A Framework of Multidisciplinary Team-Working in BIM for the Construction Industry

Mohammad Alsharqawi

Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Science
in
Civil Engineering

Eastern Mediterranean University
February 2017
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

Prof. Dr. Mustafa Tümer
Director

I certify that this thesis satisfies the requirements as a thesis for the degree of Master of Science in Civil Engineering.

Assoc. Prof. Dr. Serhan Şensoy
Chair, Department of Civil Engineering

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Master of Science in Civil Engineering.

Dr. Tolga Çelik
Supervisor

Examining Committee

1. Assoc. Prof. Dr. İbrahim Yitmen

2. Asst. Prof. Dr. Umut Yıldırım

3. Dr. Tolga Çelik

ABSTRACT

Construction is a project-based activity, wherein different disciplines work collaboratively to achieve the project goal. Collaboration is an important essential in the multi-disciplinary construction environment. Building Information Modeling (BIM) enables project participants to perform more efficiently and effectively. Thus encouraging different disciplines to collaborate in BIM construction projects is critical for optimizing BIM adoption and improving project performances. It is important for the project participants to work closely together to share their information, and deliver projects effectively and efficiently. The lack of right strategic planning on implementing BIM between participant is the main factor that many construction industry company are still unable to get the benefits from, which represent high challenge to collaboration by integrating the work performed by participants with varied environments, varying levels of expertise, and different perspectives, so there are Many factors need to be considered and most significantly the readiness of the organization needs to be assessed. This study aims to explore and investigate factors affecting multidisciplinary collaboration among the participants BIM processes in construction. In this respect, a questionnaire survey is designed and administered to participants in gulf countries and a total of 77 responses are collected for data analysis. In addition a case study of a New College of Engineering (COE) Building is applied to test the finalized research model. A conceptual framework model is planned to address the collaborative relationship between the participants of construction industry. Research results reveal that collaboration experiences among project participants impose significant positive influence on interoperability. also training is a critical support factor to BIM collaboration Professionals with more

BIM experiences tend to act more collaboratively in the project. In addition, early involvement of project participants also imposes a positive impact on BIM collaboration. This study provides an integrated view on inter-organizational collaboration in BIM construction projects, and addresses the Humans, financial, technological, process, and cultural resource associated with effective inter-organizational collaboration. In addition, to provide a better understanding of the essential elements of BIM implementation and guide the industry practitioners in developing proper strategies for effective management of the implementation process.

Keywords: Multidisciplinary in BIM, Building Information Modeling Framework, Collaboration, and Construction Management.

ÖZ

İnşaat, proje hedefine ulaşmak için farklı disiplinlerin işbirliği içinde çalıştığı proje tabanlı bir etkinliktir. İşbirliği, çok disiplinli inşaat ortamında önemli bir unsurdur. Bina Bilgisi Modeli (BIM), proje katılımcılarının daha verimli ve etkin bir şekilde çalışmasını sağlar. BIM inşaat projelerinde farklı disiplinleri işbirliğine teşvik etmek, BIM'in benimsenmesini optimize etmek ve proje performanslarının iyileştirilmesi için kritik öneme sahiptir. Proje katılımcıları, bilgilerini paylaşmak ve projeleri etkili ve verimli bir şekilde sunmak için birbirlerine yakından çalışmak önemlidir. Katılımcı arasında BIM'in uygulanması için doğru stratejik planlamanın eksikliği, pek çok inşaat sektörü şirketinin, katılımcıların gerçekleştirdiği çalışmayı, çeşitli ortamlarda, farklı uzmanlık düzeyleriyle entegre ederek, işbirliğine karşı yüksek bir meydan okumayı temsil eden avantajları hala elde edemediği ana faktördür , Ve farklı perspektifler vardır, bu nedenle pek çok faktör düşünülmelidir ve en önemlisi kuruluşun hazırlığı değerlendirilmelidir. Bu çalışma, katılımcıların inşaatta BIM süreçleri arasındaki çok disiplinli işbirliğini etkileyen faktörleri araştırmayı ve araştırmayı amaçlamaktadır. Bu bağlamda, körfez ülkelerindeki katılımcılara bir anket formu tasarlanmış ve uygulanmıştır ve veri analizi için toplam 77 yanıt toplanmıştır. Buna ek olarak, sonuçlandırılmış araştırma modelini test etmek için Yeni Mühendislik Fakültesi (COE) Binası için bir vaka çalışması da uygulanmaktadır. İnşaat sektörünün katılımcıları arasındaki işbirliğine dayalı ilişkiye yönelik olarak kavramsal bir çerçeve modeli planlanmaktadır. Araştırma sonuçları, proje katılımcıları arasındaki işbirliği deneyimlerinin birlikte çalışabilirlik üzerinde önemli bir olumlu etkisi olduğunu ortaya koymaktadır. Ayrıca eğitim, BIM işbirliğinde kritik bir destek faktörüdür. Daha çok BIM deneyimine sahip olan uzmanlar, projede daha fazla işbirliği yapmaya meyillidir. Buna ek olarak, proje katılımcılarının erken katılımı da BIM işbirliğine olumlu bir etki yapmaktadır. Bu çalışma, BIM inşaat projelerinde örgütler arası işbirliğine ilişkin entegre bir görüş sağlamakta ve etkili örgütlerarası işbirliği ile bağlantılı olan İnsanlar, finansal, teknolojik, süreç ve kültürel kaynakları ele almaktadır. Ayrıca, BIM uygulamasının temel unsurlarını daha iyi anlamak ve uygulama uygulamanın etkin yönetimi için doğru stratejileri geliştirmede endüstri uygulayıcılarınarehberliketmek.

Anahtar Kelimeler: BIM'de çok disiplinli, Bina Bilgi Modelleme Çerçevesi, İşbirliği ve İnşaat Yönetimi.

DEDICATION

TO MY BELOVED FAMILY

ACKNOWLEDGMENT

I would like to thank my supervisor Dr. Tolga Çelik towards the success of this research in spite of his busy schedule.

A special thanks to Associated Prof. Dr. Ibrahim Yitmen, for all his support and advices.

Finally, I would like to thank my family, specially my brother Yazan for his continuous and unlimited support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVEATIONS

2D CAD	Two Dimension Computer Aided Design
3D CAD	Three Dimension Computer Aided Design
4D	Scheduling (time) in BIM
5D	Cost Analysis (estimating) in BIM
AEC	Architecture, Engineering, and Construction
ADE	Al Darwish Engineering
AIA	American Institute of Architects
AIACC	American Institute of Architects California Council
BCF	BIM Collaboration Format
BG	BIG Room
BIM	Building Information Modeling
COBIe	Construction Operations Building Information Exchange
COE	College Of Engineering
CMAR	Construction Management at Risk
DB	Design Build
DBB	Design-Bid-Build
FM	Facility Management
GSAS	Global Sustainability Assessment System
IFC	Industry Foundation Classes
IPD	Integrated Project Delivery
IT	Information Technology
KW	Knot Working
LOD	Level Of Development

MEP	Mechanical, Electrical, and Plumbing
NBIMS	National Building Information Modeling Standards
O&M	Operation and Maintenance
QU	Qatar University
ROI	Return On Investment
US	United State
UK	United Kingdom
VDC	Virtual Design and Construction

Chapter 1

INTRODUCTION

1.1 Background

Creating teams comprising of various disciplines, in general, facilitates the resolution of complex problems by generating new and creative solutions. A multi-disciplinary approach is defined by the oxford dictionary as the act of “combining or involving several academic disciplines or professional specializations in an approach to a topic or problem. For example, the construction industry is one that deploys cooperation of various projects disciplines. The end result in these projects is traced from collective efforts and goals of the many disciplines included. Due to fragmented nature of activities, active participation and teambuilding is becoming increasingly significant in the construction projects (Suwal et al., 2016).

Successful and effective collaboration effort between the project members is viewed as noteworthy and helpful for undertakings projects, prompting to better effectiveness, quality. Therefore, expanded productivity for the construction industry. These days, diverse strategies, procedures and technologies being actively implemented to support cooperative methods for working, for example, building information modeling (BIM) (Hardin, 2009;Gu et al.,2010; Eastman et al., 2011; Arayici, Egbu, and Coates, 2012)

Construction industry project is based on activities, in which different disciplines work collaboratively to achieve the project goal. Compelling collaboration and enterprise among all project members is fundamental to accomplish the full focal points of BIM. In this manner, empowering different disciplines (architect, engineer, surveyor, contractor, etc.) to team up in BIM construction projects is basic for enhancing BIM adoption and enhancing venture exhibitions.

The following figure 1 illustrates the main disciplines in construction industry. A project team constitutes experts from various organizations (e.g. architectural, engineering, and construction). It is basic for the venture members to work firmly together to share their information, arrange working streams, mutually settle on choice, accomplish inter-organizational, and convey extends viably and proficiently.

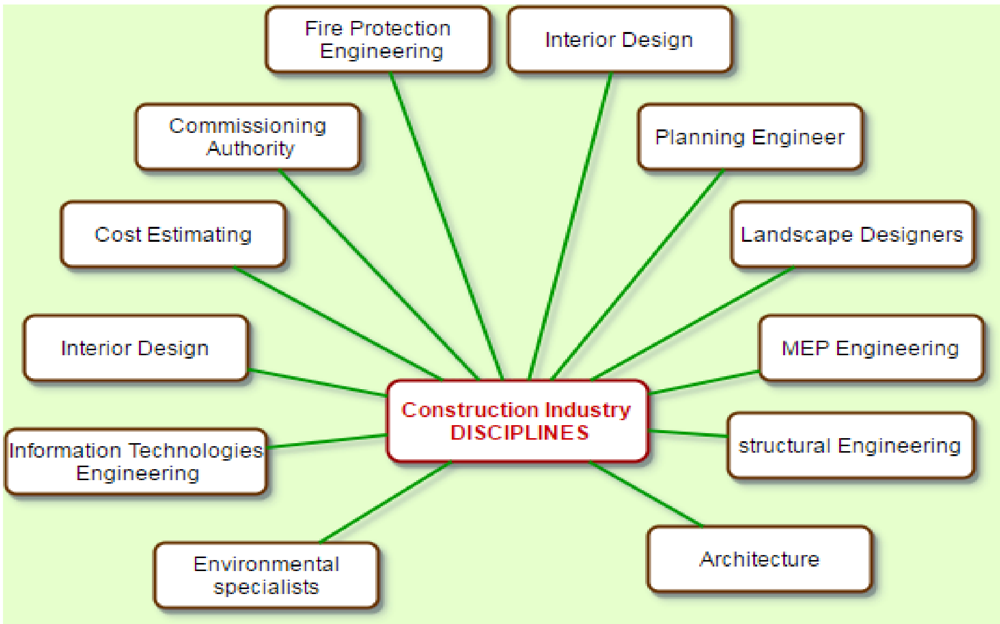

Figure 1: Main Disciplines in Construction Industry

Collaborative design using a Build Information Modeling (BIM) innovation stage guarantees to give a viable method for designing and communicating through systems administration and ongoing data sharing. (Liu, Wet al.,2014). BIM is an innovation change as well as a process change (Eastman et al., 2011); and problematic advancements have disturbed numerous different businesses and made them be reevaluated (Yalcinkaya et al.,2016).and BIM is a far-reaching knowledge space inside the AEC industry (Azhar, 2012).

Thus, BIM involves more noteworthy difficulties contrasted with those saw with the presentation of advancements in the AEC business during the most recent 30 years BIM implementation has made modifications in corporate hierarchical structures, and new positions, for example, BIM Managers, BIM managers and Model Coordinators have developed. These positions are indispensable, and endeavor to encourage benefits in efficiency, coordination, scheduling, and planning, and in addition to lessen the weight of detailed and conflicting processes including various orders (McDonnell and Hayden, 2013). This exploration investigates the outlook changes happening with the current presentation of BIM and the significance of coordination communication and the development of a collaborative environment.

1.2 Problem Statement

The multidisciplinary collaborative atmosphere is complex, making project coordination, model data management, and object-based communication highly correspondence tasks (Hossain et al., 2013). One of the basic constituents of successful BIM implementation is efficient collaboration amongst project participants and the multidisciplinary of the team involved (Eastman, 2011).

Participant may utilize BIM in every phase of a construction project, but the BIM model has not been delivered from one participant to another: each forms their own

BIM, so there is a major problem in how to integrate these dynamic and fragmented data together. For example, during the design, shop drawing, fabrication and construction phases, nearly all required information is developed for a facility. Unfortunately, it is typically not captured and stored for future use. (Xu.M, et al., 2014).

The absence of right strategic planning on implementing BIM between participant is the main factor that many construction industry company are still unable to get the benefits from, which represent high challenge to collaboration by integrating the work performed by participants with varied environments, varying levels of expertise, and different perspectives, so there are Many factors need to be considered and most significantly the readiness of the organization needs to be assessed.

BIM projects still suffer from lack of integration, even in the projects with high level of BIM adoption. Because collaboration is essential to project integration and collaboration reflects the willingness to collaborate and willingness to share information between project participants. However, there is no clear evidence of successful collaboration approach for BIM implementation, or the reasons for failure in BIM collaboration. Therefore, there is research gap to identify the characteristics of BIM collaboration that facilitate project participants to use BIM effectively and to explore the relationships between collaboration and project achievement.

1.3 Research Scope and Objectives

The extent of this examination includes experts who have partaken in a BIM development extend and be involved of interfacing with other colleagues in the BIM construction to decide the components influence of multidisciplinary joint effort experienced with the BIM implementation in construction industry.

Therefore, the major objectives of the research are as follows:

1. To examine outcomes of multidisciplinary collaboration in BIM for construction industry. This can be achieved through comprehensive literature review.

2. To determine the most important factors affecting of multidisciplinary team working in BIM context of construction industry using data from questionnaire survey targeting at professionals with BIM experience in the construction industry.

3. to investigate the relationship between BIM collaboration and perceived success of BIM implementation and project success by conducting a case study of building in Qatar.

4. To develop a conceptual framework that understands multidisciplinary in BIM context for construction industry.

1.4 Research Methodology

The exploration incorporates an extensive literature study, conducting a questionnaires survey research which has been done by gathering information from different experts of construction industry. Through the methodology, Secondly a case study of the New College of Engineering (COE) Building project is conducted which was built in Qatar University. the research will generate a better understanding in the experiences of interactions within the multi-disciplinary scene facilitated by

BIM. Also, the data mined will enhance more analysis of important information, establishment of findings and ultimately influence final decision process. These decisions will to a large extent adopt the BIM in the construction industry sector.

1.5 Thesis Guideline

The complete thesis constitutes of 6 chapters. Chapter 1 represents the introduction and the objectives of this study. A well modeled comparative analysis is carried out to form and correlate the relationships and patterns concerned with the selected subjects. Chapter 2 covers the literature review involving an in-depth literature study in BIM and IPD use, and software platforms and virtual collaboration. Chapter 3 gives a description of the mythologies applied in this research, While, chapter 4 involves the findings and discussions of data mined. Chapter 5 represents a suggested a conceptual framework for assessing multidisciplinary in BIM context, finally Chapter 6 contains the conclusion and recommendations of this study, It summarizes the whole study in respect to important result findings.

1.6 Summary

The implication of this study are that a a good understanding of the factors that enhance collaboration effort between the participant required in project life cycle to improves building execution, as well as improves the competitiveness of building design firms. the research aims to stay in line with the industry updates throughout its duration. The purpose for the research is to additionally comprehend the present patterns and parameters built up in the communitarian BIM environment and watch how these influences extends that take after BIM practices. It is key to comprehend the forming of the collective environment and the part of its key players, including owners or facility managers.

