Knowledge Transfer Partnership for BIM Implementation in the AEC Industry in Turkey

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ABSTRACT

The Architecture, Engineering, Construction (AEC) industry is considered as a part of the largest sources of economy incomes. Despite its great importance, it is still suffering from many work process problems, in information, collaboration and communication management process and site product development. Building information modeling (BIM) has been presented to handle these problems and herewith improving outputs in construction projects. Implementation of BIM is not only a strategy of technology updating; there is also a need for substantial changes in work style to make upgrades to productivity progresses. Since many types of research have been done on BIM Implementation and putting forward different point of views about implementation criteria and strategy, it is still a problem for the AEC industry in Turkey so far. The purpose of this thesis is to invest the Knowledge Transfer Partnership (KTP) program in BIM implementation in AEC industry in Turkey by taking advantage of the United Kingdom (UK) successful experience. Moreover, providing strategy plan and recommendations for the Turkey AEC industry to implement BIM. However, throughout a comprehensive literature review, the paper initially mentions BIM maturity levels, critical success factors (CSFs), barriers and challenges face the implementation process which paves the road for a simple statistics analysis by using quantitative method. The data analysis of questionnaire amongst the major engineering faculty in Turkey and combining the results with results conducted on a previous study carried out on firms within the AEC industry.

Keywords: Building Information Modeling, Implementation, Adoption, AEC Industry, Critical Success Factors, Knowledge Transfer Partnership.

ÖZ

Mimarlık, Mühendislik, İnşaat (AEC) sanayi ekonomisi gelirleri en büyük kaynaklarından biri olarak kabul edilmektedir. Büyük önemine rağmen, özellikle bilgi yönetimi süreci ve ürün geliştirme alanında birçok iş süreci sorunlarından muzdariptir. Bu problemlerle başa çıkabilmek için inşaat bilgi modellemesi (BIM) sunulmuş ve inşaat projelerindeki çıktılar iyileştirilmiştir. BIM'in uygulanması sadece teknoloji güncellemesinin bir stratejisidir; Ayrıca, üretkenlik artışlarına iyileştirme yapmak için iş stilinde önemli değişikliklere ihtiyaç duyulmaktadır. BIM Uygulaması üzerine pek çok araştırma yapıldığından ve uygulama kriterleri ve stratejisi ile ilgili farklı bir bakış açısı öne sürdüğü için, Türkiye'de halen AEC sektörü için bir sorun teşkil etmektedir. Bu tezin amacı, Birleşik Krallık (England) 'nin başarılı deneyiminden yararlanarak Türkiye'deki AEC sektöründeki BIM uygulamasında Bilgi Transferi Ortaklığı (KTP) programına yatırım yapmaktır. Kapsamlı literatür taramasıyla, öncelikle BIM'in olgunluk kavramı, Kritik Başarı Faktörleri (KBF), engeller ve zorluklardan bahsetmek kantitatif yöntemle analizin yolunu açan uygulama süreciyle yüzleşmektedir. Anket anketinin Türkiye'deki ana mühendislik fakültesi arasındaki veri analizi ve sonuçları AEC endüstrisindeki firmalar üzerinde gerçekleştirilen önceki bir çalışmada yapılan sonuçlarla birleştirmek.

Anahtar Kelimeler: Yapı Bilgi Modellemesi, Uygulama, Benimseme, AEC Endüstrisi, Kritik Başarı Faktörleri, Bilgi Transferi Ortaklığı.

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LIST OF SYMBOLS AND ABBREVIATIONS

2D	Two Dimension
3D	Three Dimension
4D	Four Dimension
5D	Five Dimension
6D	Six Dimension
7D	Seven Dimension
AEC	Architecture, Engineering and Construction
BIM	Building Information Modelling
CSFs	Critical Success Factors
EU	European Union
ICT	Information and Communication Technology
iBIM	Integrated Building Information Modelling
KTP	Knowledge Transfer Partnership
SD	Standard Deviation
UK	United Kingdom
US	United State
μ	Mean
σ	Standard Deviation
Σ	Summation

Chapter 1

INTRODUCTION

1.1 Background

In the new global economy, the AEC companies works in a three trillion-dollar, it has been estimated that there is up to 30 percent waste of money and resources (Thomas and Wilson 2013). Also, there is a big responsibility for the AEC industry stakeholders to fix this problem which has received considerable critical attention.

The AEC industry has been long looking-for strategies to reduce project cost and project delivery time, plus increase efficiency and quality, BIM is becoming a fast key solution to attain these goals (Azhar et al. 2008). BIM becomes ever more important technology in the AEC industry.

With BIM technology, an accurate virtual model of a project is digitally designed. This model can be used for planning, design, construction, and operation of the facility. It helps AEC industry stakeholders picture what is to be built in a simulated environment to identify any possible issues.

BIM boosts the integration and collaboration between all stakeholders on the project. (Azhar 2011). BIM presents a new process of working which aims to transform and makes the construction process more reactive to the end-user needs (Linderoth 2010; Arayici and Coates 2012; Blackwell 2012; Succar, Sher, and Williams 2013).

BIM has been developed as an innovative way to design and manage projects and enhance collaboration among project teams. So that they promote certainty by relying on in building performance and operating significantly. As BIM grows rapidly, it is also important to increase collaboration among project stakeholders to improve cost-effectiveness, customer-client relationships, and better time management. (Azhar 2011).

1.2 Research Aim and Objectives

Based on the previous background, this thesis is purposed to highlight on the academic role regarding BIM implementation through an assessment of how to establish a partnership with the AEC based on the UK program KTP to implement BIM technology in Turkey.

Also, the thesis aims to find out a comprehensive background about the potentials and capabilities of the academic institutions in Turkey regarding applying KTP program for BIM implementation in Turkey. However, this leads to creating a common concept map between AEC firms and academic institutions to build a roadmap for BIM implementation based on a partnership between the Academic sector and the AEC industry.

Furthermore, the future aim of this paper is knocking the government's door in Turkey to support this outstanding plan, by explaining the importance of the KTP program and what are the main factors contributing to the success of its implementation in Turkey.

This thesis intends to adopt a new approach to evaluate the implementation process of Information and Communication Technology (ICT) -BIM technology- in Turkish

AEC industry and focusing on the primary role of the Academic sector in this regard. Therefore, the thesis main objectives are listed as follow:

1. To highlight the most recent researches regarding BIM implementation.
2. To clarify the academic aspect regarding BIM implementation in Turkey and find out who are involved in this process.
3. To determine the most important CSFs for BIM implementation in the AEC industry in Turkey from an academic aspect.
4. Evaluating and clarifying the shared-point between the academic sector and the industrial sector regarding the CSFs of BIM implementation.
5. To develop a conceptual theoretical framework to pave the way for the Turkish government to improve the implementation process of BIM by adopting the KTP program.

1.3 Scope and Limitation

The thesis scope focuses on BIM implementation investigation in Turkish AEC industry from an academic aspect and identification of the CSFs of BIM implementation in the AEC industry of Turkey. This thesis is limited to BIM implementation in Turkey where a questionnaire survey was distributed amongst the major Construction Management departments of Engineering faculties around Turkey to gain a comprehensive result.

1.4 Research Methodology

An investigation methodology was used to determine the most important CSFs of BIM implementation in Turkey from an academic aspects, and comparing these results to those conducted in earlier study done in Turkey (Ozorhon and Karahan 2016).

A quantitative method is used to analyze the result of a data being gathered throughout a questionnaire sent to all professors of construction management departments in the engineering faculties all around Turkey.

The questionnaire consists two parts, the first part about the CSFs of BIM implementation while the second part is about KTP program adoption in Turkey. The total number of questions in the questionnaire is 30 and it took 2 months to prepare and make the necessary adjustments. Methods used to analyze the results are, mean and standard deviation and relative mean method.

1.5 Overview of Thesis

The thesis is contributed to this growing area of research -BIM- by exploring the implementation process of BIM from a different aspect including the academic sector. The general thesis structure has five chapters, including this introductory chapter.

Chapter two starts by setting the theoretical part of the research, including a comprehensive literature review about BIM and goes deeply through it by describing:

- The definition of BIM.
- BIM benefits.
- BIM challenges.
- BIM maturity levels.
- BIM implementation CSFs.
- BIM barriers, and BIM Dimensions.

Finally, the literature review gives a brief review of KTP program and how it was applied in the UK.

The third chapter is built to describe the methodology used for this thesis. The fourth chapter describes the research findings and focusing on the three keys:

- The CSFs of BIM implementation in the Turkish AEC industry.
- The implementation level of BIM within academic sector.
- The future of KTP program between the academic sector and the AEC industry.

The fourth part of the thesis is proceeded as follow: The final chapters summaries the entire thesis, tying up numerous theoretical and empirical strands in order to fully understand the meaning of this research and mentions the finding implications to future research into this area. Finally, the last chapter is about the conclusion which gives a brief summary, critique of the findings and recommendations for future researches.

Chapter 2

LITERATURE REVIEW

2.1 BIM Definitions and Concepts

BIM has been described as a computer-software developed for different purposes such as time scheduling, cost estimation, life cycle management and facility management, BIM is a computer tool developed for better collaboration and communication between project stakeholders (Eastman, Teicholz, et al. 2011). BIM has been described as an intelligent 3D model-based process that provides the AEC industry professionals with the necessary insight and tools to get more efficient and accurate plan and design (Autodesk 2018).

BIM simulates the construction project in a virtual environment. With BIM technology, an accurate virtual model of a building, known as a building information model, is digitally constructed. BIM provides a simulation model about the geometry, 3D building model, topographical information, details and assets of building elements (Structural and non-structural elements), cost estimation, material inventories, and project time schedule (Bazjanac 2006).

In 2016, the United State (US) National Building Information Modelling Standard Project Committee (NBISPC) defines BIM a digital model which represented the functional and physical characteristics of facilities and offer a source of information and details to be used in establishing the entire project life cycle.

Furthermore, the common quantities and characteristics of the materials can be easily disseminated, and the facilities can easily be isolated and identified with the ability to show details and information within a relative range within the entire facility or suite of facilities. BIM creates an online cloud to share all project documents such as operational drawings and procurement details in design plans, delivery processes, and other standards and specifications and make them interlinked among all stakeholders.

2.2 BIM Trends Globally

Over the past decade, most researches in ICT primarily focus on the BIM implementation in the AEC industry. The concept of BIM can be tracked back to the working prototype building description systems proposed in mid 70s of last century by Eastman (Eastman 1976).

Traditionally, it has been argued that the recognition of BIM utilization process in AEC industry has been discussed by many researchers (Mihindu and Arayici 2008) due to its great potential benefits. However, until now it is still quite limited application in practice. Since then, a varied range of papers have been published for different purposes that form a part of the BIM approach ranging from application suites to very detailed tools for product libraries, analysis, design (Gu and London 2010).

Recently, BIM becomes a vital research subject (Succar 2009a), where a large amount of literature was published on BIM technology, and these studies investigated over the last decade on how BIM has transformed building and infrastructure progress within the AEC industry (Eastman, Eastman, et al. 2011).

Furthermore, a research shows that BIM adoption could highly raise the level of collaboration on project execution (Eastman, Eastman, et al. 2011) and has a good impact on quality and achievement time in projects (Elmualim and Gilder 2014).

Much of the current literature on BIM pays particular attention to BIM trend and how it was slow in the past ten years (Becerik-Gerber, Gerber, and Ku 2011; Eastman, Eastman, et al. 2011; Smith 2014) with the exception of some developed countries such as Finland, Sweden, UK and US (Lan et al. 2015; Mulenga and Han 2010) where spreading quickly and making a qualitative leap in BIM implementation in ten years.

