EVALUATION SATISFACTION LEVEL OF QUANTITY SURVEYORS IN USING BUILDING INFORMATION MODELLING(BIM) SOFTWARE

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A project report submitted in partial fulfilment of the requirements for the award of Bachelor of Science (Honours) Quantity Surveying

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DECLARATION

I hereby declare that this project report is based on my original work except for citations and quotations which have been duly acknowledged. I also declare that it has not been previously and concurrently submitted for any other degree or award at UTAR or other institutions.

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APPROVAL FOR SUBMISSION

I certify that this project report entitled **"EVALUATION SATISFACTION LEVEL OF QUANTITY SURVEYORS IN USING BUILDING INFORMATION MODELING (BIM) SOFTWARE"** was prepared by **STUDENT'S NAME** has met the required standard for submission in partial fulfilment of the requirements for the award of Bachelor of Science (Honours) Quantity Surveying at Universiti Tunku Abdul Rahman.

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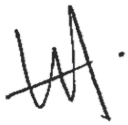
Signature : 

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Besides, I would also like to express my gratitude to my friends who had helped and given me encouragement throughout this research. In addition, I would like to express my sincere to all the quantity surveyors who spent their precious time to answer the questionnaire in this study.

ABSTRACT

Building Information Modeling (BIM) has gained attention and widely adopted in the construction industry. Numerous benefits are acquired by adopting BIM software such as increased efficiency of users, production of high-quality work, and reduction of uncertainties. As BIM software had been widely adopted, the feedback from users such as their satisfaction level played crucial role in improving the software for various aspects. A lot of BIM related previous studies have been conducted such as benefits and challenges for implementing BIM, adoption rate of BIM in certain country, etc. However, there is limited studies which related to the satisfaction level of users in using BIM software. Therefore, this research is conducted to evaluate the satisfaction level of quantity surveyors (QS) in using BIM software in order to accelerate BIM adoption rate in construction industry. Six main criteria are identified which are BIM software features, cost, user friendly, software vendor, software quality, and interoperability and compatibility. Questionnaire surveys were distributed and a total of 97 responses are received. The findings from the analysed data revealed that the main criterion “BIM software features” has satisfied the QSs while the least satisfied main criterion is the cost of the BIM software. Besides, by conducting Kruskal-Wallis test, the results revealed that there is a significant difference in satisfaction level of using BIM software between different natures of QSs companies. Lastly, the findings of this research served as a great source of information to the software vendor, relevant construction authorities and local government as they perceived current data of satisfaction level of QSs in using BIM software and tend to improvise the unsatisfied criteria in order to accelerate the adoption rate of BIM software.

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LIST OF SYMBOLS / ABBREVIATIONS

AGC	Associated General Contractors of America
AEC	Architect, Engineering and Construction
BIM	Building Information Modeling
BQ	Bills of Quantities
BQSM	Board of Quantity Surveyors Malaysia
CAD	Computer Aided Design
CAFM	Computer-Aided Facility Management
CIDB	Construction Industry Development Board
CLT	Central Limit Theorem
IFC	Industry Foundation Classes
PTE	Pre-tender Estimate
PWD	Director of Public Works Department
QS	Quantity Surveyor
REHDA	Real Estate and Housing Developers' Association
RISM	Royal Institution of Surveyors Malaysia
ROI	Return on Investment
SPSS	Statistical Package for the Social Sciences
TAS	Cubicost Take-off for Architecture and Structure
TBQ	Cubicost Tender Series for Bill of Quantities
TME	Cubicost Take-off for Mechanical and Electrical
TRB	Cubicost Take-off for Rebar
UK	United Kingdom
2D	Two Dimensional
3D	Three Dimensional
4D	Four Dimensional
5D	Five Dimensional

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CHAPTER 1

INTRODUCTION

1.1 General Introduction

The chapter intends to present an overview of this research. The chapter includes the background of study, problem statement, research aim, research objectives, research methodology and research scope.

1.2 Background of Study

The construction industry is one of the most significant sectors that play the crucial role in supporting the economic growth, development and economic activities of a country (Khan, 2005). It promotes growth of a country, provides employment to the people and links economy and other industries. In brief, the construction industries act as the engine which is the most important part of the growth for a country and it creates a flow of services and goods with other sectors. Globalization, demands transformation, improvement of technology and needs of customer have become the consequence of the changes of business direction which have given a rise to the competitiveness in construction industry. Besides, construction has been said to be among the least digitised sector although it is being one of the largest industries (Barbosa et al., 2017). Although there is quite a number of new technologies which are well suited to solve the problems, the industry still being slow to adapt.