Chapter 2

LITERATURE REVIEW

The literature review covers description of the multi-disciplinary approach, Multi-disciplinarily approach in construction project, BIM and Multi-Disciplinarily, BIM process with Multi-Disciplinarily, Multidisciplinary effects in BIM, BIM requirements with multidisciplinary, BIM Software's for Multidisciplinary, disadvantages of BIM with multidisciplinary, BIM with Integrated Project Delivery (IPD), Level of BIM and BIM Maturity, Open BIM, Industry Foundation Classes (IFC), BIM Collaboration Format (BCF), Virtual Design and Construction (VDC), Factors Affecting of Team-working within the multidisciplinary.

2.1 Multi-Disciplinary Approach

Creating teams of varying disciplines facilitates the resolution of complex problems by generating new and creative solutions. Various sources in literature identify the importance of multidisciplinary in teamwork. Choi & Pak (2006) defines the objective of multidisciplinary approach as "to resolve real world or complex problems (...and) to provide a different perspective. Similarly, Cross (2004) identifies the importance of multidisciplinary as an approach to increase the potential generation of creative solutions through interconnection of interdisciplinary knowledge of participants.

Multidisciplinary teams are beneficial for solving critically important and complex problems, while providing new dimensions towards innovative, knowledge, production and creation. Individual expertise, skills and competencies directly impacts on dynamics of multidisciplinary in teamwork. So, a balanced interaction amongst required fields is important for effective multidisciplinary team building. Given the complexity of social, technical and process variables in various construction related projects, to understand the meaning of multidisciplinary is essential particularly in the specific context of AEC industry. This understanding is particularly necessary given the traditional mentality that exists between the engineering disciplines (Suwal, S.et al., 2016).

2.2 Multi-Disciplinary in Construction Projects

Construction projects have naturally involved the cooperation of various disciplines. Construction projects in their uniqueness and large phases require huge investments. Construction project success is a collective-based effort of multiple disciplines. Fragmentation nature of activities, active collaboration and teamwork is implemented as a modern-day construction project (Lu W., Zhang D., and Rawlinson S., 2013).

Various processes tools, and technologies have been developed and applied to power multidisciplinary collaboration. Contractual models such as PPP (Private Public Partnerships), IPD (Integrated Project Delivery), Alliance contracts and partnering, encourage shared interest in project success by giving the participants a vested ownership. Further development of integrated contractual arrangements tools designed to enhance the efficiency of organization capabilities. Building Information Modeling (BIM), BIG room (BR) and Knot working (KW) are amongst the models enhancing collaboration in multidisciplinary projects. All these approaches are enablers to create multi-disciplinary environments, in exception to not affecting major final team decisions what so ever (Suwal.s.,et al., 2016).

2.3 BIM and Multi-Disciplinary

NIBS (2015) defines BIM as “a process involving generation and management of digital representations of physical and functional characteristics of places, which can be exchanged or networked to support decision-making in architecture, engineering and construction (AEC) sector. As such, it serves as a collaborative platform for all stakeholders to share their knowledge resource and information.

BIM is a collaborative approach to construction that includes incorporating the various disciplines to build a structure in a virtual environment. The pith of BIM implementation is the collaborative working process in construction work. Accordingly, project participants produce greatest advantage for collaborative arrangements, expanding efficiency and effectiveness (Greenwood, D. & Wu, S., 2012).The process allows project team to work effectively, identifying potential problems before they commission building on site.

2.4 BIM Process with Multi-Disciplinary

Contractors are in charge for the way and methods while the architects are responsible for the design. In any case, with the advances of BIM and the early involvement set by Integrated Project Delivery (IPD), not only do these parties perform different tasks, they perform per different standards in a collaborative fashion. This makes issues in relation to the degree in which disciplines can rely on the information provided by the corresponding disciplines in the BIM process. It is imperative to recognize the roles of the disciplines and allocate the risks and responsibilities involved in the participating disciplines.

BIM benefits from the capacity of the owner, designers, and contractors to share data boundlessly, however this is not generally the case. The contract needs to address information ownerships and protection methods. In IPD contracts, disciplines address contractual obligations, however, the information moves freely and are shared among the disciplines, consultants, and subcontractors. This approach would display a higher success rate if the parties have contractual obligations to increase collaboration and reduce or eliminate the traditional pressure areas between owner, designer, and builder (Dirik, 2009).

2.5 BIM Effects in Multi-Disciplinary

Most interest and focus (about BIM approach) is in 3D coordination. Per Jung and Lee (2015) 85% of AEC companies surveyed show this to be the most important utilization of BIM today. The 3D models made by BIM pushes the architects and engineers when passing on their framework ideas to proprietors, and aides multidisciplinary communication and coordinated exertion, 4D (Scheduling) and 5D (cost) analysis.

Cleves and Dal Gallo (2012) expressed that an IPD contract itself does not warrant viable delivery of the project. Participants' ability to collaborate and engaging key personnel of various parties are necessary to implement IPD as intended (Abdirad H., Pishdad P., 2014) Sufficient information increases communication effectiveness. Effective communication allows stakeholders to exchange accurate, update and clarified information for decision makers to form a reliable decision.

There is absence of BIM capability assessment criteria, standards or standardized accreditation. As various BIM tools and technologies are present, there is not yet any regular system for assessing individual BIM competencies and guidelines to support the level of BIM expertise needed. There is much variance in individual BIM competences dependent upon level of BIM knowledge, BIM skills and the level of expertise required for a project of differing types. Assessment of individual BIM tool competences can be seen emerging for specific BIM applications conducted primarily by private industry such as software vendors. These individual levels of competences are imperative; however, necessity varies per the project type, location and diversity of BIM tool utilization. No system characterizing these levels or competences has yet been developed. (Suwal and Singh and shaw,2016). Advance, Bryde, Briquets, and Volm (2013) perceive that coordination flaws are the second biggest negative impact to venture execution after programming issue in development ventures BIM empowered undertakings.

The owners can profit from using BIM in few perspectives to reduce cost and time and enhance quality, health and safety. A wide range of ownership of almost all types of projects can achieve benefits from utilizing BIM; it is clearly that the amount and types of these advantages from case to case. Using 3D modeling will make extremely less demanding to involve valuable inputs form all stakeholders into project model. Applying changes to designs regardless of the reason of those changes is much faster and easier in BIM model and will be open by relevant stakeholders (Wong, Wong, and Nadeem, 2010). BIM models enable owners to virtually review the accessibility and maintainability of facilities.

By using BIM model, BIM makes incorporating structural and mechanical systems into design much quicker by importing data from analysis software, understanding about details better by BIM 3D model and executing structures cheaper by facilitating using prefabricated structures. Synchronizing different software data is practicable by new neutral format called IFC (Industry Foundation Classes).

Construction model contains specialist service providers' input data like information of MEP systems, precast concrete, and structural steel, which require special design, engineering and fabrication. Considering each of these services delivered by separate organizations, using BIM has notable influences on collaboration between these organizations. BIM model also can be utilized as legal and contractual source of information instead of 2D drawing s and specifications (Eastman et al., 2011).

By utilizing BIM model, contractor can save time and cash by diminishing mistakes and modifies "While portion of the potential value of a contractor's knowledge is lost after the design phase is complete, significant benefits to the contractor and the project team can still be realized by using a building model to support a variety of construction work processes. These advantages can prefab ally be achieved by developing a model in-house with the collaboration of subcontractors and fabricators" (Eastman et al., 2011).

2.6 BIM Requirements with Multi-Disciplinary

BIM technologies, their adoption and implementation require collaborative teamwork and processes. Improvements of new roles and demand for new competencies of disciplines suggest new approaches and requirements for multidisciplinary collaboration amongst the project participants. for instance, the occupation of BIM coordinator/BIM administrator swings to be a typical role within approx. 5-10 years. Thusly, BIM requires multidisciplinary abilities and knowledge both at individual and team level. Individuals well versed in their own discipline need also to have BIM aptitudes and learning. Overall The team should be familiar with project management skills which employ mostly all the work layout to be executed by all participants. I.e. task knowledge as well as teamwork knowledge and including teamwork in the context of BIM. Therefore, it is desirable to understand the balance of domain vs. BIM knowledge that is required at individual levels, and similarly, the balance of task vs. team knowledge to be involved at group level. at present, there are no methodological approaches to assess or comprehend these requirements.

2.7 BIM Software's for Multidisciplinary

The advantages from BIM can be augmented when a variety of software that fit under the BIM spectrum is utilized in concurrence. A 3D model of a building can be displayed about 4D information (schedules and timing issues) as well as 5D information. A feedback loop is created by the incremental data computed by the participating members, streamlining the project delivery (Dispenza 2010). The software options most pertinent to our study are discussed below.

2.7.1 Autodesk-Revit

Autodesk Revit is building information modeling software for architects, structural engineers, MEP engineers, designers and contractors developed by Autodesk. It is a solution for collaborative BIM in 3D model, Revit has highlights for all disciplines involved in a building project.. Revit is 4D BIM capable with tools to plan and track various stages in the building's lifecycle, from concept to construction and later demolition. Reliable data exchange is critical to project collaboration. Autodesk is the leader in supporting the .IFC open file format and other openBIM data formats, including Construction Operations Building Information Exchange (COBie) for BIM data, gbXML, LandXML, and more.

2.7.2 Bentley

Bentley is a supplier of building information modeling (BIM) software, AECOsim Building Designer for the architecture, civil, structural, and mechanical and electrical engineering disciplines. Bentley also provides Generative Components, a parametric modeling product used primarily by architects and engineers in building design. Bentley has three principal software product lines: MicroStation, ProjectWise, and AssetWise. Micro Station is a desktop 2D/3D CAD platform. ProjectWise is project information management and cloud collaboration AECO software for sharing project information. AssetWise is Bentley's project risk management software to determine how safe infrastructure assets are. A critical contrast between Bentley offers and its competitors is that their BIM solution is integrated and multidisciplinary. Meaning that the architectural, civil, electrical, mechanical and infrastructure work together. The information and the components within the multiple disciplinary constantly interact.

2.7.3 Autodesk Navisworks

Navisworks can consolidate various models including the architecture, structure, and MEP models that were exported from their respective RevitBIM applications. The force of the application lays in its ability to import the corresponding 3D file formats and append multiple models into one file. Navisworks is equipped with a powerful compression technology that allows them to be easily reviewed project, regardless of the file size or format. Additionally, it offers a4D construction simulation in its Navisworks Simulate and Navisworks Manage products. The 4D capabilities are capable and instinctive and permit several scheduling options (Khemlani 2007).

2.8 Challenges Hinder the Implementation of BIM

The implementation of BIM is not free of challenges, since there are several challenges that hinder the change to BIM. most of changes to adopt new technology or processes are facing sever resistance; hence resistance to change towards BIM is one of the most significant challenge. . However, organizations and the AEC industry can avoid or be prepared for these challenges by promoting the real awareness of BIM. (Arayici et al. 2011; Simona 2012).

Implementation of BIM significantly changes the normal processes and accordingly changes the workflow, roles and responsibilities where some employees will lose their power and some new careers will be created with high authorities. Therefore, this challenge deemed critical due to the sever resistance from the impacted employees especially the top management or old employees, which require familiarizing themselves with the new processes, roles and responsibilities (Elmualim& Gilder 2014; Love et al. 2014). Furthermore, BIM model requires rigorous control for inputs, otherwise the BIM final model will encompass several mistakes and the liabilities of these mistakes could be lost (Gu & London 2010; Azhar et al. 2012). So, lack of skilled resources to operate the BIM software models, where the demand for the BIM operators is extremely more than the available resources. Eadie et al. 2013; Migilinskas 2013).

In addition, technical challenges which entail BIM model interoperability where the project teams are always using different and incompatible software, which hinders the free flow of the information and data among the project teams especially the design teams (Bryde et al. 2013; Chien et al. 2014).

One of the obstacles to implement BIM the influence on the way to implement BIM by the AEC players on the organizations. Which means lack of government or client demand to implement BIM is recognized as one of the most paramount drawbacks that hinder the organizations to utilize BIM (Eadie et al. 2013; Chain, 2014).

the lack of utilization of BIM by some owners prevents BIM users of reaping the full benefits of BIM. Consequently, if most the project owner are not using BIM the BIM user will be forced to stop using BIM in the project otherwise BIM user could lose the communication and streamlining of information with the project owners (Eastman et al. 2011; Migilinskas et al. 2013).

The costs associated with the implementation of BIM are considered as a great challenge for small and some medium size organizations. Because implementation of BIM requires big funds within a short duration which SMEs' cannot afford (Won et al. 2013).

Most of the used procurement strategies are not fully supporting the collaboration principles. That means there is crucial need to change the current procurement strategies to follow the procurement strategy that is integrated with BIM such as IPD. However, the domination of the traditional procurement strategies is one of the recognized challenges to reap the full benefits of BIM (Love et al. 2014).

It is very important for the organizations intending to implement BIM to well understand the recognized challenges and obstacles to be ready with the appropriate plans for swift and successful implementation of BIM.

2.9 Integrated Project Delivery (IPD)

Previously, there were four method project delivery models available to owners: Design-Bid-Build, Design-Build, CM at Risk, and Multiple Prime. Each offers an alternate level of predictability to project outcome and risk. Integrated Project Delivery (IPD) is a fifth delivery model that is gaining momentum. IPD offers owners the maximum opportunity to optimize their business case within predicable risks as shown in the figure 2. In 2014 the American Institute of Architects California Council (AIACC) has updated IPD definition as:

> A project delivery method that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction (AIACC, 2014).

Per AIACC (2014), the IPD method must at the least contains all the following:

- Continuous involvement of owner, key designers and builders from early design through project completion.
- Business interest aligned through shared risk/reward, including financial gain at risk that is depend upon project outcome
- Owner involvement in project control with and key designers and builders.
- A multi-party agreement or equal interlocking agreements.
- Limited liability among owner, key designers and builders.

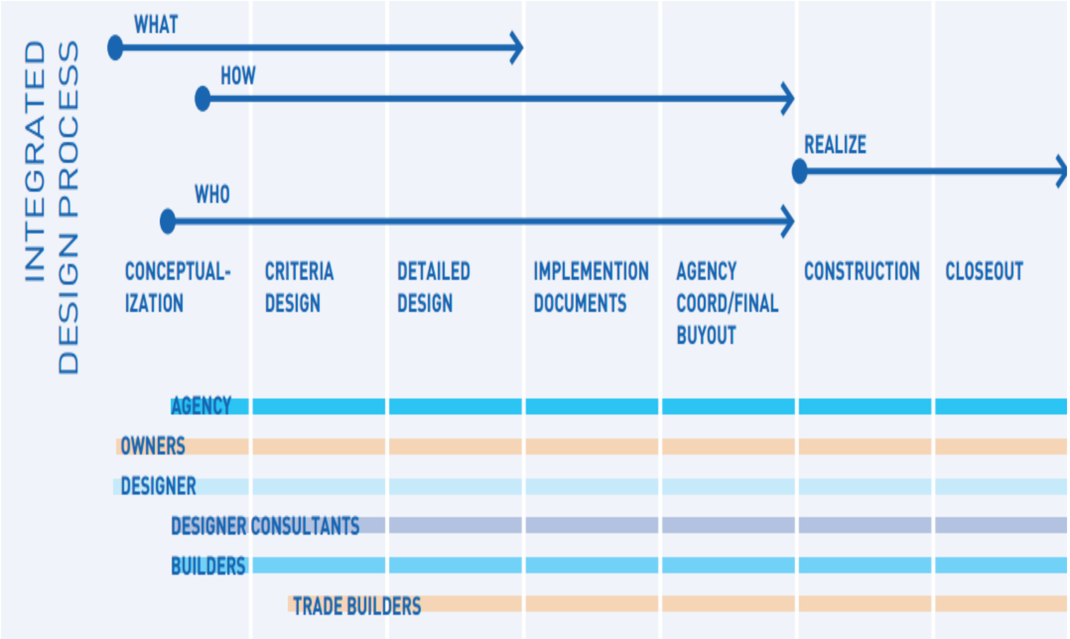

Figure 2: Integrated Organizational Structure, Phasing and Roles (AIAA, 2014)

• Who: The project participants

• What: The physical and functional requirements of the project

• How: The means and methods that will be used to make the "What" real

• Realize: The act of making the "What" real – i.e. construction the phases of an Integrated Project differ from traditional phases (Schematic Design, Design Development, Construction Documents, etc.) to take advantage of two critical factors**:**

• In addition to the design expertise of a traditional design team, expertise in construction aspects (cost, scheduling, material performance and availability, means and methods, etc.) is available throughout the design process.