However, it has been a major shift since the last research published in 2008 (Yan and Demian 2008) and found that very few within the AEC industry in the UK and the US have knowledge about BIM and its capabilities. Since 2007 (Hill 2014) the implementation and development of BIM in the AEC industry have been tracked worldwide throughout a large-scale study around the world.

McGraw Hill (Hill 2014) has found critical change over that period and a significant increase in the implementation process over the past five years. The results show that BIM implementation by the AEC industry increased from 28% in 2007 to 71% in 2012 in US and Canada.

It also shows that the implementation of BIM was led by countries such as the United States, the United Kingdom, France, Canada, and Germany, while new nations are being adopted BIM such as Australia, Turkey, New Zealand, South Korea, Japan, and Brazil. Very active and even passed the most established states in certain areas.

Figure 1 shows the significant rise of BIM implementation during the period from 2013 to 2015.

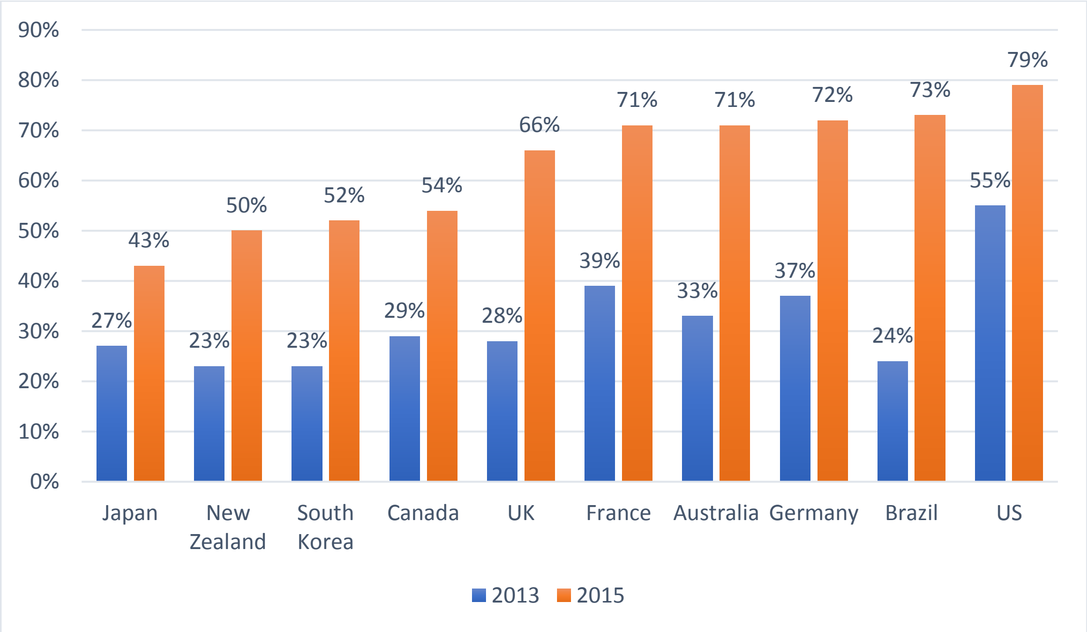

Figure 1. Percentage of contractors implemented BIM (Hill 2014).

By January 2014 the European Parliament decided to take a step toward developing the public sector in European Union (EU) by recommending the use of Information and Communication Technology (ICT) like BIM in public projects. Figure 2 shows these steps (Autodesk 2014).

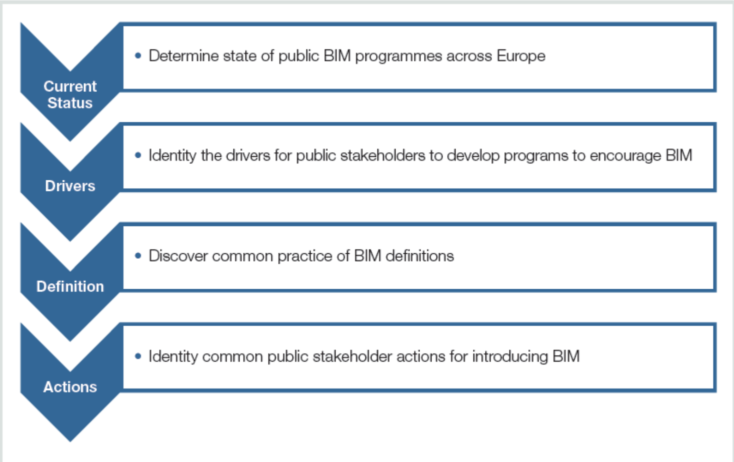

Figure 2. Development of BIM implementation in EU (Autodesk 2014).

This strategy, officially called the European Union Public Procurement Directive (EUPPD) means that all the 28 European Associate nations may inspire, require or directive the use of BIM for governments' projects in the European Union by 2016. In fact, the following nations already require the use of BIM as a condition for public projects: The UK, Denmark, Netherlands, Norway and Finland.

2.2.1 UK Experience in BIM Implementation

Recently, several studies attempted to explain how the UK is one of few countries which has successfully adopted and implemented BIM in the AEC industry throughout exclusive strategies invested in public projects (Coates, Arayici, and Koskela 2010; Coates et al. 2010; Eadie, McLernon, and Patton 2015; Arayici, Coates, et al. 2011a; Arayici, Egbu, and Coates 2012; Kassem et al. 2014; Kundríková 2014).

However, the relationship between these strategies and the successful implementation of BIM was based on government insights and objectives for the transformation of the AEC industry in the UK to the leader of BIM worldwide in a short time (Blackwell 2015).

> *"BIM usage is accelerating powerfully, driven by major private and government owners who want to institutionalize its benefits of faster, more certain project delivery and more reliable quality and cost. BIM mandates by US, UK and other government entities demonstrate how enlightened owners can set specific targets and empower design and construction companies to leverage BIM technologies to meet and exceed those goals, also driving BIM into the broader project ecosystem in the process"* (Construction 2014).

Past investigate discoveries demonstrate that the execution process is isolated into five stages over five years from 2011 to 2016 and has had a noteworthy effect on the UK AEC industry where companies confront the reality of creating technological capabilities to meet government necessities. (Eadie, McLernon, and Patton 2015).

However, the CSF’s that helped and ensure that implementation process is moving forward have been mentioned in many earlier studies (Table 1) referring to related literature on CSFs for implementing BIM (Smith 2014; Antwi-Afari et al. 2018).

The strategies of developed countries' governments such as UK and US encourage other developing countries like Turkey to follow their path and keep abreast of the great development that is taking place in the AEC industry.

2.3 Challenges of BIM Implementation

The economic output and benefits of BIM technology on the AEC industry are widely recognized and ever more well known. Further, the technology to implement BIM is readily existing and rapidly growing. Also, the effectiveness and values of BIM have been increasing scholarly interest in the past 10 years.

Drawing on secondary data from scholarly and professional sources, (Bryde, Broquetas, and Volm 2013) subjectively survey how the utilization of BIM might impact the key success criteria related to project results. Unfortunately, BIM implementation has been much slower than expected (Azhar et al. 2008). The reason for that can be classified within two categories, technical and managerial.

Past ponders have detailed that the challenges of executing BIM have gotten significant cash consideration, and these more imperative challenges relate to the nature of the AEC industry for the level of improvement in BIM. Later prove classified the challenges to technical and managerial challenges.

For example, the format handle for BIM implementation or the BIM model used in facility management after project delivery is considered preventable under legally binding agreements. Thus, all stakeholders consider that communication is the first preventive activity to be undertaken to ensure significant participation in implementation.

However, the owner, in this case, is the person most concerned about the determination of his part and the binding legal obligations from and to the contractor. (Hamdi and Leite 2013). Even though these challenges are having a serious effect on the BIM implementation process. To understand and have clear vision of these challenges, a full comprehension and defines of BIM maturity, critical success factors and barriers must be described.

2.4 BIM Maturity Levels

A research paper conducted by (Khosrowshahi and Arayici 2012) defined BIM maturity in three stages, including object based modelling, model-based collaboration, and network-based integration. In the literature on BIM maturity, the BIM strategy report (Group 2011) as shown in figure 3 described BIM maturity levels.

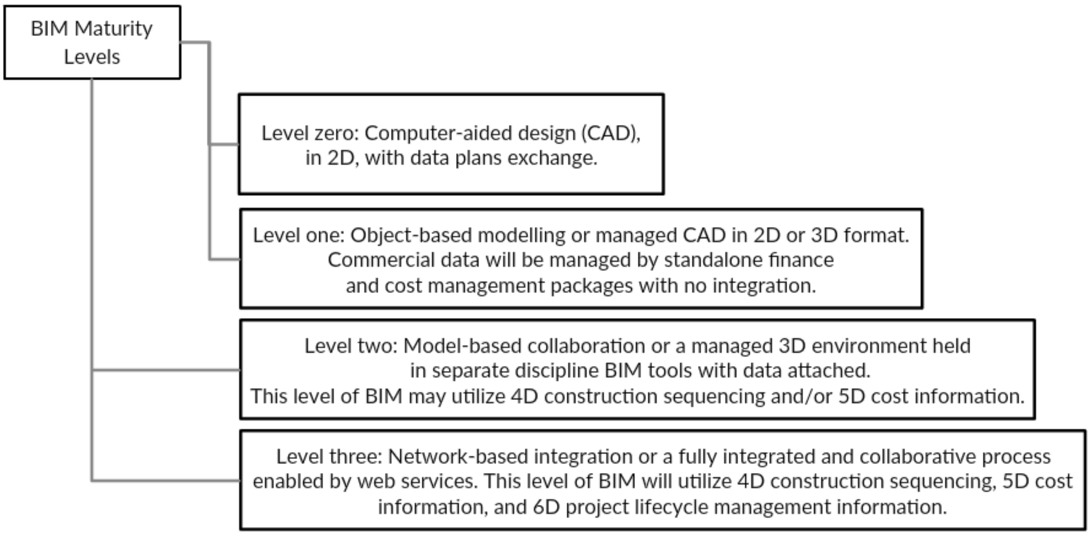

Figure 3. BIM maturity levels (Group 2011).

In fact, BIM maturity are important to establish an ideal base for effective strategies and assess the real performance of BIM by engineers, projects, and firms. BIM maturity refers to "*the quality, repeatability and degrees of excellence within a BIM capability competency*" (Succar 2009b). Figure 4 explain BIM maturity levels.

