Barriers to Utilize Building Information Modeling (BIM) in the Construction Industry of Saudi Arabia

BY

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DEDICATION

This research is dedicated to:

My parents and all my family members

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All praise and thanks to Almighty Allah who guided me and gave me the knowledge to complete this work, and peace and blessings be upon our Prophet Muhammad, his family and his companions.

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ABSTRACT

Full Name : Mohammed Ahmed Abdullah Al-Gahzari

Thesis Title : Barriers to Utilize Building Information Modeling (BIM) in the Construction Industry of Saudi Arabia

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Building information modeling (BIM) is the 3D visualization of the physical characteristic and detailed information of the building components in one system, which can be accessed by all participants of construction projects in all phases of the project's life cycle. Despite the huge development of the building construction industry in Saudi Arabia, and the benefits of using BIM in construction management and the use of this system in many developed countries, BIM technology is not utilized in Saudi construction industry. Therefore, the objectives of this study is to review the stakeholders' understanding of the benefits of the BIM in the whole construction project life cycle and to identify the major barriers to utilize BIM in Saudi Construction Industry. An intensive literature review on the BIM benefits and barriers was carried out followed by Delphi multiple rounds questionnaire distributed through the experts in this field to achieve the objectives of this research. For the first objective, the study concluded that the stakeholders have the same understanding and agreement on the benefits of using BIM throughout the construction projects' lifecycle. For the second and main objective, the study found that there are 15 major barriers to utilize BIM in Saudi Arabia. These barriers are distributed between culture, new technology, new process, and policy and legal barriers, and the majority of these barriers was related to the new technology barriers.

ملخص الرسالة

الاسم الكامل: محمد أحمد عبدالله الجحزري
عنوان الرسالة: عوائق الإستفادة من نمذجة معلومات البناء في صناعة التشييد في المملكة العربية السعودية
التخصص: هندسة وإدارة التشييد
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نمذجة معلومات البناء هي عبارة عن التمثيل ثلاثي الابعاد للخصائص الفيزيائية لمكونات وعناصر البناء متضمنة المعلومات الدقيقة الخاصة بها مجموعة في نظام واحد يمكن الوصول إليه من قبل جميع المشاركين في مشروع البناء في مراحل مختلفة من دورة حياة المشروع. بالرغم من التطور الكبير في صناعة التشييد بالمملكة العربية السعودية، وأيضا بالرغم من الفوائد الكثيرة من نمذجة معلومات البناء واستخدامها في كثير من البلدان المتقدمة، الا انه لا يتم الاستفادة من هذه التكنولوجيا في صناعة التشييد في المملكة العربية السعودية. ولذلك، فإن أهداف هذه الدراسة هي استعراض فهم أصحاب المصلحة من فوائد نمذجة معلومات البناء في دورة حياة مشروع البناء بأكمله وتحديد العوائق الكبرى للاستفادة من هذه التكنولوجيا. لبلوغ اهداف هذه الدراسة، تم اجراء مراجعة أدبية شاملة للدراسات السابقة المتعلقة بفوائد نمذجة معلومات البناء والعوائق التي تحول دون استغلال هذه التكنولوجيا، تُبعت هذه المراجعة الأدبية بإجراء استطلاع متعدد الدورات يسمى (اسلوب دلفي) تم توزيعه على الخبراء في هذا المجال. بالنسبة للهدف الأول فإن الدراسة استخلصت أن هناك فهم عام وموافقة جماعية من قِبل المشاركين في الدراسة فيما يتعلق بفوائد نمذجة معلومات البناء في شتى مراحل التشييد, أما فيما يتعلق بالهدف الثاني والرئيسي فإن هذه الدراسة وجدت أن هناك خمسة عشر عائقاً يحول دون الإستفادة من نمذجة معلومات البناء في صناعة التشييد في المملكة العربية السعودية موزعة بين عوائق ثقافية, وعوائق للتكنولوجيا الجديدة و طريقة العمل التي تتطلبها هذه التكنولوجيا والتي وجد أنهما تمثلان القدر الكبير من عوائق نمذجة معلومات البناء , وأيضا العوائق المتعلقة بسياسة الشركات والأمور القانونية.

CHAPTER 1

INTRODUCTION

1.1 Background

Construction industry is a complex field consisting of several tasks with different participants such as owners, contractors, sub-contractors, and designers and the communication among these parties is essential for the success of any construction project (Cheng et al. 2001). Currently, the delivery of most construction projects is still fragmented depending on the paper-based type of communication between parties. Important details that could be omitted in paper documents may result in delays and more effort and time to estimate the errors in the design, and eventually this increases the cost of the project and results in delays on the delivery. There are many real time technologies that can be implemented to reduce the frequency of errors and conflicts in the design and construction processes such as the sharing of information through the web-site and the use of 3D CAD tools (Eastman et al. 2011). One of the most effective communication and collaboration tools that enhance the integration between the different project parties to achieve an error free design is the building information modeling (BIM).

BIM has become a well-known recognized collaboration process in the construction industries of many developed countries around the world. This new technology improves the communication among all the participants in the project through the collaborative work it offers.

It is being widely used in the whole project life cycle; from planning and scheduling phase, passing through the design and cost estimating phase to the construction phase.

BIM is also used at the post occupancy phase in the operating and management of the facility. Adding 4D "schedule" and 5D "estimating" to the 2D and 3D model in a BIM project will create an environment that enhances the profitability for the construction organizations. This profit is achieved by the early detection of the design errors and clashes that are discovered at the construction phase. Because of that, the change orders will be reduced and known even before the start of the construction. Hence, the cost of changes is eliminated and the completion time is reduced.

1.2 Statement of the problem

As the construction industry is a complex field consisting of several tasks with different participants working toward finishing their tasks, the construction process involve the exchange of information among the participants to complete their work. Therefore, a huge number of data are created from these various sources of information throughout the project stages from the conceptual and feasibility phase to the facility management phase. This huge amount of information and documentation results in miscommunication and errors if they are not well arranged and managed. These problems of miscommunication and errors in the documentation of the projects cause the fragmentation nature to the construction industry resulting in project delivery delays, cost overrun and poor quality. The need of an integrated system of whole project information is very essential at the time of large-scale project with huge number of multidisciplinary information documentations. Building information modeling system is one of the solutions to overcome the miscommunication and errors generated in the construction industry.

The Building Information Modeling is implemented in many developed countries all over the world due to its large benefits in the collaborative construction and management industry. It became a field of study in different universities in the world (Barison and Santos 2010, Clevenger et al. 2010, Sabongi 2009). In Saudi Arabia, the concept of BIM is not taken seriously into consideration. Hence, in Saudi Arabia the use of this technique "BIM" in construction and management industries does not exist, this is because of many factors such as: insufficient knowledge of the benefits of BIM , "Resist to change" from traditional methods of managing construction. Barriers and Obstacles that prevent the spread and implementing of the BIM in Saudi construction industry.

1.3 Research Questions

It was relevant to ask some questions, which make up the basic research questions that this study attempts to provide answers to:

1- How are the construction companies aware of the advantages and benefits of using building information modeling (BIM)?

2- What are the barriers that prevent the adoption of BIM in Saudi Arabia?

1.4 Research Objectives

The main objectives of this study were:

1- To review the stakeholders' understanding of the benefits of the BIM in the whole construction project life cycle.

2- To identify the major barriers to utilize BIM in Saudi Construction Industry.

1.5 Significance of the study

The Saudi Construction Industry is fragmented as other construction industries in the world and it needs a change in the way that the participants in any project communicate their information with modern techniques of exchanging information. The use of such technique as building information modeling in Saudi construction Industry will enhance the delivery of projects by reducing the time needed by the participants to complete the design at the initial stage of the project and improving the construction monitoring. In addition, the facility management will be enhanced if BIM is utilized in this phase. Despite the many benefits of utilizing BIM in the construction industry, there are no researches regarding the application of BIM in Saudi Arabia, and as a result of that, this technology virtually does not exist and applied, except for a few of the major companies in the region

Research in this area will:

1 - Reveal the obstacles and major barriers that prevent the utilization and application of the BIM in the Kingdom

2 - Provide an integrated vision for what is the BIM and what are its benefits in the modern construction and engineering management.

1.6 Scope and Limitations

Literature survey revealed that there are no studies focusing in the barriers of implementation of BIM in Saudi Construction industry. Accordingly, the scope of this study will be limited to investigate the barriers and challenges that prevent and delay the use of BIM in the construction industry of the Kingdom of Saudi Arabia. It will also review the stakeholders' understanding of the benefits gained from the use of BIM in the whole life of the construction project. The study will be limited to three types of organizations such as owners, contractors with grades 1, 2, and 3, and construction consulting organizations. The study will be limited to the above three types of participants located in the Eastern Provence of the Kingdom of Saudi Arabia , and the results gained from the participant's answers could be applicable to the whole AEC industry in the Kingdom of Saudi Arabia due to the similarity of the nature and culture of AEC industry throughout the Kingdom.

1.7 Thesis Organization

This study is into five chapters as described below:

Chapter 1: introduction and background about the study, Statement of the Problem, Research Questions, objective of study, the reason why this study is performed, significance of conducting this research, and the scope and limitations.

Chapter 2: literature review that involves searching the literature about the concept of BIM, its usage and benefits in different phases of the project lifecycle, introducing some successful applications of BIM worldwide, and present the barriers preventing the adoption of BIM in the construction industry

Chapter 3: Research methodology describes how the objectives of the study will be acquired.

Chapter 4: Data analysis and discussion of the results obtained from the questionnaire.

Chapter 5: Conclusions and recommendations of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the existing literatures related to the Building Information Modeling. The review is partitioned into four parts. The first part briefly discusses the definition of BIM. The second part reviews the literatures focusing on the Benefits and uses of BIM in project's lifecycle. The third part reviews the literatures focusing on the barriers of using BIM in the construction industry. The fourth and last part presents an example of successful application of BIM and the strategy used to overcome the BIM barriers.

2.2 Building Information Modeling (BIM)

The development of information technology and digital age has been serving the construction industry since four decades. One of the innovative tools, which served the construction industry, is the computer-aided design (CAD) which facilitates the work for architects and engineers. The new generation of these CAD solutions is the new technology of the integrated building information modeling

2.2.1 What is BIM?

BIM is the term used to describe a process used by architects, engineers, owners and contractors to coordinate information between disciplines in a 3-dimensional environment or 3D accurate model with detailed information and building attributes

According to the BIM handbook, BIM is defined as *"a modeling technology and associated set of processes to produce, communicate, and analyze building models. Building models are characterized by*:

- ***Building components** that are represented with digital representations (objects) that carry computable graphic and data attributes that identify them to software applications, as well as parametric rules that allow them to be manipulated in an intelligent fashion.*
- ***Components that include data that describe how they behave**, as needed for analyses and work processes, for example, takeoff, specification, and energy analysis.*
- ***Consistent and non-redundant data** such that changes to component data are represented in all views of the component and the assemblies of which it is a part.*
- ***Coordinated data** such that all views of a model are represented in a coordinated way.(Eastman et al. 2011)".*

There are several definitions with different perspective of BIM technology. Some define it as a tool; others define it as a process. As there is no exact definition of BIM and it was found that "*For some, BIM is a software application; for others it is a process for designing and documenting building information; for others it is a whole new approach to practice and advancing the profession which requires the implementation of new policies, contracts and relationships amongst project stakeholders*" (Aranda-Mena et al. 2009).

Other definitions are taken from the organizations that practiced BIM in their construction project and they are considered as leading organizations in the field of BIM. One of the organizations is The General Services Administration (GSA) that defined BIM as:

"*Building Information Modeling is the development and use of a multi-faceted computer software data model to not only document a building design, but to simulate the construction and operation of a new capital facility or a recapitalized (modernized) facility. The resulting Building Information Model is a data-rich, object-based, intelligent and parametric digital representation of the facility, from which views appropriate to various users' needs can be extracted and analyzed to generate feedback and improvement of the facility design* (GSA, 2007, p3)".

The National Building Information Modeling Standard Project Committee defines BIM as: "*Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition (NBIMS 2007)*".

Lee et al (2006) defines BIM as "*a process of generating and managing, building information in an interoperable and reusable way*"; and the system of BIM could be defined as "*as a system or a set of systems that enables users to integrate and reuse building information and domain knowledge through the lifecycle of a building* (Lee, Sacks, and Eastman 2006)."

In this thesis, BIM is defined as the 3D visualization of the physical characteristic and detailed information of the building components in one system, which can be accessed by all participants of construction projects in different project phases.

2.2.2 **Benefits and Uses of BIM in Construction Project Phases**

The important benefit of BIM is its precise geometrical illustration of the building elements in an integrated data model (Azhar 2011). Building information modelling (BIM) is used throughout the lifecycle of the construction projects from the planning and designing (preconstruction phase) passing through the construction phase and arriving to the operating and management phase of the built facility as described in details in the following sections and shown in the figure below

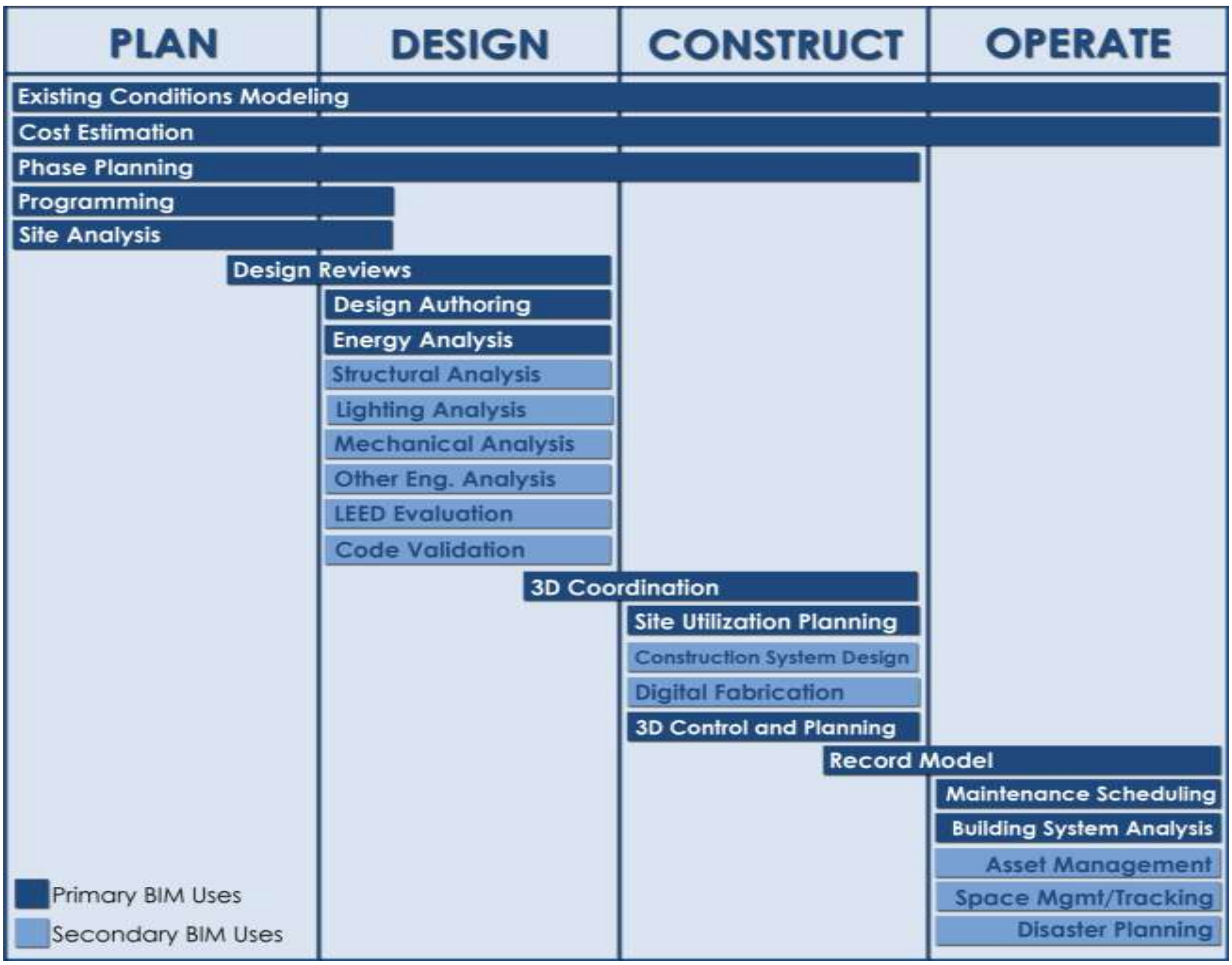

Figure 2.1: Uses of BIM in Construction Projects

2.2.2.1 Pre-construction phase

At the preconstruction phase of the project lifecycle, the BIM has its maximum value since its influence to reduce the cost is higher than in the other phases.

BIM improves the collaboration among all project participants including architect, engineers, contractors, construction managers, and owners. Every participant involved in the project can help in reducing the cost of the project at this initial phase (Hergunsel 2011).

Before the start of a detailed design of any construction project, it is very important that the owners should determine whether the building with its size, level of quality could be built within their budget and required time. Clear answers to these questions will significantly help the owners in their expectations regarding the success or failure of their investments. Discovering that the actual design is not feasible after a long time, money and effort have been spent is inefficient and uneconomical. So by building an approximate model of the exact building linked to a cost of material data-base can give the owners, designers and contractors a preliminary feasibility clarification of that particular building (Eastman et al. 2011).

According to (Li et al. 2009) there are two main reasons for the application of BIM in preconstruction phase. Firstly, it allows the construction planners to view their static realistic images of the projects that will be built and check if there are design errors and clashes by using the information included in the three dimensional model. Secondly, BIM is used to simulate the sequencing of the construction activities.

The virtual design developed by the building information model facilitates the study of alternatives of design. “What if” scenarios can be easily modeled and compared. Also the capability to produce early visualization of the design proposals of the project is improved by the better communication between the project team members to achieve the desired requirements (Kymmell 2008). With the 3D/4D models the project team can efficiently communicate their knowledge in the design, construction sequencing, and scheduling during the constructability review process (Hartmann and Fischer 2007).

The development of virtual 3D project model consists of several work by multiple team members, such as structural, MEP (mechanical, electrical, and plumping), and FP (fire protection) teams. Every team generates the models that are under their responsibility in the project, and then these individual models can be combined together to gain more completed model of the project. The combined model is checked if there are conflicts between the models and this process is called “clash detection”(Kymmell 2008). Building information models allow different function information to be interchanged within one integrated digital building information model (Cheng and Ma 2013).

Another huge benefit of using BIM in the preconstruction phase of the project is the using of building information model in the cost estimation. The traditional cost estimating process involves the quantity takeoff (QTO) and then determine the dimensions of all elements of the building by using drawing either hard copy or from CAD drawings and compile these quantities in the list of QTO. This manual process requires the cost estimator to spend a long time to complete the takeoff of the entire project especially in huge projects and the errors largely affect the quality of the quantity takeoff. Because of the time spent in the traditional manual calculations of the quantities, the cost estimation may be available after the completion of the design phase, which is undesirable situation. If the designed project is over the budget of the owner, there will be only two options: either to cancel the whole project, or applying the value engineering to cut cost and manipulate the quality (Eastman et al. 2011).