• Building Information Modeling (BIM) tools and processes empower the group to integrate this broader range of knowledge to provide powerful support for design decisions.

BIM and IPD supplement each other by improving the management of the project through increased data exchange and cooperation between stakeholders, which results in:(a) less risk of defects and rectification;(b) less waste of materials; and(c) less issues during construction.

2.10 The Levels of BIM and BIM Maturity

The evolution from traditional CAD to the integrated and interoperable Building Information Model passes through stages. Its objective was to clarify BIM maturity, to give people a sense of their BIM maturity, and to provide a strategic direction for BIM implementation development. The movement from one level to another is referred to as 'BIM maturity'. The levels of BIM are listed below (Barnes and Davies, 2014):

- Level 0 isn't really BIM at all. It relates to use of 2D CAD files for design and production information.
- Level 1 represents the first step toward genuine BIM and the use of 3D data to present design. Designers at this level usually use managed CAD in 2D or 3D format with collaborative tool providing a common data environment, where standards for data structures and formats are utilized. Finance and cost management packages are not integrated in the general BIM model.
- Level 2 is distinguished by collaborative working – all parties use their own 3D CAD models, but not necessarily working on a single, shared model. The collaboration comes in the form of how the information is exchanged between different parties – and is the crucial aspect of this level.
- Level 3 this represents full collaboration between all disciplines by means of using a single, shared project model which is held in a centralized repository. All parties can access and modify that same model, and the benefit is that it removes

the final layer of risk for conflicting information. This is known as Open BIM' (NBIMS 2014). Figure 3 represent BIM maturity from zero level to full integration level.

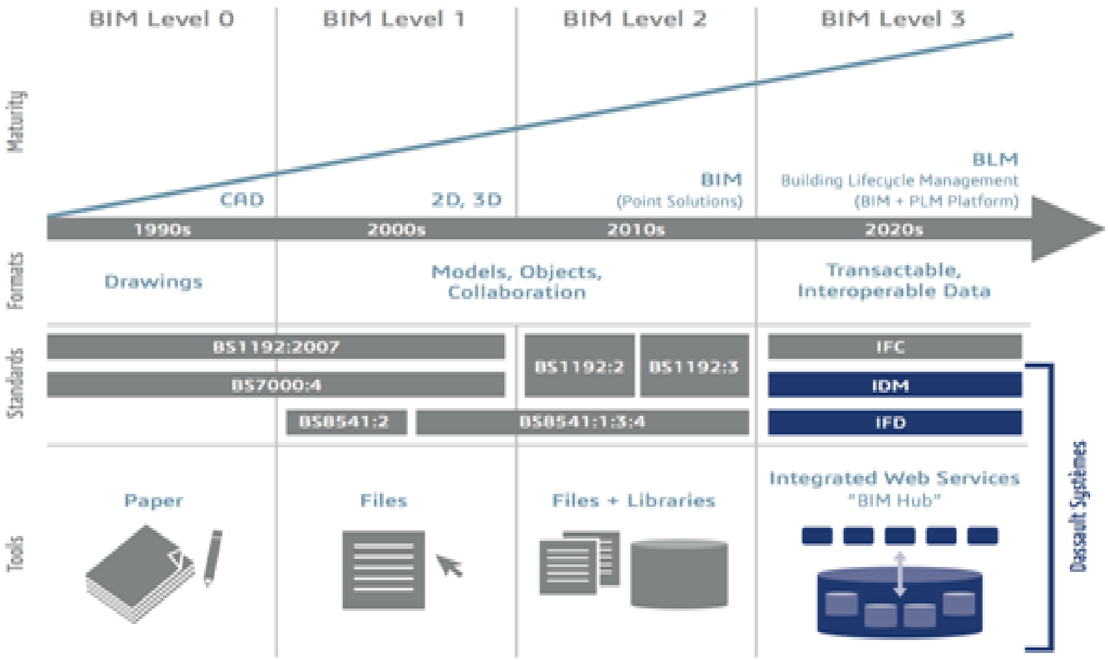

Figure 3: BIM Level of Maturity (DASSULT SYSTEMS, 2016)

2.11 Open BIM

OpenBIM is a widespread approach to the collaborative design, acknowledgment and operation of buildings based on open standards and workflows. OpenBIM is an initiative of building SMART and several leading software vendors using the open building SMART Data Model.

It permits project team members to participate in building information modeling (BIM) regardless of the software tools they use. It promotes a transparent and collaborative open workflow, creates a common language for widely referenced processes, and provides enduring project data for use throughout the asset life-cycle. Open BIM permits building information modeling to focus on workflow compatibility rather than the data compatibility, and means that project team members can be selected based on their capability rather than their use of a brand of software. Thus, team members can use the software that best suits their needs, and are better able to retain control over their own design data while still being able to collaborate with others (Building SMART, Technical vision).

2.12 Industry Foundation Classes (IFC)

As construction projects typically involve teams coming together from different organizations, they will inevitably use different hardware and software. To facilitate collaboration between team members in creating building information models whilst enabling them to continue to use software that they have invested in and are familiar with, a standard has been developed for the exchange of data.

The Industry Foundation Classes (IFC) specification is a neutral, non-proprietary data format used to describe exchange and share information. It is the international standard for building information modeling used for sharing and exchanging construction and facility management data across different software applications. It has been registered with the International Standardization Organization since 2013 as ISO16739 'Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries.

IFC was developed to facilitate interoperability, but it does not itself guarantee interoperability. This is dependent on the software that interfaces with it. Building SMART offers a software certification process, and currently IFC is supported by approximately 150 software applications worldwide. Industries (IFC) are the open and neutral data format for OpenBIM. They are the international standard for building information modeling used for sharing and exchanging construction and facility management data across different software applications

2.13 Virtual Design and Construction (VDC)

Virtual Design and Construction (VDC) is the management of integrated multi-disciplinary performance models of design-construction projects, including the product (i.e., facilities), work processes and organization of the design - construction - operation team to support explicit and public business objectives. Virtual Design and Construction BIMs are virtual because they show computer-based descriptions of the project. The BIM project model emphasizes those aspects of the project that can be designed and managed, i.e., the product (typically a building or plant [and infrastructure]), the organization that will define, design, construct and operate it, and the process that the organization teams will follow, or POP. These models are logically integrated in the sense that they all can access shared data, and if a user highlights or changes an aspect of one, the integrated models can highlight or change the dependent aspects of related models. The models are multi-disciplinary in the order that they represent the Architect, Engineering, Construction (AEC) and Owner of the project, as well as relevant sub-disciplines (John Kunz & Martin Fischer,2012)

2.14 BIM Collaboration Format (BCF)

BIM Collaboration Format (BCF) is an open file format based on XML that supports workflow communication in BIM processes and allows the addition of comments to an Industry Foundation Classes BIM model (IFC is a neutral, non-proprietary data format used for sharing and exchanging BIM data across different software applications. (Designing Buildings BCF,2016)

The BIM Collaboration Format Enhancing team communication with BCF files proves to be very helpful to project coordination, and this applies to most project stages, size and teams. BCF is intended to simplify collaboration between different parties working on a model by allowing them to raise issues, provide answers and make comments within an open file format that does not itself contain model elements. That is, it provides a communication capability that is separated from the model itself. (Mogollon, N., BCF 2014).

2.15 Factors Affecting on Team Working of Multidisciplinary

Won et al. (2013) ensure that effective collaboration is the critical successful factor to the BIM implementation and poor collaboration among participants need to be addressed in current adoption of BIM. There is no obvious evidence regarding either the characteristics of successful BIM collaboration approaches then again, the reasons of why BIM joint effort may come up short. Furthermore, existing writing and reasonable use of BIM don't give an unmistakable sign of what particularly constitutes the execution of BIM cooperation handle. A few professionals see BIM as a community oriented innovation and device, though others consider BIM from a perspective of developing collaborative relationships among project participants. Therefore, it is important to identify the factors of BIM collaboration that companies can promote and to explore how these relate to project performance and effectiveness

To determine the main factors influencing the multidisciplinary collaborative in BIM within the AEC industry an extensive literature review was conducted. The following section will elaborate on the recognized factors influencing the implementation of BIM for organization in AEC industry that is intending to implement BIM. the key factors that affect the extent of collaboration in between disciplines can be categorized as following:

2.15.1 Organization-Level Factors

The Organizations level factors refers to the decision-making process of an organizational infrastructure due to changes in the characteristics of an organization after a new investment technology is introduced and diffused to adapt to new challenges. There is a limited collaboration all over the construction players due to the differences of their background and culture. Most of the organization has been domination by traditional practice in construction project. This has been considered as a barrier toward implementation of BIM that required high collaboration. For example, construction players tend to used or viewed project design through hardcopy compare to softcopy. Considered BIM as a new technology that required specific skill to use it, training and learning program for the construction players such as architect is a must (Latiffi et al., 2014). Furthermore, the program must be available for each of project stakeholders and in line with global requirement (Singh et al., 2011). BIM has proven capable of enhance communication and collaboration in organization such as construction company, yet the effectiveness of BIM is depending on user its self. For example, the ability of project leaders towards other project stakeholders. Table 1 represent most important factor that affect on multidisciplinary collaboration per organization level.

Table 1: Organization-Level Factors

Factors	Description	References
Level of BIM adoption at industry	the client's perception on the level of BIM maturity of the industry influences his likeliness to ask for BIM in projects	(Eastman, et al., 2011), Khosrowshahi and Arayici (2012)
Required knowledge and experience for changing contractual arrangements to work with BIM	Contractual arrangements should be able handle collective responsibility and risk sharing between project parties when working with BIM.	(Smith, et al., 2009)
Defined organizational structure	Need to reestablish new communication channel and redefine the working pattern based on the new organization structure and role of their partners, which has direct impact on the BIM collaboration.	(Singh et al. 2011), Ozturket. al. (2016),*Howard W. Ashcraft (2008)*
Expected economic impact (return on investment(ROI))	ROI (Return on initial capital investment) examination is one of the numerous approaches to assess a proposed venture. It is about the increase expected (or accomplished) from a venture against the cost of the speculation.	Qian.A(2012)
Government Support	Existence of government-led initiatives to promote BIM implementation within the industry	Arayici and Coates (2012), and Eadie et al. (2013)

BIM policy of the company	Existence and effectiveness of a corporate strategy on BIM implementation	Jung and Joo (2011)
Availability of financial resources of organization	Ability of the organization to allocate sufficient budget for BIM implementation	McGraw Hill Construction (2014), Ganah and John (2013), Bryde et al. (2013), Succar et al. (2013),
availability of BIM software experts in a company	Existence of competent personnel within the organization	Jung and Joo (2011), Ganah and John (2013), Succar et al. (2013), Won et al. (2013), Chien et al. (2014), and Lee et al. (2015)
Availability of information and technology	Existence of necessary information and technology infrastructure within the organization implementing BIM	Arayici and Coates (2012), Khosrowshahi and Arayici (2012), and Boktor et al. (2014)
Experience level BIM project within the firm	Existence of relevant previous experience on BIM implementation within the organization	Gu et al. (2010), McGraw Hill Construction (2014), Won et al. (2013), and Chien et al. (2014)
Training of employees	Is needed to satisfy the technical know-how need &to deliver a successful implementation of BIM.	Deutsch (2011), Rezgui (2013)
client's awareness and requesting of BIM	level of awareness and use of BIM between the clients of an organization has an important impact	HM Government (2012), Ganah and John (2013), Succar et al. (2013), and Lee et al. (2015)

2.15.2 Project Level Factors

The Project team factors allude to the implementation through successful teamwork of BIM projects after the applications and instruments of BIM have been defined. The construction industry is well-known as a project-based business, and construction project is both unique and brief. Therefore, forming a project team within a collaborative environment is crucial for each project as it is one of the major driving forces for project success. The assembled team must work together and effectively and efficiently respond to the project and individual goals (Meng-Han Tsai, Mony Mom & Shang-Hsien Hsieh 2011). It should be noted that the project goals must be tied to the company strategies (Bernold and AbouRizk 2010; CIC Research Program 2010).Table 2 represent most important factor that affect on multidisciplinary collaboration per project level.

Table 2: Project-Level Factors

Factors	DESCRIPTION	References
Collaborative environment (network)	The climate or condition that encourage project participants to collaborate	Bogaert et al. (2012), Kensak, et al., 2012)
Early Involvement of project team	Whether contractor or other disciplines join project team before construction	Xue et al. (2010); Eastman et al. (2011)
Selection of project delivery methods	The selected project delivery method had a significant effect on team integration.	Franz.Bet al. (2016)
Coordination among project parties	Existence of a cooperative project environment to successfully implement BIM	Boktor et al. (2014), and McGraw Hill Construction (2014)
Support from top management	top management support as the most influential factor on decision-making	Liu et al. (2010); Nikas, A. (2007)
willingness to share information among project participants	this requires effective information and knowledge exchange, and efficient inter-organizational communication.	Won et al. (2013)
Risks associated with bidding BIM projects (types, size, teams, cost, locations)	The scale of the project in terms of its budget	Bryde et al. (2013), Arayici et al. (2011), and Jung and Joo (2011)

2.15.3 Individual-Level Factors

Project participants today require adequate BIM knowledge and skills of tools and processes along with the discipline specific knowledge and processes There is lack of BIM capability assessment criteria, standards or standardized accreditation. As diverse BIM tools and technologies are present, there is not yet any common system for assessing individual BIM competencies and guidelines to support the level of BIM expertise needed. There is much variance in individual BIM competences dependent upon level of BIM knowledge, BIM skills and the level of expertise required for a project of differing types. Assessment of individual BIM tool competences can be seen emerging for specific BIM applications conducted primarily by private industry such as software vendors. These individual levels of competences are important; however, requirements vary per the project type, location and diversity of BIM tool utilization. No system defining these levels or competences has yet been developed. For example, Dossick and Neff (2010) outlined that the conflicts between an individual’s scope of work with project’s goals and company’s strategies are inherent in organizations and cultural divisions and project-based leadership may substitute for stronger cohesion in the project team and organization. Table3 represent most important factor that effect on multidisciplinary collaboration per individual level.

Table 3: Individual-Level Factors

Factors	DESCRIPTION	References
Clear Role and Responsibility	Whether the role or responsibility is clear among project participants	Greenwood and Wu (2012)
Worker attitudes and ethical behavior	Individual perception on cooperating with other participants	Dossick and Neff (2010)
Collaboration Experience	Whether project participants have experience of working together before	Jin and Doloi (2008)
Individual and group motivation	individual is willing to work together with other professionals in BIM area	Mom.met al. (2013)
Technical skills	required skills and availability of technical means	(Partridge, et al., 2007)
Effective leadership	Commitment and approach of the top management to facilitate BIM within the organization	HM Government (2012), Won et al. (2013), and Lee et al. 2015

2.15.4 BIM Requirement

The modeler is commonly given the modeling guidelines or standards to follow. However, the guidelines are only useful when there are clear specifications on what information must be expressly in the model for specific purposes or rules. One of the critical steps in a rule checking implementation process is the rule requirement analysis. This step is unique for building rules, especially building codes, A part of the rule analysts who capture the rule requirements from the rule texts and the human experts for the benefit of the software developers, part of the knowledge should also be accessible to the BIM authoring tool providers for their support of the significant data exchange requirements. Table4 represent most important factor that effect on multidisciplinary collaboration per BIM Requirement factors.