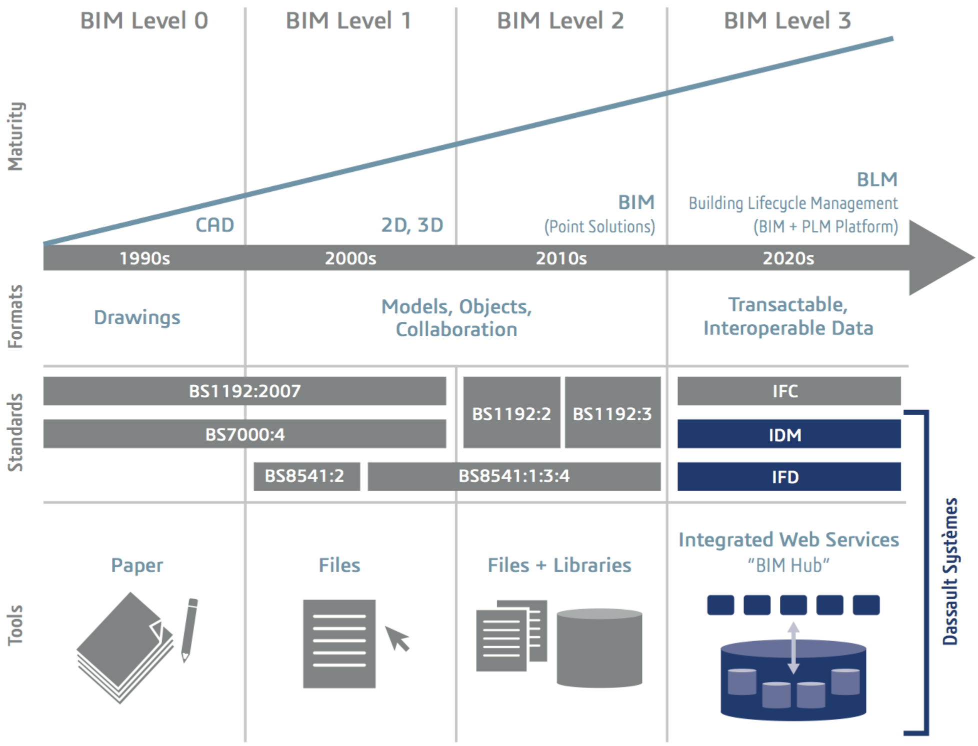

Figure 4. BIM maturity levels (Systèmes 2014).

2.5 BIM Dimensions and Benefits

BIM is the method of making data models including both graphical and non-graphical data in a Common Data Environment (CDE). The data that's made gets to be ever more point by point as a project progresses with the total dataset at that point given to the client once it's completed to utilize it within the building's In-Use stage and decommissioning stage.

BIM dimensions are different to BIM maturity levels. Its particularly refers to which kind of data to an information model. BIM is about adding additional dimensions of data to the digital model to have a full background of information about the construction project, such as supply chains, cost estimation, project life cycle, maintenance and operation.

These dimensions are up to 7 dimensions. This thesis explores BIM dimensions and how its looks like in practice and what are the benefits might be expected.

2.5.1 3D (The shared information model)

The shared information model is the traditional model 3D model and have been used by engineers in the last 15 years. This 3D model is limited to design phase that only included design plans in a 3D virtual. It is the process of creating graphical and non-graphical information and sharing this information in a Common Data Environment (CDE).

2.5.2 4D (Construction sequencing)

The 4D BIM is about adding additional type of information to the project model which have been classified in the planning phase of the project. This type of data made a clear vision about the project timeline progress by creating a 4D virtual project model and providing accurate information and visualizations that shows how the program would be developed step by step.

This 4D model provides a progress timeline information including details about the main time for all project stages, how long it takes to finish the construction elements, the time needed to become read for the operational phase, the supply chain management through organizing the material importing process and which components should be installed first and so on. And takes into account the collaboration made with other project facilities.

It's important to note that working with 4D information doesn't cancel the importance of having planners in the project team. In contrast, it helps in improving the traditional work process, in a digital work process planner can work in the pre-construction phase more effectively. Indeed, by being close to the project staffs from the earlier stages, there is a great potential to create more significant value for a construction project.

2.5.3 5D (Cost)

5D model is an integrated model of cost estimation including capital cost of the project, supply cost, equipment cost, material cost, and other costs. The cost estimation cost can be calculated based on the associated quantities of every single component provided in the model.

This model will help financial managers access the cost details of any components easily, establishing quantity rates, thereby reaching an overall cost for the project development and stay updated with any changes in quantities or costs.

Furthermore, this model help managers tracking the project budget, and the actual expenses spend over the project. This will support financial managers control the budget, expenses, and ensure the project is running on a high efficiency without tolerance throughout getting a regular cost and budget reports.

2.5.4 6D BIM (Project lifecycle information)

Building sustainability is the new trend for the upcoming projects, and this where 6D BIM comes in. The traditional way of proceeding project by focusing on the upfront capital cost of the projects is gone and shifted to consider the project life-cycle.

However, this 6D model will help managers create a full background about the power and energy consumption on long-term process and increase the efficiency of the project

2.5.5 7D BIM (Facility Management)

This 7D model facility management, operation and maintenance management, this 7D integrated BIM (iBIM) will help optimizing these concepts throughout a 7D digital model full of required data about projects facilities.

These data include detailed information about material manufacturer, specifications, required maintenance and details of how the project items should be used and operated for optimal performance on a long-term basis.

Adding this kind of detail to the information model allows decisions to be made during the design phase and allowing investors to create a pre-plan for their investment. Figure 5 illustrate BIM dimensions (CÉH+ 2018). Figure 6 illustrate benefits of BIM (Goubau 2018).

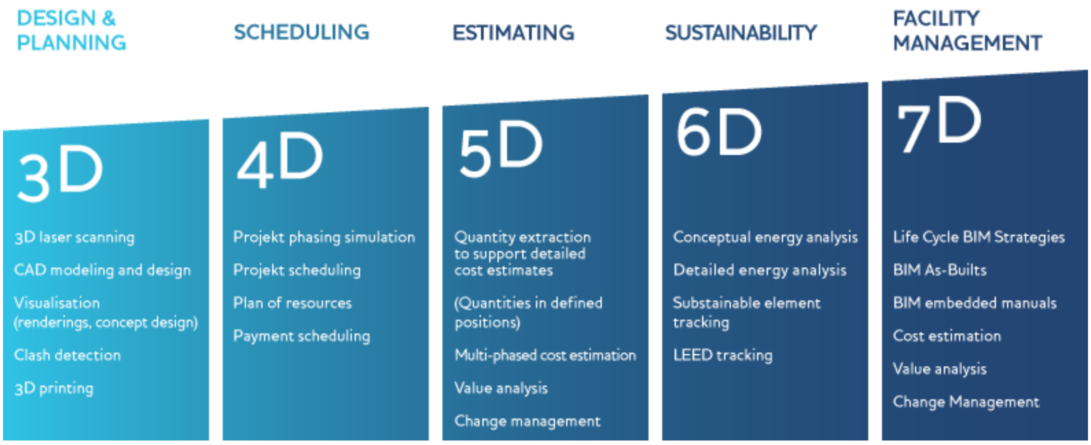

Figure 5. BIM dimensions (CÉH+ 2018).

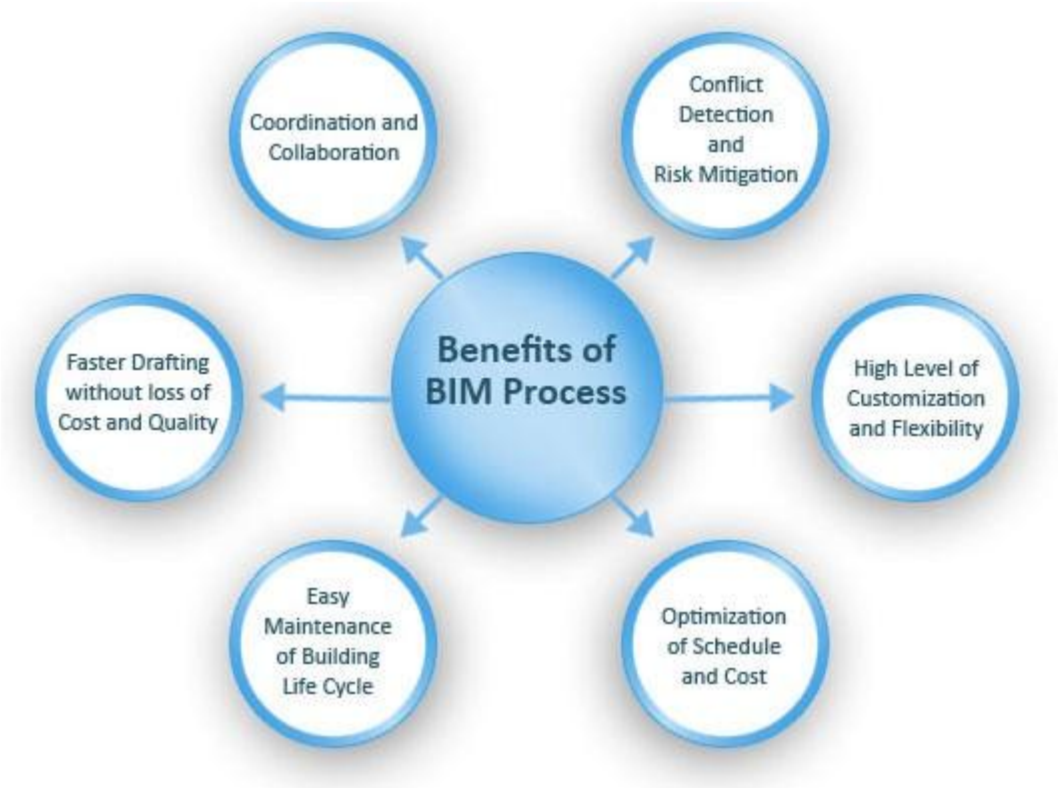

Figure 6. Benefits of BIM (Goubau 2018).

2.6 Barriers of BIM Implementation

In addition to the various types of barriers, legal barriers to BIM are directed to make BIM implementation move forward to achieve the UK Government's 2016 goal (Blackwell 2015). If it is addressed through legislation or protocols, users will see that they are no longer a barrier to further implementation (Eadie, McLernon, and Patton 2015). Figure 7 shows the importance of major to BIM use in the UK.

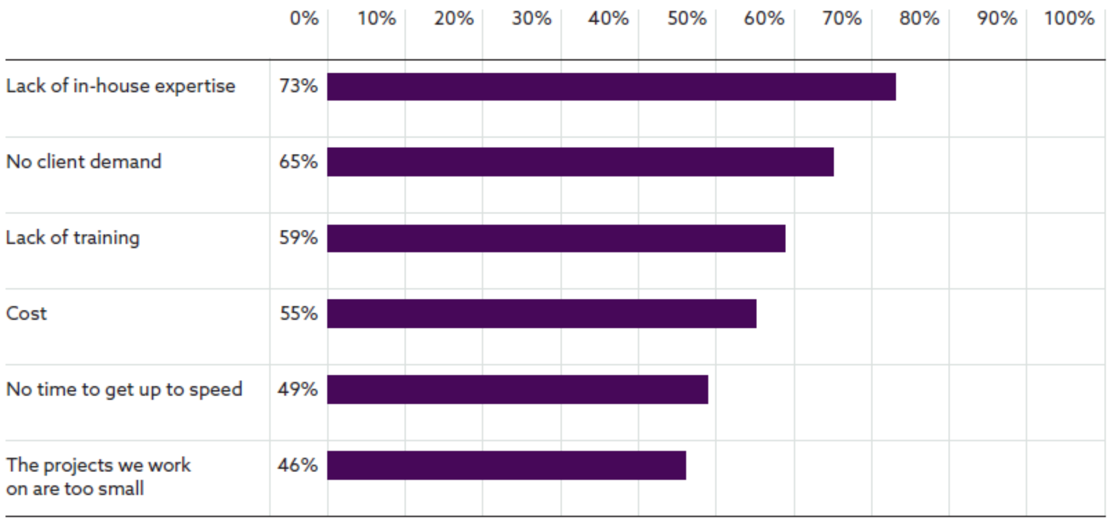

Figure 7. List of the main barriers to using BIM in UK (Hill 2014)

Furthermore, the following table (Table 1) shows the main barriers attempted in different literature globally.