2.2.2.2 Construction phase

Building information modeling (BIM) process is used to improve the quality of construction schedule by integrating the visual representation of the building with the schedule information. This combination between the schedule information and the 3D visual representation of the construction schedule helps in improving the communication between the project staff. This enhanced communication facilitates the brain-storming to come up with a clear feedback to the project team, then recognizing the most suitable and effective construction strategies to shorten the project duration, adjust the resource allocation, check the workability of these strategies and judge the schedule quality (Russell et al. 2009).

The building information models can help in the simulation of construction processes, effectively catch the design and construction information and knowledge, and use this database as a background to be used in the future construction projects (Li et al. 2008). The coordination of material orders, fabrications, and the delivery schedules of the building parts can be easily achieved by using the building information models (Azhar 2011)

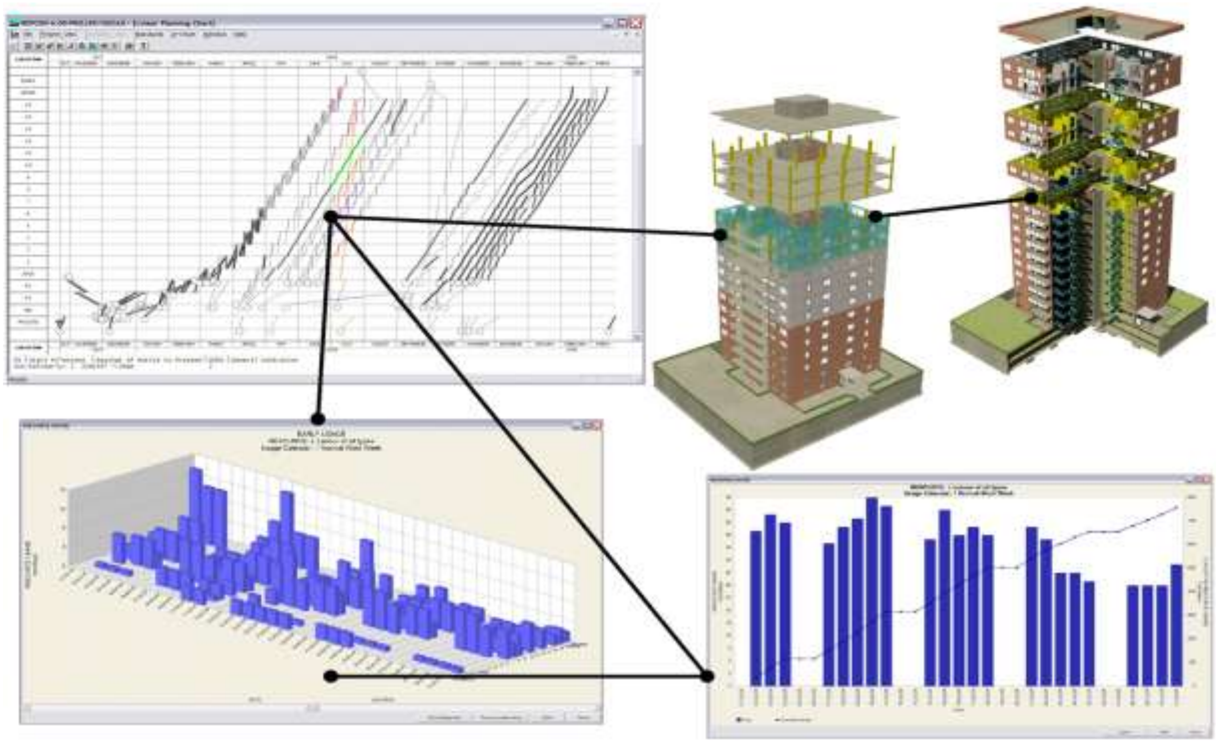

Figure 2.2: Benefits and Uses of BIM in Construction Project Phase

By using building information modeling, it is easy to simulate the whole construction processes and show the status of the building and the surrounding space at any point of a time (Li et al. 2008). This is achieved by linking the 3D model of the design with the construction plan to get a 4D CAD simulation. This graphical simulation provides a clear and improved vision about how the building will be built with a possibility of day-by-day simulation of the progress of the work, discovers the omitted problems that can be faced by project participants and give them the opportunity to improve the space allocation of the crew, equipment, and materials to avoid space conflicts and insure safety (Eastman et al. 2011).

The site space planning and management are very essential steps in construction phase of any project. Ma et al. (2005) presented “4D Integrated Site Planning System (4D-ISPS)” which merge 3D model, schedule, resources, and site space in a unified 4dimensional CAD system to provide graphically better visualization of the construction space and layout. This helps to improve the management of resources, labor, machines running in the project space and enhances the construction progress visualization (Ma, Shen, and Zhang 2005).

The visualization of the building fabrications can be extracted from BIM if the model is detailed to the level of fabrication (shop model). The components can be fabricated automatically by using numerical control machinery. This benefit from BIM facilitates the offsite fabrication of building components like precast, fenestration, and glass fabrication, and shorten the construction time with cost minimization (Eastman et al. 2011).

2.2.2.3 Post-construction phase

The use of building information models BIM in the post-construction phase is one of the BIM benefits to the owners through the improved handover of the facility information. At the construction phase of the project, the contractors (general and MEP contractors) gather all the information about materials and equipment that they have installed and the maintenance information for the systems in the building. This information when linked to building model will be ready for the owner to use it in the facility management systems (Eastman et al. 2011).

In the Post-construction phase of the building lifecycle, BIM provide the 6D sustainability services and 7D Facility Management & Asset Management, by the availability of the synchronous information on the use of the building, its components, and renovation schedules (Desai 2013).

The building information model provides the owners with all the required kinds of information including (drawings and specifications) describing all the installed systems in their building. In addition, the previous analysis of the control systems, mechanical equipment, and other purchases can be delivered to the owners after the construction finished, to check that all the installed systems are working as they were designed for, and to verify the design decisions (Eastman et al. 2011).

In the traditional practice of conducting facility management (FM) activities, the facility managers usually use index sheet to look for a specific detail. When this practice is conducted for a complex building with a mass of drawings, it becomes a time-consuming and tedious work. In addition, the traditional FM systems are having a number of disadvantages: like the independency of their software platforms, software Interface is not intuitive, and the data is scattered.

The building information model improves the efficiency of practice of FM by its incredible visualization and simplicity, and the extensibility feature of BIM and FM system database. The decision for the next similar building can be easily supported by basic data that is provided by the data accumulation and the system platform, and it also rises innovative solutions on how to utilize the information technology in O&M in the future (Wang et al. 2013).

BIM is integrated with the facility O&M systems. The building information model that has been updated throughout the construction phase of the project will provide an accurate database containing the as-built systems and spaces, which create a start point to operate, manage, and operate the building (Eastman et al. 2011). Table 2.1 is a summary of the BIM benefits throughout the project lifecycle that were described before.

Table 2.1: Summary of the BIM Benefits throughout the Project Lifecycle

Pre-Construction Phase Benefits
improving the communication and collaboration among all project participants
Making fast and accurate cost estimation
Showing the realistic image of the project in virtual environment
Simulating the sequencing of the construction activities before the start
Facilitating the study of alternatives of design
Allowing different participants of the project to share and exchange data within one integrated 3D model
Detecting clashes and design errors with lesser time
Construction Phase Benefits
Improving the quality of construction schedule by integrating the visual representation of the building with the schedule information
Simulating the whole construction processes and show the status of the building and the surrounding space at any point of a time
Improving the management of resources, labor, machines running in the project space
Reducing rework
Improving construction productivity
Post-Construction Phase Benefits
BIM provides an accurate database containing the as-built systems and specifications, which create a start point to operate and manage the building properly
The integration between BIM and building management systems will significantly improve the operation and maintenance of building
The decision for the next similar building can be easily supported by basic data that is provided by the data accumulation

2.3 Barriers to Utilize BIM in the Construction industry

2.3.1 Introduction

The economic benefits of using the building information modeling and its productivity improvements to the construction industry are broadly agreed and gradually well agreed by the key players in the industry. In addition, the technology to apply the BIM is available. However, the adoption of the BIM is much slower than what it has been expected (Azhar 2011).

This new technology of doing business is facing significant barriers and challenges because of the displacement of the traditional established working process, and this change in process necessitates that many aspects of industry's business should be changed. It requires a clear technological understanding and studies implementation plans before the transformation can start (Eastman et al. 2011). Therefore, the meaning of BIM changes is in the way of working process, the information usage, and the project organization and staff requirements (Rundell 2005).

Although BIM has been famous as (AEC) industry transformer, several AEC companies are still careful about the adoption of BIM in the organization, generally because of the barriers faced by these companies in terms of standards, training, and investment on software. Some barriers and challenges are related to the organization's size. For example, the big organizations with larger cash flow and resources, are willing to invest on the new technology and innovative working processes more than the smaller organizations (Partridge et al. 2007).

Numerous potential barriers and obstacles can prevent the utilization of BIM benefits in the AEC industry. These barriers to use BIM can be classified as follow

2.3.2 Cultural Barriers

For any new technology comes to our hands, there are several barriers and factors preventing the use of it. One of the most significant factors that is considered as potential barrier to the adoption of new information technology is culture (Hasan and Ditsa 1999). From psychological point of view, it is the character of humans to initially resist any changes that may disturb the usual way of their living or working for a long time, and this resistance to change arise because of many factors such as “mental rigidity”, “reaction to the mandatory change”, “routine seeking”, and “short-term thinking" (Hetland and Saksvik 2009, Oreg 2003). The potential changes in the cultural way and processes of construction that have been considered as a regular practice for a long time in the AEC industry are the most considerable barriers that preventing the use of the new BIM technology (Hartmann and Fischer 2008). One of the most significant barriers to implement new technology, especially BIM technology in a construction organization is the cultural transition in making senior design group leaders who represent the success of any construction firm to accept new practices offered by BIM technology, and to attract them to realize the new capabilities of BIM when used in parallel with their own experience (Aranda-Mena et al. 2009, Eastman et al. 2011). The unawareness of the benefits and capabilities of BIM and the lack of knowledge and training creates the perception that BIM is not beneficial to the construction industry and limits the availability of skilled staff.(Al Mohannadi et al. 2013, Gilligan and Kunz 2007).

Furthermore, the lack of request from owners to use BIM is a primary reason in not using BIM technology (Gilligan and Kunz 2007).

2.3.3 New Technology Barriers

The complete utilization of the building information modeling technology requires the interoperability among the various BIM applications used by the construction project participants. The interoperability of the various BIM software applications can accelerate the adoption of using BIM technology (Eastman et al. 2011). Interoperability means the ability of the different AEC experts to exchange their data among different BIM applications and share in their contribution to the processes of design and construction (Eastman et al. 2011). The interoperability between the BIM applications allows for smooth and seamless exchange of data between the AEC participants in order to avoid the re-input of data by other project participants which is a waste of time and effort (Fox and Hietanen 2007). Many researchers have suggested solutions to the fragmentation and absence of integration between the BIM software programs, including the use of one particular proprietary BIM application to be used within the entire construction project participants to enhance the smoothness of exchanging data through different applications (Tse, Wong, and Wong 2005). Another solution to the problem is the using of the such open standards as Industry Foundation Classes (IFC) that help the data exchange formats among various BIM applications by exporting a neutral model generated on the base of an open standard, which then can be imported by other BIM applications (Howard and Björk 2008). These and other innovative solutions provide solution keys to overcome the problem, but as the time passes, new software applications are developed by different developers, and the number of users and participants increases, so there are still many problems regarding the sharing and exchange of data among the projects participants (Eastman et al. 2011). Therefore, the lack of interoperability between the BIM software applications is one of the most significant barriers preventing the application of BIM technology (Ashcraft 2008, Fox and Hietanen 2007).

The use BIM technology as delivery project process has many technology implications that should be considered by the organizations intending to implement BIM, such as the software and hardware limitations, the implementation of the new technologies (e.g. geographical information system GIS, laser scanning, web portals), interoperability, handling of very large model file sizes, and techniques for exchanging the information (Mitchell and Parken 2009). The spread of BIM could be prevented by the absence of some essential technical capacities required by its applications, because the large file size of the BIM models requires a high-speed internet to easily exchange information and BIM data between the various participants in the organization and project stakeholders (Williams 2007). Despite the cost saving which can be achieved by the BIM technology, cost of technology represents a major barrier to the spread of this innovative technology due to its requirements (Gilligan and Kunz 2007, Kunz and Fischer 2005).

The complexity of the BIM software familiarity and the need for training are considered as primary barriers to implement the new innovative technology (Al-Mannai 2011, Eastman et al. 2011, Gilligan and Kunz 2007, Kunz and Fischer 2005).

2.3.4 New Process Barriers

The Architecture/Engineering/construction AEC is fragmented by the fact that engineers work independently in their specific disciplines with boundaries and little communication between them, and the results of their work are combined and presented to the company. The following figure shows the comparison between the current fragmented processes implemented in construction industries and the more collaborative and shared model process proposed by BIM.

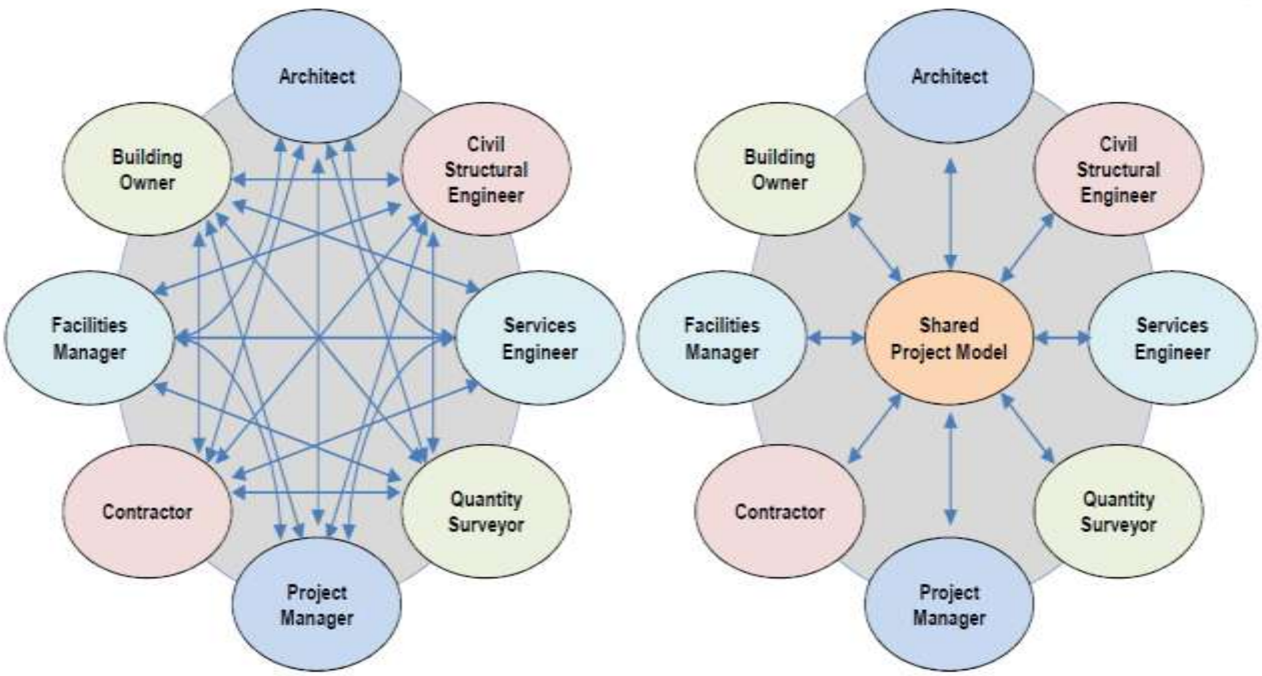

Figure 2.3: Fragmented Process VS Shared Project Model of BIM

The process change from this fragmented system of working between different disciplines to the more collaborative and systematic process offered by BIM is considered as a barrier to the adoption of this innovation, and it needs to be integrated incrementally in small steps (Hartmann and Fischer 2008). Even though, the construction industry has relied for a long time on the old fragmented approaches of delivering the projects, and BIM technology calls for enhanced collaboration and communication between project participants, it was observed that, as a result of the significant changes caused by BIM to the AEC industry, it may create a field of opportunities for opacity in the allocation of responsibilities, thus resulting in the people resistance to change (Jernigan 2007). The assignment of responsibility is one of the primary barriers to implement BIM because the information embedded in a BIM model is broadly accessible, depends on continuous updating, so the potential liability to the designers is increased (Eastman et al. 2011). This creates the resistance of people to change, which is the major cause for the failure of change tried by organizations, and this confirms the thought that the cultural aspects are the primary obstacles to the employment of information technology IT in the AEC industries (Davis and Songer 2008).

BIM is relatively new technology, and many problems arise from this fact such that the current AEC industry in not until now ready to take the advantages of using this new approach of delivering projects proposed by the use of BIM because of the cost of training, changing workflow and processes (Eastman et al. 2011). In addition, many owners feel that requesting new technologies such as 3D model and building information models will reduce the number of competitive bids received, limiting their potential pool of bidders and significantly increase the price of the project (Eastman et al. 2011). This fact was proved in other researches that, because of the limited bids received, many construction companies are not effectively utilizing BIM technology in their construction (Gilligan and Kunz 2007).

2.3.5 Policy and Legal Barriers

The technology of BIM is new in the construction and many construction organizations lack BIM formal standards of the implementation, and this slows the adoption of BIM (Howard and Björk 2008). Mitchell & Parken (2009) presented a number of policy implications for delivering projects with the application of BIM, these implications are: *"(1) Need for industry standards, (2) Government/organization commitment and resourcing for BIM implementation, (3) Risks of sharing model data and the need to protect intellectual property, legal, insurance, risk, responsibility issues and cost. (4) Quality Assurance (QA): can others trust your model and data? (5) New definitions of services and fee splits, with levels of model detail and categories of information to be specified"*

The lack of clear BIM standards for the contract document is a primary barrier that delays the adoption of BIM technology within the AEC industry (Ashcraft 2008). These standard are essential in the application of BIM technology because they validate the business model, create an agreement for the distribution of risks, and facilitate the assignment of roles and responsibilities (Ashcraft 2008).

Another legal problem arise in BIM adoption is that there is no copyright rules to protect and determine the ownership of the building information model data, and also who can control the data input to the model and on who is the responsibly laid for the inaccuracy of the model (Azhar 2011). There is a lack of official protocols for defining the responsibilities if something was wrongly made while many members in the process participated and contributed their data (Sieminski 2007). BIM technology is a relatively modern style of design and construction in the AEC business and for that; there is a lack in the legal seniority to control the judgment of potential problems (Ashcraft 2008, Eastman et al. 2011, Sieminski 2007). The insurance issues represent another barrier to use BIM as the insurance companies have not yet established policy language for covering the risk associated with this new technology which cannot be controlled by a contractual language, and thus the insurable or non-insurable aspects of it cannot be identified (Sieminski 2007).

2.3.6 Example of Barrier Overcoming and Successful Application of BIM

In this section, an example of the successful application of BIM technology is presented; In addition, the overcoming strategy of the barriers, which disrupt the smooth application of BIM is also presented.

Source: "*BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors"*, Wiley by Eastman et.al. 2011.