Table 4: BIM Requirement Factors

BIM Requirement	DESCRIPTION	References
Interoperability (data exchange formats)	ability of information exchange and use of the exchanged information between two or more systems	Grilo and Jardim-Goncalves (2010); (Underwood, et al., 2010)
Technical support from suppliers	mainly caused by software bug and incorrect modeling procedures resulting in difficulty recognizing the right use of software objects	Olatunji (2011a)
Security in data sharing	he advancement in encryption technology has made transfer of project data much safer,	(Alfred. 2011, Lam et al. 2010)
technical requirements	technical requirements for using BIM-server as a multi-disciplinary collaboration platform to facilitate technology management and implementation across disciplines	(Singh et al. 2011)
BIM standards, codes, rules, and regulations	Standard processes and agreed protocols are required to assign responsibilities. Existence of BIM guidelines, standards, and roadmaps within the industry	Won et al. (2013), and Chien et al. (2014)

2.15.5 BIM Application Area

BIM application, a new transporter of project information, goes through all phases of development process for the duration of the life cycle of project, which renders all project participants to obtain proper information at due time as necessary, assists project understanding, reduces common mistakes and supports project related decision. BIM technique application features distinct characteristics and boasts advantages of visualization, parameterization, simulation and collaboration. BIM applications as knowledge based systems have a lot of integrated interdisciplinary and organizational knowledge. Table 5 represent most important factor that affect on multidisciplinary collaboration BIM Application Factors.

Table 5: BIM Application Area

BIM Application Area	**DESCRIPTION**	**References**
Site Analysis	A process in which BIM/GIS tools are used to evaluate properties in each area to determine the most optimal site location for a future project.	Tsai.Met al. (2014), Kreider, et al., (2010
3D control and Planning	A process that utilizes information model to layout facility assemblies or automate control of equipment's movement and location.	Mom.m et al (2014), Kreider, et al., (2010)
Structural Analysis	process in which analytical modeling software utilizes the BIM design authoring model so to determine the behavior of	Kreider, et al., (2010)

MEP analysis and simulation (HVAC)	A process in which intelligent modeling software uses the BIM model to determine the most effective engineering method based on design specifications.	Suwal.s el al. (2016)
Clash Detection& Conflict resolution	Two or more models can be analyzed to detect clashes between discipline models or different versions of the same model. Ability to manage the coordination workflow for clash resolution, e.g. support for BIM collaboration format (BCF)	*Shafi.t* et al. (2013), Azhar (2012),
3D Navigation & Design Reviews	Users can navigate and view components of the model in 3D and provide their feedbacks to validate multiple design aspects.	Shafi.t et al. (2013), Kreider, et al., (2010),
4D Scheduling	Mature 4D modeling includes: schedule and BIM import, BIM model update, reorganization, temporary components, animation, analysis, output and automatic linking processes	Zhou et al.(2012).
5D Cost Estimating	5D model is Take-offs and Estimating cost tools, automatically extract and update material quantities when any changes are made in the model, preliminary cost estimating during the early design phase, track variance between budget and actual cost, and enhance procurement management during construction phase	Azhar(2011), Howard W. Ashcraft (2008)
Integrates FM and building lifecycle information.	FM data support (Including COBie data extraction), archiving data for long periods of time, Building Maintenance Scheduling, Improving Building Performance	E.A. Pärn, D.J.Edwards, M.C.P.Sing (2017)
Design Reviews from consultant	consultants can better understand the owner's requirements and help ensure that the project is on track	(Hwang and Lim. 2013)

BIM model for Shop drawing and Fabrication (Parametric Modeling)	The models can provide construction details and fabrication information, prefabricated material will fit when delivered	Eastman et al. (2011), Howard W. Ashcraft (2008)
Workflow reporting	Enables the generation of project management reports at pre-defined intervals	*Shafi.t* et al. (2013)
Disaster Planning	A process in which emergency responders would have access to critical building information in the form of a model and information system.	Suwal.s el al. (2016)

Chapter 3

METHODOLOGY

3.1 Introduction

The absence of proper strategic planning on implementing BIM between participants is the main factor that many construction industry players are still unable to gain the benefits from, which represent high challenge to collaboration by integrating the work performed by participants with diverse backgrounds, varying levels of expertise, and different perspectives so there are Many factors need to be considered and most importantly the readiness of the organization needs to be assessed. The objective of the thesis is to determine the factors that effect on multidisciplinary of collaboration between the main branches of the industry in regards to the new and upcoming technological trends. This chapter presents the research methodology adopted to analyze the factors affecting multidisciplinary of team-working in BIMfor construction industry.

3.2 Research Categories

Categories are normally channeled through different sources: raw data, previous studies, and theories. Moreover categories may have two forms of development; either inductively or deductively. To be channeled through raw data, categories that derive have not been yet mentioned in previous theories or current studies. . Researcher may develop categories inductively to describe the phenomenon. This is helpful and appropriate for theory development and creation. When there is a preliminary model or theory mentioned in current or previous literature, same categories could be implied straightforwardly. Researcher can develop a list of categories from previous study first and modify the list later. New categories may emerge from analysis of raw data. Adopting accessible or previous categories can support and enhance the accumulation of outcomes of analysis across different researches; however researcher should make sure that adopted categories are truly appropriate for the study and represent the data sufficiently (Wildemuth, 2009).

A wide range literature review has performed for identifying the most appropriate critical successful factors. The critical successful factors used in this research are listed in Table 6 which shows the different categories that include most important, critical, and successful factors of multidisciplinary team-working in BIM. The table shows each category with related factors. An extensive review of CSFs was performed to generate a list of factors. The final list was obtained by removing, merging, and/or renaming some factors having similar meanings to avoid overlapping.

Table 6: Team-Working Critical Successful Factors of Multidisciplinary in BIM

Categorize	**Recourses factors**	**Factors**
Organization Level	**Humans**	Training of employees
		Availability of BIM software experts in a company
	Financial	Expected economic impact (return on investment(ROI))
		Availability of financial resources of organization
	Technology	Availability of information and technology

	Process	BIM policy of the company
		Required knowledge and experience for changing contractual arrangements to work with BIM
		Defined organizational structure
	Culture	Level of BIM adoption at industry
		clients awareness and requesting of BIM
		Government Support
		Experience level of BIM project within the firm
Project Level	**Humans**	Support from top management
		Coordination among project parties
		Early Involvement of project team
	Process	Risks associated with BIM projects (types, size, teams, cost, locations)
		Selection of project delivery methods
		willingness to share information among project participants
		Collaborative environment (network)
Individual Level	**Technology**	Technical skills
		Collaboration Experience
	Culture	Effective leadership
		Individual and group motivation
		Clear Role and Responsibility

BIM Requirement	**Technology**	Interoperability (data exchange formats)
		Technical support from suppliers
		Security in data sharing
		BIM standards, codes, rules, and regulations

3.3 Data Source

According to Naoum (2001) to accomplish goals for a study, it is important to give type of method would be used a good attention. A questionnaire survey is considered as the main source of data. Data is collected from questionnaire issued to large organizations. The questionnaires are designed to be specific, direct, simple, clear and easily readable by all participants. In addition to that, a case study BIM with multidisciplinary are conducted which will be discussed in chapter 5.

3.4 Reason for the Questionnaire

The aim of the survey is to explore the validity of the selected critical success factors by distributing it among the companies and professionals working in the industry.

3.5 Research Methodology

This study proposes a five-step procedure to derive Critical successful collaboration factors: (1) objectives, (2) questionnaire design, (3) data survey, (4) preliminary data analysis, and (5) data analysis. The questions are designed to be easily understood and shorten the survey time. Its contents are then checked for validity. At this stage, the target groups are defined for a data survey. The data collection involves administration of a survey. The online survey conducted via Google Form.

The questionnaire consists of two parts: (1) general information regarding the respondents and their companies; and (2) the critical successful collaboration factors. The respondents were asked to evaluate the importance of the listed CSFs using a 1–5 point Likert scale (1: very low, 2: low, 3: medium, 4: high, 5: very high). A sample of the questionnaire can be found in Appendix.

The data obtained from the survey should have rules to handle missing data and discrepancy of answers and to code the data for analysis. The reliability test, statistical data summary, ranking analysis, factor analysis, causal relationship analysis, and reliability tests analysis are then performed in sequence to process the raw data to obtain the critical successful collaboration factors.

3.6 Data Collection

The survey was conducted in January, 2017 among the AEC industry's business owners, managers, architects, engineers, designers, contractors, subcontractors, and BIM model builders who had experience with CAD and are in the process of changing to BIM technology. This careful selection of respondents was needed because BIM adoption in the AEC industry is still in its infancy and collecting suitable and logical information from this small and selective sample, it was necessary to understand the industry. It is indicated in the introductory part of the survey that respondents should have experience in BIM implementation in the construction industry. It is expected that this would provide more reliable responses.

3.7 Data Analysis

In all the data analyses performed, the reliability analysis is a statistical test to check the internal consistency of measured items in a construct. The data summary interprets the sample characteristics including statistical tests for inferential differences between groups. The ranking is based on the mean scores and standard deviation from the descriptive statistics. The factor analysis is a statistical test used to reduce the number of variables to a more manageable size and identify clusters of a set of variables that measure similar things. The causal relationship analysis is a statistical test used to determine the strength of relationships between two variables. The reliability tests analysis is used here as a confirmation of the factor analysis.

3.7.1 Factor Loading

Factor loading is representing of how much a factor could explain a particular variable in factor analysis, thus factor loading represents the correlation of the variable and the factor (Livesley. et al., 1998).

Using "Ensuring Practical Significance" approach, the first suggestion is not based on any mathematical proposition but relates more to practical significance (Livesley. et al., 1998).

Ensuring Practical Significance is a rule of thumb used frequently as a means of making a preliminary examination of the factor matrix. In short, factor loadings greater than ±.30 are considered to meet the minimal level; loadings of ±.40 are considered more important; and if the loadings are ±.50 or greater, they are considered practically significant. Thus the larger the absolute size of the factor loading, the more important the loading in interpreting the factor matrix. Because factor loading is the correlation of the variable and the factor, the squared loading is the amount of the variable's total variance accounted for by the factor. Thus, a 0.30 loading translates to approximately 10 percent explanation, and a 0.50 loading denotes that 25 percent of the variance is accounted for by the factor. The loading must exceed 0.70 for the factor to account for 50 percent of the variance. The researcher should realize that extremely high loadings (0.80 and above) are not typical and that the practical significance of the loadings is an important criterion. These guidelines are applicable when the sample size is 100 or larger. The emphasis in this approach is practical, not statistical, significance (Livesley. et al, 1998).

3.7.2 Reliability (Coefficient Alpha Cronbach) (α)

According to Cronbach, (1951), "Reliability can be expressed in terms of stability, equivalence, and consistency. Consistency check, which is commonly expressed in the form of Cronbach Coefficient Alpha".

Cronbach's alpha is often used when having multi-items scales (e.g., measurement procedure, such as a survey, with multiple questions). It is also a versatile test of reliability as internal consistency because it can be used for attitudinal measurements, which are popular among researchers (e.g., attitudinal measurements include Likert scales with options such as very high, high, neutral, low, very low). However, Cronbach'salpha does not determine the multi-dimensionality of a measurement procedure (i.e., that a measurement procedure only measures one construct). This is because getting a high Cronbach's alpha coefficient (e.g., 0.80) when testing a measurement procedure that involves two or more constructs.

3.7.3 SPSS Software

The questions are analyzed by using (Statistical Package for Social Science) SPSS. Using SPSS, pie charts and bar charts are plotted, and percentages and frequencies for each question in part (A) and (B) are computed. Part (C) SPSS is used to calculate the mean score and Standard deviation for each factor.

3.7.4 Relative Importance Index (RII)

Following formula is used to calculate Relative Importance Index (RII) (Mbamali ,2012):

$$\text{RII} = \frac{\sum Fx}{\sum F} * \frac{1}{K}$$

The researcher classified the variables into 5 groups on Likert Scale.

RII : Relative Importance Index

x : Point on Likert Scale (1,2,3,4, and 5)

F: Frequency of choices selected by respondents

K: Max point for likert scale (5).

When ranking factors or items using RII, the highest value takes the 1st rank, the following one takes the 2nd rank and so on until the lowest rank (Mbamali ,2012) .

The following limitations are used in the interpreting of RII results in accordance with (Mbamali ,2012).

RII < 0.60 refers factor or item is low rating.

$0.60 \le$ RII ≤ 0.80 refers factor or item is High rating.

RII > 0.80 refers factor or item is Very High rating.

Chapter 4

RESULTS AND ANALYSIS

4.1 Introduction

This chapter explains the analysis and discussion of the data collected from the questionnaires. Invitation for participation was send via Google form to firms/individuals, and 77 responses were collected. The majority of the individuals who completed the survey worked for large international architecture, engineering, construction (AEC) companies which are focused on the middle east region..As part of private policy between the respondents and the researchers, personal information was made confidential through a non-disclosure agreement. After the methodology chapter, this chapter determines the detailed procedure of data normalization and analysis to drive end results. The data is analyzed by using Statistical Package for Social Science software, SPSS version 18. Relative Importance Index, RII is computed to rank the twenty eight factors

4.2 Preliminary Data Analysis and Ranking Analysis

The survey data were statistically analyzed using the Statistical Package for Social Science (SPSS) version 18. The following steps were taken to analyze the data toward derivation of the CSFs: (1) raw data reliability test: test of the internal consistency of raw data. (2) Data summary: summarizing the sample characteristics. (3) Ranking analysis including inferential statistical tests: identifying key factors for further processing into critical successful factors.

4.3 General Information about the Respondents

It is found that around seventy-seven have successfully responded. The questionnaire are asked to determine; BIM users based on organization type, BIM use based on project type, BIM use based on project phase, years of working experience in the construction industry.

4.3.1 Type of Organization

The figure show equal percentage 31.2% of respondent are working in designer, consultant and construction (contractor and sub-contractor) companies, which indicate the same number of questionnaire was distributed very well. While 6% client member, moreover 31.2% as a consultant adding up 19.5% main constructor, ending up 11.7% sub-contractor supplier.

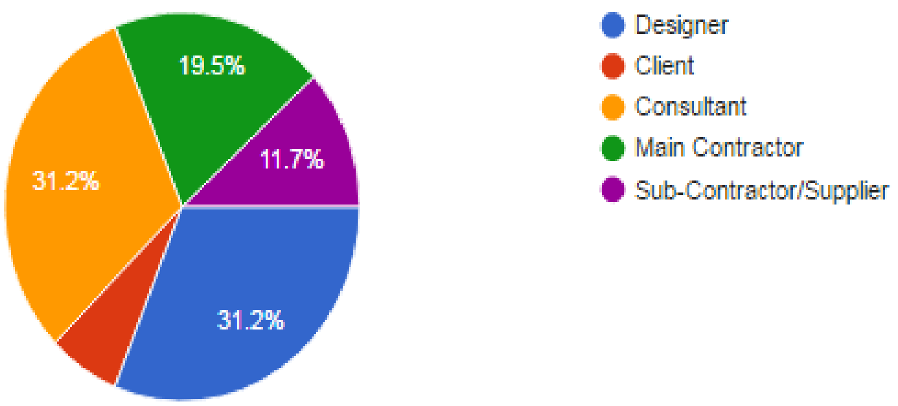

Figure 4: BIM Users Based on Organization Type

4.3.2 Type of Projects

BIM is used based on the project type , here comes the RH residential housing with 44.2% use , industrial construction with 27.3% , CB institutional and commercial Building with 66.2% use , ending with the IH intrafraction and Heavy Construction with 23.4% use .