Table 1. Barriers of BIM implementation

Barrier	Reference
Lack of national and international standards regarding BIM	(Bernstein and Pittman 2004; BCIS 2011; Liu et al. 2015)
High cost of BIM software's	(Kiani and Ghomi 2013; Liu et al. 2015)
Lack of skilled personnel	(Wu and Issa 2013a)
Organization culture	(Arayici, Coates, et al. 2011b)
Legal issues	(Azhar 2011)
Lack of training programs	(Wu and Issa 2013a; Chan 2014)
Lack of education	(Chan 2014)
Lack of government's lead/laws	(BCIS 2011)
Lack of client demand	(BCIS 2011)
Suspicion over BIM software workability with other software	(BCIS 2011)
Lack of ICT knowledge base	(Alreshidi, Mourshed, and Rezgui 2014)
Suspicion over BIM data ownership	(BCIS 2011)

High cost of implementation	(Chan 2014)
Professional insurance policies	(Chan 2014)
Lack of suitable engineering contract forms for BIM	(Azhar 2011)

2.7 CSFs of BIM Implementation

The concept of BIM development has become a recognized concept of the standards required for BIM to be considered, by making the implementation process as next steps in taking the AEC industry from the traditional painting to the computer and in nearly future to the next level.

Furthermore, quite recently, considerable attention has been paid to considering what also can effect on adopting process. The critical success factors and barriers which play an important role if they are properly invested in the implementation process through the BIM maturity different levels.

To do so, several studies have been conducting the BIM implementation, and analysis CSF's regarding this process (Arayici et al. 2009; Gerçek et al. 2017; Ezcan et al. 2013; Yilmaz, Akcamete-Gungor, and Demirors 2017).

The major problem with this kind of applications fails in providing a complete analysis of CSFs based on project and organizational characteristics; they also do not consider the observation of non-adopters of BIM according to a previous study conducted by (Ozorhon and Karahan 2016). There is also a gap in the literature in terms of BIM studies in developing countries.

A full understanding of CSFs is important to generate suitable BIM implementation, specifically in nations where BIM is novel to the AEC industry. However, in order to determine the effects of CSFs, several research papers have mentioned and classified all possible CSFs under different circumstances. Table 2 illustrates the CSFs of BIM implementation based on previous literatures.

Table 2. Critical Success Factors (CSFs).

Factor No.	CSF	Reference
F1	Structural analysis and design	(Arayici, Coates, et al. 2011b; Hartmann et al. 2012)
F2	Ensuring effective communication between project stakeholders	(Acharya, Lee, and Im 2006)
F3	Collaboration between design, construction, engineering and facility management stakeholders	(Chong, Lee, and Wang 2017; Wu and Issa 2014)
F4	Providing BIM models for shop drawings	(Eastman, Teicholz, et al. 2011; Arayici, Coates, et al. 2011b; Succar 2009a)
F5	Providing better implementation of lean construction and integrated project delivery	(Arayici, Coates, et al. 2011b; Eastman, Teicholz, et al. 2011)
F6	4D construction scheduling and sequencing	(Eastman, Teicholz, et al. 2011; Sebastian and van Berlo 2010; Succar 2009a)
F7	5D cost estimation and scheduling	(Government 2003)
F8	Coordination and planning of construction works	(Eastman, Teicholz, et al. 2011; Arayici, Coates, et al. 2011b)
F9	Accuracy and reliability of data	(Barlish and Sullivan 2012)
F10	Photorealistic rendering for marketing purposes	(Hartmann et al. 2012)
F11	Remodelling and renovation	(Azhar 2011)
F12	Effective leadership	(Won et al. 2013; Ozorhon and Karahan 2016)

F13	Enhancing exchange of information and knowledge management	(Pektaş and Pultar 2006; Ozkaya and Akin 2006)
F14	Governmental schemes	(Arayici et al. 2009; Succar 2009b)
F15	Qualified staff	(Succar, Sher, and Williams 2013)
F16	Financial resources	(Construction 2014; Succar, Sher, and Williams 2013)
F17	Organizational cultural	(Arayici and Coates 2012; Khosrowshahi and Arayici 2012)
F18	Project duration and cost	(Jung and Joo 2011; Arayici, Coates, et al. 2011b)
F19	Project performance and quality	(Suermann and Issa 2009)
F20	Integrating project documentation	(Olatunji and Sher 2010)
F21	Client requirements	(Ozorhon and Karahan 2016)
F22	Improved operations and maintenance	(Azhar 2011; Eastman, Eastman, et al. 2011)

However, researches published worldwide have released that consulting sector is highly important (Gu et al. 2007; Isikdag et al. 2009; Suermann and Issa 2009; Khosrowshahi and Arayici 2012). However, a previous paper conducted by (Isikdag et al. 2009) evaluated that consulting firms must hold the state of art of the AEC industry in the field of Information and Communication Technology (ICT) adoption from a vital point of view along with the key part of ICT inside within the AEC firms.

So far leadership is still the main key solution for BIM implementation process (Ozorhon 2012), and this does not only consider AEC organization leaders or mangers, which they have always been considered responsible for every single complication or obstacle facing the industry. However, what about the role of the government and the academic sector regarding BIM implementation.

Therefore, in a nation like Turkey the most recent research paper regarding the CSFs of BIM implementation was conducted by (Ozorhon and Karahan 2016), this paper provides a clear understanding of the CSFs and quantified their effects on BIM implementation in Turkey in terms of the AEC. However, this research paper was conducted without addressing the academic sector.

2.8 The Academic Role in BIM Implementation

Several publications came to the view in the past years documenting that the partnership between the AEC industry and academic sector has long been valued (Tener 1996; Bakens 1997; Becerik-Gerber, Gerber, and Ku 2011; Clevenger and Rush 2011).

Also, The implicit supply demand relationship between academic institutions and the AEC industry has been more depending on students' qualifications who will become the future employees (Bilbo et al. 2000) and their technical preparation (Barison and Santos 2010), specifically in the BIM case.

The problem with this, the academic institutions and the industry professionals together have known the significant distance between students' qualifications and employees expectation from managers in the AEC industry, provoked by the expected insufficiency in BIM professionals abilities for the next 20 years (Smith and Tardif 2009).

Researchers have been criticizing colleges for their lack of procedures and capabilities to successfully teach and use BIM into courses or certificates (Sabongi and Arch 2009; Clevenger et al. 2010), also several academic programs are striving to meet construction industry and student prospects (Clevenger and Rush 2011).

In this case, several publications consider training programs as a critical success factor (Suermann and Issa 2009; Jung and Joo 2011; Arayici and Coates 2012; Succar, Sher, and Williams 2013) with knowledge transferring (Eastman, Eastman, et al. 2011; Azhar 2011).

Recently, scholars are still searching the best strategy for BIM education which has been considered as a key solution to accelerate the BIM learning trend so the construction firms can hire well educated BIM alumni (Construction 2008). However, the effective inclusion of BIM into civil or architecture programs has turned into both an academically and practically demanding for well preparing future employees for the AEC industry (Young et al. 2009; Crumpton et al. 2008).

Nevertheless, a few literatures discussed the impact of BIM education on colleges alumni career development, and how recruiting programs in organizations could affect colleges BIM curriculum (Wu and Issa 2013b). Taking into account that both academic and industry stakeholder care about enhancing students qualifications and accelerate their career development trend which seems interested in both sides (Wu and Issa 2013b).

Therefore, the relationship between both academic and industry sector is more important than it seems, and what should be done is removing the restriction between the two sectors. To do so, a unique and new approach to Turkish AEC industry has been considered, called Knowledge Transfer Partnership (KTP) program.

2.9 KTP for BIM Implementation

> *"KTP is a UK-wide program that has been helping businesses for the past 40 years to improve their competitiveness and productivity through the better use of knowledge, technology and skills that reside within the UK Knowledge Base"* (UK 2003).

Therefore, it is proceeded by linking business organizations with the academic sector and research institutions, the KTP helps business organizations by providing a new skills and academic knowledge to bring a specific strategic innovation project through a knowledge-based partnership (Government 2003; Coates, Arayici, and Koskela 2010; Coates et al. 2010; Arayici, Coates, et al. 2011a; Arayici, Egbu, and Coates 2012; Yousefzadeh et al. 2015; Kassem et al. 2016; Rodriguez et al. 2017).

The KTP program considers as the most interesting approach to establishing an ideal partnership between the academic institutions and the AEC companies, this UK government-wide program funded by Innovate UK, helping business firms to improve competitiveness, performance, and efficiency.

> *"The academic or research organization partner will help to recruit a suitable graduate, known as an Associate. They will act as the employer of the graduate, who then works at the company for the duration"* (Government 2003).

Chapter 3

RESEARCH METHODOLOGY AND PLAN

3.1 Introduction

This paper focus on finding out the CSFs that help implementing BIM in the AEC industry in Turkey from an academic perspective. A particular attention is paid to public projects in order to get a high quality and accurate data.

The questionnaire was created in a way to collect data from professors majoring in construction management in the academic sector, the questionnaire designed based on the CSFs related to BIM implementation which were collected from previous works published worldwide, take into account the most recent researches concerning the Turkish AEC industry.

3.2 The Questionnaire

The questionnaire survey created by using Google Forms and sent by e-mail to the academic professors majoring in construction management in all institutions around Turkey. The questionnaire consists of two parts. The first part created to determine the required CSFs for A successful BIM implementation in the AEC industry in Turkey.

The second part of the questionnaire was designed to find out and create a comprehensive background about the potentials and capabilities of the academic institutions regarding applying KTP program for BIM implementation in Turkey.

The questionnaire was sent to 72 faculty members of the construction management department who are associated with the AEC industry, the ICT and would provide critical data on BIM technology in both AEC industry and academic institutions in Turkey. The 72-faculty members were selected based on their research and academic background. Also, to make data more reliable it was mentioned in the questionnaire that respondents should either have experience in BIM technology or have been teaching it in any different mechanism.

The total number of questions in the questionnaire was 12. A questionnaire sample is shown in Appendix A. The first part seeks to classify the CSFs of BIM implementation in Turkey based on their level of importance from an academic point of view. The respondents were asked to determine the importance level for all the CSFs listed by using Likert scale (from 1: very low to 5: very high) to determine the most important items between a list of 22 CSFs which have been mentioned in table 2.

The results in this section have been analyzed by using simple statistical analysis to sort the CSFs from the highest level of importance to the lowest one's depending on their relative mean which has been calculated for each factor based on the average importance degree.

The questionnaire was prepared to introduce an efficient approach for BIM implementation in the AEC industry through determining its critical success factors. Finally, by using these results and those conducted in a research published by (Ozorhon and Karahan 2016) a common concept map between AEC firms and the academic institution has been established to build a roadmap for BIM implementation based on a partnership between both sectors.

3.3 Data Collection and Analysis

Out Of the study population, a total number of 33 out of 72 professors finished and sent back the questionnaire, resulting a response rate of 45.8%. The finding of the questionnaire is presented by bar charts, pie charts, maps, and tables to make it very clear and simple. Referring to the first section of the questionnaire, the results analyzed by using simple statistical method. The Likert scale results distributed from 1 (very low) to 5 very high).

3.3.1 Mean and Standard Deviation

The mean (μ) is the average of data set. The formula of mean score is:

$$\mu = \frac{(1*N1)+(2*N2)+(3*N3)+(4*N4)+(5*N5)}{N1+N2+N3+N4+N5}$$

μ: The mean, N is number of respondents.

The Standard Deviation (σ) is used to measure the dispersion of a data set relative to its mean. Lower standard deviation means that results are too close the mean, while higher standard deviation means that results was distributed in wide range. The formula of the standard deviation is:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}(xi-\mu)^2}{N}}$$

Where σ is the standard deviation, N is number of respondent, x is the results and μ is the mean score.