According to Barbosa, Mischke and Parsons (2017), an intractable productivity problem exists in the construction industry. The construction sector is described as stopping at a certain spot while other sectors such as retail sector and manufacturing sector keep making improvement. Besides, there is only averaged 1 percent of global labour-productivity growth over the past two decades as compared with total world economy which grow 2.8 percent and 3.6 percent in manufacturing (exhibit) (Barbosa et al., 2017). The report also stated that some of the reasons which are the strict rules applied, over depending on the public-sector demand, industry fragmentation, occurrence of corruption and fail to perform risk management. The project owners also mentioned the navigation of the opaque construction marketplace is a challenging task and

especially when they are inexperience in managing a big project. This results in poor project scheduling and resource managing, inappropriate design and cost overruns. Besides, Olsen and Taylor (2017) advocated that the construction industry has, historically, been very reluctant to change.

In order to improve the construction productivity, Building Information Modeling (BIM) has been introduced. BIM act as a cooperative mechanism that used by architectural, engineering and construction (AEC) industries (Latiffi, et al., 2013). Rodriguez (2018) mentioned that BIM is the process of creating and managing 3D building data during the project development. It is a complex multiphase process that gathers the input from team members such as Architect, Engineer and etc. to model the components of the construction project and it is a tool that will be used during the construction process in order to create a unique perspective of the building process.

According to Chan, Olawumi and Ho (2019), the main reason of implementation of BIM is that it helps balancing the project management triangle of scope (features and quality), cost and time. These three components are an essential concern by clients in the AEC industries. For example, in a project, BIM played a great role for the communication between construction players such as design decision can be made within a shorter period and early clash detection and analysis during design stage that help to avoid variation order which might be very costly. Hence, BIM application in a construction process helps reducing time spent for design which lead to cost saving and shortening the construction period (Latiffi et al., 2013). Lastly, BIM also act as the construction project quality assurance as it assists the organizing part of construction activities and phasing during planning stage of a project. In summary, BIM has been slowly replacing the traditional method of performing tasks in the AEC industries.

1.3 Problem Statement

The use of BIM is popular in the AEC industries. Nowadays, BIM has been widely adopted for construction project as it can be used for all phases such as pre-construction phase, construction phase and post-construction phase. Besides, the implementation of BIM which increased rapidly has lured the attention of numerous researchers and practitioners within AEC industries. According to

Jung and Lee (2015), since year 2007, the Smart Market Report series has been annually reporting the BIM adoption status in multiple regions. Besides, Yonsei University in Seoul, South Korea has been collecting the data regarding the BIM adoption rate in South Korea annually since 2008. In addition, there are a lot of surveys in measuring BIM adoption rate and its status has been conducted within specific country or specific domain. One of the surveys shows that the BIM adoption and awareness rate has grown from 10% in 2011 to around 70% in 2019 (National BIM Report 2019, 2019).

Numerous numbers of researchers showed a great research interests on BIM. Most of the previous studies were focused on the benefits, barriers, disadvantages, adoption rate of BIM and implementation of BIM on different type of building work. For instance, the researches about benefits and barriers of adopting BIM were done by Chan, Olawumi and Ho (2019), Guo, Yu and Fang (2019) and Yang and Chou (2019) that targeting on different parties such as the BIM user from different nature of construction company which are the contractor firm and the stakeholder of a project. Besides, research of BIM with green buildings was done by Lu et al. (2019) and Ahuja, Sawhney and Arif (2017). On the other hand, the linkage of BIM toward infrastructure construction work was also investigated. For example, Chapman, Providakis and Rogers (2019) and Li, Yu and Liu (2018) conducted a research of BIM for the underground work. There are also studies done by Wu and Lepech (2020), Najjar et al. (2019), Rezaei, Bulle and Lesage (2019), and Seyis (2020) regarding integrating BIM and life-cycle appraisal. The example of life-cycle appraisal included life-cycle appraisal of durability performance, life-cycle appraisal for generating energy efficient buildings and life-cycle appraisal during the early and detailed building design stages. In addition, Akram et al. (2019) investigated of BIM roles in construction safety through science mapping. Furthermore, study of design of reinforcement steel with BIM was conducted by Liu et al. (2020), Mangal and Cheng (2018), and Laefer and Hong (2017).