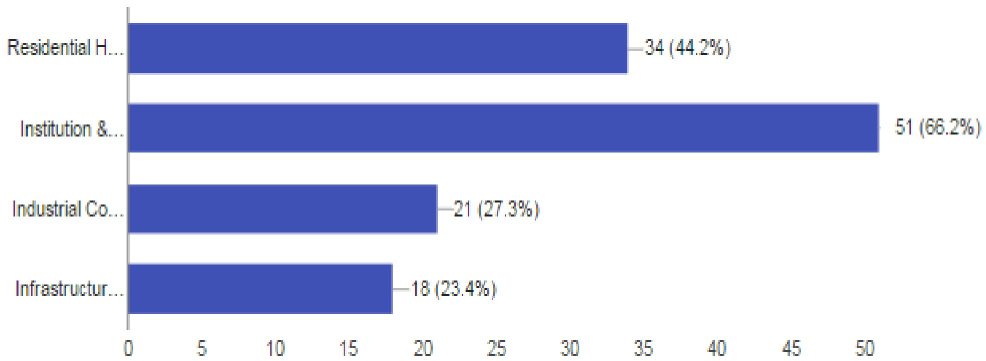

Figure 5: BIM Use Based on Project Type.

4.3.2 Phase of Project

The phase of project uses BIM feasibility and preliminary phase with 22.1% and detailed design 46.8%, construction 57.1% ending up with operation and maintenance.

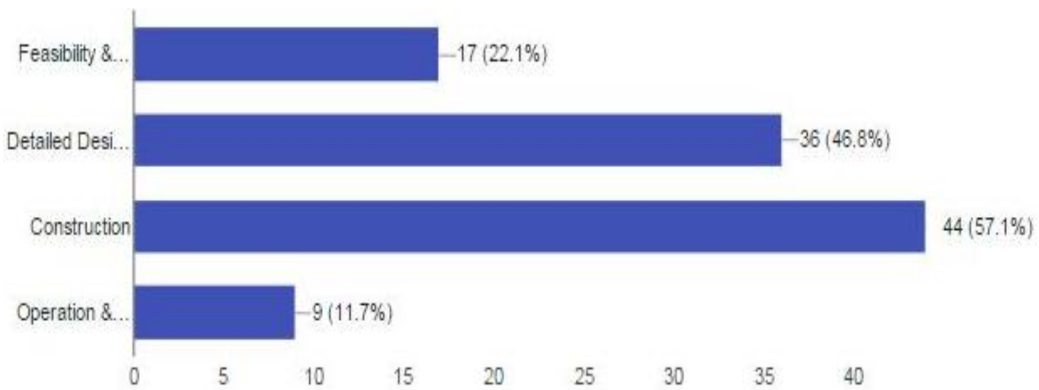

Figure 6: BIM User Based on Project Phase

4.3.4 Years of Experiences

As shown in Figure 4.3.2, 13% of the respondents mentioned that their organizations have 0-1 year working experience in construction industries, 31.2% of the organizations have 2-5 years working experience, 18.2% mentioned their organization have been operating in construction fields for 6-10 Years, however, 16.9 % mentioned working 11-15 years. while 20.8 % goes to the organizations which have more than 15 years working experience in construction industry.

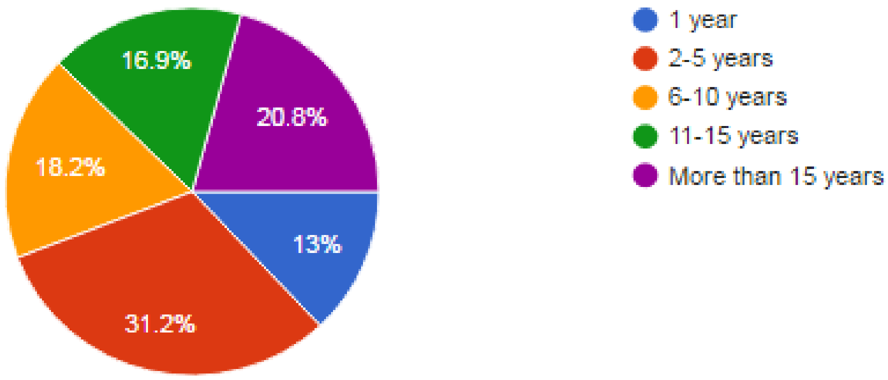

Figure 7: Years of Working Experience in the Construction Industry.

4.4Factors Analysis

4.4.1 Factor Loading and Reliability Coefficient (Cronbach α)

Loadings are assigned to each factor according to "Ensuring Practical Significance" (Livesley. et al, 1998). Reliability coefficient is calculated for each dimension. Loading factors range between 0.700 to 0.841 which indicates that all factors have impact on variables (dimensions).Collaboration Experience and willingness to share information among project participants and Expected economic impact (return on investment (ROI)), are 0.841,0.83, and 0.787 respectively. These factors have the highest factor loading. While project level and individual level categories are 0.915

and 0.877 sequentially. These factors are considered as the highest reliability coefficients α. As shown in Table 7.

Table 7: Factor Loading and Reliability Coefficient (Cronbach α)

Categorize	Resources factors	Factors	Factor Loading	α
Organization Level	Humans	Training of employees	0.72	.859
		Availability of BIM software experts in a company	0. 738	
	Financial	Expected economic impact (return on investment(ROI))	0. 787	
		Availability of financial resources of organization	0. 754	
	Technology	Availability of information and technology	0.7	
	process	BIM policy of the company	0.71	
		Required knowledge and experience for changing contractual arrangements to work with BIM	0. 767	
		Defined organizational structure	0.719	
	Culture	Level of BIM adoption at industry	0. 737	
		clients awareness and requesting of BIM	0.705	
		Government Support	0.71	
		Experience level of BIM project within the firm	0.7	

Project Level	**Humans**	Support from top management	0. 724	0.91 5
		Coordination among projectparties	0. 691	
		Early Involvement of project team	0. 737	
	Process	Risks associated with BIM projects (types, size, teams, cost, locations)	0.7	
		Selection of project delivery methods	0. 725	
		willingness to share information among project participants	0. 83	
		Collaborative environment (network)	0. 704	
Individual Level	**Technology**	Technical skills	0.708	0.87 7
		Collaboration Experience	0.841	
	Culture	Effective leadership	0.702	
		Individual and group motivation	0.761	
		Clear Role and Responsibility	0.7	
BIM Requirement	**Technology**	Interoperability (data exchange formats)	0.72	.856
		Technical support from suppliers	0.71	
		Security in data sharing	0.704	
		BIM standards, codes, rules, and regulations	0.71	

4.4.2 Respondents View on Multidisciplinary Team Working in BIM Factors

Table 8 shows the percent responses for each factors which are 35.1% Availability of BIM software experts in a company, and the Expected economic impact (return on investment (ROI)) 22.4% to 50% respectively. while training of employees takes from 28.6 %– 29.9% respectively, while as Availability of financial resources of organization 51.9% as the highest, 37.7% - 39% Availability of information and technology. BIM policy of the company takes from 31.2% decreasing to 29.9 %.converting to the Required knowledge and experience for changing contractual arrangements to work with BIM 19.5% increasing up to 39 %.moreover, defined organizational structure 16.9 % increasing to 39%.Level of BIM adoption at industry 29.9% decreasing to 26 % client's awareness and requesting of BIM 16.9% -23.4% here comes to the government support 24.7% decreasing to 19.5% Experience level of BIM project within the firm 28.6% to 35.1% Support from top management the highest 37.7% decreasing to 27.3% Coordination among project parties 20.8% increasing highly to 36.4% continuing this concept BIM standards, codes, rules, and regulations at its highest 35.1%.

Table 8: Multidisciplinary Team-Working in BIM Factors as Respondents View

Factors	Very Low	Low	Neutral	High	Very High
Training of employees	5.2%	5.2%	28.6%	29.9%	31.2%
Availability of BIM software experts in a company	6.5%	11.7%	35.1%	35.1%	11.7%
Expected economic impact (return on investment(ROI))	0%	3.9%	22.4%	50%	23.7%
Availability of financial resources of organization	1.2%	10.4%	19.5%	51.9%	16.9%
Availability of information and technology	0%	6.5%	16.9%	37.7%	39%
BIM policy of the company	9.1%	7.8%	31.2%	29.9%	22.1%

Required knowledge and experience for changing contractual arrangements to work with BIM	1.3%	6.5%	19.5%	39%	33.8%
Defined organizational structure	1.3%	2.6%	16.9%	39%	40.3%
Level of BIM adoption at industry	6.5%	19.5%	29.9%	26%	18.2%
clients awareness and requesting of BIM	6.5%	20.8%	16.9%	23.4%	32.5%
Government Support	18.2%	20.8%	24.7%	19.5%	16.9%
Experience level of BIM project within the firm	1.3%	14.3%	28.6%	35.1%	20.1%
Support from top management	5.2%	3.9%	26%	37.7%	27.3%
Coordination among project parties	1.3%	6.5%	20.8%	36.4%	35.1%
Early Involvement of project team	2.6%	9.1%	19.5%	35.1%	33.8%
Risks associated with BIM projects (types, size, teams, cost, locations)	5.2%	18.2%	39%	28.6%	9.1%
Selection of project delivery methods	2.6%	9.1%	23.4%	45.5%	19.5%
willingness to share information among project participants	5.2%	7.8%	20.8%	35.1%	31.2%
Collaborative environment (network)	5.2%	9.1%	20.8%	44.2%	20.8%
Technical skills	0%	3.9%	18.2%	42.9%	35.1%
Collaboration Experience	1.3%	5.3%	22.4%	42.1%	28.9%
Effective leadership	0%	5.2%	32.5%	27.3%	35.1%
Individual and group motivation	1.3%	10.4%	27.3%	37.7%	23.4%
Clear Role and Responsibility	1.3%	2.6%	24.7%	40.3%	31.2%
Interoperability (data exchange formats)	3.9%	9.1%	27.3%	35.1%	24.7%
Technical support from suppliers	7.8%	16.9%	24.7%	31.2%	19.5%
Security in data sharing	5.2%	9.1%	39%	26%	20.8%
BIM standards, codes, rules, and regulations	2.6%	7.8%	22.1%	35.1%	32.5%

4.4.3 Mean Score, Standard Deviation and Relative Importance Index (RII)

4.4.3.1 Organization Level

In organizational level humans are responsible for the training of employees due the availability of BIM software experts in a company, considering the expected economic impact ROI and the availability of financial resources of organization, taking in advance the availability of information technology in the process of BIM policy of the company and the required information and experience needed to work with BIM.

4.4.3.2 Project Level

Humans are supported from top management and coordinating among project parties moreover involving early in project team. while the process risks associated with BIM projects and selection of projects delivery methods, willingness to share information among the participant having a suitable network. the highest percentage is the support from managers for humans with a percentage of 0.724.

4.4.3.3 Individual Level

The technical skills in the technology including collaboration experience and effectuate leadership in the culture of individuals and group motivation to have the clear role and responsibility with the highest percentage in the collaboration experiences 0.841.

4.4.3.4 BIM Requirement

BIM requires technology only specifying in Interoperability (data exchange formats), Technical support from suppliers, Security in data sharing, BIM standards, codes, rules, and regulations while still security in data sharing takes the highest percentage in factor rolling 0.621.

Table 9: Mean Score, Standard Deviation (statistic) and Relative Importance Index (RII)

Categorize	Resources factors	Factors	Mean		Std. Deviation	RII	Ranking
			Statistic	Std. Error	Statistic		
Organization Level	Humans	Training of employees	3.77	.127	1.111	0.75	1st
		Availability of BIM software experts in a company	3.34	.119	1.046	0.67	2nd
	Financial	Expected economic impact (return on investment(ROI))	3.94	.089	.784	0.79	1st
		Availability of financial resources of organization	3.73	.104	.912	0.75	2nd
	Technology	Availability of information and technology	4.09	.103	.906	0.82	1st
	process	BIM policy of the company	3.48	.135	1.188	0.70	3rd
		Required knowledge and experience for changing contractual arrangements to work with BIM	3.97	.109	.959	0.79	2nd

		Defined organizational structure	4.14	.101	.884	0.83	1st
	Culture	Level of BIM adoption at industry	3.30	.133	1.171	0.66	4th
		clients awareness and requesting of BIM	3.55	.150	1.313	0.71	2nd
		Government Support	2.96	.154	1.352	0.59	3rd
		Experience level of BIM project within the firm	3.60	.116	1.016	0.72	1st
Project Level	Humans	Support from top management	3.78	.121	1.059	0.76	3rd
		Coordination among project parties	3.97	.111	.973	0.79	1st
		Early Involvement of project team	3.88	.121	1.063	0.78	2nd
	Process	Risks associated with BIM projects (types, size, teams, cost, locations)	3.18	.115	1.010	0.64	4th
		Selection of project delivery methods	3.70	.111	.974	0.74	2nd
		willingness to share information among project participants	3.79	.129	1.128	0.76	1st

		Collaborative environment (network)	3.66	.122	1.071	0.73	3rd
Individual Level	**Technology**	Technical skills	4.09	.095	.830	0.82	2nd
		Collaboration Experience	3.91	.105	.920	0.78	1st
	Culture	Effective leadership	3.92	.107	.943	0.78	2nd
		Individual and group motivation	3.71	.112	.985	0.74	3rd
		Clear Role and Responsibility	3.97	.101	.888	0.79	1st
BIM Requirement	**Technology**	Interoperability (data exchange formats)	3.68	.122	1.069	0.74	2nd
		Technical support from suppliers	3.38	.137	1.203	0.68	4th
		Security in data sharing	3.48	.123	1.083	0.70	3rd
		BIM standards, codes, rules, and regulations	3.87	.119	1.043	0.77	1st

Chapter 5

CONCEPTUAL FRAMEWORK OF MULTI-DISCIPLINARY TEAM-WORKING IN BIM FOR CONSTRUCTION INDUSTRY

5.1 Introduction

This chapter provides a conceptual Framework of Multidisciplinary Team working in BIM For Construction Industry developed by the researcher. The framework will provide a unified platform for information management and ensure data integrity. The model of framework represents critical success factors and requirement from which have vital impact to implement BIM for multidisciplinary in construction. The framework consists of categories and resources from multi-level (Organization Level, Project Level, individual level BIM Requirement and BIM Application Area). In more detail, the resources It is located around Categories with different parts that have concerned with Human, Financial, Technology, Process and Culture.

Successful collaboration in BIM adoption has been studied and found to depend on many factors: the nature and state of organizations, project, individual, BIM requirement and BIM application area. To visualize the concept of team-working in BIM adoption, a conceptual framework for multidisciplinary team working in BIM for construction industry was established to comprise three level areas of the BIM performance within multidisciplinary: organizations, project, individual, BIM requirement and two BIM implementation; BIM application area and BIM requirement as shown in Figure 8.All these factors are connecting together to reach high development integration levels of BIM adoption. The BIM integration is a solutions implemented by leading owners, facility managers, architects, engineers and construction companies to forge integrated teams - as though they were sitting around the same table - and improve collaboration to reduce the duplication of work and ensure projects are delivered on time and on schedule.. The framework also provides a logical procedure to assist screening the factors: (1) organizations, (2) applications, (3) tools, (4) project teams, (5) processes, and (6) business models. First, it is necessary to assess the existing infrastructure of an organization and identify the specific applications that are needed. Project level then selected, the project teams assigned to enable the required BIM applications area to be realized. The individual level and BIM requirement that exist within the work environment are also important in affecting the adoption of new technologies.