3.3.2 Relative Mean

The relative mean calculated in order to find out the importance level for the CSFs of BIM implementation. The formula of the relative mean is:

$$Realtive\ Mean = \frac{Mean}{5}$$

3.4 Validation of the Questionnaire

When the outcome measure cannot be measured directly or difficult to observe directly such as the CSFs of BIM implementation, several questionnaire items are conducted to a group of subjects where the relationship between those items are investigated.

Thus, if the relationship between those items in reliability analysis is high, this mean that the scale yields consistent results and therefore the sample obtained from the questionnaire will be reliable sample to be used for further analysis. However, there are four different approaches in reliability analysis (Çokluk, Şekercioğlu, and Büyüköztürk 2010). In this thesis, the split half reliability approach was performed in SPSS where Cronbach's alpha is calculated.

3.4.1 Cronbach's alpha

Cronbach's alpha is evaluated when several responders are available for the items.in this way, variance is calculated for each item and for the sum of scale. In theory, the variance for the sum of scale will be less than the sum of each item's variance only when the items measure the identical variability between responders.

The variance for the sum of scale is equal to the sum of variances of each of the two items minus the covariance where the covariance is the true score variance that is mutual for the two items (Çokluk, Şekercioğlu, and Büyüköztürk 2010).

Alpha is calculated by the following equation:

$$\alpha = \left(\frac{k}{k-1}\right) \times \left(1 - \frac{\sum \mathrm{Si}^2}{S^2 sum}\right)$$

Where S_i^2 is the variance for each k items separately, S^2_{sum} is the variance for the sum of the items.

The results obtained from the coefficient of Cronbach's alpha is between 0 to 1. If there is no true score and items are not correlated across responders, then the coefficient will be 0. If the items all measure the same true score and perfectly reliable, then the coefficient will be 1. In order to say that the sample is reliable, the coefficient of Cronbach's alpha should be 0.7 or higher (Çokluk, Şekercioğlu, and Büyüköztürk 2010).

Chapter 4

RESULTS AND DISCUSSION

4.1 Introduction

To our knowledge, this is the first study to investigate BIM implementation in the Academic sector in Turkey, this study sets out with the aim of assessing the importance of the KTP program in BIM implementation. The originality of our solution lies in the fact that BIM technology would not be implemented in the UK AEC industry without applying the KTP program under governmental support and supervision.

4.2 Respondents' Profile

The questionnaire was sent to the academic professors majoring in construction management around Turkey. The professors were classified based on their academic classification as shown in figure 8 where 29.7% of them are associate professors, 33.3% are assistant professors and 37% of them are full professors.

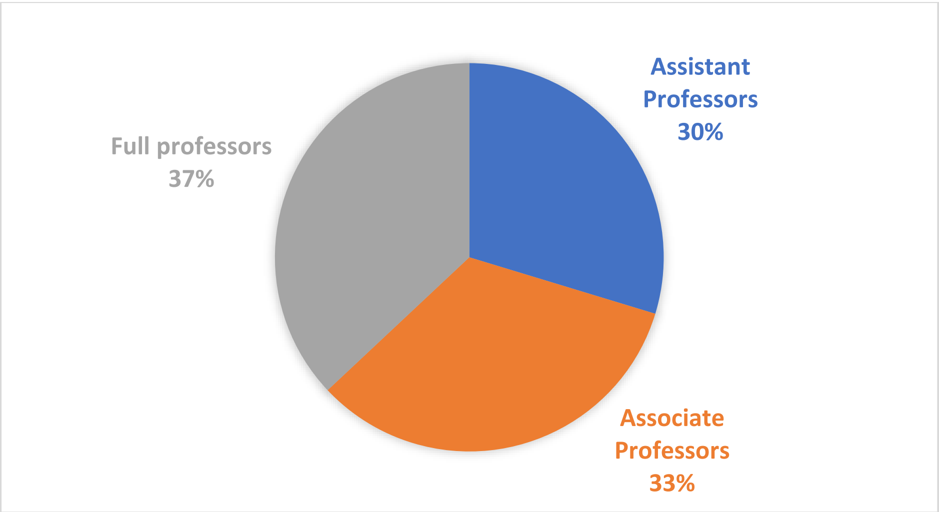

Figure 8. Professors classification

4.2.1 Description of Academic Institutions/Universities

The professors are working in universities distributed all around turkey as shown in figure 9. The total number of universities are 25, where some of these universities are private and the others are public universities as shown in figure 10. The purpose of this classification to highlight on the role played by the government in the academic sector.

Figure 9. Universities distribution in Turkey

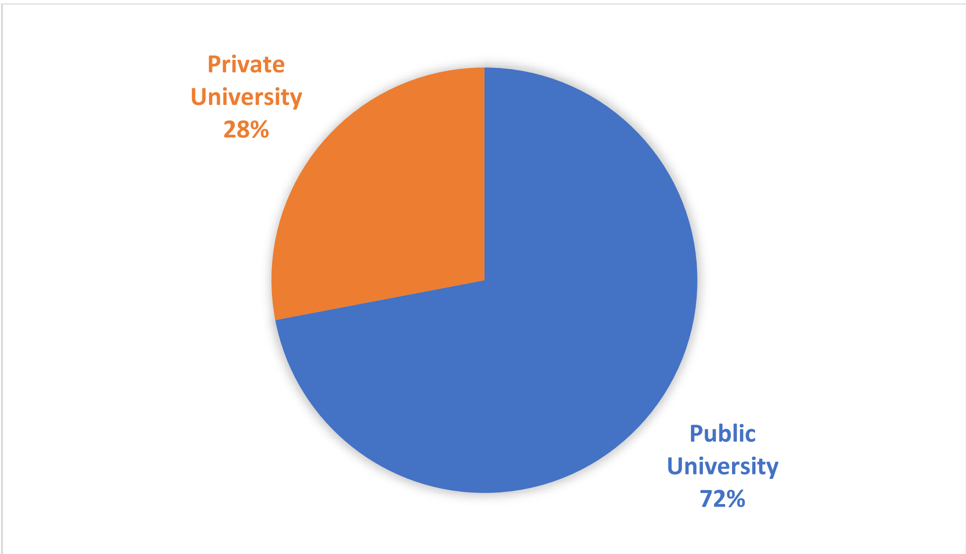

Figure 10. Type of universities

4.3 CSFs of BIM Implementation

4.3.1 Reliability Analysis

The Likert scale questions are further investigated statistically. In total, 22 questions are in Likert scale. Each question is represented as an item, so initially 22 items are taken into consideration.

Firstly, sample must be validated before moving on for further analysis. To test the adequacy of the sample, reliability analysis is performed on the data obtained from the questionnaire. In this research, the split half reliability approach is performed in SPSS where Cronbach's alpha is calculated.

The reliability test was done with SPSS software, the test has been done on 22 Likert scale questions which represent the CSFs of BIM. The result of the test show that all the 33 respondents are valid and no need for excluding as shown in table 3. As shown in table 4, the Cronbach's alpha value is 0.933 which is above 0.7, meaning that it is reliable and excellent in the internal consistency scale (Cortina 1993).

Table 3. Case processing summary

		N	%
Cases	Valid	33	100.0
	Excluded [a]	0	.0
	Total	33	100.0
a. Listwise deletion based on all variables in the procedure.			

Table 4. Reliability result

Reliability Statistics	
Cronbach's Alpha	Number of items
0.933	22

The results shown in table 5 shows that the corrected-item-total-correlation values are all above 0.35, so no need to eliminate any of the variables. According to these results, the affecting measurements are identified as can be seen in table 6.

Table 5. Item-total statistics

Variables	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
V1	81.0526	131.719	0.867	0.926
V2	80.5789	143.924	0.367	0.934
V3	80.4737	144.152	0.396	0.935
V4	81.4737	144.152	0.396	0.935
V5	80.6842	132.450	0.850	0.926
V6	80.8947	141.211	0.396	0.937
V7	80.8947	133.655	0.711	0.929
V8	80.7895	140.953	0.387	0.934
V9	80.8947	134.655	0.875	0.927
V10	81.3158	129.673	0.859	0.926
V11	81.4211	131.591	0.894	0.926
V12	80.8947	139.322	0.433	0.933
V13	80.6842	132.450	0.850	0.926
V14	80.6842	130.561	0.691	0.929
V15	80.6842	131.450	0.731	0.928
V16	81.8421	131.140	0.808	0.927
V17	80.5789	134.702	0.836	0.927
V18	81.6316	136.023	0.515	0.932
V19	81.4211	134.702	0.889	0.927
V20	81.0000	130.111	0.905	0.925
V21	80.3684	165.579	0.925	0.950
V22	81.4211	131.591	0.894	0.926

4.3.2 CSFs with Mean and Standard Deviation

Table 7 shows the CSFs with their mean and standard deviation.

Table 7. The CSFs with mean and Standard deviation

Factor No.	CSF	Mean	Standard deviation
F1	Structural analysis and design	3.789	0.83
F2	Ensuring effective communication between project stakeholders	4.263	0.64
F3	Collaboration between design, construction, engineering and facility management stakeholders	4.368	0.67
F4	Providing BIM models for shop drawings	3.368	0.67
F5	Providing better implementation of lean construction and integrated project delivery	4.158	0.81
F6	4D construction scheduling and sequencing	3.947	1.00
F7	5D cost estimation and scheduling	3.947	0.89
F8	Coordination and planning of construction works	4.053	0.83
F9	Accuracy and reliability of data	3.947	0.69
F10	Photorealistic rendering for marketing purposes	3.526	0.94
F11	Remodelling and renovation	3.421	0.82
F12	Effective leadership	3.947	0.89
F13	Enhancing exchange of information and knowledge management	4.158	0.81
F14	Governmental schemes	4.158	1.09
F15	Qualified staff	4.158	0.99
F16	Financial resources	3.000	0.92
F17	Organizational cultural	4.263	0.71
F18	Project duration and cost	3.211	1.00
F19	Project performance and quality	3.421	0.67
F20	Integrating project documentation	3.842	0.87
F21	Client requirements	4.474	0.68
F22	Improved operations and maintenance	3.421	0.82

4.3.3 CSFs with Relative Mean

As shown in table 8, the CSFs illustrated based on their relative mean which represent the importance value of each CSF.

Table 8. The CSFs based on their importance level

Factor No.	CSF	Mean	Relative Mean
F21	Client requirements	4.474	0.89
F3	Collaboration between design, construction, engineering and facility management stakeholders	4.368	0.87
F12	Effective leadership	4.313	0.86
F2	Ensuring effective communication between project stakeholders	4.263	0.85
F17	Organizational cultural	4.263	0.85
F14	Governmental schemes	4.158	0.83
F13	Enhancing exchange of information and knowledge management	4.158	0.83
F5	Providing better implementation of lean construction and integrated project delivery	4.158	0.83
F15	Qualified staff	4.158	0.83
F8	Coordination and planning of construction works	4.053	0.81
F6	4D construction scheduling and sequencing	3.947	0.79
F7	5D cost estimation and scheduling	3.947	0.79
F9	Accuracy and reliability of data	3.947	0.79
F20	Integrating project documentation	3.842	0.77
F1	Structural analysis and design	3.789	0.76
F10	Photorealistic rendering for marketing purposes	3.526	0.71
F11	Remodelling and renovation	3.421	0.68
F19	Project performance and quality	3.421	0.68
F22	Improved operations and maintenance	3.421	0.68
F4	Providing BIM models for shop drawings	3.368	0.67
F18	Project duration and cost	3.211	0.64
F16	Financial resources	3.000	0.60

The most interesting findings were that client requirements are the most important CSF, and since this thesis is focusing on public projects, it means that client requirements depend on the government itself and its future goals which represents the governmental scheme factor.