Name of the project: **SUTTER MEDICAL CENTER, CASTRO VALLEY**

- **Project Description:**
  This application study describes the building of hospital by Sutter Health in Castro Valley, California that replaced Eden Medical Center, an older building that required state-mandated seismic replacement.

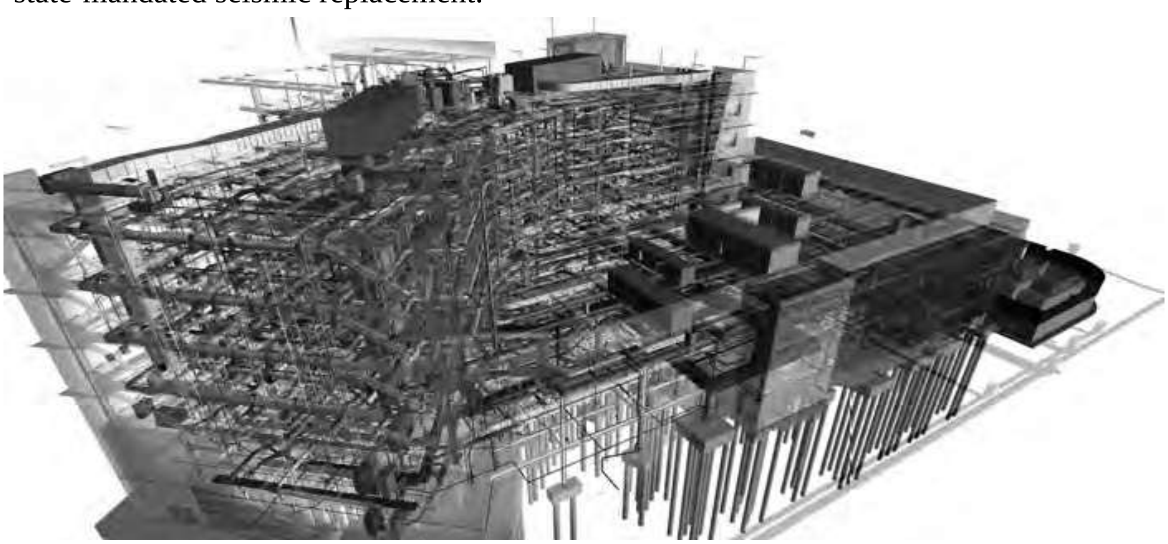

Figure 2.4: Sutter Medical Center Project BIM Model

The project team consists of eleven members as described in the following table:

Table 2.2: Team Members of Sutter Medical Center Project

Function	**Firm**
Owner	Sutter Health*
General Contractor and self-performer of Concrete, Framing, Drywall	DPR Inc.*
Architect	Devenney Group*
Mechanical & Plumbing Design	Capital Engineering*
Electrical Design	The Engineering Enterprise
Structural Design	TMAD/Taylor and Gaines
Fire Protection—Design-Build	Transbay Fire Protection
Mechanical design assist and contractor	Superior Air Handling
Process and Technology managers	Ghafari & Associates
Plumbing design assist and contractor	J.W. McClenahan*
Electrical design assist and contractor	Morrow-Meadows

*Members of Core Group which also included a representative from the Eden Medical Center

The project team used 3D modeling in parallel with the integrated project delivery method (IPD) from the start of the project. Many of the team members had some prior experience with 3D.

One of the initial challenges faced by the team is the selection of the appropriate software tools and applications, and if the whole team should use a single platform? Does this platform satisfy everyone in the team with different output? The team discussed about these problems and came up with a strategic decision to make the 3D model data possible from the design to the construction. The results of the discussion are written below:

• As the architectural and structural team are very close to each other, so they can use the same platform.

• Using a single platform for the systems of MEP and fire protection as they work closely and are required later in the checking of clashes and detailed coordination.

• The selection of appropriate tools that will allow the exchange of information from the design to the detailing and fabrication without recreation and reworks.

• Other problems and how they were solved:-

1. Collaboration between MEP designers and subcontractors-:

The integration of piping and mechanical Single line diagrams into CAD Duct were not easy. Designers moved to CAD Duct Design Line product and sometimes create design using the libraries provided by the trade contractors.

2. Transfer between structural analysis and design programs:

The data of the structural model created by the structural design program ETABS could not be automatically transferred to the design program Revit except the column lines. This made the team to manually update the Revit model

3. Model use beyond Design and for Estimating:

The main objective of the modeling process was to use the model for more than the deign process. This idea was successful when the team realized that the Revit program has the capability to integrate information into the Revit Architecture program to make the estimating process and quantity takeoff much easier.

4. Lack of interoperability between Revit and Tekla models:

The models created by Revit cannot be directly imported into Tekla. Revit can export an Industry Foundation Classes (IFC) file, where only the shape information are imported and the size data will be lost. To solve this problem the team made some manual efforts to create a reference model.

- Conclusion

This was a successful application of the new technology of BIM. It was not easy to use this modern approach at the initial phases of this project. But as the project team used to work together with good communication between them, they could overcome many barriers related to the use of BIM such as interoperability between software programs used, and collaboration issues. This project was successful because it started with clear vision from the owner and good support from the project team, and this collaborative work resulted in under budget cost and earlier start of the construction than the traditional approach.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the steps conducted to achieve the objectives of this study. It includes all information relevant to where and how the required data were obtained, and the method that was used for the analysis of the responses. These steps are summarized in figure 3.1 and described briefly below

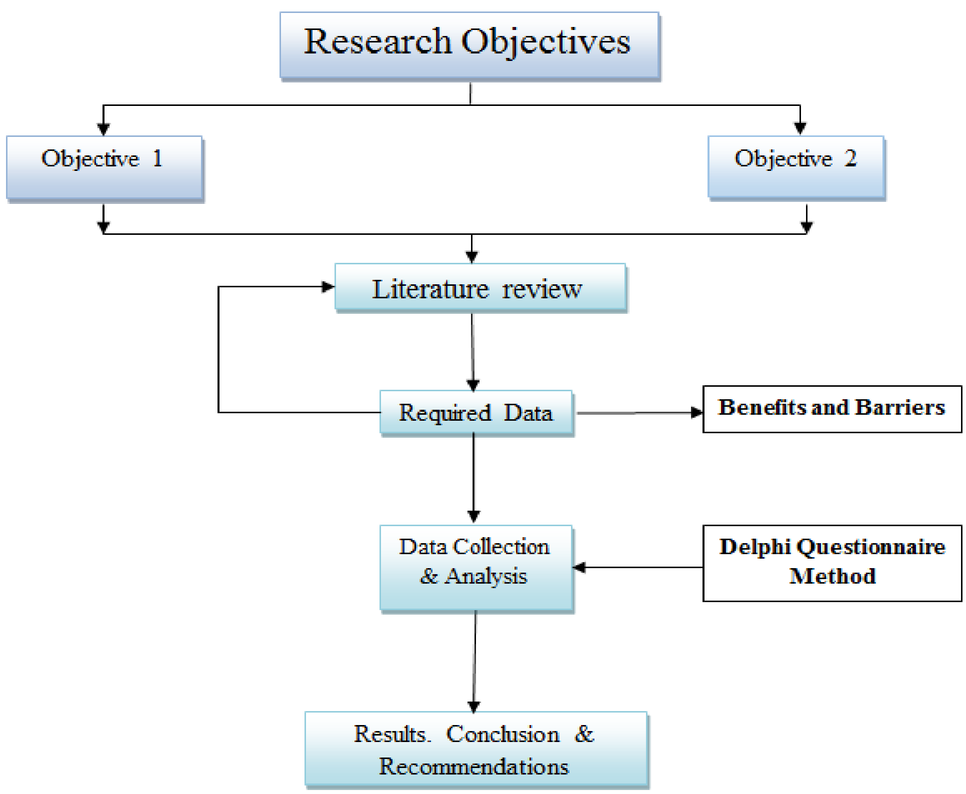

Figure 3.1: Research Methodology

3.2 Required Data

An intensive literature review revealed the potential barriers to the usage of BIM and its advantages. The literature review covers the benefits of using the new innovative technology of BIM in the entire project's lifecycle, and for the main objective of this study, it covers the potential barriers that prevent the utilization of BIM in AEC industries. The following is a list of potential and applicable barriers preventing the utilization of BIM in the Saudi AEC industry collected from an intensive review of literatures on the topic with particular reference to the work of (Mutai 2009) and divided into four categories; Cultural Barriers, New Technology Barriers, New Process Barriers, and Policy and Legal Barriers. These potential barriers are listed in the questionnaire and briefly described in the following.

3.2.1 Potential Barriers prevent the adoption of BIM in Saudi Arabia

(a) Barriers related to culture

The culture here means the behavior, knowledge, and belief of people participating in the construction industry and how they act with such new technology like BIM.

1- Resistance to Change:

- The difficulty of changing the way of doing work for a long time.
- Slow acceptance of new construction technologies in Saudi Arabia.
- Lack of attention from construction firms to the new technology of BIM and its benefits and capabilities.

2- Support of Upper level management:

- Lack of support from top management in construction organizations
- Lack of promotions offered by the top management to the BIM users.

3- Job Relevance

- Irrelevance of BIM to the business and management tasks of the organizations.
- Lack of requests from owners to implement BIM.

(b) Barriers related to the new technology

The new technology means the requirements involved in the application of any innovative technology including the software and hardware requirements and the complexity of using such new technology like BIM

1- Interoperability:

- The lack of interoperability between BIM software applications.
- The lack of open standards used to smoothly exchange data.

2- Technology Requirements

- Limitation in organization's budget for using new technologies.
- Lack of organizational updating to new software and hardware
- Absence of some essential technical capacities required by BIM applications.

3- Complexity

- The complexity of BIM applications and their interface.
- The long time needed to learn BIM applications.

4- Cost of BIM Technology

- The cost of BIM software and hardware.
- The cost of BIM modeling effort (time spent in modeling and managing BIM data).
- The cost of BIM training.

5- . Quality of Output

- Low quality of output that may be created by BIM influences the use of this technology.

(c) Barriers related to the new process

The new process offered by BIM; the integrated system of delivering projects, which use one database to share the building information.

1-Process Change

- The difficulty to change from fragmented system of delivering project to the more collaborative system of BIM.
- The new process of BIM involves new rules and responsibilities and this may represent an obstacle to the BIM diffusion
- The unreadiness of Saudi AEC industry to use BIM in delivering projects.
- The lack of bidders using the technology of BIM.

2 - Training

- Insufficient training offered by the company.
- Lack of institutions offering courses of BIM in our region.

3 - Experience

- Lack of enough experience on the use of the applications used in the BIM process

(d) Barriers related to the policy and legal issues

The policies of organizations in doing their contractual strategies and their scope of works. The legal issues related to the government standards in allocating of risk and responsibilities, insurance and other issues.

1-Scope of work:

- The new collaborative style of doing works offered by BIM may generate a barrier to the technology diffusion.
- The lack of contractual languages and standards related to BIM.
- The changes in the organizational policy of work required by BIM.
- The difficulty to establish a clear work flow processes on the use of BIM technology within the organization.

2-Liability:

- The use of BIM technology increases the liability in organizations' work.
- The unexpected liability fears produced by BIM limit the use of it.
- The cost of insurance of the organization may increase due to the use of BIM

3.3 Data Collection

The required data were collected from key informants who are experts on the use of BIM and other CAD technologies, specifically: architects, structural engineers, MEP engineers, Construction/Project Managers, Estimation Engineers, and Project Engineers, who work for owners, consultants, and contractors. The data were collected using the Delphi technique, which is described below.

3.3.1 Delphi Questionnaire Survey

RAND Corporation firstly used the Delphi technique for conducting researches on national security issues in the 1950s, and later in the 1980s, it was used for educational and scientific researches (Okoli and Pawlowski 2004, Skulmoski, Hartman, and Krahn 2007, Von Der Gracht 2012). In Delphi method, both quantitative and qualitative data can be obtained through the repeated method in where experts' opinions are obtained through a series of surveys (O'Boyle, Jackson, and Henly 2002). Delphi method consists of several rounds. In the first round, the panel of experts in related fields are asked to assess issues according to their individual experience and then in the second round, they are provided with the feedback from the first round so that they can modify their judgment and change their opinions. This iteration process repeated until consistency and consensus are achieved (Powell 2003, Von Der Gracht 2012, Wang, Gao, and Guo 2012). The Delphi method is a continuous and repeated process until the consensus in said to be achieved (Hsu and Sandford 2007).

The purpose of conducting Delphi method in this research was to seek consensus on:

- Participants' understanding of the benefits of Building information modeling (BIM) to the whole project life cycle.
- Barriers to utilize building information modeling (BIM) in Saudi Arabia.

- **Questionnaire Contents:**

The Delphi questionnaire intended to collect the participants' opinions with regard to the benefits of using building information modeling in the whole construction projects life cycle, and the barriers to utilize the (BIM) technology in Saudi Arabia

For round one, the questionnaire was constructed based on the intensive literature review. In this round, the questionnaire was consisted of three parts, **appendix (A).** The first part consists of questions seeking information about the participants' awareness of the building information modeling, and general information of the individual participants and their organizations. The second part consists of questions seeking the participant's agreement on statements regarding the BIM benefits throughout the project lifecycle. The benefits were categorized into three categories, namely: pre-construction, construction phase, and post-construction phase benefits. The third and main part of this study presented the potential barriers to BIM use for the experts to express their agreements on the level of effect of these barriers to implement BIM in Saudi Arabia. The barriers were consisted of four main groups, namely: cultural barriers, new technology barriers, new process barriers, and policies and legal issues barriers.

A five-point Likert scale was used to assess the agreement of the participants in the second and third parts of the questionnaire. The five-points Likert scale consisted of 1=strongly disagree; 2=disagree; 3=neutral; 4=agree; and 5=strongly agree.

In addition, the participants were requested to add any other benefits or barriers from their point of view, which were not listed in the questionnaire. In the last section of the questionnaire, the participants could add comments about the answers that they had provided.

For the second round of the Delphi questionnaire **appendix (B)**, the questionnaire was developed based on the results from the first round of Delphi questionnaire survey. The participants were given questions similar to those in parts 2 and 3 in the first round. However, the format of the questionnaire was different. The experts were asked to consider the ratings that resulted from the Delphi round one. They could answer "Yes" or "No" to respond to the questions. If they answered "No", they were asked to revise the rating.

3.3.2 Population and Sample size

In Delphi technique of conducting questionnaire surveys, there is no exact number of participants. There is a wide variation in the numbers of participants (Powell 2003).The panel size range from 4 to 3000 and it depends on the time, expense, and qualities of experts panel rather than the number of participants (Thangaratinam and Redman 2005a). Okoli and Pawlowski (2004) argues that the Delphi panel size depends on the dynamics for achieving consensus within the experts rather than the statistical power and recommends a number of experts to be 10 to 18 informed participants in a Delphi panel. Skulmoski et al.(2007) found in their research on using Delphi metod for graduate researches that, there is no typical Delphi method and the number of participants may vary from 4 to 171. In addition, Hallowell and Gambatese (2010) recommended in their research on the application of the Delphi Method to CEM Researches that the researcher can easily manage a number of participants between 12 to 15 in a panel. It should be taken into consideration that some participants may drop from the study (Hallowell and

Gambatese 2009). Therefore, for this study 30 participants from 30 leading construction organizations were invited to participate. Only 12 of them were aware of the building information modeling (BIM) and they were classified as experts (have the knowledge and experience on this specific subject) (Hallowell and Gambatese 2009, Kennedy 2004), and this number of experts is still in the range of acceptable number of participants in Delphi method (Hallowell and Gambatese 2009, Okoli and Pawlowski 2004, Skulmoski, Hartman, and Krahn 2007, Thangaratinam and Redman 2005b). In addition to the agreement of the experts to participate in this multiple rounds Delphi questionnaire, they presented their interest to see the results from the questionnaires.

3.4 Data Analysis

The responses from the Delphi multiple rounds questionnaire were collected and analyzed. Statistical descriptive analyses (Frequency and percentage) was used to summarize the awareness of the participants, background, and their organizations from part one of the questionnaire. For parts, 2 and 3 the analysis included calculation of the mean, median, mode and standard deviation of each benefit and barrier in the first round. For the second round, the questions were the same but presented in a different way; the rating of agreement results from Round 1 were given to the experts. The frequency, inter-quartile range (IQR) and standard deviation were calculated. Those values were used to measure the consensus among the experts. All the analysis were carried out by using Microsoft Excel program and Statistical Package for the Social Sciences (SPSS).

CHAPTER 4

DATA ANALYSIS, RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the analysis of the data collected from the Delphi questionnaire survey in order to review the stakeholders' understanding of the benefits of the building information modeling (BIM) in the whole construction project life cycle and to identify the major barriers to utilize building information modeling (BIM) in Saudi Construction Industry

4.2 Questionnaire Distribution

Pilot-tested Delphi questionnaires were distributed to 30 participants from different leading construction organizations to participate in this study with making short interviews with them. From the 30 participants, only 12 participants were considered as experts for their knowledge and experience in the field of BIM, and they were asked to complete the round 1 questionnaire and were invited to participate in the second round. The responses of the first round were completely received after 2 weeks from distribution. The second round questionnaires were sent by e-mail to the participated experts, and they spent 3 weeks to complete their feedback.

4.3 Data Analysis

This phase involves the analysis of the data received from the participants to the Delphi questionnaire survey. For the first round, part 1 of the questionnaire was related to the awareness of the participants about BIM, their demographic information and their organizations. Statistical descriptive analyses was used (Frequency and percentage) to summarize the awareness of the participants, background, and their organizations. For parts 2 and 3 the analysis included calculation of the mean, median, mode and standard deviation of each benefit and barrier indicator. A median of 4 and above was implemented to determine the high ratings of these two aspects, median of 3 and 3.5 was indicating medium rating, and below 3 was indicating low rating. Standard deviation was calculated to see the convergence; while, to see the trends in the responses, the mode was calculated.

For the second round, the questions were the same but presented in a different way; the rating of agreement results from Round 1 were given to the experts. The frequency, inter-quartile range (IQR) and standard deviation were calculated. Those values were used to measure the consensus among the experts. If the agreements among experts were more than 67% on nominal scale (yes/no), and the interquartile-range (IQR) is less than 1, consensus was said to be achieved (Alexandrov et al. 1996, Rayens and Hahn 2000, Von Der Gracht 2012). After the analysis of round two, if consensus was achieved (percentage of agreements is more than 67% and IQR less than 1), only indicators with high rating from round one and consensus on agreement from round two were discussed and considered as major barriers to utilize BIM in Saudi Arabia. Indicators with medium rating from round one and consensus on agreement from round two were considered as minor barriers, neglected, and not discussed as well as those low rated indicators. All the analysis were carried out by using Microsoft Excel program and Statistical Package for the Social Sciences (SPSS). The output from SPSS are shown in appendices (C&D).

4.3.1 Characteristics of Participants and their Organizations

This part aims to collect basic characteristics of the participants who answered the survey and their organizations. It started by asking the participants about their awareness of the building information modeling (BIM), level of experience, and sources of knowledge. Then, they were asked about their level of education, their position in the organization, and their working experience. After that the participants were asked about their organizations' size, experience in construction business, classification, types of construction projects that their organizations work on, and services offered by organization.. The data received were analyzed using simple statistical techniques, including percentages, tables, and graphs.