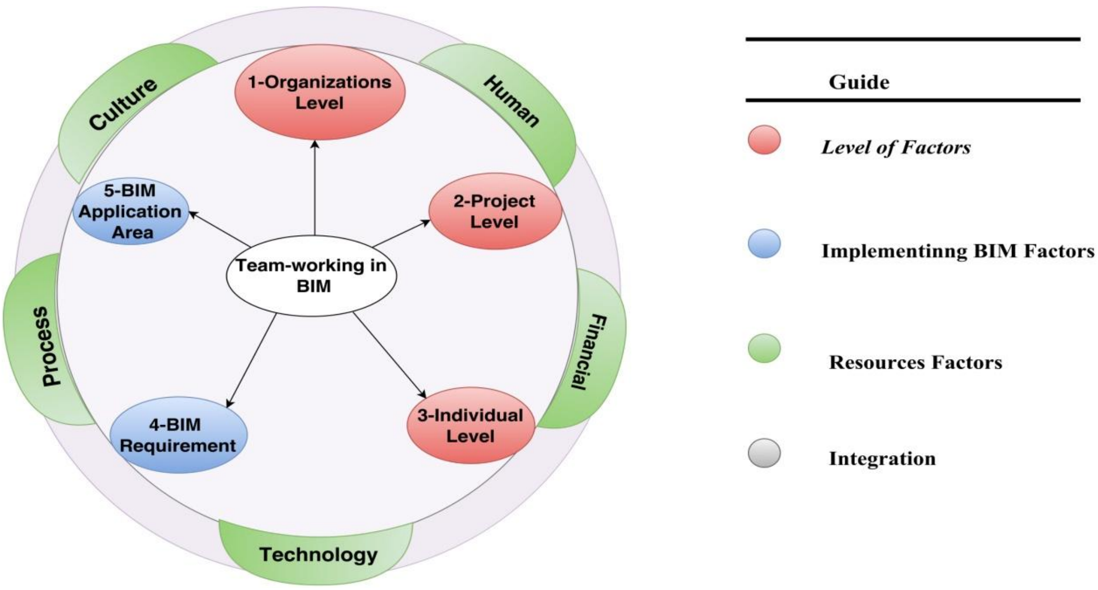

Figure 8: A Conceptual framework of Multidisciplinary Team-Working in BIM for Construction Industry

Organizations: Organizations factors can be divided into small parts, every part have factors depend on different resources, starting from Human resource which has two factors are training of employee and availability of BIM software experts in a company that has high effect on the organization. Secondly financial perspective it take a look for two factor including expected economic impact which is mean account return of investment (ROI) and the other is availability of financial resource of organization. Technology it should be considered as main part, so the availability of information and technology had effect on the organization success. finally business process that deal with BIM policy of the company and required knowledge and experience for changing contractual arrangements to work with BIM. In the construction industry the organizations which responsible to deliver the project to last stage is (Designer, consultant, contractor, sub-contractor, supplier etc,.

Project Level: the factors that have a relevant to this level has distributed to two-part. First part which related to the Human resources that contain three main factors which it is support form top management, Coordination among project parties, early involvement of project team. In addition the factors related to the project like type, size, team, cost and location has involved in process part which are affected on progress operation of success team working. Finally the process part that considered under the project level has main also three factors which are; selection of project delivery methods, collaborative environment, and willingness to share information among project participants. The project team it contains engineering from different disciplines collaborating together in wholes stage of project will lead to success of project.

Individual Level: which examine the factor and requirement that effect of the nature of the relationship collaborative between multidisciplinary, for example collaborative experience and technical skills etc,.

BIM Implementation: To implement BIM process some factor should take into account starting from security sharing and interoperability that have to apply it in order to get integration framework of multidisciplinary.

BIM Application Area: these applications should all activated together to get high efficiency collaborative between all participant during whole lifecycle project in order to increase the benefit from using BIM, which starting from establish 3D model till Integrates FM and building lifecycle information.

In additional the researcher also developed a strategy involving seven stages for implementation of BIM process through life cycle project in construction industry. To organize the workflow information well, the information components and information flow during the project life-cycle are defined. Then, the application of BIM in life-cycle information management is analyzed as illustrated in the figure 9.

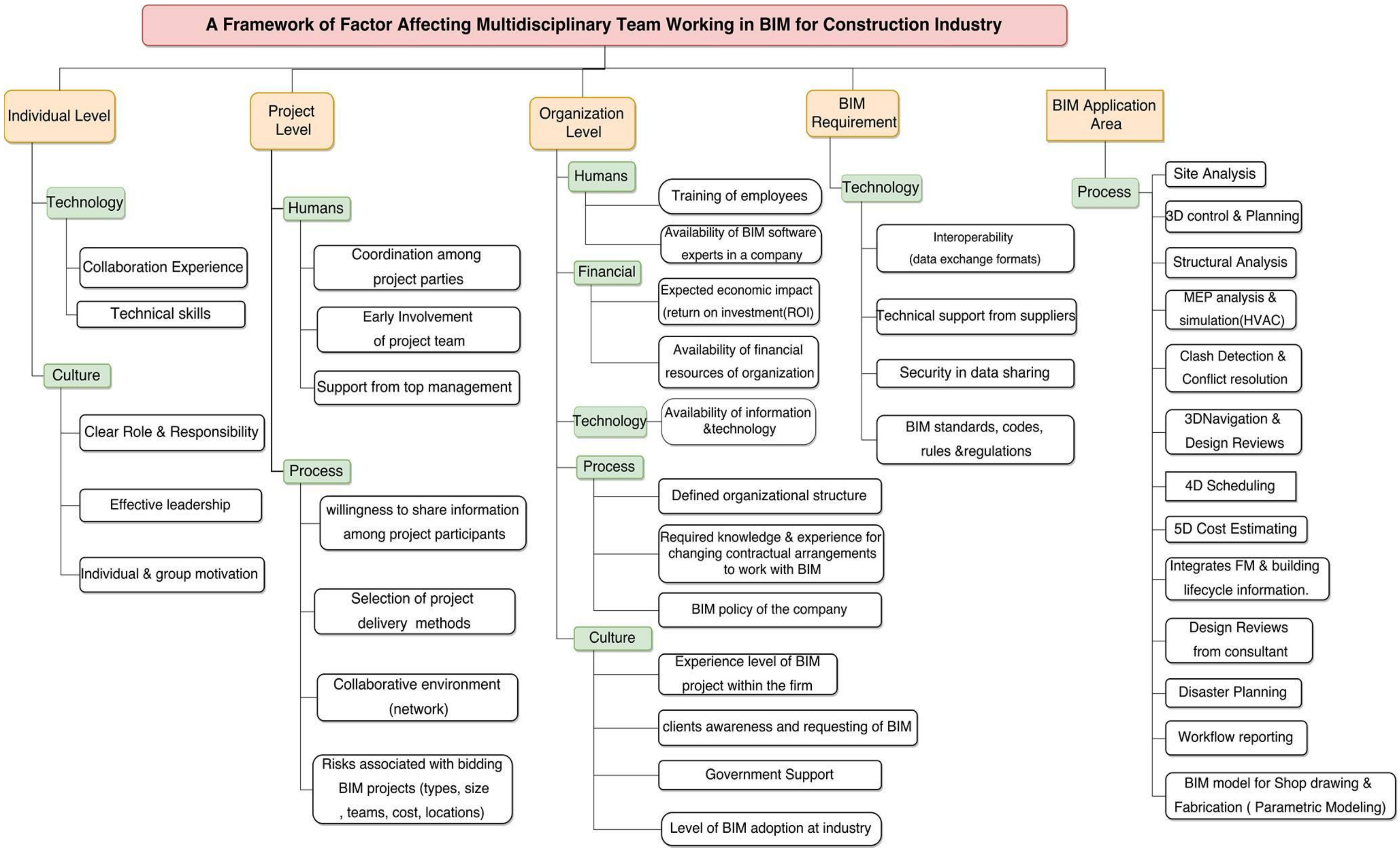

Figure 9: Framework of Factors Affecting Multidisciplinary Team-Working in BIM for Construction Industry

5.2 BIM Life Cycle, Phases and Stages, and Requirements for Development Industry

BIM is proposed to empower and encourage a coordinated technique for project flow and delivery by the collaborative oriented utilization of semantically rich 3D digital building models at all phases and stages of the project and building life-cycle. It uses the object-oriented concept to expand the productivity of data management in the building life-cycle. Moreover, it gives the ability to see and examinations the construction project in close real-life fidelity. Subsequently, one can formalize the facility data connections, which then yields examination that couldn't already be performed. It is imperative to build up a framework for BIM cooperative data management so as to guarantee the data is retrievable and reusable. This research applied seven phases to integrated BIM project life cycle.

5.2.1 Inception Stage

Inception is considered as first stage in BIM life cycle. In order to complete this stage a specific Identification of client's needs, targets and business case. From that point onward, Development of initial statement of requirements into the design briefly. The design works require a multi-disciplinary cooperative working method keeping in mind to make sure the maximization of owners' intentions.

5.2.2 Feasibility and Strategy Stage

Practicality And Strategy Stage is starting with Preparation of feasibility studies and evaluation of choices to empower the client to make a decision whether to proceed. At that point Identification of procurement method, project sustainability and BIM methods, building design lifetime and project organization structure and scope of consultant and others company to be participated for the project, including meaning of responsibility and additionally execution of design brief and preparation of additional data. Agreement of project quality arrangement incorporates BIM and change control procedures. Arranging of concept design include outline proposals for structural and environmental approaches and organizations structures, site landscape and biology, outline specification, preliminary outline and cost plans.

5.2.3 Scheme Design Stage

Scheme design stage incorporate development of concept design utilizing BIM to Complete of Project briefly, to co-ordinate elements and components of the project, to close co-ordination of design team contributions, to empower execution specified work to begin and empower tenders to be acquired to coordinate execution specified configuration work into model. They then get the approvals of the government department in indict of construction plans.

5.2.4 Tendering Stage

The main activities in the design stage incorporate those in which Preparation as well as collation of tender documentation in adequate detail to empower tenders to be acquired for the project, Identification and assessment of potential contractors as well as experts for the project. Obtaining and evaluating tenders' submission of suggestions to the client. After that, owners organize, design and sign bidding and contract documents with designer, consultants, contractors, and other participant.

5.2.5 Construction Stage

Construction Stage contains data delivered in construction activities. Beginning with arranging site can be handover to the contractor. The data in this stage is more plentiful since management and control of construction is a dynamic procedure. It is likewise an enduring and entangled work, which includes the owner, design company, general contractor, subcontractors, material suppliers, equipment and relevant government departments. What's more, a lot of human and material assets ought to be prepared for use in construction stage.

In construction stage; the BIM with this scheduling data can help each one of those included in the project (architects, engineers, general contractor and subcontractors) to envision the step by step progress of a given project. the building team are able to monitor - ahead of time - an energetic description of the planned construction process.

5.2.6 Commissioning Stage

Commissioning Stage contains audit of project implementation being used and examination with BIM data, management of the building contract after Practical Completion and making last inspections. Furthermore Clarification and resolution of design questions as they emerge, Assist with preparation for commissioning, handover, training future monitoring and maintenance.

5.2.7 Operating Maintenance and Facility Management Stage

In this stage a completely BIM Model project will fuse data about every bit of equipment and system inside the building. At that point, facility managers will have the ability to update the virtual model as the real building is modified, so the 3D "virtual" building remains a correct copy of the real structure. Therefore, the utilization of a BIM could mean major savings for facilities’ owners after some time.

5.3 Case Study BIM with Multidisciplinary

The case study is a New College Of Engineering (COE) Building Site is located on Plot No. 309 at Al Tarfa, Doha – Qatar, approximately 10KM towards north of central Doha City, this project consider as BIM project. A number of requirements need to be achieved, across 76,605 square meters, during the project duration of 910 calendar days. The building consists Basement , Ground, First and Second floor which contain Class rooms, Laboratories,, Offices, Atrium Auditorium, Lecture halls, Cafeteria & kitchen, Learning resource center, Workshop, Basement & surface car park. The total budget of the project is 150 million (US$) The project is aiming a four-star sustainability rating as per Global Sustainability Assessment System (GSAS), and the scope of BIM includes 3D/4D/5D modeling which illustrate in figure 10.

Figure 10: New College Engineering Building at Qatar

The project delivery method selected is design bid build and it focused on establishing a multidisciplinary collaborative project environment of ceaseless and trust communication. The owner have awareness of BIM technology and require to implement BIM, The use of BIM added value to the project in many ways, for instance, by generating accurate structural design to enable cost saving and clash detection exercises in addition to generating accurate quantities.

The College of Engineering procured as packages and the Qatar University (the owner) has engaged Al Darwish Engineering (ADE) to Build Package New College of Engineering .Khatib and Alami Consolidated Consultants has been appointed by the owner as the supervision entity and shall be referred to as the Contractors Consultant.

The BIM Execution Plan has been written by BMTEC to describe how model data will be managed by BIMTEC/ADE in pursuance of the scope of the owner for BlM use on the project. The contractor required to submit a Building Information Modeling Execution Plan and the information contained within BlM Execution Plan is intended to form inputs into the Contractor's Information Management Plan.

A 3D BIM model was created as per Level of Development (LOD) 300 specification in order to be used in 3D coordination, clash resolving, 4D construction scheduling, and 5D cost planning. 3D models are in progress in order to finalize the LOD 400 models to generate shop drawing and as built models in later stages.

Autodesk software (Revit, Navisworks and Robot) were used for authoring, viewing, collaborating, coordinating and design checking of 3D models. On the other hand, RIB iTWO software was used to build 4D/5D model, RIB iTWO combines traditional construction planning and trailblazing 5D planning.

With the latest development of BIM standards, QU has adopted the AEC UK BIM Standards Version 2013 – released on August 22nd 2013. QU is focused on developing a Parametric 3D Model with defined Level of Development to Achieve

Coordinated and useable BIM model for Site information, Operation and maintenance use.

QU developed with its construction key stakeholders a:

- LOD 300 Model for coordination.
- LOD 350/400 for Shop drawings Generation and insure the use of BIM extracted data by its Sub-Contractors.
- LOD 500 Model for As-Built.
- LOD 500 Accurate Geometry Reflected on Model .
- LOD 500 O&M Data linked with FM Solution.
- A combined model derived from the 3D BIM Model Data to level of development 350/400 will be published to the selected 4D/5D System. It has been incorporated that the 3D/4D/5D system will be published with vendor developed plug-in to ensure integrity of data and interoperability.

Workflow progress: External access to Project engineering information on the approval of the Contractor's BIM Manager. Information shared via the Prolog and will conform to the processes described within best practice approach and the Project BIM. The data file workflow employed for the assurance of information models on COE Project is shown in the data assurance process diagram in Figure 11.

Cross Project collaboration facilitated by an Electronic Document Management Systems (Prolog). A single CAD platform used, capable of modeling object data in 3D and attaching attribute data to it.

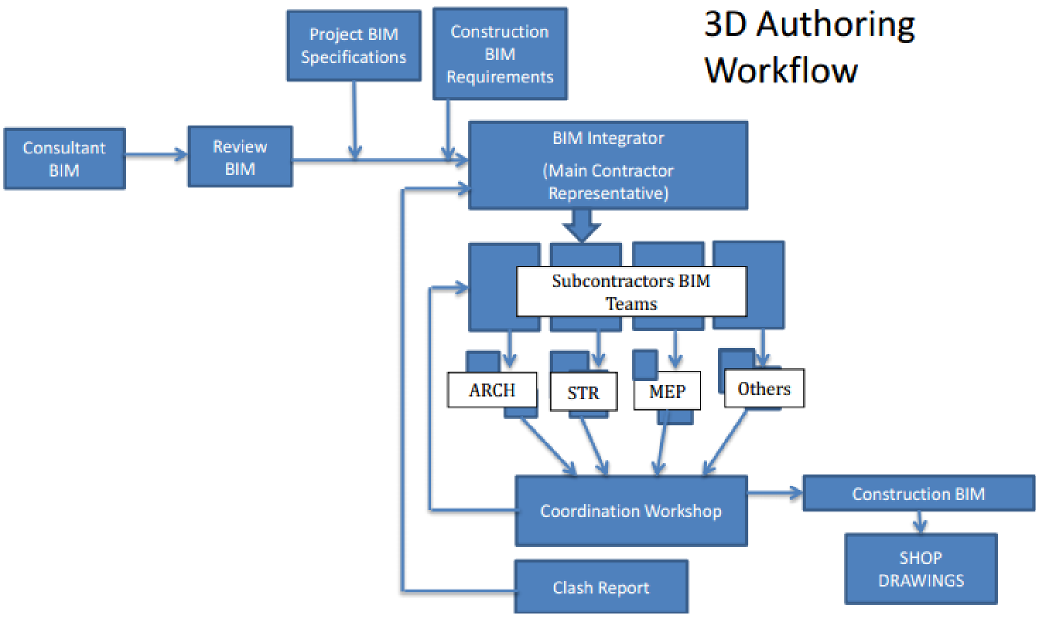

Figure 11: 3D Authoring Workflow progress During Construction Stage

Coordination among project participant: The ADE BIM Team and Engineering team will interact with the client Representative on a regular basis to access the progress of BIM as per the project requirements. A proposed Meeting Schedule is illustrated below.