Although, these two factors have been supported and found highly important in a previous study conducted by (Eadie et al. 2013), which means that the government is considered as the main contributor to BIM implementation.

Besides that, as shown in table 4, the remaining CSFs factors whose mean value equal or above 4 such as:

- Collaboration between design.
- Construction, engineering and facility management stakeholders.
- Effective leadership.
- Organizational cultural.
- Enhancing exchange of information and knowledge management.
- Qualified staff.
- Coordination and planning of construction works.
- Enhancing exchange of information and knowledge management.

Play a primary role in supporting BIM implementation through KTP program. While the remaining factors, whose mean value less than 4 play a secondary role to support this approach.

4.4 BIM and the Government Rule

Consequently, the obtained results show that 66.7 % of respondents think that the Turkish government should establish new rules and policies to force construction firms to use BIM on public projects, and 33.3% of them either they are not sure or disagreed as shown in figure 11.

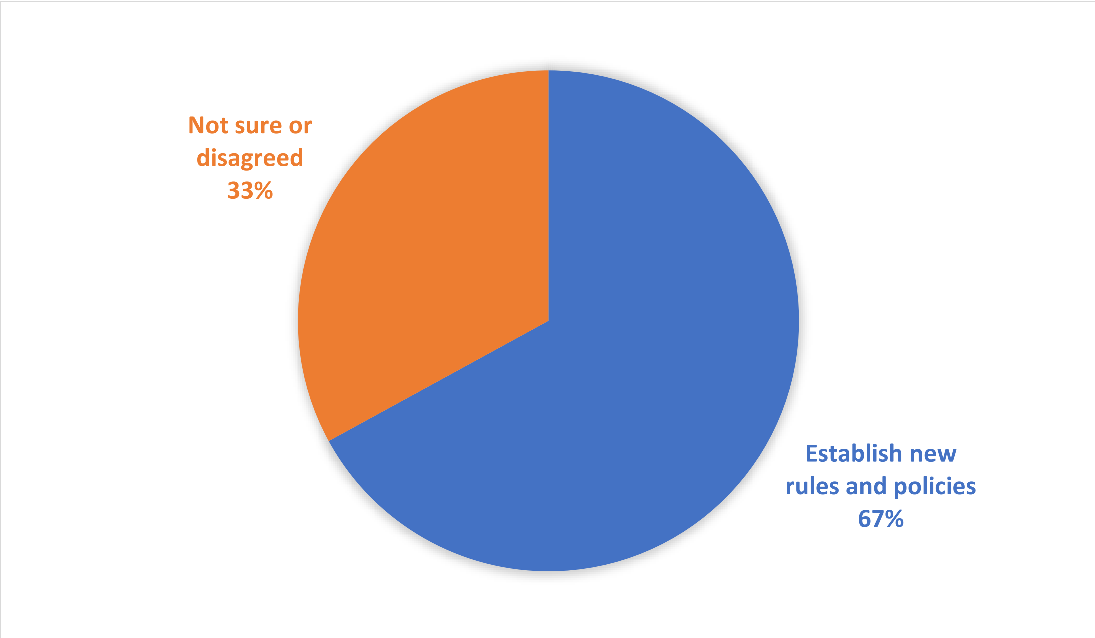

Figure 11. Respondent opinions about Government rules regarding BIM.

Furthermore, those who agree regarding the previous point, 66.7% of them said that the new rules and policies must be applied in heavy construction and highway projects, while 33.3% of them said it must be applied in industrial construction projects, residential construction projects, and specialized industrial construction projects as shown in figure 12.

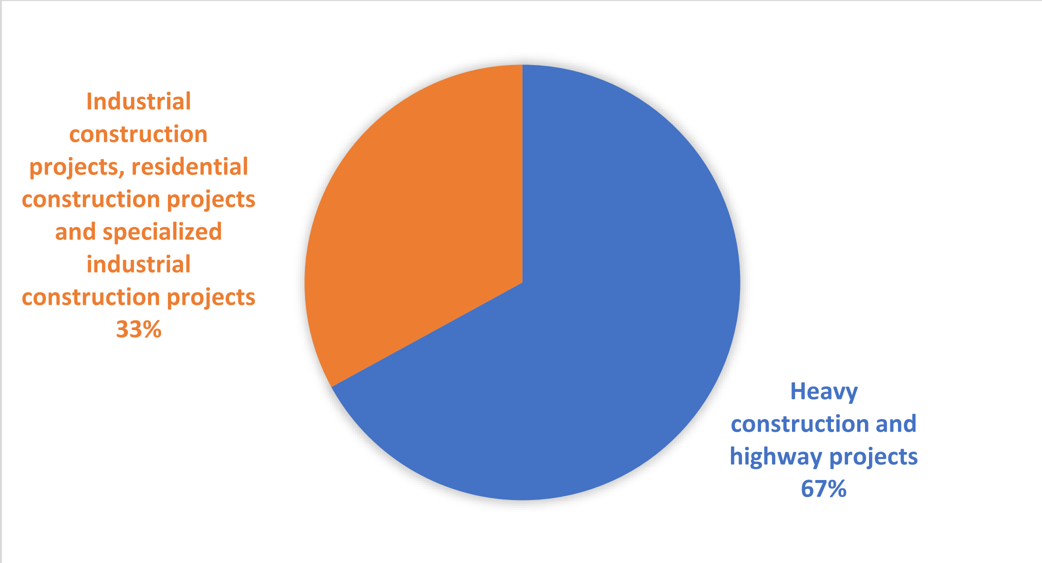

Figure 12. Type of public project to implement.

4.5 Results Evaluation with (Ozorhon and Karahan 2016) Study

In reviewing the literature, no data was found on the association between the AEC industry and the academic sector in Turkey. To do so, it is encouraging to evaluate these results in table 7 which was conducted from an academic point of view with those conducted by (Ozorhon and Karahan 2016) as shown in figure 14, which was proposed to find out the CSFs of BIM implementation in the AEC industry in Turkey from professional aspect.

The point behind this evaluation is finding a common point of views between the academic sector and the AEC industry to create a roadmap for KTP program implementation in Turkey which will help accelerating the process of BIM implementation, the KTP program has three main partners: The government, the academic sector, and the industrial sector.

The data of (Ozorhon and Karahan 2016) study was collected from Turkish companies to reflect their experiences and perceptions regarding BIM. However, this study was chosen because it is the only and the first published study was conducted using the proposed CSFs in the AEC industry in Turkey. Also, making the evaluation on data collected from a different country might produce different results and might be not reliable. Figure 13 shows the importance level of CSFs conducted on this thesis. While figure 14 shows those conducted on (Ozorhon and Karahan 2016) study.

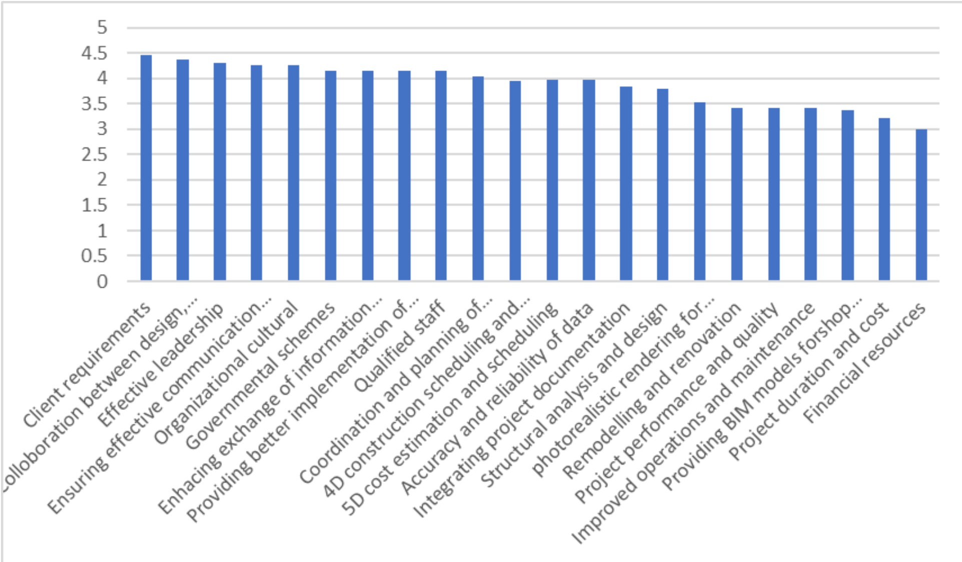

Figure 13. Importance level of CSFs on this thesis.

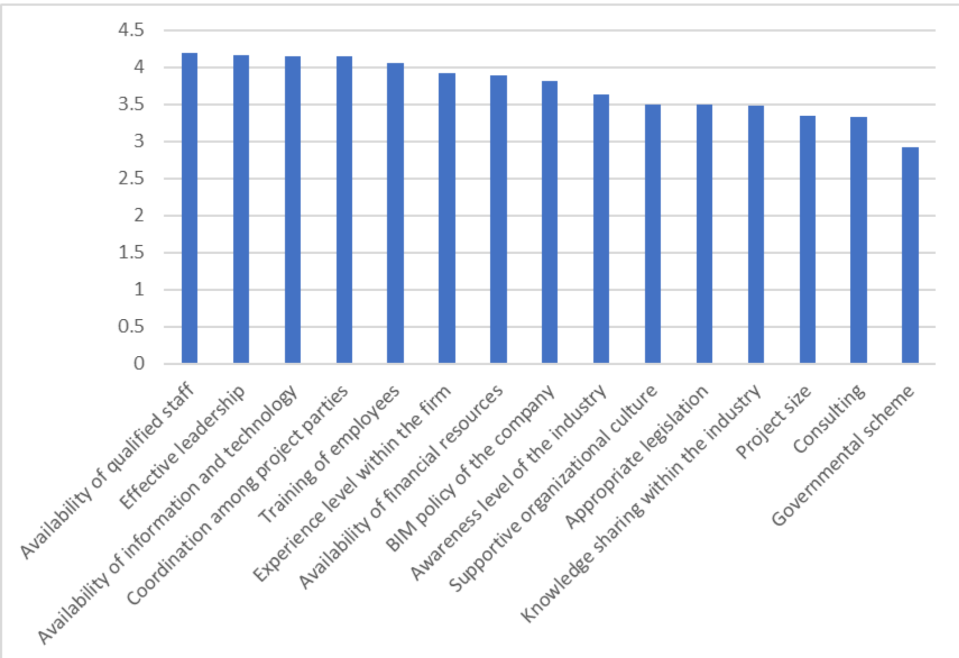

Figure 14. Importance level of CSFs conducting by (Ozorhon and Karahan 2016).

The results described in the previous figure shows the importance level of the CSFs based on their relative mean values. However, the availability of qualified staff, effective leadership, availability of information and technology, coordination among project parties, and training of employees are the most important factors for the professional managers in the AEC industry.

While governmental scheme, consulting, project size, knowledge sharing within the industry, and appropriate legislation are less important. However, to evaluate these findings with the current study, the same factors used in both studies have been compared based on their importance level as shown in figure 15.

