Limitations of the study

Limitations such as distribution of respondents in the questionnaire had to be taken into consideration the primary tool for data collection was the questionnaire, which gave sound realistic results. Although the number of respondents was 37, the results were accurate, and the readability factor was accepted. However, this is considered as a limitation, since generalizations are more possible with greater numbers.

The unbalanced distribution of respondents that focused on the contractors rather than clients will make the result and analysis of this research bias towards their opinion thus, the result of the comparison will become unfair or inaccurate. For instance,

having only two participants form the engineering firms make the results of this part weak as the minimal number required for chi-square is 5. Moreover, respondents needed to be balanced between top and middle level management, as they are the group that has a clear understanding of the BIM implementation, the innovation effects and the operation of an organization, In addition to their experience.
There is other limitation related to the respond survey company type, there aren’t any respond from client, the respond come from consultant company just three responds, which may cause bias in results and study finding.

In this industry also will make their answer or point of view more reliable and thus the analysis also. The limitations of this study include the relatively small number of participants, as the operators’ questionnaire was sent to 50 operators, yet only 37 responded, and only.

5.5 Recommendations for Further Research Study

- Building Information Modelling is continuously developing as it is related to the nonstop developing technology. This study recommends the following areas for future research.
- After the challenges identification there should be studies to propose alternatives with less barriers.
- Investigation of the differences between the projects that are BIM based and other projects that do not adopt this technology.
- Undertake the same research addressing the middle and top mangers’ insights on the BIM.
- Improve an appropriate model to solve the problem related to the ability to run different BIM applications together in the local construction industry.

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Appendix 1

Dear participants,

Thank you for your contribution in this research study. Please note that this questionnaire will be used only for the academic research purpose, the information will be kept confidential and anonymous.

This questionnaire will require about 10-15 minutes to be completed. It includes two main sections the demographic information and questions related to your experience in BMI applications in the design stage and in the construction stage.

Demographic Information

Position	Senior Mechanical Engineer
Gender	• Male • Female
Experience	• 1-4 years • 5-9 years • 10-15 years
Company Type	• Client • Contractor • Consultant

BIM application areas in design and construction stages

Design Stage:

Design stage	Application area	Description	Choice
1	Selection of the site office's location	Was BIM used during the selection of the site office's location and the related Logistics?	• Never Used. • Partially used. • Fully used including
2	Design Options	How many Models were prepared for the same Project?	• One Model only. • Two Models were compared. • Three Models were compared.
3	3D Presentations	Were you involved in a 3D presentation of a complex structure to non-professionals? If yes, how	• No. • Yes, one time. • Yes, more than 3 times
4	Design coordination	Were you involved in the design coordination of architectural, structural, and MEP services?	• Never. • Yes, once in the beginning of the design stage. • When any change
5	Cost estimate	Were you involved in project cost estimation in the design stage?	• Never. • Yes, once in the beginning of the design stage. • When any change
6	Energy simulations	Were you involved in building energy distribution and consumption simulations?	• Never. • Yes, once in the beginning of the design. • When any change

7	Other performance simulations	Were you involved in buildings other performances; such as: Lighting, acoustics, ventilation, and air flow	• Never. • Yes, once in the beginning of the design. • When any change

Construction stage:

Construction stage	Application area	Description	Choice
1	Clash detection	How often do you check clashes among services prior to construction?	• Never. • Yes, once in the beginning of the construction stage.
2	Construction system design	Were you involved in any planning activity prior to construction?	• Never. • Yes, once in the beginning of the construction stage.
3	Schedule simulation	Were you involved in simulating the master schedule and the sequence of work?	• Never. • Yes, once in the beginning of the construction stage.
4	Quantity take off	Did you do the quantity take off and the cost estimate during the construction stage?	• Never. • Yes, once in the beginning of the construction stage.

5	Site resources	Were you involved in the integration of schedule and onsite information, to manage the storage and procurement process	• Never • Yes, once in the beginning of the construction • When any
6	Offsite fabrication	Did you produce any prefabrication components that were used in the project?	• Never • Yes, once in the beginning of the construction • When any