4.3.1.1 Awareness of BIM

This part aims to gain insight into the level of awareness that the participants have about building information modeling (BIM) before completing the whole questionnaire survey. In other words, to identify who has the knowledge and expertise of the building information modeling (BIM) and can be classified as "expert" to participate in the Delphi questionnaire. Therefore, the participants were firstly asked whether they had heard about "BIM" before today, then they were asked to indicate their level of experience in using BIM, and finally they were asked on how they knew about BIM. The data received were analyzed using simple statistical techniques, including percentages and simple graphs.

As shown in table 4.1 when the participants were asked about their knowledge about building information modeling (BIM), 33.3% of the participants answered that they know BIM and they are currently working with it, 16.7% answered that they know BIM, but they are not currently working with it. On the other hand, 50% of the participants answered that they do not know BIM and they have never heard about it.

Table 4.1: Number of Participated Experts

Have you ever heard about "BIM" before today? (If yes, please continue the questionnaire).	**Frequency**	**%**
Yes, and currently I am working with BIM	10	33.3
Yes, but currently I am not working with BIM	5	16.7
No, I have never heard about BIM	15	50

To explore the level of awareness of participants who had heard of building information modeling (BIM), they were asked to indicate their level of experience of BIM by choosing one of the following levels of experiences: expert, Intermediate, and beginner.

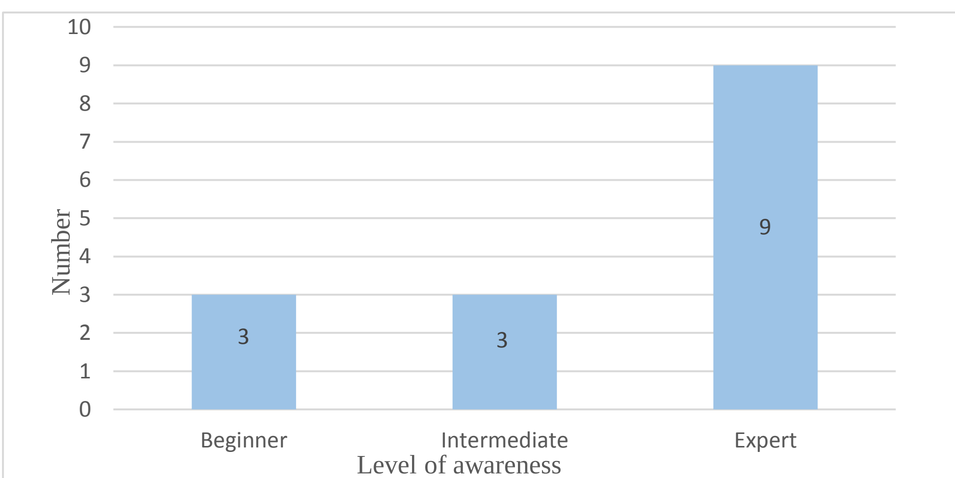

Figure 4.1: Level of Awareness of the Participants

The results are shown in figure 4.1. Nine out of 15 of the participants indicated that they are experts in BIM, three participants indicated that they have intermediate experience, and the remaining three participants indicated that they are beginners and have a short knowledge about BIM. All of the 12 participants (9 experts and 3 intermediates) were classified as experts and were asked to complete the Delphi questionnaire round one and invited to the second round.

The participants, who were considered as experts in BIM, were asked about how they had the knowledge and experience on BIM and the source from where they had their knowledge of BIM. The participants were requested to select all the applicable options. As shown in figure 4.2, among all participants (12 experts), 7 out of 12 (58%) indicated that they had their knowledge from education, 10 participants (83%) answered that BIM is applied in their organizations, and all of the participants (100%) indicated that they have developed their knowledge by self-learning and they are updating themselves from the internet websites and other resources.

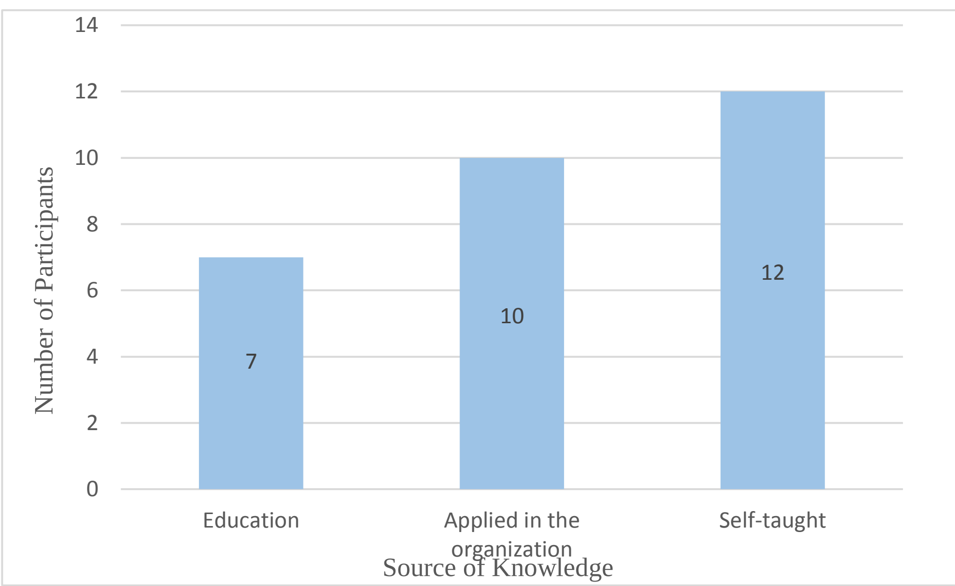

Figure 4.2: Source of Knowledge of the Experts

4.3.1.2 Participants' Level of Education

The results illustrated in figure 4.3 indicated that (50%) of the participants (6 out of 12) had a Master degree. 42% of the participants (5 out of 12) had a Bachelor degree, while one of the participants had an engineering diploma.

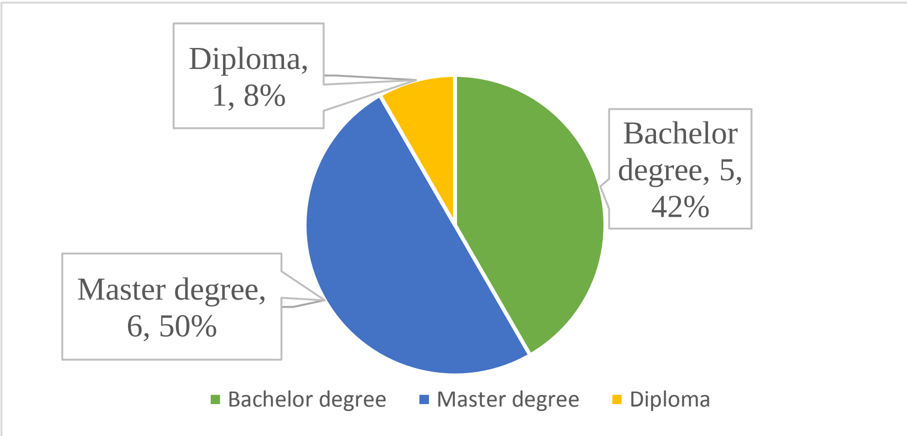

Figure 4.3: Participants' Level of Education

4.3.1.3 Participants' Position in the Organization

As shown in figure 4.4, it can be seen that the majority of the participants (5 out of 12), about (42%) were architects, 25% (3 out of 12) were civil engineers, one BIM manager, one electrical engineer, one project engineer, and one project manager.

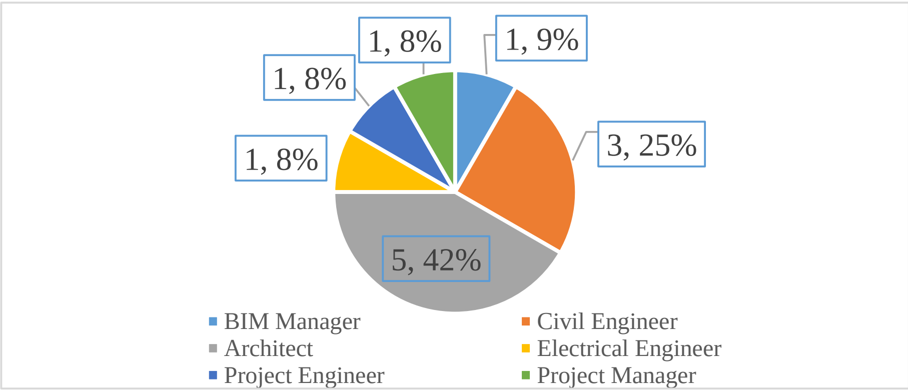

Figure 4.4: Participants' Position in the Organization

4.3.1.4 Participants' Working Experience

The levels of experience among the participants in their specializations have been classified as follows:

Very long (15 years or more)

Long (between 10 to less than 15 years)

Short (between 5 to less than 10 years)

Very short (less than 5 years)

As shown in figure 4.5, the majority of participants 50% (6 out of 12) have experience between 5 to 10 years, one quarter of the participants 25% (3 out of 12) have more than 15 years of experience in their specializations. Only 17% of the participants (2 out of 12) have an experience of less than five years, and only one participant has an experience between 10 to 15 years.

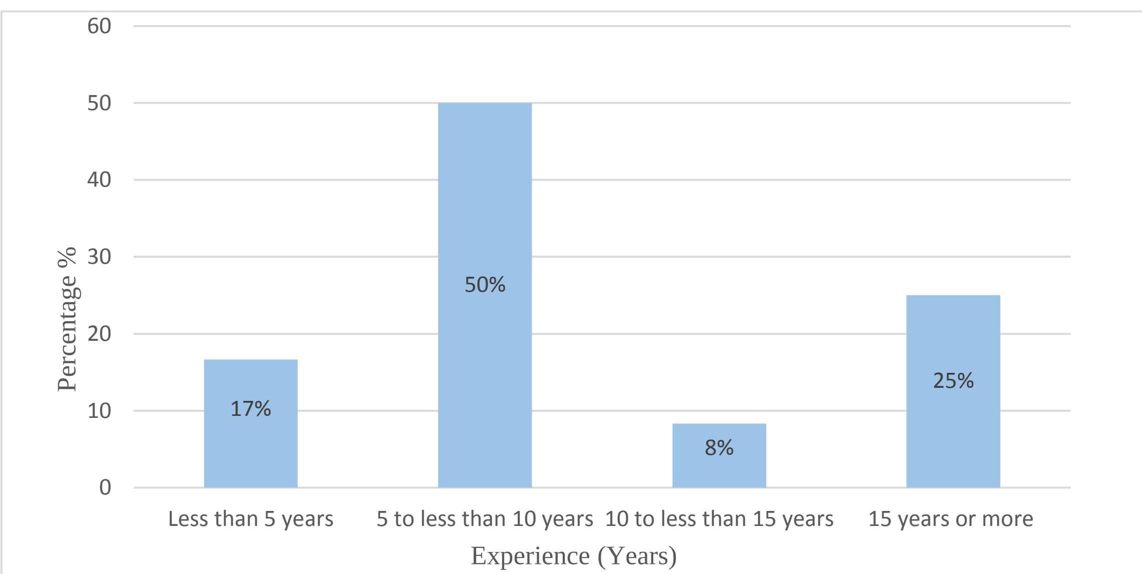

Figure 4.5: Participants' Working Experience

4.3.1.5 Size of the Organization

The sizes of the participating organizations have been classified in terms of number of employees working with them:

Very large (more than 150 employees)

Large (between 100 and 150 employees)

Medium (between 50 and 99 employees)

Small (less than 50 employees)

The distribution of the organizations sizes is shown in Figure 4.6. It can be seen that one organization (8%) has less than 50 employees, one organization (8%) has between 50 to 99 employees, and two organizations (17%) have between 100 and 150, while most of the organizations (over 67%) have more than 150 employees.

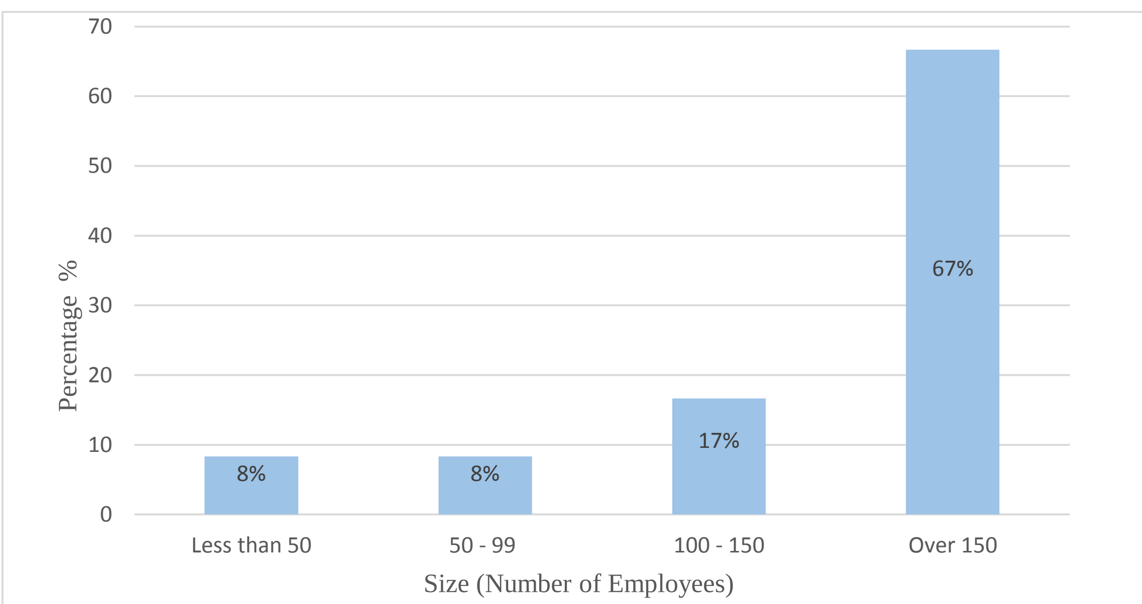

Figure 4.6: Size of the Organization

4.3.1.6 Experience of organization in Construction business

The levels of experience among the participating organizations in construction business have been classified as follows:

Very long (15 years or more)

Long (between 10 to less than 15 years)

Short (between 5 to less than 10 years)

Very short (less than 5 years)

The distributions are shown in Figure 4.7. It can be seen that 83% of the organizations reported over 15 years of experience, only one organization (8%) has between 10 to less than 15 years of experience, and only one organization (8%) has less than 5 years of experience in construction business. Furthermore, it is shown that none of the participating organizations has years of experience between 5 to less than 10.

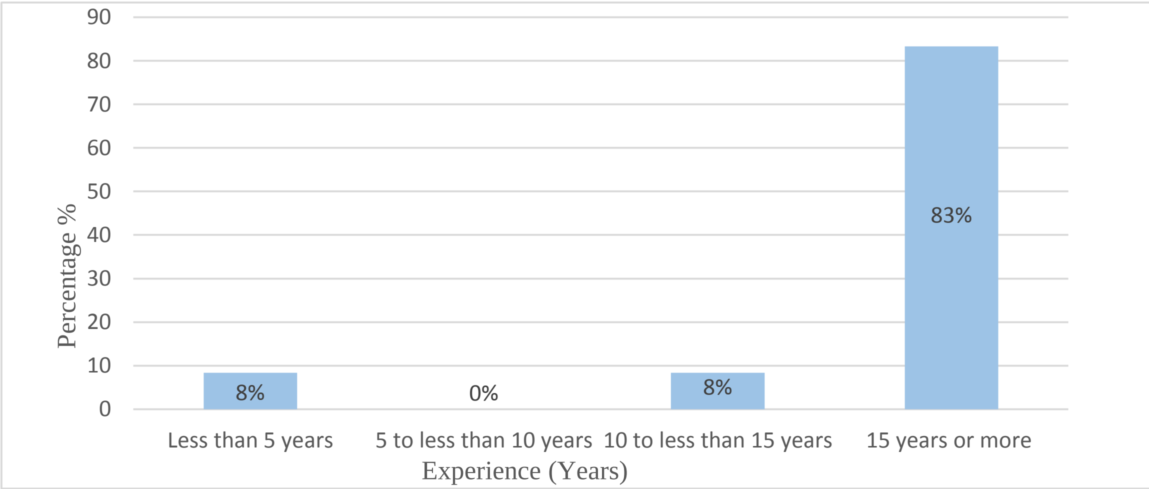

Figure 4.7: Experience of organization in Construction business

4.3.1.7 Classification of organizations

The participated organizations were classified according into owners, consultants, and contractors. Figure 4.8 shows the distribution of the categories of the organizations participated in this study. It can be seen from the figure that most of the participated organizations (58%) were classified as consultants. 25% of the organizations were classified as contractors with a grade 1 according to (MOMRA). Only 17% of the organizations were from the owner category.

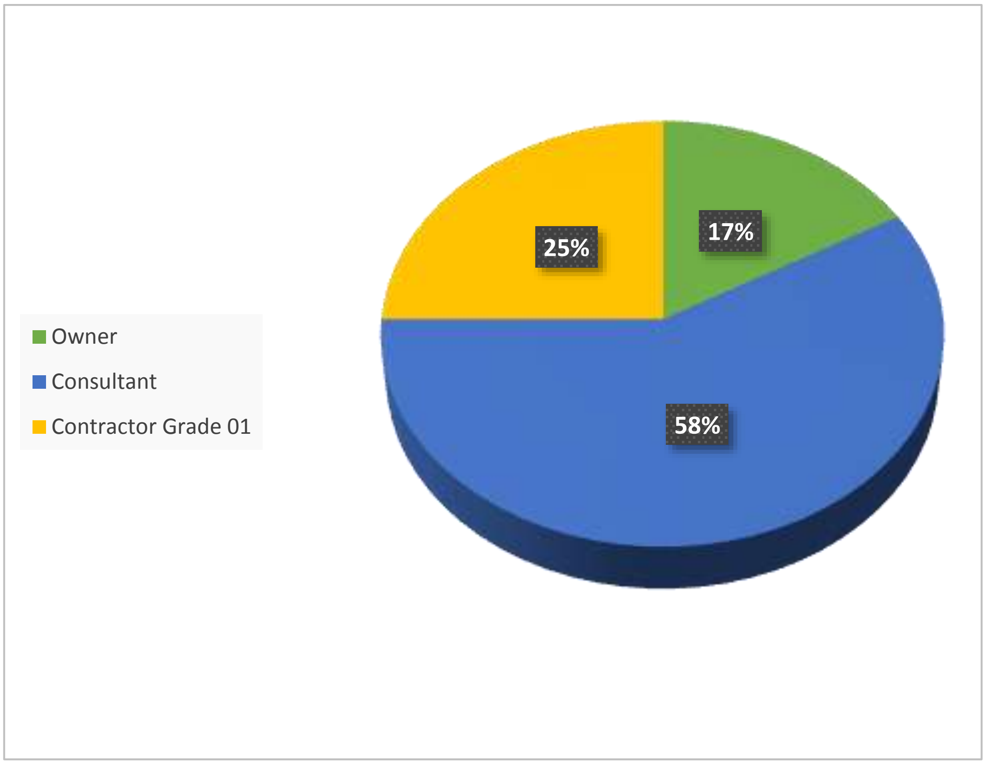

Figure 4.8: Classification of organizations

4.3.1.8 Type of Construction Projects Organizations work on

The main types of the construction projects have been categorized to four types namely: Residential buildings; Commercial buildings, Industrial/ Engineering projects, and Highway construction. Figure 4.9 shows the distribution of the proportion of organizations working in each type of construction project.