Availability of information and technology: Appointed sub-contractors to use capable and approved hardware software combinations. The software used for modeling and coordination shall be with ADE Selected Software. The sub-contractors are to submit a BIM Plan outlining their approach to implementing BIM on the project. The document included details on Zoning, model development schedule and quality control. The strategy also outlines processes for integration of data models.

Security sharing: BIM Teams established a data security protocol to prevent any possible data corruption, virus "infections," and data misuse or deliberate. The BIM

Models stored on project Server and on Meridian prolog, to ensure copy on both systems. Furthermore, the IT Department of ADE conducted continuous backups to ensure recovery of models

Government support and level of BIM adoption at industry: it is clear that existing and prospective strategies, procedures, technologies, standards, challenges and opportunities for adoption of BIM by the Qatar construction industry are considered as high-level requirements to facilitate projects' lifecycle information flow, reflecting the global construction trends. For sure there is still more space for improvement in several aspects such as policy, upgrading of people skills on BIM roles, process, and the companies' existing software used for creating, viewing, collaborating, coordinating and content managing. To date, there is no official BIM standard in Qatar, but a Qatar BIM standard will not take too much time to come to life.

Defined of organization structure and clear roles and responsibility: As shown in the figure 12, AL Darwish Engineering (ADE) established BIM team organization chart to identify the each team members' role, responsibility and rules and regulations of team work.

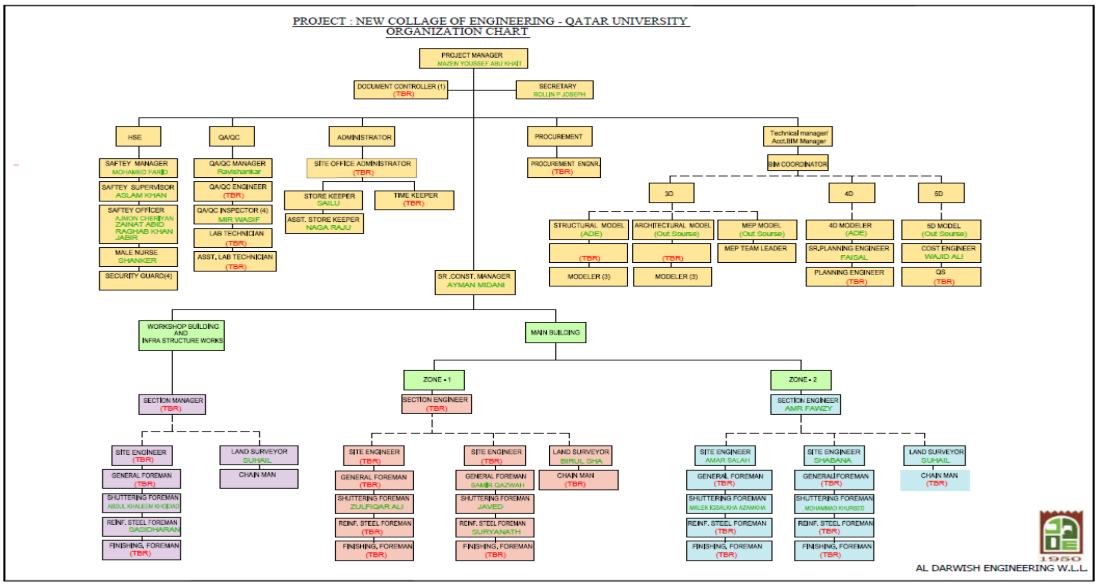

Figure 12: Define of Organization Structure

The researcher also developed a strategy involving seven stages for implementation of BIM process through life cycle project in construction industry. To organize the workflow information well, the information components and information flow during the project life-cycle are defined. Then, the application of BIM in life-cycle information management is analyzed as shown the figure 13.

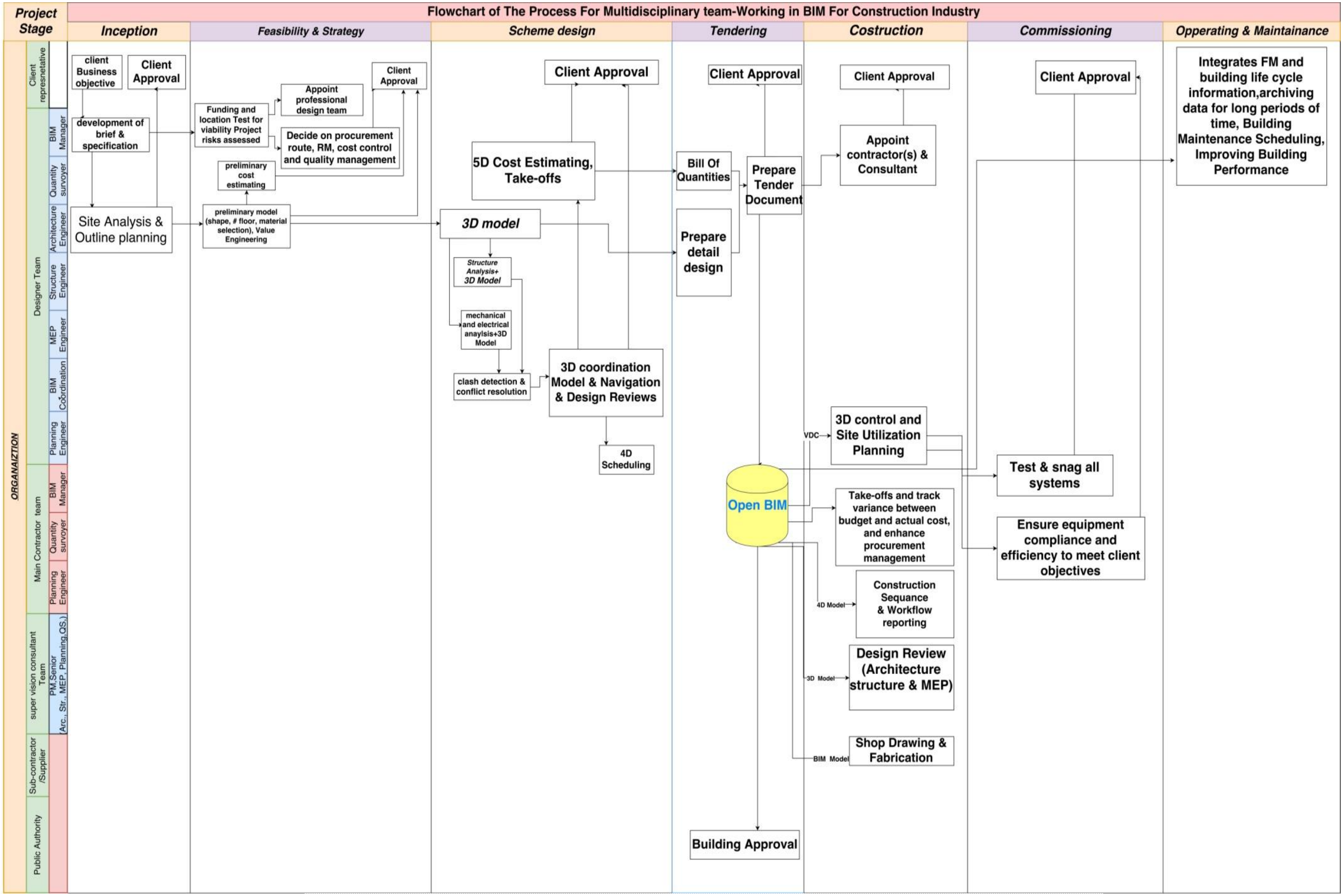

Figure 13: A Flowchart of the Process for Multidisciplinary Team Working in BIM for Construction Industry

Chapter 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Construction project is a comprehensive activity including for phases: design, construction, operation and maintenance. The collaborative actions and processes between multidisciplinary during all phases of construction is a quite important aspect in shaping the construction world. Today's technologies highly support the teamwork operations for building constructions. Yet, this easier said than done, because the work force operating in AEC come from different backgrounds. Recently, not many years ago, BIM was found. BIM is the dominant language that AEC uses to accomplish collaborative operations through software. BIM has reached a very high level of maturity that represents a fully collaborative process to achieve integration between parties and process by single shared model. But the biggest concern involves the absence of accurate strategic planning on implementing BIM between the participants which create a gap between organizations that impact the operation of construction excellence and efficiency. This research has examined the most important factors that have a huge impact on the degree of successful collaboration and integration between all participants. The researcher has developed a framework includes five different categories which contains three different levels; organizations' level, projects' level and individuals' level as well as BIMs' Implementation factors which contain; BIM requirements and BIM applications area.

Those categories that was mention earlier involve five different recourses; Humans, Financials, Technologies, Processes, as well as cultures.

BIM users have not been able to consume all the benefits of its power due to humans' resource factors such as Training of employees, Coordination among project parties, Clear Role and Responsibility as well as Collaboration Experience, those factors were ranked the most important. However, these factors that are usually enabled by a high level of collaboration will help achieve the multiple benefits experienced by many. Hence, experience with multiple BIM projects is fundamental. The most experienced BIM users will have to take a leadership position and facilitate the coordination to ensure a high degree of collaboration across the fields for each project.

The analysis result also implies that there are major differences in the responses based on organizations or projects characteristics. For example, BIM policy is a more critical factor for contractors than the consultants. This finding indicates that crafting and executing proper strategies requires attention to promise BIM success within contracting companies. A supportive company culture is more important for large firms where unwillingness to innovations might be at a more extensive rate compared with small firms. These results in that large companies need to work harder in order to achieve a successful BIM process. There are more factors for which significant differences are found in the responses in terms of implementation level than any other company or project specific characteristic. Availability of BIM software experts in a company, consulting, and client's awareness and requesting of BIM play significant roles as the level of implementation is at a higher rate. The companies should more carefully take into account these factors in case of higher BIM maturity levels because implementation process becomes more complex and needs more resources. The results suggest that human, process, technological, cultural and financial resources are the basic sources of success that have a moderate effect. These variables are supportive mechanisms and may perform as enablers; however, in the absence of critical resources, these are not sufficient for a successful implementation of BIM.

In regard to case study New College Of Engineering (COE) Building Autodesk software (Revit, Navisworks and Robot) were used for authoring, viewing, collaborating, coordinating and design checking of 3D models. On the other hand, RIB iTWO software was used to build 4D/5D model, RIB iTWO combines traditional construction planning and trailblazing 5D planning. The software tools that help bring the disciplines together becomes the fundamental of the BIM project and its efficiency, compatibility, ease of use, speed, coordination, communication collaboration and integration capabilities are essential for the appropriate implementation of BIM. In addition, Coordination among project participant, Defined of organization structure and clear roles and responsibility which plays a big role in its BIM adoption.

There are many factors affecting teamwork between disciplines in BIM implementation and since most of the procedures are relatively new to most AEC professionals and the expectations involve a lot of hype. However, it is evident that as the learning curve fades in the horizon, an environment of collaboration will rise.

6.2 Recommendation

The findings of this research can be advantageous for over sighting senior managers of construction organization and BIM consultants in developing countries for a better implementation BIM between participant. The organizations that intend to implement BIM are recommended first to invest on relevant resources and then foster a work environment that will be beneficial for a new project management approach. They should keep in mind that benefits will be recognized in the long term, so they should be patient to achieve profits on their investment.

6.3 Limitations

This research focuses on the construction industry in gulf countries. Data observed from a different nation could possibly produce different results due to different culture and characteristics of the construction industry. It encourages other researchers to explore similar topics in their regions.

6.4 Recommendation for Future Research

In order to obtain a better understanding of the different views of the industry, the survey should have been distributed evenly across the multiple disciplines in the industry. Ideally the same number of responses should have been collected from the architecture, engineering, and construction management fields as well as from subcontractors, structural, mechanical electrical and plumbing branches of work. With a more balanced set of data, the study would gain more validity and the comparisons among the fields of practice could have been use to better understand the existing issues practitioners face in the BIM collaborative environment.

However, similar studies might be undertaken using the proposed critical successful of collaboration factors, and the findings could be used to observe the market-specific variations. It is also planned to extend this research by producing case studies to have a better understanding of the implementation of BIM. Such a study will explore why and how BIM is implemented in different types of projects. As a future research, a new framework could be created that will allow to consider the links among the mutual factor groups and/or the critical successful collaboration factors. Such a study will be useful to measure the affection of the components more precisely because these are more likely to be interconnected to each other.

REFERENCES

Abdirad H., Pishdad P., (2014). Developing a Framework of Metrics to Assess Collaboration in Integrated Project Delivery.*50th ASC Annual International Conference Proceedings.*

Alfred, O. (2011). A preliminary review on the legal implications of BIM and model ownership.*Journal Information Technology Construction*, 16, 687-696.

American Institute of Architects California Council (AIACC).INTEGRATED PROJECT DELIVERY: AN UPDATED WORKING DEFINITION. VERSION 3 UPDATED 7/15/14

Arayici, Y., and Coates, P. (2012). A system engineering perspective to knowledge transfer: A case study approach of BIM adoption. *Virtual reality—Human computer interaction*, X.-X. Tan, ed., InTech, Rijeka, Croatia, 179–206.

Azhar, S. (2012).Building Information Modeling (BIM): Trends, Benefits, Risks, and Challenges for the AEC industry.*Leadership. Manage. Eng.*, 11, 241-252.

BARNES, P. & DAVIES, N. (2014).BIM in principle and in practice, *London, ICE Publishing.*

Bentley AECOsim Building Designer. (2016, November 20).Retrieved fromhttps://www.bentley.com/en/products/product-line/building-design-software/aecosim-building-designer

Bogaert, S., Boone, C., & Van Witteloostuijn, A. (2012). Social value orientation and climate strength as moderators of the impact of work group cooperative climate on affective commitment. *Journal of Management Studies*, 49(5), 918-944.

Boktor, J., Hanna, A., and Menassa, C. (2014).The state of practice of building information modeling (BIM) in the mechanical construction industry.*J. Manage. Eng.*, 10.1061/(ASCE)ME.1943-5479.0000176, 78–85.

Bryde, D., Broquetas, M. &Volm, J. (2013). The project benefits of Building Information Modeling (BIM). *International Journal of Project Management*, vol. 31(7), pp. 971-980.

Chien, K., Wu, Z. &Haung, S. (2014). Identifying and assessing critical risk factors for BIM projects: Empirical study. *Automation in construction*, vol. 45, pp. 1-15.

Choi, B. C., & Pak, A. W. (2006).Multidisciplinarityinterdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness.

Chien, K. F., Wu, Z. H., and Huang, S. C. (2014).Identifying and assessing critical risk factors for BIM projects: empirical study.*Automation Construction*, 45(1), 1–15.