Based on these previous studies, it is noticeable that the study about the satisfaction level of using BIM software is limited although many countries and domains have adopted BIM in the industry. Moreover, user satisfaction especially quantity surveying in using BIM software is being less emphasis.

Thus, the intention of carrying out this study is to evaluate the satisfaction level of quantity surveyor (QS) in using BIM software.

1.4 Research Aim

This study seeks to evaluate the satisfaction level of quantity surveyors in using BIM software to enhance BIM adoption in the construction industry.

1.5 Research Objectives

In order to achieve the research aim, three research objectives have been formulated.

i. To identify the criteria in measuring the satisfaction level of quantity surveyors in using BIM software.
ii. To evaluate the satisfaction level of quantity surveyors in using BIM software.
iii. To compare satisfaction level of quantity surveyors from different nature of companies in using BIM software.

1.6 Research Method

The research started with the study of BIM technology and its application in QS practice, the BIM software, user satisfaction, the criteria in measuring user satisfaction of using BIM and a study of satisfaction level among different nature of people or company. Quantitative approach was adopted as data collection. Questionnaire was prepared based on the criteria that affecting the satisfaction level of QS in using BIM. The questionnaire was being distributed by e-survey form to contractor firm, consultant firm and developer firm that have the experience of using BIM software. Cronbach's Alpha Reliability Test, Arithmetic Mean and Kruskal-Wallis Test were used to analyse the collected data.

1.7 Research Scope

The targeted group for this study is the QS profession from different nature of companies within Klang Valley such as consultants, contractors and developers firms who have experiences in using BIM software in their practices.

1.8 Chapter Outline

Five chapters are proposed in this research. Firstly, chapter one discusses about the introduction of this research. It includes the background of study, research problem, research aim and objectives, research method, research scope and chapter outline of the whole study.

Chapter two tabulates the literature review of this study. This chapter gathers information of BIM technology from previous studies and the sources were from online research, journals and articles. BIM technology is being focused and criteria that affect the satisfaction level of user are being discussed in detailed.

Chapter three presents the methodology of this research. The content covers research design, research selection justification, strategy, data collection process and data analysis method. Chapter four presents the outcomes from analysing and interpreting of the collected data in a detail way. Lastly, chapter five concludes the entire research. Limitation and recommendation are also provided in this chapter for the purpose of future study.

1.9 Summary of Chapter

In a nutshell, currently BIM had been widely adopted but the satisfaction level of QS using it is less emphasized. The research problem has been identified. The research aim and three research objectives are addressed. In addition, the method together with its scope used are identified in the subsection. Lastly, there is a subsection about the overview of the research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter includes the literature review and studies regarding Building Information Modeling (BIM), user satisfaction, criteria used to measure satisfaction level of quantity surveyor (QS) using BIM software and comparison of satisfaction level of QS from different nature of companies in using BIM software.

2.2 Building Information Modeling (BIM)

Pursuant to Sawhney (2015), the universally accepted definition of BIM is not existed but there are many sources that provided similar answer to the question 'what is BIM?'. The main reason of this is because BIM was evolving from time to time plus the new areas and frontiers are slowly entering the boundaries of what BIM could be defined as. Chuck Eastman et at., (2011) defined BIM as one of the most promising developments that enable the creation of high precision virtual digitally constructed models of a building to assist in various activities such as design of building, construction process, fabrication of components, and procurement. On the other hand, Jones (2013) mentioned that BIM acts as the digital representation of a facility's physical and functional attributes. Within shared database, all information regarding the facility are obtainable. Associated General Contractors of America (AGC) (2005) explained that BIM is the growth and usage of software to form a building information model for the facility. The building information model is able to generate views and data to fulfil users' needs which is to generate information for decisions making purpose and help to achieve process improvement for delivering the facility.

First of all, BIM has been described as the technology which generate and manage the parametric object-oriented model of a building (Ghaffarianhoseini et al., 2017). The word 'parametric' is defined as element medication process and the process where adjustment is performed automatically on the adjacent element or other components to maintain the relationship which is established

before (Stine, 2011). Instead of referring to 2D drawings which is the conventional way, BIM concept software showed a built virtually model in 3D space. The built model can precisely show the relative location of elements and enable the observation of elements from arbitrary viewpoint. Most importantly, the elements actually self-carrying their attributes like material, paint, class of fire safety, etc. In brief, a building information model existed as a project simulation that included the 3D models of the project components which consist the required information and linked them toward project planning, design of the building, the construction process and operation. Figure 2.1 shows the BIM concept.