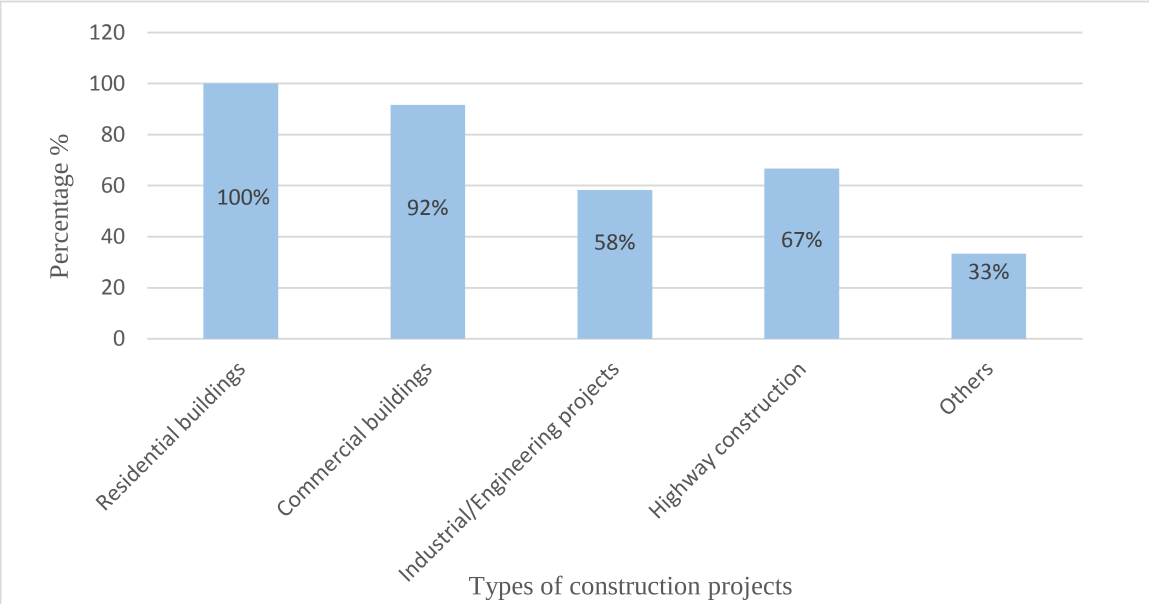

Figure 4.9: Type of Construction Projects Organizations work on

It can be seen from the figure that all of the organizations (100%) are working in residential building projects. Also, (92%) of the organizations indicated that they are working in commercial building. More than fifty percent of the participated organizations (58%) are working in the industrial and engineering construction projects, while (67%) are working in highway construction. In addition, Thirty three percent (33%) of the organizations are working in different categories other than the above four categories; they are working in infrastructures, and refineries construction.

4.3.1.9 Services Offered by Organization

The various categories of services offered by the organizations identified and relevant to this study have been classified as follows:

- Design and Build Services
- General Contracting
- Construction Management
- Consultation Services

In general, some of the organizations are offering more than one type of service. However. Figure 4.10 shows that only (25%) of the participated organizations in this survey reported that they undertake both design and build services. 33% of them provide general contracting services. More than half of the organizations (58%) provide construction management services, and more than half of them (58%) provide consultation services.

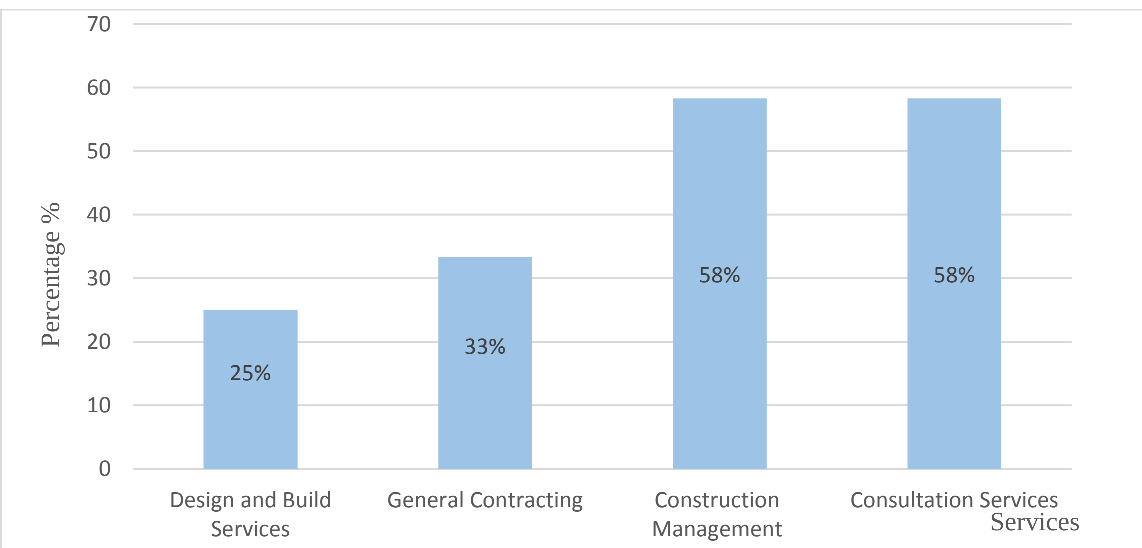

Figure 4.10: Services Offered by Organization

4.3.2 BIM Benefits

The first objective of this study was to review the stakeholders' understanding of the benefits of the BIM in the whole life cycle of construction projects. Based on the literature review, benefits of the building information modeling (BIM) were structured in this Delphi survey.

4.3.2.1 Delphi Round 1: Rating Scores

The indicators related to the BIM benefits for the whole projects' life cycle were divided into three groups, namely, pre-construction, construction, and post-construction phase benefits. Tables 4.2 to 4.4 list the experts' understandings with regard to the benefits of building information modeling (BIM) for the whole projects' life cycle.

Table 4.2: Pre-Construction Phase Benefits - Delphi Round 1 Analysis

#	BIM Benefits	Mean	Median	Mode	SD	Rating
Pre-Construction Phase Benefits						
V1	Improving the communication and collaboration among all project participants	4.58	5.00	5	0.515	High
V3	Showing the realistic image of the project in virtual environment	4.25	5.00	5	1.215	
V6	Allowing different participants of the project to share and exchange data within one integrated 3D model	4.42	5.00	5	0.996	
V7	Detecting clashes and design errors with lesser time	4.67	5.00	5	0.888	
V2	Making fast and accurate cost estimation	4.17	4.50	5	1.193	
V4	Simulating the sequencing of the construction activities before the start	4.17	4.00	4	0.577	
V5	Facilitating the study of alternatives of design	4.08	4.00	4	0.793	

As illustrated in table 4.2, all the participants have high level of agreement on the group of indicators related to the pre-construction phase benefits of BIM. These indicators were “improving the communication and collaboration among all project participants” (with a median score of 5), “showing the realistic image of the project in virtual environment” (with a median score of 5), “allowing different participants of the project to share and exchange data within one integrated 3D model” (with a median score of 5), “detecting clashes and design errors with lesser time” (with a median score of 5), “making fast and accurate cost estimation” (with a median score of 4.5), “simulating the sequencing of the construction activities before the start” (with a median score of 4), and “facilitating the study of alternatives of design” (with a median score of 4), In addition, the participants provide some pre-construction benefits from their point of view namely the BIM minimizes the time required for design outputs, drawings and details, and BIM is used for sustainable; green building and cost reduction

Table 4.3: Construction Phase Benefits - Delphi Round 1 Analysis

#	BIM Benefits	Mean	Median	Mode	SD	Rating
Construction Phase Benefits						
V11	Reducing rework	4.67	5.00	5	0.492	High
V12	Improving construction productivity	4.58	5.00	5	0.515	
V9	Simulating the whole construction processes and show the status of the building and the surrounding space at any point of a time	4.33	4.50	5	0.888	
V8	Improving the quality of construction schedule by integrating the visual representation of the building with the schedule information	4.08	4.00	4	1.084	
V10	Improving the management of resources, labor, machines running in the project space	3.83	4.00	4	0.937	

Table 4.3 illustrates the high level of agreement among all the participants about the benefits of BIM in the construction phase of the projects. These indicators were "reducing rework" (with a median score of 5), "improving construction productivity" (with a median score of 5), "simulating the whole construction processes and show the status of the building and the surrounding space at any point of a time" (with a median score of 4.5), "Improving the quality of construction schedule by integrating the visual representation of the building with the schedule information" (with a median score of 4), and "Improving the management of resources, labor, machines running in the project space" (with a median score of 4).

Table 4.4: Post-Construction Phase Benefits - Delphi Round 1 Analysis

#	BIM Benefits	Mean	Median	Mode	SD	Rating
Post-Construction Phase Benefits						
V13	BIM provides an accurate database containing the as-built systems and specifications, which create a start point to operate and manage the building properly	4.33	4.00	4	0.651	High
V14	The integration between BIM and building management systems will significantly improve the operation and maintenance of building	4.33	4.00	4	0.651	
V15	The decision for the next similar building can be easily supported by basic data that is provided by the data accumulation	4.17	4.00	4	0.718	

Table 4.4 illustrates that all the indicators related to the post-construction phase benefits of BIM had high level of agreements through all the participants. The indicators were "BIM provides an accurate database containing the as-built systems and specifications, which create a start point to operate and manage the building properly" (with a median

score of 4), “the integration between BIM and building management systems will significantly improve the operation and maintenance of building” (with a median score of 4), and “the decision for the next similar building can be easily supported by basic data that is provided by the data accumulation” (with a median score of 4).

4.3.2.2 Delphi Round 2: Considering the Ratings

After the analysis of the first Delphi round, the results were represented to the participants with the same indicators with a different form of questions. The objective of the second Delphi round was to consider the ratings that resulted from the responses analysis of the first Delphi round. The participants were asked to consider the rating of agreements resulted from the first round; whether they agree or to revise the rating if they were disagree with the rating. Tables 4.5 to 4.7 illustrate the analysis of the second Delphi round of the indicators related to experts’ understandings of the benefits of building information modeling (BIM) for the whole projects’ life cycle. Percentage of agreement, IQR and standard deviation were used to analyze the ratings of each indicator.

Table 4.5: Pre-Construction Phase Benefits - Delphi Round 2 Analysis

#	Rating	BIM Benefits	%	IQR	SD
Pre-Construction Phase Benefits					
V1	High	improving the communication and collaboration among all project participants	100	0	0.000
V3		Showing the realistic image of the project in virtual environment	91.7	0	0.289
V6		Allowing different participants of the project to share and exchange data within one integrated 3D model	100	0	0.000
V7		Detecting clashes and design errors with lesser time	91.7	0	0.289
V2		Making fast and accurate cost estimation	75.0	0.25	0.452
V4		Simulating the sequencing of the construction activities before the start	91.7	0	0.289
V5		Facilitating the study of alternatives of design	83.3	0	0.389

As illustrated in table 4.5, most of the participants agreed with the high rating on the group of 7 indicators related to the pre-construction phase benefits of BIM. All of the participants had the same understanding of the pre-construction phase benefits of (BIM) namely, “improving the communication and collaboration among all project participants”, “showing the realistic image of the project in virtual environment”, “allowing different participants of the project to share and exchange data within one integrated 3D model”, “detecting clashes and design errors with lesser time”, “making fast and accurate cost estimation”, “simulating the sequencing of the construction activities before the start”, and “facilitating the study of alternatives of design”. The percentages of agreement of all the participants regarding the high rating of all indicators related to pre-construction phase benefits were greater than 67%, the interquartile ranges IQR were less than 1, and with lesser standard deviations than the first Delphi round.

Table 4.6: Construction Phase Benefits - Delphi Round 2 Analysis

#	Rating	BIM Benefits	%	IQR	SD
Construction Phase Benefits					
V11	High	Reducing rework	100	0	0.000
V12		Improving construction productivity	100	0	0.000
V9		Simulating the whole construction processes and show the status of the building and the surrounding space at any point of a time	91.7	0	0.289
V8		Improving the quality of construction schedule by integrating the visual representation of the building with the schedule information	100	0	0.000
V10		Improving the management of resources, labor, machines running in the project space	83.3	0	0.389

Similarly, table 4.6 indicates that the majority of the participants agreed with high rating on the group of 5 indicators related to the construction phase benefits of BIM. The indicators were “reducing rework”, “improving construction productivity”, “simulating the whole construction processes and show the status of the building and the surrounding space at any point of a time”, “improving the quality of construction schedule by integrating the visual representation of the building with the schedule information”, and “improving the management of resources, labor, machines running in the project space”. The percentages of agreement of all the participants regarding the high rating of all indicators related to construction phase benefits was greater than 67%, the interquartile ranges IQR were less than 1, and with lesser standard deviations than the first Delphi round.

Table 4.7: Post-Construction Phase Benefits - Delphi Round 2 Analysis

#	Rating	BIM Benefits	%	IQR	SD
Post-Construction Phase Benefits					
V13	High	BIM provides an accurate database containing the as-built systems and specifications, which create a start point to operate and manage the building properly	91.7	0	0.289
V14		The integration between BIM and building management systems will significantly improve the operation and maintenance of building	91.7	0	0.289
V15		The decision for the next similar building can be easily supported by basic data that is provided by the data accumulation	91.7	0	0.289

Likewise, table 4.7 shows that in the post-construction phase benefits indicators group, most of the participants agreed with the high rating resulted from the first Delphi round. The indicators were “BIM provides an accurate database containing the as-built systems and specifications, which create a start point to operate and manage the building properly", "The integration between BIM and building management systems will significantly improve the operation and maintenance of building", and "The decision for the next similar building can be easily supported by basic data that is provided by the data accumulation". The percentages of agreement among the participants were greater than 67%, the interquartile ranges IQR were less than 1, and with lesser standard deviations than the first Delphi round.

Consensus was indicated for all the 15 indicators related to the pre-construction, construction, and post-construction benefits of using BIM. All the stakeholders "experts" have the same understanding and agreement on the benefits of BIM.

4.3.3 BIM Barriers

The second objective of this study was to identify the major barriers that slow the utilization of BIM in Saudi Arabia. Based on the literature review, the barriers to utilize (BIM) in Saudi Arabia were identified in this Delphi survey.

4.3.3.1 Delphi Round 1: Rating Scores

The barriers that slow the utilization of (BIM) in Saudi Arabia were categorized into four main groups namely Cultural Barriers, New Technology Barriers, New Process Barriers, and Policy and Legal Barriers. Each main group has a number of subgroups, which in turn contains several indicators inside it. Tables 4.8 to 4.11 list the experts‟ agreements with regard to the barriers to utilize building information modeling (BIM) in Saudi Arabia.

Table 4.8: Cultural Barriers - Delphi Round 1 Analysis

#	Cultural Barriers	Mean	Median	Mode	SD	Rating
Resistance to Change						
V16	The difficulty of changing the way of doing work for a long time	3.92	4.00	4	0.515	High
V17	Slow acceptance of new construction technologies in Saudi Arabia	3.58	4.00	4	1.311	
V18	Lack of attention from construction firms to the new technology of BIM and its benefits and capabilities	2.42	2.00	2	1.240	Low
Support of Top Management						
V19	Lack of support from top management in construction organizations	3.00	3.00	2	1.414	Medium
V20	Lack of promotions offered by the top management to the BIM users	2.92	3.00	3	1.564	
Job Relevance						
V22	Lack of requests from owners to implement BIM	3.50	3.50	3	1.000	Medium
V21	Irrelevance of BIM to the business and management tasks of the company	1.50	1.00	1	0.674	Low

As illustrated in table 4.8, two indicators were rated highly and only one indicator was rated low in the “resistance to change” subgroup of cultural barriers. A high level of agreement was achieved on these two indicators namely, “the difficulty of changing the way of doing work for a long time” (with a median score of 4), and “slow acceptance of new construction technologies in Saudi Arabia” (with a median score of 4). One indicator was rated low, namely, “lack of attention from construction firms to the new technology of BIM and its benefits and capabilities” with a median score of 2.

In the “support of top management” subgroup of the cultural barriers, all the indicators were rated medium namely, “lack of support from top management in construction organizations” (with a median score of 3), and “lack of promotions offered by the top management to the BIM users” (with a median score of 3).

In the “job relevance” subgroup of the cultural barriers, one indicator was rated medium namely, “lack of requests from owners to implement BIM” (with a median score of 3.5). One indicator was rated low “Irrelevance of BIM to the business and management tasks of the company” with a median score of 1.

Table 4.9: New Technology Barriers - Delphi Round 1 Analysis

#	New Technology Barriers	Mean	Median	Mode	SD	Rating
Interoperability						
V23	Lack of BIM software applications interoperability	3.50	4.00	4	1.446	High
V24	The unavailability of open standards such as IFCs in order to solve interoperability problems	3.75	4.00	3	1.215	
Technology Requirements						
V25	Limitation in organization’s budget for using new technologies represent a barrier to BIM spread	3.58	4.00	4	1.240	High
V26	Lack of organizational updating to new software and hardware slows the use of BIM	3.33	4.00	4	1.303	
V27	Absence of some essential technical capacities required by BIM applications (storage capacity,speed,etc.)	3.83	4.00	4	1.193	
Complexity						
V28	The complexity of BIM applications and their interface	3.00	3.00	2	0.953	Medium
V29	The long time needed to learn BIM applications	2.67	2.00	2	0.888	Low
Cost of BIM Technology						

V30	The cost of BIM software and hardware	3.58	4.00	4	0.900	High
V31	The cost of BIM modeling effort (time spent in modeling and managing BIM data)	3.58	4.00	4	0.669	
V32	The cost of BIM training	3.33	4.00	4	0.888	
Quality of Output						
V33	Low quality of output that may be created by BIM influences the use of this technology	3.83	4.00	5	1.337	High

As illustrated in table 4.9, in the new technology barriers group, a high level of agreement was achieved in the two indicators of the "interoperability" subgroup, namely, "lack of BIM software applications interoperability" (with a median score of 4), and "the unavailability of open standards such as IFCs in order to solve interoperability problems" (with a median score of 4).

Likewise, in the "technology requirements" subgroup of new technology barriers, all the indicators were rated high namely, "limitation in organization's budget for using new technologies represent a barrier to BIM spread" (with a median score of 4), "lack of organizational updating to new software and hardware slows the use of BIM" (with a median score of 4), and "absence of some essential technical capacities required by BIM applications (storage, capacity, speed, etc.)" with a median score of 4.

In the "complexity" subgroup of the new technology barriers, one indicator was rated medium namely, "The complexity of BIM applications and their interface" (with a median score of 3). One indicator was rated low namely "the long time needed to learn BIM applications" with a median score of 2.

In the "cost of BIM technology" subgroup of the new technology barriers, all the participants had high agreements with regard to all indicators related to the cost of BIM technology namely, "The cost of BIM software and hardware" (with a median score of 4), "The cost of BIM modeling effort (time spent in modeling and managing BIM data)" (with a median score of 4), and "The cost of BIM training" with a median score of 4.