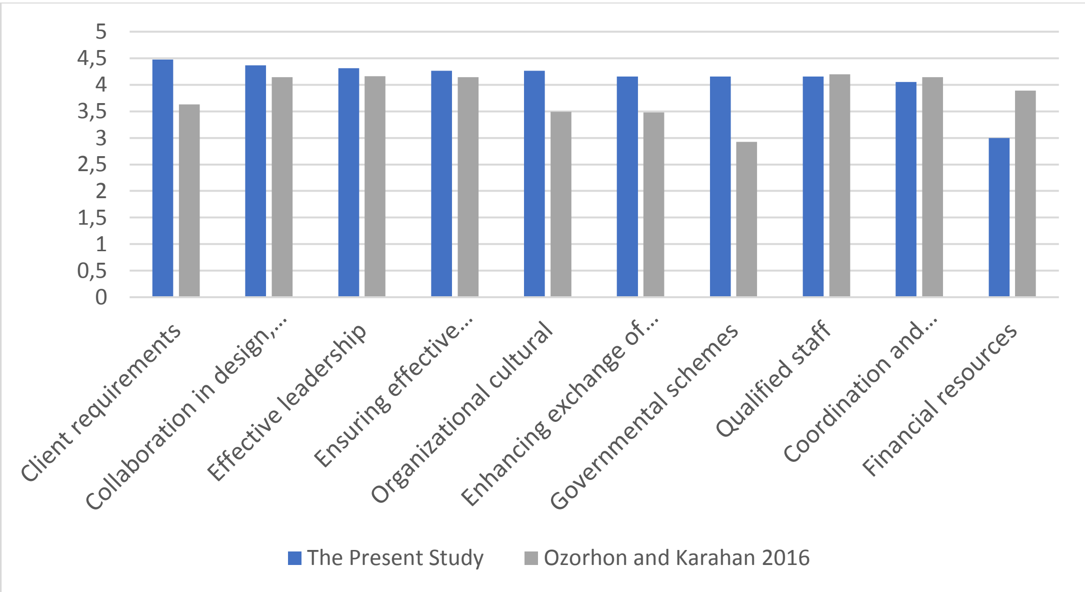

Figure 15. The common CSFs between this thesis and (Ozorhon and Karahan 2016) study.

As shown in figure 15 there is 10 factors is used on both studies. The observed difference between them was not significant and they are partially consistent which means that the AEC firms and the academic sector agree on several common points regarding BIM implementation.

Moreover, figure 15 shows that there is a significant difference between the academic professors and the AEC industry professionals’ opinions about the importance of the financial resources need, the governmental scheme and the client requirements. Since this research is focusing on BIM implementation in the public projects, the previous three factors can be reformulated to become:

- Government funds
- Government scheme.
- Government requirements for public projects.

From this point of view, with the aim of assessing the importance of government role in the BIM implementation process this study sets out to develop a new version of the UK government program (Knowledge Transfer Partnership) and apply it on both Turkish universities and AEC industry firms.

Furthermore, this study findings as shown in figure 15 support the fact that the academic professors are fully aware of the needs of the AEC industry. Besides that, unlike firms in the AEC industry, professors in the academic sector fully understand that the dilemma is not in the financial resources.

However, its related to the mechanism followed by the government in the labor market, and government schemes for developing the AEC industry, as well as the organizational culture of AEC firms and their commitment for sharing professional experiences with other sectors and firms to achieve the desired benefit between all stakeholders.

There are several possible explanations for this implication, but it might be related to the unilateral competition pursued by some firms, as well as their believes that government should not be the primary contributor in BIM implementation process (Ozorhon and Karahan 2016).

Likewise, some firms in the AEC industry has no intentions to change their organizational culture by adopting new things such as facilities management and creating a strong organizational structure which helps in establishing a better senior management that lead to having an effective leadership.

4.6 BIM Implementation in the Academic Sector

Currently, BIM technology is a cornerstone of the construction sector and highly recognized by the AEC industry since it has become a major requirement for many government projects around the world.

However, many challenges and obstacles stand in the way of implementing this technology (Khosrowshahi and Arayici 2012). By using the maturity level of BIM scale, the second section of the questionnaire has shown that 40% of respondents implemented BIM technology at level 1 in their academic department, while 40% of respondents implemented BIM at level 2, and the remaining 20% of respondents implemented BIM at level 0 as shown in figure 16.

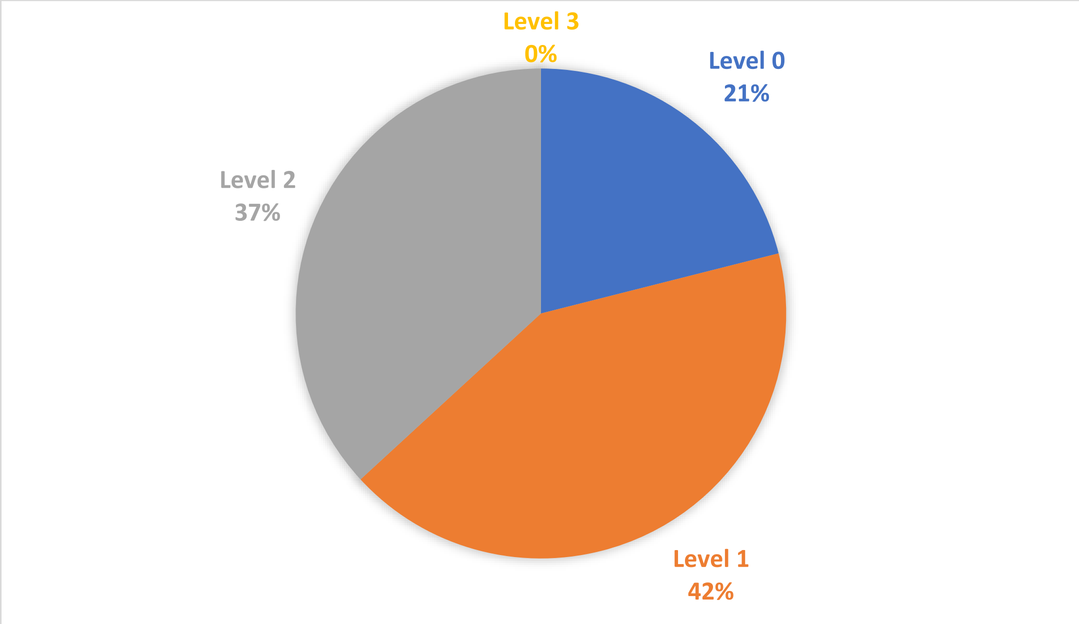

Figure 16. Implementation level of BIM

Moreover, the results indicated that almost 66.7% of respondents have been teaching BIM concepts and going on its details in the undergraduate courses, graduate courses, and the academic research. while 33.3% of respondents use training or laboratory courses to practice using BIM software.

4.7 KTP in Turkey

Referring to results obtained about the KTP program, figure 17 shows that only 16.7% of respondents have a clear and full background in regarding the KTP program, while 33.2% have just a few concepts and simple details, and the last 50.1% has just a very little information in this regard.

However, 50.1% of respondents are not sure neither the universities nor the academic institutions have the capability to establish a partnership with business firms in Turkey as a part of the KTP program goals or not. While 33.2% of respondent believe that it can be possible and there is a good chance to establish such a partnership.

On the other hand, 16.7% of respondents believe that there is no chance to establish the KTP program.

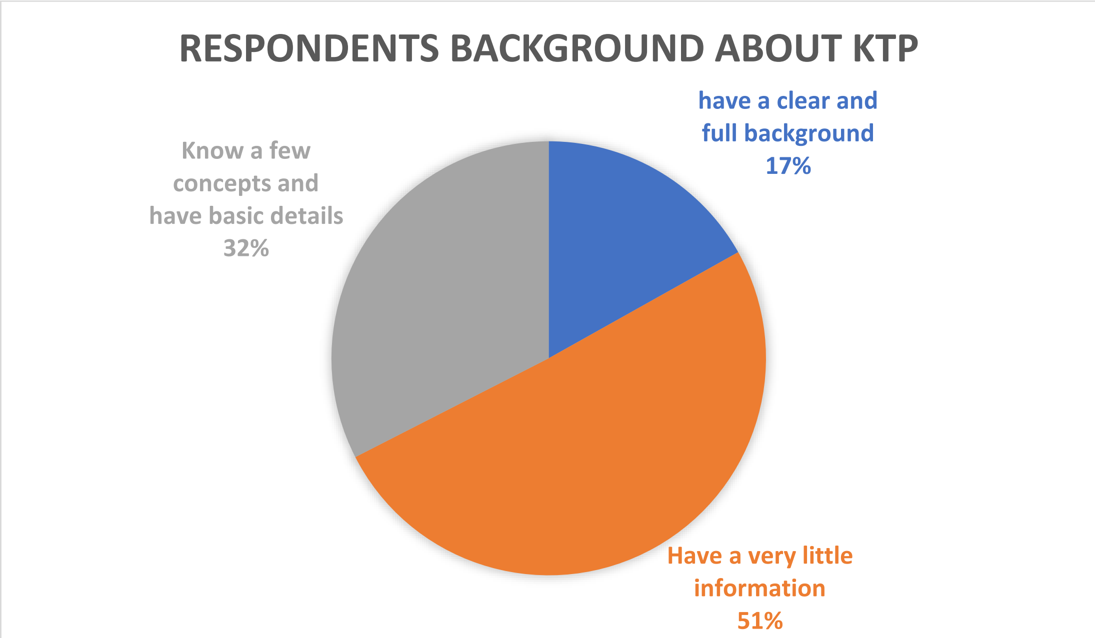

Figure 17. Respondents background about KTP

Finally, almost 75% of respondents believe that making the KTP program running well should be started by letting postgraduate students to be part of this program throughout giving them the opportunity to join a full paid position in a business firms based on their academic major and that should be considered as a degree requirement.

Furthermore, respondents suggested that construction management conferences, workshops, training programs and internships are helpful to bring together the industry professionals and academic professors and students to discuss their opinions and past experiences and create new innovations (Suermann and Issa 2009; Succar, Sher, and Williams 2013; Ozorhon and Karahan 2016).

In fact, this finding has important implications for developing the academic programs and its curriculums regarding Civil Engineering and Architecture departments in order to provide qualified employees in the future.

This combination of findings gives a few back for the conceptual introduce that the KTP program will help to build an integrated relationship between the AEC industry and the academic institutions based on sharing information and experience (Arayici, Coates, Koskela, and Kagioglou 2011).

As many of respondents said, *"we have the capability to provide a qualified staff and offer consultancy services to the AEC industry firms and get BIM knowledge in return"*.

Chapter 5

CONCEPTUAL FRAMEWORK OF KTP PROGRAM FOR BIM IMPLEMENTATION IN TURKEY

5.1 Introduction

In this chapter, a conceptual framework graph is provided by the author and developed according to the results and literature reviews provided in previous researches.

The conceptual framework illustrates a common concepts map between the AEC industry, the Academic institutions and the government as shown in figure 18 and consists of partners, factors, partners' roles, knowledge needed to conduct the KTP, shared benefits and a five-step process of BIM implementation.

5.2 Partners

The main partners involve in the KTP program are the government, the AEC firms and the academic institutions. Each one of those partners has their own role in BIM implementation, those roles are all integrated within the KTP program.

5.3 CSFs

The implementation process of BIM technology throughout the KTP program are totally based on the CSFs that had been mentioned before in table 7.

5.4 Partners' Roles

Starting by the academic sector, where the academic institutions are responsible for develop the students' skills throughout providing courses, research opportunities, software training, and workshops. This will lead to export qualified graduates to the business market and the graduate students will be familiar with BIM technology.

However, to make this happen the academic sector have to collaborate with the AEC industry to gain knowledge about the industry needs and develop the courses outlines to be proportional with the help provided by AEC professionals.

Moreover, the AEC firms are responsible to keep their employees updated with the new technology developments and providing a training programs to increase the technological skill of their staffs. The training programs could be established with both academic institutions training centers and software's creators such as: Autodesk, Graph iSOFT, Tekla.