Cronbach, L. J. (1951).Coefficient alpha and the internal structure of the tests.Psychometrika, 16, 297-334.

Cross, N. (2004). Expertise in design: an overview. Design studies, 25(5), 427-441.

Cleves, J. A., & Dal Gallo, L. (2012).Integrated Project Delivery: The Game Changer. Paper presented at the American Bar Association Meeting: Advanced Project Delivery: Improving the Odds of Success.

Deutsch, R. (2011). BIM and integrated design: strategies for architectural practice (1st ed.), *New Jersey: John Wiley & Sons.*

BIM Collaboration Format (BCF). (2017, January 10).Retrieved fromhttps://www.designingbuildings.co.uk/wiki/BIM_collaboration_format_BCF

Dirik, J. (2009). Integrated project delivery, part two: Legal issues. *Texas Construction*, 38.

Dossick C.S. and Neff G. (2010).Organizational divisions in BIM-enabled commercial construction, *Journal of Construction Engineering and Management*, Vol.136, No.4, 459-467.

E.A. Pärn,D.J. Edwards,M.C.P. Sing (2017). The building information modelling trajectory in facilities management: A review. *Automation in Construction Elsevier Volume 75,* March 2017, Pages 45–55 dx.doi.org/10.1016/j.autcon.2016.12.003.

Eadie, R., Browne, M., Odeyinka, H., McKeown, C., and McNiff, S. (2013). BIM implementation throughout the UK construction project lifecycle: An analysis. *Automation Construction*, 36(1), 145–151.

Eastman, Chuck, et al. (2011). BIM Handbook, A guide to building information modeling for owners, managers, designers, engineers and contractors, *Second edition. s.l. : Wiley,* 2011.

Elmualim, A. & Gilder, J. (2014). BIM: innovation in design management, influence and challenges of implementation, *Architectural Engineering & Design Management*, vol.10 (3/4), pp. 183-199.

Ganah, A., & John, G. (2013).Suitability of BIM for enhancing value on PPP projects for the benefit of the public sector.*Public Private Partnership Int. Conf. 2013 Body of Knowledge,* Univ. of Central Lancashire, Preston, U.K., 347–356

Greenwood, D. & Wu, S. (2012). Establishing the association between collaborative working and construction project performance based on client and contractor perceptions. *Construction Management and Economics*, 30(4), 299-308.

Grilo, A. &Jardim-Goncalves, R. (2010).Value proposition on interoperability of BIM and collaboration working environments, *Automation in Construction*, vol. 19(5), pp. 522-530.

Gu, N. & London, K. (2010). Understanding and facilitating BIM adoption in the AEC industry, *Automation in construction*, vol. 19 (8). pp. 988-999.

Hardin, B. (2009). BIM and Construction Management, Indianapolis: *Wiley Publishing.*

HM (Her Majesty's) Government.(2012). Building information modeling, industrial strategy—Government and industry in partnership.*Government Rep., London.*

Hossain M.K Munns, A., &Rahman M., (2013).ENHANCINING TEAM INTEGRATION IN BUILDING INFORMATION MODELLING (BIM) PROJECTS.*ARCOM Doctoral Workshop.*

Howard W. Ashcraft (2008). "Building Information Modeling: A Framework for Collaboration". Volume 28, Number 3, Summer 2008. *The American Bar Association.*

Hwang, B. A. and Lim, E. S. J. (2013).Critical Success Factors for Key Project Players and Objectives: Case Study of Singapore.*J. Constr. Engr. Manage.*, ASCE, 136, 204-215.

Industry Foundation Classes (IFC). (2016, December 15). Retrieved from http://www.autodesk.com/products/revit-family/overview

Jin, X. H., &Doloi, H. (2008). Interpreting risk allocation mechanism in public–private partnership projects: an empirical study in a transaction cost economics perspective. *Construction Management and Economics*, 26(7), 707-721

Jung, W., & Lee, G. (2015).The Status of BIM Adoption in Six Continents. World Academy of Science, Engineering and Technology, *International Journal of Civil, Structural, Construction and Architectural Engineering* Vol:9, No:5

Jung, Y., and Joo, M. (2011).Building information modelling (BIM) framework for practical implementation.*Automation Construction.,* 20(2), 126–133.

Kensek , Karen M. and Peng , Jinhua. (2012). Practical BIM - Management, Implementation, Coordination and Evaluation . Los Angeles, California, USA : University of Southern California , 2012 .

Khosrowshahi, F., &Arayici, Y. (2012).Roadmap for implementation of BIM in the UK construction industry.*Eng. Constr. Archit. Manage.,* 19(6), 610–635.

Kreider, R., Messner, J., &Dubler, C. (2010).Determining the frequency and impact of applying BIM for different purposes on projects.*In Proceedings of the 6th International Conference on Innovation in Architecture, Engineering & Construction* (AEC), June (pp. 9-11).

Lam, P. T. et al. (2010). “Effectiveness of ICT for Construction Information Exchange among Multidisciplinary Project Teams.”*J. Comput. Civ*. Eng., 24, 365-376.

Latiffi, A. A., Mohd, S., Kasim, N., &Fathi, M. S. (2014). Building Information Modeling (BIM) Application in Malaysian Construction Industry.*International Journal of Construction Engineering and Management*, 2(4A), 1–6. doi:10.5923/s.ijcem.201309.01

Lee, S., Yu, J., and Jeong, D. (2015).BIM acceptance model in construction organizations.*J. Manage. Eng.,* 10.1061/(ASCE)ME.1943-5479 .0000252, 04014048.

Liu W., Guo H., Li H., and Li Y. (2014).Using BIM to Improve the Design and Construction of Bridge Projects: A Case Study of a Long-span Steel-box Arch Bridge Project.*International Journal of Advanced Robotic Systems.* DOI: 10.5772/58442.

Livesley, W. J., Jang, K. L., & Vernon, P. A. (1998).Phenotypic and genetic structure of traits delineating personality disorder.*Archives of general psychiatry,* 55(10), 941-948.

Love, P., Matthews, J., Simpson, I., Hill, A. &Olatunji, O. (2014). A benefit realization management: building information modeling framework for asset owners. *Automation in Construction,* vol. 37, pp.1-10.

Lu W., Zhang D., and Rowlinson S., (2013). BIM collaboration: a conceptual model and its characteristics. ARCOM Conference, 2-4 September 2013, Reading, UK, Association of Researchers in Construction Management.

Mbamali, I., &Okotie, A. (2012).An assessment of the threats and opportunities of globalization on building practice in Nigeria.*American International Journal of Contemporary Research*, 2(4).

McDonnell, Fiachra& Hayden, Ruairi (2013) Developing a Collaborative Virtual Learning Environment Between Students Across Disciplines in the Built Environment.*Irish Journal of Academic Practice*: Vol. 2: Iss. 1, Article 4. Available at: http://arrow.dit.ie/ijap/vol2/iss1/4

McGraw Hill Construction. (2014). The business value of BIM for construction in global markets: How contractors around the world are driving innovation with building information modeling. Bedford, MA.

Meng-Han Tsai, Mony Mom & Shang-Hsien Hsieh (2014). Developing critical success factors for the assessment of BIM technology adoption: part I. *Methodology and survey Journal of the Chinese Institute of Engineers*, 2014 Vol. 37, No. 7, 845–858, http://dx.doi.org/10.1080/02533839.2014.888811.

Migilinskas, D., Popov,V., Juocevicius,V.&Ustinovichius, L. (2013). The benefits, obstacles and problems of practical BIM implementation.*Procedia Engineering*, vol. 57, pp. 767-774.

Mony Mom, Meng-Han Tsai, & Shang-HsienHsieh (2014). Developing critical success factors for the assessment of BIM technology adoption: Part II . Analysis and results Journal of the Chinese Institute of Engineers, 2014 Vol. 37, No. 7, 859–868, http://dx.doi.org/10.1080/02533839.2014.888798

Naoum, S. (2001).People and Organizational Management in Construction, *Thomas Telford Publishing, London.*

NIBS (National Institute of Building Sciences, 2015), National Building Information Modeling Standard, Version 3. Downloaded from http://www.nationalbimstandard.org/

Nikas, A., Poulymenakou, A., &Kriaris, P. (2007).Investigating antecedents and drivers affecting the adoption of collaboration technologies in the construction industry. *Automation in Construction*, 16(5), 632-641.

Olatunji, A. O. (2011). Modelling organizations‟ structural adjustment to BIM adoption: a pilot study on estimating organisations.*Journal of Information Technology in Construction* 16, 653- 668.

Ozturk, G.,Arditi, D.,Yitmen, I.,Yalcinkaya, M., (2016).The Factors Affecting Collaborative Building Design.*Procedia Engineering* · December 2016DOI: 10.1016/j.proeng.2016.08.712.

Partridge, Allan &Fris, Anneliese.(2007). Building Information Modeling - *Practice Builder*.*Edmonton :* RAIC, 2007.

Qian, A. (2012).BENEFITS AND ROI OF BIM FOR MULTI-DISCIPLINARY PROJECT MANAGEMENT.Project Management.

Rezgui, Y., Beach, T. & Omer, R. (2013).A governance approach for BIM management across lifecycle and supply chains using mixed-modes of information delivery. *Journal of Civil Engineering and Management*, vol. 19(2), pp. 239-258.

Shafi.t,Matthews.j, Lockley.s (2013).A Study OfBim Collaboration Requirements And Available Features In Existing Model Collaboration Systems. ITcon Vol. 18 (2013), Shafiq, et.al., pg. 148. *Journal of Information Technology in Construction* - ISSN 1874-4753.

Simona, M. (2012). The Romanian centralized organizations' resistance to change. *Constanta Maritime university's annals*, vol.13 (18), pp. 313-320

Singh, V. et al. (2011). "A theoretical framework of a BIM-based multidisciplinary collaboration platform*." J. Autom. Constr*., 2011, 20, 134-144.

Smith, D. K., and M. Tardif. 2009. Building Information Modeling. New York: *John Wiley.*

Succar B. (2010). The five components of BIM performance measurement, published electronically, 2010 CIB World Congress, May 11-13, Salford, UK.

Succar, B., Sher, W., and Williams, A. (2013).An integrated approach to BIM competency assessment, acquisition and application.Automation Construction, 35(1), 174–189.

Suwal, S., Singh, V. & Shaw, C. 18 Jun 2016 Towards a Framework to Understand Multidisciplinarity in BIM Context - Education to Teamwork. Kähkönen, K. &Keinänen, M. (eds.). Tampere: Tampere University of Technology, p. 658 672 p. DC29320. *(Proceedings of the CIB World Building Congress* 2016)

Underwood, Jason and Isikdag, Umit. (2010). Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies. Hershey: Information Science Reference, 2010.

Won, J., Lee, G., Dossick, C., and Messner, J. (2013).Where to focus for successful adoption of building information modeling within organization.*Journal Construction Engineering Management*, 10.1061/(ASCE)CO.1943 - 7862.0000731, 04013014.

Wong, A. K., Wong, F. K., &Nadeem, A. (2010).Attributes of building information modelling implementations in various countries.*Architectural Engineering and Design Management*, 6(4), 288-302.

Xu, X., Ma.L&Ding,L., (2014). A Framework for BIM-enabled Life-cycle Information Management of Construction Project.*International Journal of Advanced Robotic Systems*. DOI: 10.5772/58445

Yalcinkaya, M., & Singh, V. (2016). A Visual Transactive Memory System Approach Towards Project Information Management. 1. *Paper presented at CIB W78 Conference, Brisbane, Australia.*

Zhou, W. et al. (2012).Model-Based Groupware Solution for Distributed Real-Time Collaborative 4D Planning through Teamwork.*J. Comput. Civ. Eng.,* 26, 597-611.

APPENDIX

Appendix A: Survey Questionnaire

Dear participant:
You have been asked to voluntarily participate in this research study, which is a part of an MSC study being conducted under the supervision of Dr. Tolga Celik in the department of civil engineering at Eastern Mediterranean University located in Northern Cyprus.
The study aims to develop a framework of multidisciplinary team-working in BIM for construction industry.
Team-working in BIM for construction industry can be evaluated through some measures of factors. Performance of collaborative is a system which manages these factors and requirement, and provides appropriate improvement within the system by obtaining feedback from various levels.
If you agree to participate in this study, you will be asked to fill-in a questionnaire specially designed to collect data for this study.respondents should have experience in BIM implementation, Your responses to the questionnaire will be kept confidential, and used for academic issues only.
In case of having any questions about the study prior, during or after your participation, you can contact me at (15500495@students.emu.edu.tr) or on:
 (+905338556588- KKTCELL), Northern Cyprus
Thank you very much for your participation.
Researcher: Mohammad AL Sharqawi

*Required

1. **Email address** *

____

Section A : General Information

2. **what is the type of Organization do you work for ?** *
Mark only one oval.
- ( ) Designer
- ( ) Client
- ( ) Consultant
- ( ) Main Contractor
- ( ) Sub-Contractor/Supplier

3. **what is BIM project type do you work on?** *
Tick all that apply.
- [ ] Residential Housing
- [ ] Institution & Commercial Building
- [ ] Industrial Construction
- [ ] Infrastructure & Heavy Construction

4. **Which is BIM project Phase do you work on?** *
Tick all that apply.

- [ ] Feasibility & Preliminary Phase
- [ ] Detailed Design
- [ ] Construction
- [ ] Operation & Maintainance

5. **Your experience in construction industry?** *
Mark only one oval.

- ( ) 1 year
- ( ) 2-5 years
- ( ) 6-10 years
- ( ) 11-15 years
- ( ) More than 15 years

Section B :Factor Affecting on Multidisciplinary Team-Working

To what extend do you agree or disagree that the following factors have impact on multidisciplinary Team-working in BIM ?

Organization Level

6. **Training of employees** *
Mark only one oval.

	1	2	3	4	5	
Very Low	( )	( )	( )	( )	( )	Very High

7. **Availability of BIM software experts in a company** *
Mark only one oval.

	1	2	3	4	5	
Very Low	( )	( )	( )	( )	( )	Very High

8. **Expected economic impact (return on investment(ROI))** *
Mark only one oval.

	1	2	3	4	5	
Very Low	( )	( )	( )	( )	( )	Very High

9. **Availability of financial resources of organization** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

10. **Availability of information and technology** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

11. **BIM policy of the company** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

12. **Required knowledge and experience for changing contractual arrangements to work with BIM** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

13. **Defined organizational structure** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

14. **Level of BIM adoption at industry** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

15. **clients awareness and requesting of BIM** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

16. **Government Support** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

17. **Experience level of BIM project within the firm** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

Project Level

18. **Support from top management** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

19. **Coordination among projectparties** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

20. **Early Involvement of project team** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

21. **Risks associated with BIM projects (types, size, teams, cost, locations)** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

22. **Selection of project delivery methods** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

23. **willingness to share information among project participants** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

24. **Collaborative environment (network)** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

Individual Level

25. **Technical skills** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

26. **Collaboration Experience** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

27. **Effective leadership** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

28. **Individual and group motivation** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

29. **Clear Role and Responsibility** *
Mark only one oval.

	1	2	3	4	5	
Very Low	◯	◯	◯	◯	◯	Very High

BIM Requirement

30. **Interoperability (data exchange formats)** *
Mark only one oval.

	1	2	3	4	5	
Very Low	⬭	⬭	⬭	⬭	⬭	Very High

31. **Technical support from suppliers** *
Mark only one oval.

	1	2	3	4	5	
Very Low	⬭	⬭	⬭	⬭	⬭	Very High

32. **Security in data sharing** *
Mark only one oval.

	1	2	3	4	5	
Very Low	⬭	⬭	⬭	⬭	⬭	Very High

33. **BIM standards, codes, rules, and regulations** *
Mark only one oval.

	1	2	3	4	5	
Very Low	⬭	⬭	⬭	⬭	⬭	Very High