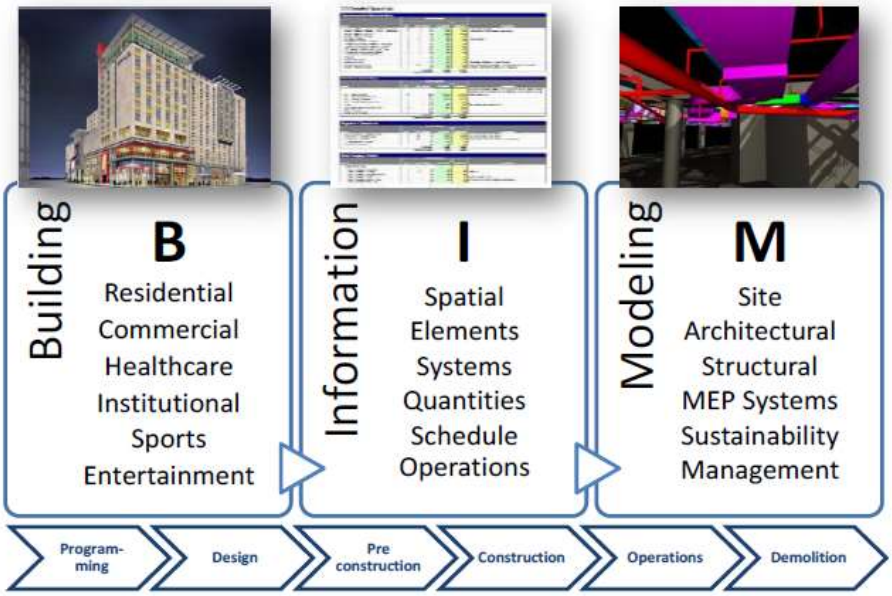

Figure 2.1: Visual Representation of BIM Concept
(Source: Azhar, Khalfan and Maqsood, 2012)

Other than the three dimensions of the model and elements' properties attached to them, time, which is the fourth dimension, was also incorporated in the BIM concept. For the 4D design approach, it enables coordinating function for all parties involved during the building construction phase, exploitation phase, reconstruction phase, and utilization phase. The information from the starting of the project until its completion is being updated from time to time and kept in the common database (Dobelis, 2013). Besides, the fifth dimension of BIM concept which is 'money' acts as the most important attributes for

elements and processes of a building. The so called 5D design approach included the database that consist of the attributes of building elements from different vendors and designers. In this case, various design scenarios 'what if' could be played in order to figure out the most effective solution. Aside of these dimensions, there is also the sixth dimension which is sustainability and the seventh dimension – facility management applications such as Computer-Aided Facility Management (CAFM). A common standard has been introduced in order to support all these dimensions of BIM concept as the information of a project is shared between so many parties. Figure 2.2 shows the dimensions of BIM.

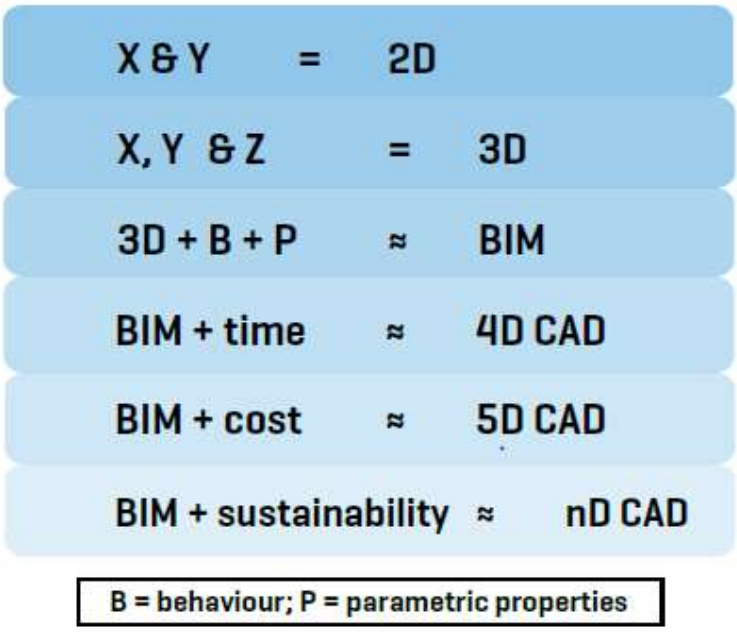

Figure 2.2: Dimensions of BIM
(Source: Sawhney, 2015)