All the participants had high agreement in the "quality of output" indicator namely, "low quality of output that may be created by BIM influences the use of this technology" with a median of 4.

Table 4.10: New Process Barriers - Delphi Round 1 Analysis

#	New Process Barriers	Mean	Median	Mode	SD	Rating
Process Change						
V34	The difficulty to change from fragmented system of delivering project to the more collaborative system of BIM	3.33	4.00	4	1.073	High
V37	Lack of bidders using the technology of BIM	3.67	4.00	4	0.985	
V35	The new process of BIM involves new rules and responsibilities and this may represent an obstacle to the BIM diffusion	2.92	3.00	4	0.996	Medium
V36	The unreadiness of Saudi AEC industry to use BIM in delivering projects	2.42	2.50	3	0.900	Low
Training						
V38	Insufficient training offered by our company	3.50	4.00	4	1.567	High
V39	Lack of institutions offering courses of BIM in our region	3.75	4.00	4	1.288	
Experience						
V40	Lack of enough experience on the use of the applications used in the BIM process	2.92	3.00	2	1.240	Medium

As illustrated in table 4.10, two indicators were rated highly and two indicators were rated medium and low in the “process change” subgroup of new process barriers. A high level of agreement was achieved on the two indicators namely, “the difficulty to change from fragmented system of delivering project to the more collaborative system of BIM” (with a median score of 4), and “Lack of bidders using the technology of BIM” (with a median score of 4). One indicator was rated medium, namely, “The new process of BIM involves new rules and responsibilities and this may represent an obstacle to the BIM diffusion” with a median score of 3. One indicator was rated low, namely, “unreadiness of Saudi AEC industry to use BIM in delivering projects” with a median score of 2.5.

In the “training” subgroup of the new process barriers, all the two indicators were rated high with a median score of 4, namely, “insufficient training offered by our company” and “lack of institutions offering courses of BIM in our region”

In the “experience” subgroup of the new process barriers, one indicator was rated medium namely, “Lack of enough experience on the use of the applications used in the BIM process” with a median score of 3.

Table 4.11: Policy and Legal Barriers - Delphi Round 1 Analysis

#	Policy and Legal Barriers	Mean	Median	Mode	SD	Rating
Scope of work						
V42	The new collaborative style of doing works offered by BIM may generate a barrier to the technology diffusion	3.42	3.50	4	0.669	Medium
V44	The lack of contractual language for use with BIM technology inhibits its diffusion	3.42	3.50	4	1.084	
V41	The changes in the organizational policy of work required by BIM represent a barrier to use it	3.17	3.00	4	1.030	

V43	The difficulty to establish a clear work flow processes on the use of BIM technology within the organization	2.50	2.00	2	0.905	Low
Liability						
V46	The use of BIM technology increases the liability in company's work	3.58	4.00	4	0.793	High
V45	The unexpected liability fears produced by BIM limit the use of BIM	3.58	3.50	3	0.900	Medium
V47	The cost of insurance of the company may increase due to the use of BIM	3.08	3.00	3	0.996	

As illustrated in table 4.11, three indicators were rated medium and one indicator was rated low in the "scope of work" subgroup of policy and legal barriers. The three medium rated indicators were namely, "the new collaborative style of doing works offered by BIM may generate a barrier to the technology diffusion" (with a median score of 3.5), "lack of contractual language for use with BIM technology inhibits its diffusion" (with a median score of 3.5), and "the changes in the organizational policy of work required by BIM represent a barrier to use it" (with a median score of 3). One indicator was rated low, namely, "the difficulty to establish a clear work flow processes on the use of BIM technology within the organization" with a median score of 2.

In the "liability" subgroup of policy and legal barriers, one indicator was rated high, namely, "the use of BIM technology increases the liability in company's work" with a median score of four. Two indicators were rated medium, namely, "the unexpected liability fears produced by BIM limit the use of BIM (with a median score of 3.5), and "the cost of insurance of the company may increase due to the use of BIM" with a median score of 3.

4.3.3.2 Delphi Round 2: Considering the Ratings

The objective of the second Delphi round was to consider the ratings that resulted from the responses analysis of the first Delphi round. The participants were asked to consider the rating of agreements resulted from the first round; whether they agree or to revise the rating if they were disagree with the rating. Tables 4.12 to 4.15 illustrate the analysis of the second Delphi round of the indicators related to experts' agreements on the barriers to utilize building information modeling (BIM) in Saudi Arabia. Percentage of agreement, IQR and standard deviation were used to analyze the ratings each indicator.

Table 4.12: Cultural Barriers - Delphi Round 2 Analysis

#	Rating	Cultural Barriers	%	IQR	SD
Resistance to Change					
V16	High	The difficulty of changing the way of doing work for a long time	91.7	0	0.289
V17		Slow acceptance of new construction technologies in Saudi Arabia	58.3	1	0.515
V18	Low	Lack of attention from construction firms to the new technology of BIM and its benefits and capabilities	83.3	0	0.389
Support of Top Management					
V19	Medium	Lack of support from top management in construction organizations	75.0	0.25	0.452
V20		Lack of promotions offered by the top management to the BIM users are	75.0	0.25	0.452
Job Relevance					
V22	Medium	Lack of requests from owners to implement BIM	91.7	0	0.289
V21	Low	Irrelevance of BIM to the business and management tasks of our company	75.0	0.25	0.452

As illustrated in table 4.12, in the first indicator related to the "resistance to change" subgroup of cultural barriers group namely, "the difficulty of changing the way of doing work for a long time”, most of the participants agreed with the high rating (with a high percentage of agreement of 91.7% and IQR=0). On the other hand, low percentage of agreement was indicated in the high rating of “Slow acceptance of new construction technologies in Saudi Arabia” with a percentage of agreement equal to 58.3%, , and IQR equal to 1. In the “Lack of attention from construction firms to the new technology of BIM and its benefits and capabilities” indicator, most of participants agreed with the low rating resulted from the first Delphi round with a percentage of agreement was 83.3%, and IQR equal to zero.

In the “support of top management” subgroup of the cultural barriers group, an agreement on the medium rating was indicated for the two indicators namely, “lack of support from top management in construction organizations”, and “lack of promotions offered by the top management to the BIM users are” with a percentage of agreement equal to 75%, and IQR equal to 0.25 for both indicators.

For the “job relevance” subgroup of the cultural barriers group, an agreement on the medium rating was indicated for the indicator “lack of requests from owners to implement BIM” with a percentage of agreement equal to 91.7%, and IQR equal to 0. Also, a 75% of agreement, and IQR equal to 0.25 was indicated for the low rating of the indicator “irrelevance of BIM to the business and management tasks of our company”.

Table 4.13: New Technology Barriers - Delphi Round 2 Analysis

#	Rating	New Technology Barriers	%	IQR	SD
Interoperability					
V23	High	Lack of BIM software applications interoperability	100.0	0	0.000
V24		The unavailability of open standards such as IFCs in order to solve interoperability problems	100.0	0	0.000
Technology Requirements					
V25	High	Limitation in organization's budget for using new technologies represent a barrier to BIM spread	83.3	0	0.389
V26		Lack of organizational updating to new software and hardware slows the use of BIM	75.0	0.25	0.452
V27		Absence of some essential technical capacities required by BIM applications (storage, capacity, speed, etc.)	83.3	0	0.389
Complexity					
V28	Medium	The complexity of BIM applications and their interface	75.0	0.25	0.452
V29	Low	The long time needed to learn BIM applications	75.0	0.25	0.452
Cost of BIM Technology					
V30	High	The cost of BIM software and hardware	100	0	0.000
V31		The cost of BIM modeling effort (time spent in modeling and managing BIM data)	75.0	0.25	0.452
V32		The cost of BIM training	75.0	0.25	0.452
Quality of Output					
V33	High	Low quality of output that may be created by BIM influences the use of this technology	75.0	0.25	0.452

As illustrated in table 4.13, all the participants agreed with the high rating with a percentage of agreement equal to 100% and IQR equal to 0 in the indicators related to the "interoperability" subgroup of new technology barriers group namely, "lack of BIM software applications interoperability”, and “the unavailability of open standards such as IFCs in order to solve interoperability problems”.

Most of the participants agreed with the high rating on the indicators related to the “technology requirements” subgroup of new technology barriers group namely, “limitation in organization’s budget for using new technologies represent a barrier to BIM spread” (with an agreement percentage of 100% and IQR=0), “the cost of BIM modeling effort (time spent in modeling and managing BIM data)” (with an agreement percentage of 75% and IQR=0.25), and “absence of some essential technical capacities required by BIM applications (storage, capacity, speed, etc.)” (with an agreement percentage of 83.3% and IQR=0).

High agreement was indicated in the medium and low rating of the indicators related to the “complexity” subgroup of new technology barriers group namely, “the complexity of BIM applications and their interface” and “the long time needed to learn BIM applications”. The percentage of those two indicators was 75% and IQR=0.25 for both.

Most of the participants agreed with the high rating on the indicators related to the “cost of BIM technology” subgroup of new technology barriers group namely, “the cost of BIM software and hardware” (with an agreement percentage of 83.3% and IQR=0), “lack of organizational updating to new software and hardware slows the use of BIM” (with an agreement percentage of 75% and IQR=0.25), and “the cost of BIM training” (with an agreement percentage of 75% and IQR=0.25).

On the “quality of output” barrier that is related to the new technology barriers namely “low quality of output that may be created by BIM influences the use of this technology", high agreement was indicated on the high rating of this indicator with an agreement percentage of 75% and IQR=0.25.

Table 4.14: New Process Barriers - Delphi Round 2 Analysis

#	Rating	New Process Barriers	%	IQR	SD
Process Change					
V34	High	The difficulty to change from fragmented system of delivering project to the more collaborative system of BIM	91.7	0	0.289
V37		Lack of bidders using the technology of BIM	100	0	0.000
V35	Medium	The new process of BIM involves new rules and responsibilities and this may represent an obstacle to the BIM diffusion	91.7	0	0.289
V36	Low	The unreadiness of Saudi AEC industry to use BIM in delivering projects	75.0	0.25	0.452
Training					
V38	High	Insufficient training offered by our company	75.0	0.25	0.452
V39		Lack of institutions offering courses of BIM in our region	91.7	0	0.289
Experience					
V40	Medium	Lack of enough experience on the use of the applications used in the BIM process	91.7	0	0.289

As illustrated in table 4.14, in the first indicator related to the "process change" subgroup of new process barriers group namely, "The difficulty to change from fragmented system of delivering project to the more collaborative system of BIM", most of the participants agreed with the high rating (with a high percentage of agreement of 91.7% and IQR=0), and also in the second indicator namely, "Lack of bidders using the technology of BIM" all the participants agreed with the high rating (with a high percentage of agreement of 100% and IQR=0). High percentage of agreement (91.7% with IQR=0) was indicated in the medium rating of "the new process of BIM involves new rules and responsibilities and this may represent an obstacle to the BIM diffusion", and high percentage of agreement (75% with IQR=0.25) was indicated in the low rating of "the unreadiness of Saudi AEC industry to use BIM in delivering projects".

Most of the participants agreed with the high rating on the indicators related to the "training" subgroup of new process barriers group namely, "insufficient training offered by our company" (with an agreement percentage of 75% and IQR=0.25), and "lack of institutions offering courses of BIM in our region" (with an agreement percentage of 91.7% and IQR=0).

In the "experience" barrier that is related to the new process barriers namely "lack of enough experience on the use of the applications used in the BIM process", high agreement was indicated on the medium rating of this indicator with an agreement percentage of 91.7% and IQR=0.

Table 4.15: Policy and Legal Barriers - Delphi Round 2 Analysis

#	Rating	Policy and Legal Barriers	%	IQR	SD
Scope of work					
V42	Medium	The new collaborative style of doing works offered by BIM may generate a barrier to the technology diffusion	75.0	0.25	0.452
V44		The lack of contractual language for use with BIM technology inhibits its diffusion	91.7	0	0.289
V41		The changes in the organizational policy of work required by BIM represent a barrier to use it	91.7	0	0.289
V43	Low	The difficulty to establish a clear work flow processes on the use of BIM technology within the organization	83.3	0	0.389

Liability					
V46	High	The use of BIM technology increases the liability in company's work	75.0	0.25	0.452
V45	Medium	The unexpected liability fears produced by BIM limit the use of BIM	100	0	0.000
V47		The cost of insurance of the company may increase due to the use of BIM	91.7	0	0.289

As illustrated in table 4.15, Most of the participants agreed with the medium rating on the 3 indicators related to the "scope of work" subgroup of policy and legal Barriers group namely, "the new collaborative style of doing works offered by BIM may generate a barrier to the technology diffusion" (with an agreement percentage of 75% and IQR=0.25), "the lack of contractual language for use with BIM technology inhibits its diffusion" (with an agreement percentage of 91.7% and IQR=0), and "the changes in the organizational policy of work required by BIM represent a barrier to use it" (with an agreement percentage of 91.7% and IQR=0). The participants also highly agree with low percentage of the fourth indicator namely, "the difficulty to establish a clear work flow processes on the use of BIM technology within the organization" with a percentage of agreement equal to 83.3% and IQR equal to 0.

For the "Liability" subgroup of the policy and legal barriers group, an agreement on the high rating was indicated for the indicator "the use of BIM technology increases the liability in company's work" (with a percentage of agreement equal to 75%, and IQR equal to 0.25). In addition, a 100% of agreement, and IQR equal to 0 was indicated for the medium rating of the indicator "The unexpected liability fears produced by BIM limit the use of BIM", and a 91.7% of agreement, and IQR equal to 0 was indicated for the medium rating of the indicator "the cost of insurance of the company may increase due to the use of BIM".

Consensus was achieved as the percentages of agreements on different ratings resulted from round 1 were more than 67% for 31 indicators related to the cultural, new technology, new process, and policy and legal barriers to utilize BIM in Saudi Arabia. Only one indicator had no consensus of agreements among the experts, as the agreement percentage was 58.3%, which is less than 67% and the IQR equal to 1. The major and minor barriers are summarized in table 4.16 below, and as the second objective of this study is to identify the major barriers, only major barriers are discussed in section 4.4.3.

Table 4.16: Summary of Major and Minor Barriers

#	Major Barriers	Minor Barriers
1	The difficulty of changing the way of doing work for a long time	Slow acceptance of new construction technologies in Saudi Arabia
2	Lack of BIM software applications interoperability	Lack of support from top management in construction organizations
3	The unavailability of open standards such as IFCs in order to solve interoperability problems	Lack of promotions offered by the top management to the BIM users are
4	Limitation in organization's budget for using new technologies represent a barrier to BIM spread	Lack of requests from owners to implement BIM
5	Lack of organizational updating to new software and hardware slows the use of BIM	The complexity of BIM applications and their interface
6	Absence of some essential technical capacities required by BIM applications (storage capacity, speed, etc.)	The new process of BIM involves new rules and responsibilities and this may represent an obstacle to the BIM diffusion
7	The cost of BIM software and hardware	Lack of enough experience on the use of the applications used in the BIM process
8	The cost of BIM modeling effort (time spent in modeling and managing BIM data)	The new collaborative style of doing works offered by BIM may generate a barrier to the technology diffusion
9	The cost of BIM training	The lack of contractual language for use with BIM technology inhibits its diffusion
10	Low quality of output that may be created by BIM influences the use of this technology	The changes in the organizational policy of work required by BIM represent a barrier to use it
11	The difficulty to change from fragmented system of delivering project to the more collaborative system of BIM	The unexpected liability fears produced by BIM limit the use of BIM
12	Lack of bidders using the technology of BIM	The cost of insurance of the company may increase due to the use of BIM
13	Insufficient training offered by the company	
14	Lack of institutions offering courses of BIM in our region	
15	The use of BIM technology increases the liability in company's work	

4.4 Discussion of Results

This part discusses the results obtained from the two Delphi round conducted for achieving the two objectives of this research. The discussion is divided into three parts namely, characteristics of participants and their organizations, BIM benefits, and BIM barriers.

4.4.1 Characteristics of Participants and their Organizations

The results obtained from the awareness part of the first part of the questionnaire present that only 50% (15 out of 30) of the invited participants were aware of BIM, and this reflects the level of awareness of BIM among the stakeholders in Saudi Arabia. Moreover, only 12 of the 15 (BIM aware) participants were considered as experts on BIM as most of them are currently working with the process of BIM and all of them have a good experience in the applications of BIM in construction gained from education, self-though, and application on BIM in their organizations. On the organizational scale, the results revealed that only 33.3% (10 out of 30) of the organizations are applying the BIM technology in their construction works, and this reflect the awareness and use of BIM technology by the organizations in Saudi Arabia as these organizations represent the leading construction organizations in the area.

In the participants' characteristics part of the questionnaire, the results revealed that participated experts were well educated as 50% of them have the Master degree and more than 40% have the Bachelor degree; and this indicated one of the sources from where they had their knowledge.

The results indicate that the majority of the experts participated in the study were architectural engineers, and this was an expected result as the most the software applications used by BIM are familiar among the architectural engineers. In addition, a variety of positions were indicated in the results namely, civil engineer, electrical engineer, project engineer, project manager, and BIM manager. This variation in positions reflects the collaborative means of BIM concept.

The research also shows that most of the participants have a working experience between 5 to 10 years. This level of experience indicated that this new technology is more interested and used by young engineers more than older engineers with long experience of more than 15 years who represent 25% of the participants in this study.

In the organizations' characteristics part of the questionnaire, the results indicate that the majority of the participated organizations were classified as very large organization (with more than 15 years of experience in construction business). This fact was matched with Partridge et al. (2007) practice builder, which indicated that the large organizations with larger cash flow and resources are willing to invest on the new technology and innovative working processes more than the smaller organizations. Moreover, the research shows that more than half of the participated organizations were classified as consultants more than contractors and owners. These consultants are offering consultations and construction managements services on different types of construction projects.

4.4.2 BIM Benefits

The research results show that all the stakeholders (participated experts) have the same understanding and agreement on the benefits of using building information modeling (BIM) throughout the construction projects' lifecycle. This understanding was indicated from the first and second round of the Delphi questionnaire. All the experts highly rated the entire indicators related to the benefits of BIM in the three phases of construction (pre-construction, construction, and post-construction phase) in the first Delphi round, and in the second round, they also agreed with the high ratings resulted from the first Delphi round. Consensus was achieved in the second round, as the percentages of agreements for all the indicators were more than 67%, and the interquartile ranges IQR were less than one.