The government is the main contributor of BIM implementation, and it is the main player in the implementation process of BIM. The government is also responsible for adopting a short-term and long-term strategies to develop the AEC industry and the academic sector. Also, it is also responsible for funding the KTP program to make it successfully proceed. Figure 18 illustrates the conceptual framework for BIM implementation.

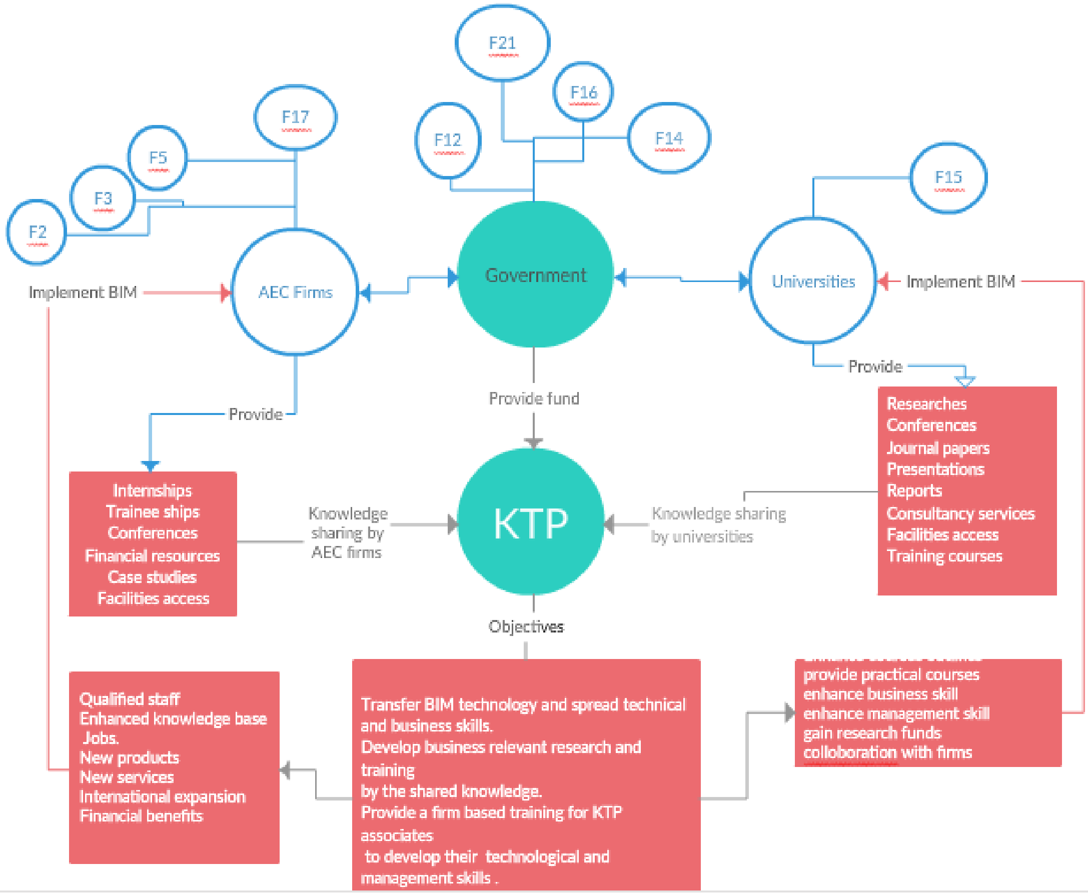

Figure 18. Conceptual framework of KTP for BIM implementation.

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The BIM implementation process has already started in Turkey as some of the government mega-projects have already adopted BIM technology and have become a key learning hub for all AEC firms in Turkey. Unfortunately, a few numbers of firms are implemented BIM technology and the reason behind that was the existence of many challenges, the lack of information resources, the need for a clear vision, and finding the right approach.

6.2 Conclusion

In this thesis, the aim is to assess a new approach for BIM implementation called KTP, this approach is a UK government program focusing on creating a partnership between the academic sector and the industrial sector to share knowledge and experience.

This thesis focuses on determining the most important CSFs regarding BIM implementation in public projects from an academic point of view, determining the main contributor CSF in implementation process, and creating a common concept map between the AEC firms and the academic institution to have a clear vision about what both sectors can do regarding BIM implementation.

Based on the findings of the analysed results, the client requirements, the collaboration between design, construction, engineering and facility management stakeholders, effective leadership, ensuring effective communication between project stakeholders, organizational cultural and governmental schemes considered as the highest important CSFs and the main contributor in BIM implementation process as shown in table 9.

Table 9. Top CSFs for BIM implementation

Critical Success Factors (CSFs)	Relative Mean
Client requirements	0.89
Collaboration between design, construction, engineering and facility management stakeholders	0.87
Effective leadership	0.86
Ensuring effective communication between project stakeholders	0.85
Organizational cultural	0.85
Governmental schemes	0.83

While remodelling and renovation, project performance and quality, improved operations and maintenance, providing BIM models for shop drawings, project duration and cost, and financial resources considered as the lowest important CSFs regarding implementation process of BIM.

One of the most critical findings of this study is ten CSFs between the present study and the study conducted by (Ozorhon and Karahan 2016) were found in common, and five CSFs of them are partially consistent on their importance level, which show that the AEC industry and the academic sector have a common points of views regarding the factors that take part and play important role in BIM implementation.

While the other five CSFs have significant differences on their importance level, which mean that there is a disagreement between the two sectors at some points of views. For example, from an academic perspective, both client requirements and government schemes factors are more important than what considered in the AEC industry perspective.

Furthermore, the second major findings of this thesis consider that the implementation process has been weighted in level-1 and level-2 in the academic institutions. An implication of this finding is the capability that the academic institutions have and the role they can play if the government supports them to participate in BIM implementation process in the AEC industry throughout the KTP program.

6.3 Recommendations

The findings of this study can be investing to make the first step and being valuable for the Turkish government and the AEC industry firms to create a valuable partnership with the academic institutions around Turkey aims for sharing information and experience. Thus, increasing the opportunity to provide the market with qualified alumni and skilled workers.

The KTP program should be funded by both the government and the AEC industry firms. The business firms should take into consideration that the benefits of KTP program will appear in a long-term period, and they should first prepare a five-year strategic plan in cooperation with the government and the academic institutions and should word and develop their organizational culture and structure to provide a better BIM implementation.

It is recommended for the Turkish government, the AEC firms and the academic institutes to work together in order to reduce BIM implementation costs, create a five-year strategy plan to implement BIM in the AEC industry, and develop BIM education.

With cooperation and investing the identified CSFs, BIM will help the AEC industry to grow fast.

6.4 Future Research

Further work is required to establish the KTP program and additional research on this matter should be conduct before establishing the partnership between the academic sector and the AEC industry firms. Moreover, several questions remain unanswered at present. To do so, this paper will be extended in the future by preparing a special case study about one of the current largest public projects in Turkey.

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APPENDIX

Appendix A: Sample Questionnaire

Section 1 CSFs of BIM implementation

Questionnaire Survey - Critical Success Factors of BIM implementation in AEC industry in Turkey

"BIM is an increasingly important technology in the AEC industry. With BIM technology, an accurate virtual model of a project is digitally designed. This model can be used for planning, design, construction, and operation of the facility. It helps AEC industry stakeholders have a clear vision of what is to be built in a simulated environment to identify any possible issues. BIM encourages integration of the roles of all stakeholders on a project. Our research paper aims to diagnose Turkey's AEC industry to develop a clear understanding about BIM adoption, provide strategies and recommendations for the AEC industry to implement BIM in Turkey. The questionnaire indicates a numerous CSFs for implementing BIM in the AEC industry which have been collected from different researches published worldwide. a longitudinal analysis of CSFs within existing literature is required to develop a universal set of CSFs for measuring the successful implementation of BIM in Turkey"

Please indicate the importance degree level of below listed factors in the success of BIM implementation in the AEC industry of Turkey:

Variable No.	Factors	Very Low 1	Low 2	Medium 3	High 4	Very High 5
V1	Structural analysis and design					
V2	Ensuring effective communication among project participants					
V3	Collaboration in design, construction, engineering and facility management stakeholders					
V4	Providing BIM models for shop drawings					
V5	Providing better implementation of lean construction and integrated project delivery					
V6	4D construction scheduling and sequencing					
V7	5D cost estimation and scheduling					
V8	Coordination and planning of construction works					
V9	Accuracy and reliability of data					
V10	Photorealistic rendering for marketing purposes					
V11	Remodeling and renovation					
V12	Effective leadership					
V13	Enhancing exchange of information and knowledge management					
V14	Governmental schemes					
V15	Qualified Staff					
V16	Financial Resources					
V17	Organizational or firm Cultural					
V18	Project Duration and Cost					
V19	Project performance and Quality					
V20	Integrating project documentation					
V21	Client requirement					
V22	Improved operations and maintenance					

Section 2 BIM in Academia and KTP

In your university/department, what is the mechanism of BIM teaching you have been currently following?

☐ Undergraduate course ☐ Postgraduate course ☐ Practical courses ☐ Training courses ☐ Graduation projects ☐ Laboratory course ☐ Academic research ☐ Nothing ☐ Others ___________

If your answer is NOTHING to the previous question, you can skip the rest of the questionnaire.

What is the level of BIM you have been teaching in your department?

☐ Level 0 (design based modeling). This level of BIM will utilize 2D or 3D CAD design plan.

☐ Level 1 (object-based modeling). This level of BIM will utilize 2D, 3D CAD and commercial data will be managed by standalone finance and cost management packages with no integration.

☐ Level 2 (model-based collaboration). This level of BIM may utilize 4D construction sequencing and 5D cost information.

☐ Level 3 (network-based integration). This level of BIM will utilize 4D construction sequencing, 5D cost information and 6D project lifecycle management information.

Knowledge Transfer Partnership (KTP)

"The Knowledge Transfer Partnership (KTP) program was established in 2003, it's a part of government-funded program to encourage collaboration between businesses and universities in the United Kingdom (UK). The KTP helps businesses in the UK to innovate and grow by enables a business to bring in new skills and the latest academic thinking to deliver a specific, strategic innovation project through a knowledge-based partnership. The academic or research organization partner will help to recruit a suitable graduate, known as an Associate. They will act as the employer of the graduate, who then works at the company for the duration. The scheme can last between 12 and 36 months, depending on what the project is and the needs of the business"

To which degree you know about Knowledge Transfer Partnership (KTP) program?
(1: Nothing | 5: Very good)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

As an academic, do you think universities and institutions have the capability to establish a partnership with business firms in turkey as a part of the KTP program goals?

☐ Yes | ☐ No | ☐ Not sure

From your point of view, do you think the Turkish government should establish a new rules and policies to force construction firms use BIM on public projects?

☐ Yes | ☐ No | ☐ Not sure

If your answer is YES to the above question, please indicate what type of construction projects for which government should adopting BIM, if your answer is NO you can skip this question.

☐ Residential Housing Construction ☐ Institutional and Commercial Building Construction
☐ Specialized Industrial Construction ☐ Infrastructure and Heavy Construction

Since Postgraduate degree programs do not offer a summer semester for their students, students should be held a full paid position (Internship program) in business firms based on their academic major, and should be considered as a degree requirement. Do you agree or not?

☐ Agree ☐ Do not agree

If your answer is DO NOT AGREE you can skip the next question.

If your answer is AGREE for the previous question, does your department has the capability to consider this option?

☐ Yes, please indicate the success factors ___________
☐ No, please indicate the barriers ___________

Thank you for taking the time to fill out our survey. Your input is greatly appreciated.