Nowadays, a lot of countries such as Australia, China, United Kingdom (UK), Denmark, and Singapore have implemented BIM. In Malaysia, during the year 2007, Director of Public Works Department (PWD) had made the decision to impose BIM for local AEC industries. The reason of this action is because the government started to aware of the capabilities of BIM which help in increasing project performance, saving the construction cost and preventing problems when designing the project. On 27 August 2007, the government had formulated the PWD committee and the purpose of the committee is to

determine the construction project processes that involved BIM implementation. Besides, PWD were using the established BIM standard manual documentation as a guidance for construction players' referral is prepared and there is also preparing courses and advisory support to the relevant parties in utilizing BIM software.

2.3 BIM Application in Quantity Surveying Practise

Quantity take-off was defined as a practise where measuring and counting of building elements are carried out and it is a very fundamental and necessary task for a construction project (Khosakitchalert, Yabuki and Fukuda, 2019). The measured quantities are used for several procedure in construction project such as estimating and managing the cost, procurement and scheduling the construction activities. Traditionally, quantity surveyors within construction firm have to refer some blueprints or 2D plan sheets to carry out project estimates (Olsen and Taylor, 2017). Every single drawing from design team must be reviewed, calculate the amount of specific materials needed while assuring that double count or disregard of elements is being avoided. This is a time-consuming process and very detail oriented. Due to a lot of variables, mistakes occur quite frequent during this process. Besides, along the process of a project which is from inception to completion, QS has the main role to conduct financial controlling task together with cost and contractual administrating work (Nagalingam, Jayasena and Ranadewa, 2013). Table 2.1 tabulates the roles played by QS when managing the cost of a construction project.

Table 2.1: The Roles of QS in Cost Managing

Pre - Contract	**Post - Contract**
Preliminary cost estimating	Interim valuation and Payment
Procurement Advice	Final account preparation
Cost planning	Settlement of contractual disputes
Measurement of Quantities	Cost control during construction
Preparing Bills of Quantities	Analysis of Financial Risks
Bidding Process	Insurance Valuations

(Source: Nagalingam and Ranadewa, 2013)

BIM, a digital modeling approach which representing the geometric and semantic information of a facility has now change the process of quantity take-off radically (Khosakitchalert, Yabuki and Fukuda, 2019). By utilizing the geometric data and semantic properties of each building element from building information model, the quantity can be measured automatically, and this is called BIM-based quantity take-off. Besides, BIM also functions as design interpretation tool and cost managing tool for construction projects.

2.3.1 Preliminary Cost Estimating

Preliminary cost estimating is defined as a process where the usage of BIM modelling to perform quantity take-off is able to provide a logical and precise estimate during the early stage of a project. It also provides cost effect of modification and addition which bring up the potential for time and cost saving and prevent the budget from overspends. During the preliminary cost estimating, designers are able to observe the increasing or decreasing of the cost due to the design changes which help avoid the budgets to overspend because of performing modification on the project. During the time where the building information model is available or placed within a common database with the contractors, it expedites the detail estimate process and precision of the estimate goes up too.

2.3.2 5D Cost Planning

BIM enable the automated facilitation of cost plan along the building elements. The main purpose of facilitating a cost plan is to forecast the contractual value by allocating the cost differently on components of a construction work and it helps to prevent failure during the design stage and serve as a fundamental for cost management. BIM offers services regarding the cost planning and offer cost certainty by ensuring the cost estimates are realistic and accurate (Brandtman, 2013). Through 5D cost planning using BIM software by QS, client is ensured to receive an economical and efficient project.

2.3.3 Cost Estimating

By using BIM software, data is being generated in a faster and more accurate way as it able to generate quantities automatically. For instance, by performing

quantity take-off based on building information model, project team is able to carry out cost estimates and this helps a lot in making decision and obtaining useful cost information regarding other methods or materials and being informed to the owners during the early design phase and also throughout the project lifecycle. This is due to building information model contained the information which is regarding to the cost from an estimating database. Thus, this action is faster, and it helps to avoid errors and omission. Besides, the time taken for quantity take-off is reduced dramatically and estimators can fully concentrate on those higher value activities which included generating pricing, construction assemblies and factoring risks.