4.4.3 BIM Barriers

The research results show that consensus was achieved among all the participated experts there was almost a complete unanimity as the percentages of agreements on high ratings resulted from round 1 were more than 67% for 15 indicators related to the cultural, new technology, new process, and policy and legal barriers to utilize BIM in Saudi Arabia. These 15 indicators were considered as major barriers to utilize BIM in Saudi Arabia. Table 4.17 below shows the summary of major barriers and their classification percentage

It can be seen from the table that 60% of the major barriers are related to the new technology of BIM and its requirements, 26.7% are related to the new process of BIM, 6.7% are related to cultural barriers, and 6.7% are related to policy and legal barriers

Table 4.17: Summary of Major Barriers and Their Classification Percentage

#	Major Barriers	Classification	%
1	The difficulty of changing the way of doing work for a long time	Culture	**6.7**
2	Lack of BIM software applications interoperability	New Technology	**60.0**
3	The lack of open standards such as IFCs	New Technology	
4	Limitation in organization's budget for using the new technologies of BIM	New Technology	
5	Lack of organizational updating to new software and hardware required by BIM	New Technology	
6	Absence of some essential technical capacities required by BIM applications (storage capacity, speed, etc.)	New Technology	
7	The cost of BIM software and hardware	New Technology	
8	The cost of BIM modeling effort (time spent in modeling and managing BIM data)	New Technology	
9	The cost of BIM training	New Technology	
10	Low quality of output that may be created by BIM	New Technology	
11	The difficulty to change from fragmented system of delivering project to the more collaborative system of BIM	New Process	**26.7**
12	Lack of bidders using the technology of BIM	New Process	
13	Insufficient training offered by the organizations	New Process	
14	Lack of institutions offering courses of BIM in the region	New Process	
15	The increased liability in organizations' work due to the use of BIM technology	Policy and Legal Issus	**6.7**

The research results that are shown in table 4.17 shows that most of the major barriers that prevent the use of BIM in Saudi Arabia as per the experts' view and knowledge are related firstly to the new technology of BIM and its requirements, such as the lack of interoperability between the software applications that are used in the process of BIM and the unavailability of open standards such as IFCs in order to solve problems related to interoperability. These facts are compatible with Eastman (2011) book, which mentioned the interoperability as one of the major barriers to utilize BIM in construction industries.

In addition, the results present that the lack of the organizations budget offered to provide the essential requirements of BIM technology such as hardware storage capacity, speed, updated software, etc. represent a major barrier preventing the spread of BIM technology in Saudi Arabia. This is consistent with previous studies conducted by Mitchell and Parken, (2009) and Williams, (2007) who concluded that the BIM process has many technology implications and the absence of the essential technical capacities required by its applications may represent a barrier to the use of it.

The results indicate that the cost of BIM software, hardware, training, and effort spent to model and manage BIM data is a major barriers to the spread of BIM. This is supported by Gilligan and Kunz, (2007), Kunz and Fischer, (2005) who pointed out that despite the benefits of BIM, the cost of this technology represents a major barrier due to its requirements. Furthermore, the study indicates that due to the lack of skilled and well-trained staff, the low quality of output that may be created by BIM influences the use of this technology and can be considered as a major barrier to the use of BIM.

The results shows that 26.7% of the major barriers were related to the new process of BIM which is calling to change from the traditional system of delivering project to the more collaborative system of BIM. This is supported by Jernigan, (2007) who observed that, as a result of the significant changes caused by BIM process to the AEC industry, it may create a field of opportunities for opacity in the allocation of responsibilities, thus resulting in the people resistance to change their working process.

In addition, the study presents another new process barrier, which is the lack of bidders using the technology of BIM as they still depend on the traditional working processes. Furthermore, the results indicates the insufficient training offered by the organizations to their employees and the lack of institutions offering courses of BIM in the region, represent major barriers to the implementation of the new process offered by BIM.

The results shows that the cultural perspective should be considered, as it is difficult to change the way of doing work for a long time and this can represent a barrier to the spread of BIM technology in Saudi Arabia. This fact is compatible with the study conducted by Hasan and Ditsa, (1999) who pointed out that one of the most significant factors that is considered as potential barrier to the adoption of new information technology is culture.

The results also indicate that the liability concerns represents a major barrier to the utilization of BIM in Saudi Arabia due to the lack of standards and contractual language in how BIM process is implemented. This results is consistent with the study conducted by Ashcraft (2008) who found that the lack of clear BIM standards for the contract document is a primary barrier that delays the adoption of BIM technology within the AEC industry

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the study, followed by a summary of the major barriers that prevent the utilization of building information modeling (BIM) in Saudi Arabia, followed by recommendations in order to overcome these barriers, and finally recommendations for future studies.

5.2 Summary of the Study

The Building Information Modeling (BIM) is implemented in many developed countries all over the world due to its large benefits in all phases of the projects' lifecycle, but this technology is not utilized in Saudi Arabia. Therefore, the main objectives of this research were to review the stakeholders' understanding of the benefits of the BIM in the whole life cycle of construction projects, and to identify the major barriers to utilize BIM in Saudi Construction Industry.

The methodology adopted to achieve these two objectives was by conducting a Delphi multiple rounds questionnaire. The questionnaire contents and indicators were derived from an intensive literature review related to the benefits of BIM and the barriers to implement and utilize this technology in construction industries. The Delphi questionnaire conducted in two round. The first round was asking the participated experts to express the agreements on five-points Likert scale on the indicators related to BIM benefits and barriers. The results from Delphi round one were collected and analyzed using the median to determine the high, medium, and low rating of each indicator. In the second round, the results of rating were presented to the participated expert to give their feedback and agreement on those ratings. Finally, the indicators that achieved high rating from round one, and high agreements and consensus in round two were considered and discussed in this research study.

The results related to the first objective of this research study indicated that all the stakeholders (participated experts) have the same understanding and agreement on the benefits of using BIM throughout the construction projects' lifecycle, and they agreed with all indicators related to these benefits.

The results related to the second objective of this research study indicated that there are many barriers to utilize building information modeling (BIM) in Saudi Arabia, but there are 15 major barriers as resulted from experts' who participated in the Delphi questionnaire with their knowledge and experience in the field of BIM. These barrier were of four classifications namely, new technology (with 60%), new process (with 26.7%), culture (with 6.7%), and policy and legal barriers (with 6.7%)

5.3 Summary of Major Barriers

There are many barriers to implement building information modeling in Saudi Arabia ranging in their consideration priority from high to medium. The following is a summary of the major barriers that can highly prevent the utilization of BIM in Saudi Arabia as per the experts' points of view.

1. The cultural difficulty of changing the way of doing works for a long time.
2. Lack of BIM software applications interoperability.
3. The lack of open standards such as IFCs.
4. Limitation in organization's budget for using the new technology of BIM.
5. Lack of organizational updating to new software and hardware.
6. Absence of some essential technical capacities required by BIM applications (storage capacity, speed, etc.).
7. The cost of BIM software and hardware.
8. The cost of BIM modeling effort (time spent in modeling and managing BIM data).
9. The cost of BIM training.
10. Low quality of output that may be created by BIM.
11. The difficulty to change from fragmented system of delivering project to the more collaborative system of BIM.
12. Lack of bidders using the technology of BIM.
13. Insufficient training offered by the organizations.
14. Lack of institutions offering courses of BIM in the region.
15. The increased liability in organizations' work due to the use of BIM technology

5.4 Recommendations

Based on the research results, the following recommendations are provided in order to overcome the barriers to utilize building information modeling in Saudi Arabia. These recommendations are directed to organizations and individual stakeholders as well as academic environment and government.

1. The organizations are recommended to break out the culture barriers and change their fragmented construction working processes to the by adopting the more collaborative and single project model offered by BIM.
2. Organizations are advised to conduct feasibility studies on the benefits of investing on the BIM technology to discover the ROI and cost savings due to the use of this technology in construction industries.
3. Organizations are recommended to prepare their own frameworks and execution plans to organize the adoption and implementation of BIM.
4. Special recommendations are directed to the top management level in organizations to derive the adoption of BIM by allocating budgets to provide the essential requirements of BIM technology including the hardware, software, and sufficient training for the employees. It is recommended to use software packages that are comparable to each other or to use open standards such as Industry Foundation Classes (IFC) in order to overcome the interoperability problems. Training should be organized according to the need in each discipline for example BIM modelers should be trained on the creation of models and how to interchange data models between them such as architectural, structural, and MEP models, whereas BIM managers should be trained on how to managed the flow of data in

these models, give feedback to the modelers, and reflect that on the construction process, etc. proper training can make more qualified employees and therefore high quality output can be achieved from BIM process.

5. Top management should encourage the adoption of BIM by providing promotions to BIM users within the organizations in order to make incentives for employees to learn BIM.
6. Individuals are advised to extend their knowledge on BIM technology and its applications by taking courses in BIM from institutions or other sources of knowledge such as internet websites, conferences, etc.
7. Saudi universities are recommended to integrate the BIM courses to the curriculum in various departments such as architectural, structural, mechanical, electrical, and construction management departments, in order to meet the new requirements of the construction industries.
8. Government authorities are recommended to force the use of building information modeling (BIM) process by making BIM as a mandatory requirement for the bidders on government projects, and by making contractual language and standards on the implementation on BIM in contracts in order to avoid the liability issues that may appear due to the use of this new working process of BIM.

5.5 Recommendations for Future Studies

The building information modeling (BIM) process has recently become an essential topic for international researches. However, there is a lack of researches concerning this area in Saudi Arabia. Therefore, there is a need to conduct more researches in order to overcome the barriers and improve the practice of BIM in Saudi Arabia.

Future studies in the field of BIM may consider:

- Practical framework model of the process of building information modeling (BIM) in construction organizations in Saudi Arabia.
- Practical assessment of the benefits of building information modeling (BIM) in many sides such as planning and scheduling cost estimating, clashes detecting, facility management, etc.
- The effect of BIM practice on the design-build organizations, or general contractors.

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APPENDIX – A

Delphi Questionnaire – Round 1

#	Part 1: General Information	
#	**This part includes questions seeking information about you and your organization. You are kindly requested to provide the requested information in the given spaces**	
1	**Name(optional)**	
	Company Name	
	Company Address	
	E-Mail Address	
	Telephone No.	
2	**Have you ever heard about "BIM" before today? (If yes, please continue answering the questions).**	
	Yes, currently I am working with BIM	
	Yes, but currently I am not working with BIM	
	No, I have never heard about BIM	
3	**Your level of experience in using BIM**	
	Beginner	
	Intermediate	
	Expert	
4	**How did you know about BIM?**	
	Education	
	Applied in the organization	
	Self-taught	
	Other (please specify)	
5	**What is your level of education?**	
	Bachelor degree	
	Master degree	
	PhD	
	Other (please specify)	
6	**What is your position in the organization?**	
	BIM Manager	
	CAD/BIM Modeler	
	Civil Engineer	
	Architect	
	Electrical Engineer	
	Mechanical Engineer	
	Estimator	
	Project Engineer	
	Project Manager	

	Other (please specify)	
7	**How long have you been working in your specialization?**	
	Less than 5 years	
	5 to less than **10** years	
	10 to less than **15** years	
	15 years or more	
8	**How many employees does this organization have in total ?**	
	Less than 50	
	50 - 99	
	100 - 150	
	Over 150	
9	**For how long has your organization been in business in the construction industry?**	
	Less than 5 years	
	5 to less than **10** years	
	10 to less than **15** years	
	15 years or more	
10	**Specify the classification of your organization according to Ministry of Municipal and Rural Affairs**	
	Owner	
	Consultant	
	Contractor Grade 01	
	Contractor Grade 02	
	Contractor Grade 03	
	Other (please specify)	
11	**What type/s of construction projects does this organization work on?**	
	Residential buildings	
	Commercial buildings	
	Industrial/Engineering projects	
	Highway construction	
	Other (please specify)	
12	**What are the services offered by your organization?**	
	Design and Build Services	
	General Contracting	
	Construction Management	
	Consultation Services	
	Other (please specify)	

Part 2 BIM BENEFITS						
This part includes questions seeking information about your opinion on the benefits of BIM . You are kindly requested to express your agreement on the BIM Benefits by placing a tic (✓) in the appropriate box next to the potential barrier where 1 being strongly disagree, 2 disagree, 3 neutral, 4 agree, and 5 strongly agree.						
#	**Pre-Construction Phase Benefits**					
1		**1**	**2**	**3**	**4**	**5**
V1	improving the communication and collaboration among all project participants					
V2	Making fast and accurate cost estimation					
V3	Showing the realistic image of the project in virtual environment					
V4	Simulating the sequencing of the construction activities before the start					
V5	Facilitating the study of alternatives of design					
V6	Allowing different participants of the project to share and exchange data within one integrated 3D model					
V7	Detecting clashes and design errors with lesser time					
	Other (please specify)					
#	**Construction Phase Benefits**					
2		**1**	**2**	**3**	**4**	**5**
V8	Improving the quality of construction schedule by integrating the visual representation of the building with the schedule information					
V9	Simulating the whole construction processes and show the status of the building and the surrounding space at any point of a time					
V10	Improving the management of resources, labor, machines running in the project space					
V11	Reducing rework					
V12	Improving construction productivity					
	Other (please specify)					
#	**Post-Construction Phase Benefits**					
3		**1**	**2**	**3**	**4**	**5**
V13	BIM provides an accurate database containing the as-built systems and specifications, which create a start point to operate and manage the building properly					

V14	The integration between BIM and building management systems will significantly improve the operation and maintenance of building					
V15	The decision for the next similar building can be easily supported by basic data that is provided by the data accumulation					
	Other (please specify)					

Part 3 BIM BARRIERS						
The following is a list of potential factors affecting the use of BIM in Saudi Arabia. You are kindly requested to express your agreement on the effect of these barriers in the use of BIM in Saudi Arabia by placing a tic (✓) in the appropriate box next to the potential barrier where 1 being strongly disagree, 2 disagree, 3 neutral, 4 agree, and 5 strongly agree.						
#	**Barriers related to culture**					
1	**Resistance to Change**	**1**	**2**	**3**	**4**	**5**
V16	The difficulty of changing the way of doing work for a long time					
V17	Slow acceptance of new construction technologies in Saudi Arabia					
V18	Lack of attention from construction firms to the new technology of BIM and its benefits and capabilities					
	Other (please specify)					
2	**Support of Upper level management**	**1**	**2**	**3**	**4**	**5**
V19	Lack of support from top management in construction organizations					
V20	Lack of promotions offered by the top management to the BIM users are					
	Other (please specify)					
3	**Job Relevance**	**1**	**2**	**3**	**4**	**5**
V21	Irrelevance of BIM to the business and management tasks of the company					
V22	Lack of requests from owners to implement BIM					
	Other (please specify)					
#	**Barriers related to the new technology**					
4	**Interoperability**	**1**	**2**	**3**	**4**	**5**
V23	Lack of BIM software applications interoperability					
V24	The unavailability of open standards such as IFCs in order to solve interoperability problems					
	Other (please specify)					
5	**Technology Requirements**	**1**	**2**	**3**	**4**	**5**
V25	Limitation in organization's budget for using new technologies represent a barrier to BIM spread					
V26	Lack of organizational updating to new software and hardware slows the use of BIM					

V27	Absence of some essential technical capacities required by BIM applications affects the utilization of this technology					
	Other (please specify)					
6	**Complexity**	**1**	**2**	**3**	**4**	**5**
V28	The complexity of BIM applications and their interface					
V29	The long time needed to learn BIM applications					
	Other (please specify)					
7	**Cost of BIM Technology**	**1**	**2**	**3**	**4**	**5**
V30	The cost of BIM software and hardware					
V31	The cost of BIM modeling effort (time spent in modeling and managing BIM data)					
V32	The cost of BIM training					
	Other (please specify)					
8	**Quality of Output**	**1**	**2**	**3**	**4**	**5**
V33	Low quality of output that may be created by BIM influences the use of this technology					
	Other (please specify)					
#	**Barriers related to the new process**					
9	**Process Change**	**1**	**2**	**3**	**4**	**5**
V34	The difficulty to change from fragmented system of delivering project to the more collaborative system of BIM					
V35	The new process of BIM involves new rules and responsibilities and this may represent an obstacle to the BIM diffusion					
V36	The unreadiness of Saudi AEC industry to use BIM in delivering projects					
V37	There is no availability of bidders using the technology of BIM					
	Other (please specify)					
10	**Training**	**1**	**2**	**3**	**4**	**5**
V38	Insufficient training offered by our company					
V39	There are very few institutions offering courses of BIM in our region					
	Other (please specify)					
11	**Experience**	**1**	**2**	**3**	**4**	**5**
V40	Lack of enough experience on the use of the applications used in the BIM process					
	Other (please specify)					

#	Barriers related to the policies and legal issues					
12	**Scope of work**	**1**	**2**	**3**	**4**	**5**
V41	The changes in the organizational policy of work required by BIM represent a barrier to use it					
V42	The new collaborative style of doing works offered by BIM may generate a barrier to the technology diffusion					
V43	It is difficult to establish a clear work flow processes on the use of BIM technology within the organization					
V44	The lack of contractual language for use with BIM technology inhibits its diffusion					
	Other (please specify)					
13	**Liability**	**1**	**2**	**3**	**4**	**5**
V45	The unexpected liability fears produced by BIM limit the use of BIM					
V46	The use of BIM technology increases the liability in company's work					
V47	The cost of insurance of the company may increase due to the use of BIM					
	Other (please specify)					
14						
Other Barriers not related to the above four categories...						