2.3.4 Preparation of Bills of Quantities

Due to 4D modeling capabilities in BIM, many traditional QS functions are being executed (Nagalingam, Jayasena and Ranadewa, 2013). By adopting BIM software, the quantity measured from construction drawings is computer-supported and QS will be able to acquire the design documents that included the precise quantities together with the specification regarding the materials in computerized format. By correctly utilizing the Building Information Model, the creating process of bills of quantities (BQ) is automated and then applied in order to generate the reports in the correct format.

2.3.5 Cost Control

Once the 3D function of BIM has built linkage with quantity information management, the cost and quantity control of the project is able to be well monitored and also managed in the actual time, with great accuracy and limpidity within it. Those problems such as discrepancies, cost overflows, etc. can be discover earlier and corrective action can be adopted to resolve them and reduce the consequences to minimum level. Besides, the cost information on site or in as-built basis which is done in compliance with the progress on site can be welly supervised with the utilization of BIM. In brief, a lot of advantages is provided due to the precise quantity control as it acts as the foundation to perform managing task in term of cost, time, acquisition of essential components, supply of material, machinery and labour, and resource allocation.

2.4 BIM Software

Plenty of BIM software packages are introduced and adopted for managing project information purpose, thus, collaboration among project team is being fostered. BuildingSmart (2018) mentioned that there are at least 150 number of BIM software packages are adopted within the construction industry. The type of BIM software that are most widely adopted are the BIM authoring software packages such as Revit, Bentley and ArchiCAD. Next, the BIM project management or coordination software which is the Bentley Projectwise. BIM energy analysis tool such as Green Building Studio, EnergyPlus, and Integrated Environment Solutions. By converting building to modelling inside BIM software, different project members included clients are able to view and making decisions such as agree or disagree on the details and finishes when visualisation is utilized during the early design stage of a project.

According to Eadie et at. (2013), the BIM Industry Working Group mention that the United Kingdom (UK) Government believe the usage of BIM within the construction industry is able to bring benefits and many efficiencies across the project lifecycle. Adoption of BIM is facilitated by a range of tools and resources (National BIM Report, 2019). 3D modelling software and Common Data Environment are the keys for adopting BIM. Pursuant to the survey in National BIM Report (2019), Autodesk remain the most widely adopted software vendor for models and drawings production, with 70% using Autodesk tools. Revit, the modelling platform of Autodesk, is being used by 46% of the survey respondent. Furthermore, Graphisoft's ArchiCAD (15%) which is also one of the most popular tools that enables the production of digital models. Other Autodesk software also being widely adopted but the responses to this question mention that the software users are more focusing on using modelling software which support their selection of BIM instead of software to generate 2D drawings.

On the other hand, Common Data Environment has become increasingly important for construction industry. The benefits of using the Common Data Environment is that it enables data storage in one place, and it is reducing the need for duplication of data which help to avoid conflicts. Collaboration between project team is achieved as the data is located in one cloud where any of the project team can access to it. In UK, Viewpoint, Autodesk 360, Asite and

Aconex are used and the most popular is Viewpoint which 41% of respondents are using it. Figure 2.3 shows the mainly used tool to produce drawings or models in UK and Figure 2.4 shows the Common Data Environments tool used in UK.

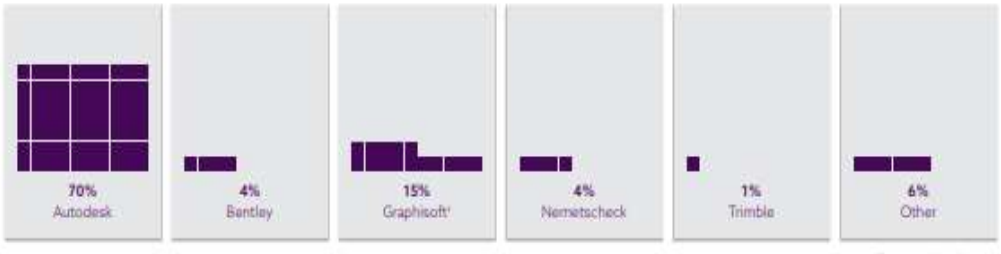

Figure 2.3: Mainly Used Tool in UK to Produce Drawings or Models
(Source: National BIM Report, 2019)

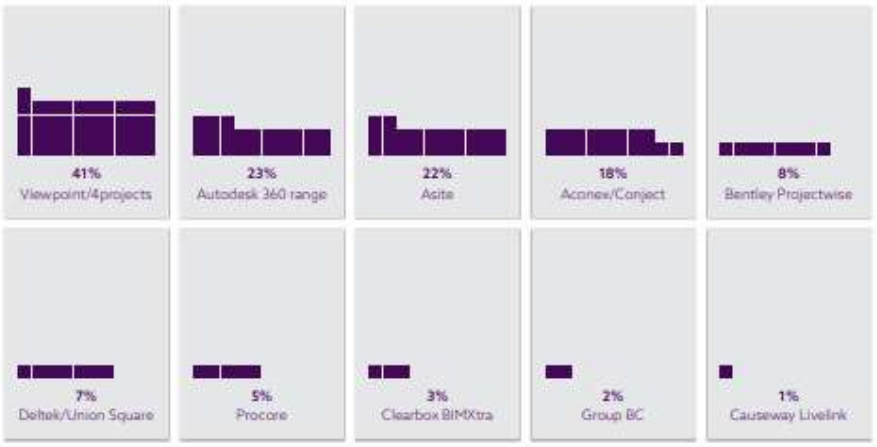

Figure 2.4: Common Data Environments Tool Adopted in UK
(Source: National BIM Report, 2019)

For China construction industry, the concept of BIM was being known roughly at the year 2002 (Zhang et al., 2016). BIM application had been implemented in China when the Ministry of Housing and Urban Rural Development (MHURD) started to plan the national-level BIM standards at the year 2012. Revit, Navisworks, Luban and Tekal are the most commonly used BIM software in China (Li et al., 2018). Besides, there are some tools which are known to industrial professionals such as Cubicost by Glodon, ArchiCad, Lumion and many others. The BIM tools are specialized in planning and design process, assisting in the process of constructing, and supporting the utilization

and maintenance of the building. There are a few series of BIM software that is providing at least three modelling tools such as MicroStation series, Midas series and Tekla series. Majority of the BIM software are able to perform scheduling, designing, and estimating. Figure 2.5 presents the common BIM tools used in China.