APPENDIX – B

Delphi Questionnaire – Round 2

Part 1 (BIM Benefits) - Round 2 (Delphi questionnaire)				
Based on result of Delphi round 1, please consider your rating by providing the agreement on the degree of the agreement below: **High** : Agreement of respondents with median **4** and **5** **Medium** : Agreement of respondents with median **3** and **3.5** **Low** : Agreement of respondents with median below **3**				
#	**Rating of Agreement Result from Round 1**	**BIM Benefits**	**Your Agreement Yes / No**	**If "No" Revise the Rating**
Pre-Construction Phase Benefits				
V1	High	improving the communication and collaboration among all project participants		
V3		Showing the realistic image of the project in virtual environment		
V6		Allowing different participants of the project to share and exchange data within one integrated 3D model		
V7		Detecting clashes and design errors with lesser time		
V2		Making fast and accurate cost estimation		
V4		Simulating the sequencing of the construction activities before the start		
V5		Facilitating the study of alternatives of design		
Construction Phase Benefits				
V11	High	Reducing rework		
V12		Improving construction productivity		
V9		Simulating the whole construction processes and show the status of the building and the surrounding space at any point of a time		
V8		Improving the quality of construction schedule by integrating the visual representation of the building with the schedule information		

V10		Improving the management of resources, labor, machines running in the project space		
Post-Construction Phase Benefits				
V13	High	BIM provides an accurate database containing the as-built systems and specifications, which create a start point to operate and manage the building properly		
V14		The integration between BIM and building management systems will significantly improve the operation and maintenance of building		
V15		The decision for the next similar building can be easily supported by basic data that is provided by the data accumulation		

Part 2 (BIM Barriers) - Round 2 (Delphi questionnaire)

Based on result of Delphi round 1, please consider your rating by providing the agreement on the degree of the agreement below:

High : Agreement of respondents with median **4** and **5**
Medium : Agreement of respondents with median **3** and **3.5**
Low : Agreement of respondents with median below **3**

#	Rating of Agreement Result from Round 1	BIM Barriers	Your Agreement Yes / No	If "No" Revise the Rating
Barriers related to culture				
		Resistance to Change		
V16	High	The difficulty of changing the way of doing work for a long time		
V17		Slow acceptance of new construction technologies in Saudi Arabia		
V18	Low	Lack of attention from construction firms to the new technology of BIM and its benefits and capabilities		
		Support of Top Management		
V19	Medium	Lack of support from top management in construction organizations		
V20		Lack of promotions offered by the top management to the BIM users are		
		Job Relevance		
V22	Medium	Lack of requests from owners to implement BIM		
V21	Low	Irrelevance of BIM to the business and management tasks of our company		

Barriers Related to The New Technology				
		Interoperability		
V23	High	Lack of BIM software applications interoperability		
V24		The unavailability of open standards such as IFCs in order to solve interoperability problems		
		Technology Requirements		
V25	High	Limitation in organization's budget for using new technologies represent a barrier to BIM spread		
V26		Lack of organizational updating to new software and hardware slows the use of BIM		
V27		Absence of some essential technical capacities required by BIM applications (storage capacity, speed, etc.)		
		Complexity		
V28	Medium	The complexity of BIM applications and their interface		
V29	Low	The long time needed to learn BIM applications		
		Cost of BIM Technology		
V30	High	The cost of BIM software and hardware		
V31		The cost of BIM modeling effort (time spent in modeling and managing BIM data)		
V32		The cost of BIM training		
		Quality of Output		
V33	High	Low quality of output that may be created by BIM influences the use of this technology		

Barriers Related to The New Process				
Process Change				
V34	High	The difficulty to change from fragmented system of delivering project to the more collaborative system of BIM		
V37		Lack of bidders using the technology of BIM		
V35	Medium	The new process of BIM involves new rules and responsibilities and this may represent an obstacle to the BIM diffusion		
V36	Low	The unreadiness of Saudi AEC industry to use BIM in delivering projects		
Training				
V38	High	Insufficient training offered by our company		
V39		Lack of institutions offering courses of BIM in our region		
Experience				
V40	Medium	Lack of enough experience on the use of the applications used in the BIM process		
Barriers Related to The Policies and Legal Issues				
Scope of work				
V42	Medium	The new collaborative style of doing works offered by BIM may generate a barrier to the technology diffusion		
V44		The lack of contractual language for use with BIM technology inhibits its diffusion		
V41		The changes in the organizational policy of work required by BIM represent a barrier to use it		
V43	Low	The difficulty to establish a clear work flow processes on the use of BIM technology within the organization		

Liability				
V46	High	The use of BIM technology increases the liability in company’s work		
V45	Medium	The unexpected liability fears produced by BIM limit the use of BIM		
V47		The cost of insurance of the company may increase due to the use of BIM		

APPENDIX – C

SPSS – Analysis of Delphi Round 1

FREQUENCIES VARIABLES=V1 V2 V3 V4 V5 V6 V7 V8 V9 V10 V11 V12 V13 V14 V15 V16 V17 V18 V19 V20 V21 V22 V23 V24 V25 V26 V27 V28 V29 V30 V31 V32 V33 V34 V35 V36 V37 V38 V39 V40 V41 V42 V43 V44 V45 V46 V47

/STATISTICS=STDDEV MEAN MEDIAN MODE

/ORDER=ANALYSIS.

Frequencies

[DataSet1] D:\KFUPM\MY THESIS\SPSS - Delphi - Round 1\Final Questionnaire - Round 1 analysis-SPSS.sav

Statistics

		V1	V2	V3	V4	V5	V6	V7
N	Valid	12	12	12	12	12	12	12
	Missing	0	0	0	0	0	0	0
Mean		4.58	4.17	4.25	4.17	4.08	4.42	4.67
Median		5.00	4.50	5.00	4.00	4.00	5.00	5.00
Mode		5	5	5	4	4	5	5
Std. Deviation		.515	1.193	1.215	.577	.793	.996	.888

Statistics

		V8	V9	V10	V11	V12	V13	V14
N	Valid	12	12	12	12	12	12	12
	Missing	0	0	0	0	0	0	0
Mean		4.08	4.33	3.83	4.67	4.58	4.33	4.33
Median		4.00	4.50	4.00	5.00	5.00	4.00	4.00
Mode		4	5	4	5	5	4	4

Std. Deviation	1.084	.888	.937	.492	.515	.651	.651

Statistics

		V15	V16	V17	V18	V19	V20	V21
N	Valid	12	12	12	12	12	12	12
	Missing	0	0	0	0	0	0	0
Mean		4.17	3.92	3.58	2.42	3.00	2.92	1.50
Median		4.00	4.00	4.00	2.00	3.00	3.00	1.00
Mode		4	4	4	2	2	1	1
Std. Deviation		.718	.515	1.311	1.240	1.414	1.564	.674

Statistics

		V22	V23	V24	V25	V26	V27	V28
N	Valid	12	12	12	12	12	12	12
	Missing	0	0	0	0	0	0	0
Mean		3.50	3.50	3.75	3.58	3.33	3.83	3.00
Median		3.50	4.00	4.00	4.00	4.00	4.00	3.00
Mode		3	4	3	4	4	4	2
Std. Deviation		1.000	1.446	1.215	1.240	1.303	1.193	.953

Statistics

		V29	V30	V31	V32	V33	V34	V35
N	Valid	12	12	12	12	12	12	12
	Missing	0	0	0	0	0	0	0
Mean		2.67	3.58	3.58	3.33	3.83	3.33	2.92
Median		2.00	4.00	4.00	4.00	4.00	4.00	3.00
Mode		2	4	4	4	5	4	3

Std. Deviation	.888	.900	.669	.888	1.337	1.073	.996

Statistics

		V36	V37	V38	V39	V40	V41	V42
N	Valid	12	12	12	12	12	12	12
	Missing	0	0	0	0	0	0	0
Mean		2.42	3.67	3.50	3.75	2.92	3.17	3.42
Median		2.50	4.00	4.00	4.00	3.00	3.00	3.50
Mode		3	4	4	4	2	2	4
Std. Deviation		.900	.985	1.567	1.288	1.240	1.030	.669

Statistics

		V43	V44	V45	V46	V47
N	Valid	12	12	12	12	12
	Missing	0	0	0	0	0
Mean		2.50	3.42	3.58	3.58	3.08
Median		2.00	3.50	3.50	4.00	3.00
Mode		2	4	3	4	3
Std. Deviation		.905	1.084	.900	.793	.996

a. Multiple modes exist. The smallest value is shown

Frequency Table

V1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	5	41.7	41.7	41.7
	5	7	58.3	58.3	100.0
	Total	12	100.0	100.0	

V2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	8.3	8.3	8.3
	3	1	8.3	8.3	16.7
	4	4	33.3	33.3	50.0
	5	6	50.0	50.0	100.0
	Total	12	100.0	100.0	

V3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	8.3	8.3	8.3
	3	1	8.3	8.3	16.7
	4	3	25.0	25.0	41.7
	5	7	58.3	58.3	100.0
	Total	12	100.0	100.0	

V4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	1	8.3	8.3	8.3
	4	8	66.7	66.7	75.0
	5	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	3	25.0	25.0	25.0
	4	5	41.7	41.7	66.7
	5	4	33.3	33.3	100.0
	Total	12	100.0	100.0	

V6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	8.3	8.3	8.3
	3	1	8.3	8.3	16.7
	4	2	16.7	16.7	33.3
	5	8	66.7	66.7	100.0
	Total	12	100.0	100.0	

V7

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	8.3	8.3	8.3
	4	1	8.3	8.3	16.7
	5	10	83.3	83.3	100.0
	Total	12	100.0	100.0	

V8

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	2	16.7	16.7	16.7
	4	5	41.7	41.7	58.3
	5	5	41.7	41.7	100.0
	Total	12	100.0	100.0	

V9

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	8.3	8.3	8.3
	4	5	41.7	41.7	50.0
	5	6	50.0	50.0	100.0
	Total	12	100.0	100.0	

V10

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	8.3	8.3	8.3
	3	3	25.0	25.0	33.3

	4	5	41.7	41.7	75.0
	5	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V11

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	4	33.3	33.3	33.3
	5	8	66.7	66.7	100.0
	Total	12	100.0	100.0	

V12

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	5	41.7	41.7	41.7
	5	7	58.3	58.3	100.0
	Total	12	100.0	100.0	

V13

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	1	8.3	8.3	8.3
	4	6	50.0	50.0	58.3
	5	5	41.7	41.7	100.0
	Total	12	100.0	100.0	

V14

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	1	8.3	8.3	8.3
	4	6	50.0	50.0	58.3
	5	5	41.7	41.7	100.0
	Total	12	100.0	100.0	

V15

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	2	16.7	16.7	16.7
	4	6	50.0	50.0	66.7
	5	4	33.3	33.3	100.0
	Total	12	100.0	100.0	

V16

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	2	16.7	16.7	16.7
	4	9	75.0	75.0	91.7
	5	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V17

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	8.3	8.3	8.3

		Frequency	Percent	Valid Percent	Cumulative Percent
	2	2	16.7	16.7	25.0
	3	1	8.3	8.3	33.3
	4	5	41.7	41.7	75.0
	5	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V18

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	3	25.0	25.0	25.0
	2	4	33.3	33.3	58.3
	3	3	25.0	25.0	83.3
	4	1	8.3	8.3	91.7
	5	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V19

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	16.7	16.7	16.7
	2	3	25.0	25.0	41.7
	3	2	16.7	16.7	58.3
	4	3	25.0	25.0	83.3
	5	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

V20

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	3	25.0	25.0	25.0
	2	2	16.7	16.7	41.7
	3	3	25.0	25.0	66.7
	4	1	8.3	8.3	75.0
	5	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V21

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	7	58.3	58.3	58.3
	2	4	33.3	33.3	91.7
	3	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V22

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	2	16.7	16.7	16.7
	3	4	33.3	33.3	50.0
	4	4	33.3	33.3	83.3
	5	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

V23

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	16.7	16.7	16.7
	2	1	8.3	8.3	25.0
	3	1	8.3	8.3	33.3
	4	5	41.7	41.7	75.0
	5	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V24

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	8.3	8.3	8.3
	3	4	33.3	33.3	41.7
	4	3	25.0	25.0	66.7
	5	4	33.3	33.3	100.0
	Total	12	100.0	100.0	

V25

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	8.3	8.3	8.3
	2	1	8.3	8.3	16.7
	3	3	25.0	25.0	41.7
	4	4	33.3	33.3	75.0

	5	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V26

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	8.3	8.3	8.3
	2	3	25.0	25.0	33.3
	3	1	8.3	8.3	41.7
	4	5	41.7	41.7	83.3
	5	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

V27

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	8.3	8.3	8.3
	2	1	8.3	8.3	16.7
	4	7	58.3	58.3	75.0
	5	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V28

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	5	41.7	41.7	41.7
	3	2	16.7	16.7	58.3

		Frequency	Percent	Valid Percent	Cumulative Percent
	4	5	41.7	41.7	100.0
	Total	12	100.0	100.0	

V29

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	7	58.3	58.3	58.3
	3	2	16.7	16.7	75.0
	4	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V30

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	2	16.7	16.7	16.7
	3	2	16.7	16.7	33.3
	4	7	58.3	58.3	91.7
	5	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V31

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	8.3	8.3	8.3
	3	3	25.0	25.0	33.3
	4	8	66.7	66.7	100.0
	Total	12	100.0	100.0	

V32

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	3	25.0	25.0	25.0
	3	2	16.7	16.7	41.7
	4	7	58.3	58.3	100.0
	Total	12	100.0	100.0	

V33

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	8.3	8.3	8.3
	2	1	8.3	8.3	16.7
	3	2	16.7	16.7	33.3
	4	3	25.0	25.0	58.3
	5	5	41.7	41.7	100.0
	Total	12	100.0	100.0	

V34

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	4	33.3	33.3	33.3
	3	1	8.3	8.3	41.7
	4	6	50.0	50.0	91.7
	5	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V35

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	8.3	8.3	8.3
	2	3	25.0	25.0	33.3
	3	4	33.3	33.3	66.7
	4	4	33.3	33.3	100.0
	Total	12	100.0	100.0	

V36

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	16.7	16.7	16.7
	2	4	33.3	33.3	50.0
	3	5	41.7	41.7	91.7
	4	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V37

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	2	16.7	16.7	16.7
	3	2	16.7	16.7	33.3
	4	6	50.0	50.0	83.3
	5	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

V38

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	16.7	16.7	16.7
	2	2	16.7	16.7	33.3
	4	4	33.3	33.3	66.7
	5	4	33.3	33.3	100.0
	Total	12	100.0	100.0	

V39

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	8.3	8.3	8.3
	2	1	8.3	8.3	16.7
	3	2	16.7	16.7	33.3
	4	4	33.3	33.3	66.7
	5	4	33.3	33.3	100.0
	Total	12	100.0	100.0	

V40

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	8.3	8.3	8.3
	2	4	33.3	33.3	41.7
	3	4	33.3	33.3	75.0
	4	1	8.3	8.3	83.3
	5	2	16.7	16.7	100.0

		Frequency	Percent	Valid Percent	Cumulative Percent
	Total	12	100.0	100.0	

V41

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	4	33.3	33.3	33.3
	3	3	25.0	25.0	58.3
	4	4	33.3	33.3	91.7
	5	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V42

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	8.3	8.3	8.3
	3	5	41.7	41.7	50.0
	4	6	50.0	50.0	100.0
	Total	12	100.0	100.0	

V43

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	8.3	8.3	8.3
	2	6	50.0	50.0	58.3
	3	3	25.0	25.0	83.3
	4	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

V44

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	3	25.0	25.0	25.0
	3	3	25.0	25.0	50.0
	4	4	33.3	33.3	83.3
	5	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

V45

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	8.3	8.3	8.3
	3	5	41.7	41.7	50.0
	4	4	33.3	33.3	83.3
	5	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

V46

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	8.3	8.3	8.3
	3	4	33.3	33.3	41.7
	4	6	50.0	50.0	91.7
	5	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V47

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	8.3	8.3	8.3
	2	1	8.3	8.3	16.7
	3	7	58.3	58.3	75.0
	4	2	16.7	16.7	91.7
	5	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

APPENDIX – D

SPSS – Analysis of Delphi Round 2

```
FREQUENCIES VARIABLES=V1 V3 V6 V7 V2 V4 V5 V11 V12 V9 V8 V10 V13
V14 V15 V16 V17 V18 V19 V20 V22 V21 V23 V24 V25 V26 V27 V28 V29 V30 V31
V32 V33 V34 V37 V35 V36 V38 V39 V40 V42 V44 V41 V43 V46 V45 V47
  /PERCENTILES=25.0 50.0 75.0
  /STATISTICS=STDDEV
  /ORDER=ANALYSIS.
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Frequencies

[DataSet1] D:\KFUPM\MY THESIS\SPSS - Delphi - Round 2\Final Questionnaire - Round 2 analysis-SPSS.sav

Statistics

		V1	V3	V6	V7	V2	V4
N	Valid	12	12	12	12	12	12
	Missing	0	0	0	0	0	0
Std. Deviation		.000	.289	.000	.289	.452	.289
Percentiles	25	1.00	1.00	1.00	1.00	1.00	1.00
	50	1.00	1.00	1.00	1.00	1.00	1.00
	75	1.00	1.00	1.00	1.00	1.75	1.00

Statistics

		V5	V11	V12	V9	V8	V10
N	Valid	12	12	12	12	12	12
	Missing	0	0	0	0	0	0
Std. Deviation		.389	.000	.000	.289	.000	.389

Percentiles	25	1.00	1.00	1.00	1.00	1.00	1.00
	50	1.00	1.00	1.00	1.00	1.00	1.00
	75	1.00	1.00	1.00	1.00	1.00	1.00

Statistics

		V13	V14	V15	V16	V17	V18
N	Valid	12	12	12	12	12	12
	Missing	0	0	0	0	0	0
Std. Deviation		.289	.289	.289	.289	.515	.389
Percentiles	25	1.00	1.00	1.00	1.00	1.00	1.00
	50	1.00	1.00	1.00	1.00	1.00	1.00
	75	1.00	1.00	1.00	1.00	2.00	1.00

Statistics

		V19	V20	V22	V21	V23	V24
N	Valid	12	12	12	12	12	12
	Missing	0	0	0	0	0	0
Std. Deviation		.452	.452	.289	.452	.000	.000
Percentiles	25	1.00	1.00	1.00	1.00	1.00	1.00
	50	1.00	1.00	1.00	1.00	1.00	1.00
	75	1.75	1.75	1.00	1.75	1.00	1.00

Statistics

		V25	V26	V27	V28	V29	V30
N	Valid	12	12	12	12	12	12
	Missing	0	0	0	0	0	0
Std. Deviation		.389	.452	.389	.452	.452	.000
Percentiles	25	1.00	1.00	1.00	1.00	1.00	1.00

	50	1.00	1.00	1.00	1.00	1.00	1.00
	75	1.00	1.75	1.00	1.75	1.75	1.00

Statistics

		V31	V32	V33	V34	V37	V35
N	Valid	12	12	12	12	12	12
	Missing	0	0	0	0	0	0
Std. Deviation		.452	.452	.452	.289	.000	.289
Percentiles	25	1.00	1.00	1.00	1.00	1.00	1.00
	50	1.00	1.00	1.00	1.00	1.00	1.00
	75	1.75	1.75	1.75	1.00	1.00	1.00

Statistics

		V36	V38	V39	V40	V42	V44
N	Valid	12	12	12	12	12	12
	Missing	0	0	0	0	0	0
Std. Deviation		.452	.452	.289	.289	.452	.289
Percentiles	25	1.00	1.00	1.00	1.00	1.00	1.00
	50	1.00	1.00	1.00	1.00	1.00	1.00
	75	1.75	1.75	1.00	1.00	1.75	1.00

Statistics

		V41	V43	V46	V45	V47
N	Valid	12	12	12	12	12
	Missing	0	0	0	0	0
Std. Deviation		.289	.389	.452	.000	.289
Percentiles	25	1.00	1.00	1.00	1.00	1.00
	50	1.00	1.00	1.00	1.00	1.00

75	1.00	1.00	1.75	1.00	1.00

Frequency Table

V1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	12	100.0	100.0	100.0

V3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V6

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	12	100.0	100.0	100.0

V7

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0
	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V5

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	10	83.3	83.3	83.3
	Disagree	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

V11

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	12	100.0	100.0	100.0

V12

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	12	100.0	100.0	100.0

V9

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V8

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	12	100.0	100.0	100.0

V10

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	10	83.3	83.3	83.3
	Disagree	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

V13

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V14

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V15

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V16

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V17

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	7	58.3	58.3	58.3
	Disagree	5	41.7	41.7	100.0
	Total	12	100.0	100.0	

V18

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	10	83.3	83.3	83.3
	Disagree	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

V19

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0
	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V20

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0
	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V22

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V21

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0
	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V23

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	12	100.0	100.0	100.0

V24

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	12	100.0	100.0	100.0

V25

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	10	83.3	83.3	83.3

	Disagree	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

V26

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0
	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V27

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	10	83.3	83.3	83.3
	Disagree	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

V28

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0
	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V29

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0

	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V30

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	12	100.0	100.0	100.0

V31

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0
	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V32

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0
	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V33

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0
	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V34

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V37

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	12	100.0	100.0	100.0

V35

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V36

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0
	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V38

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0
	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V39

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V40

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V42

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0
	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V44

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V41

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

V43

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	10	83.3	83.3	83.3
	Disagree	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

V46

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	9	75.0	75.0	75.0
	Disagree	3	25.0	25.0	100.0
	Total	12	100.0	100.0	

V45

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	12	100.0	100.0	100.0

V47

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	11	91.7	91.7	91.7
	Disagree	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

Vitae

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