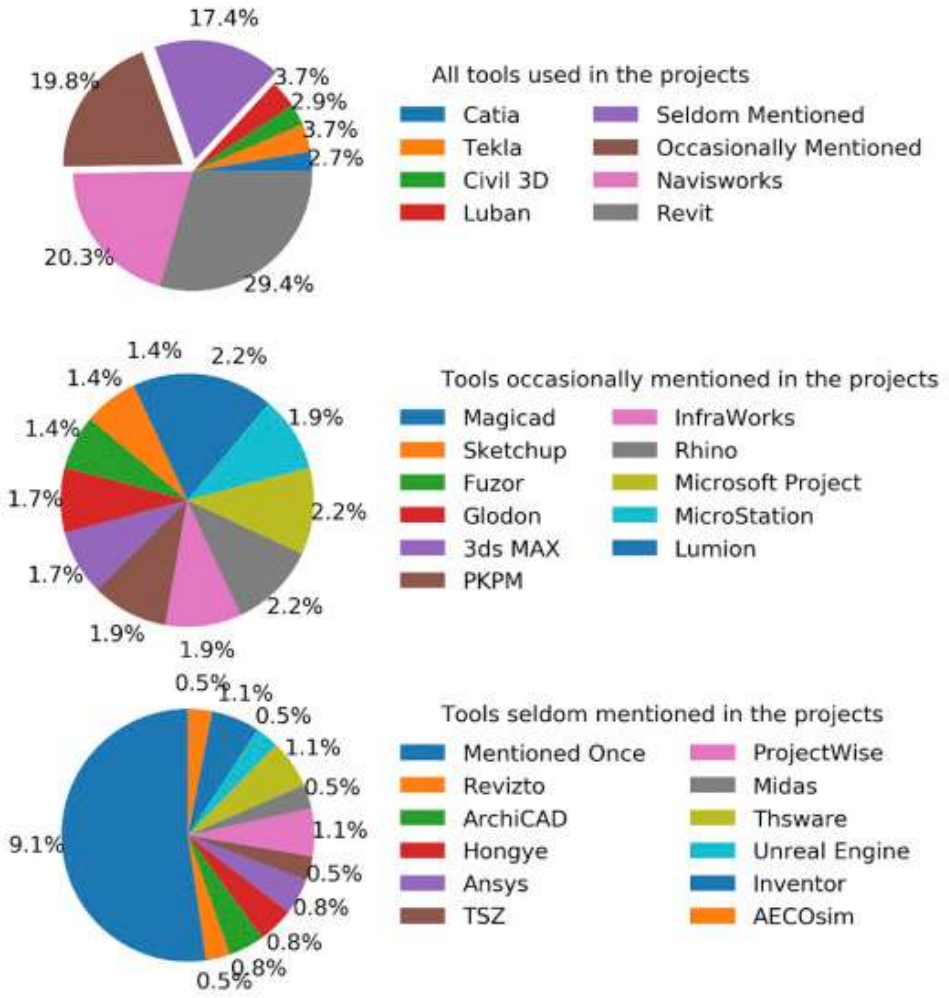

Figure 2.5: The Common BIM Tools Adopted in China
(Source: Li et al., 2018)

There is several BIM software being adopted in Malaysia construction industry. Firstly, Revit Architecture is used by architect to design every aspect of a building like wall, staircase, roof, etc (Latiffi et al., 2013). It follows by Revit Structural that enable the structural engineer to carry out their role to design and analyse the structural part of a building. Revit MEP for mechanical engineer to come out with a model regarding the building services like piping

and ducts. Besides, electrical engineer also uses Revit MEP to design the circuit of the building. Other than BIM software for designer team, there is also software for project manager which is the Autodesk Navisworks. The software helps to simulate and adjust the scheduling, determine and point out the clashes and created a partnership and teamwork between the contractor and the design team. These is achieved through creating a multidiscipline model by the project manager.

On the other hand, there is software that is used for construction cost estimating – Cost-X. The feature provided is quite useful for quantity surveyors such as improved visualisation tool and extraordinary version tool. For improved visualisation tool, the transparent and refine function help to ease and speed up the review process while doing taking off while unique revision tool identifies changes in the design and update the quantities automatically. Figure 2.6 summarises the BIM tools used in Malaysia. Apart from Cost-X, Cubicost developed by Glodon also being adopted widely. Figure 2.7 shows the percentage of BIM software types adopted by QS in Malaysia. Regarding the type of BIM software adopted by QS in Malaysia, the adoption rate of Cubicost which developed by Glodon is in the top ranking with 27.1% followed by Cost-X and Revit which is 23.7% (Ismail, Adnan and Bakhary, 2019). There is also software such as ArchiCad, Navisworks, Ripac, Tekla, etc being adopted in Malaysia but the adoption rates are lower which are lesser than 10%. In brief, Cubicost developed by Glodon is the most commonly adopted software in Malaysia as it is designed specifically for quick modelling and BIM based quantity take off which suited for QS to do building cost estimation accurately and efficiently.

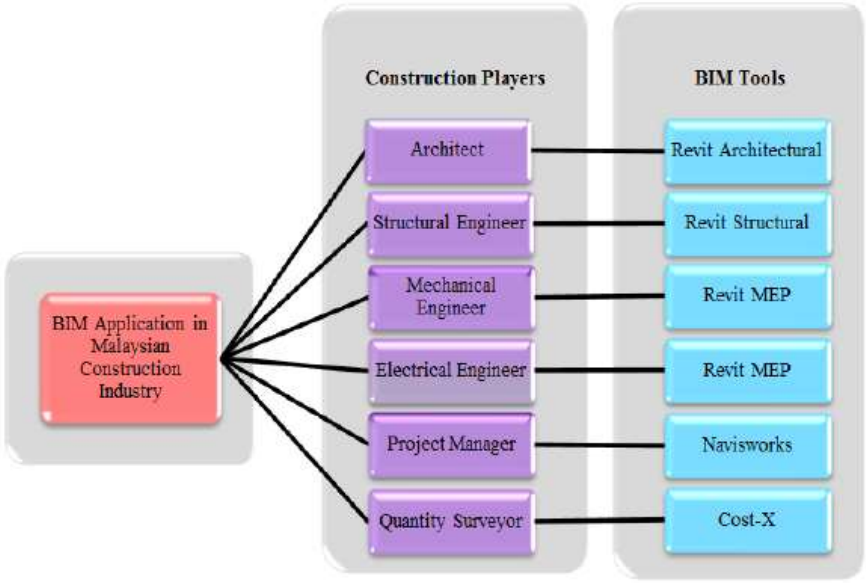

Figure 2.6: BIM Application Used in Malaysia

(Source: Latiffi et al., 2013)

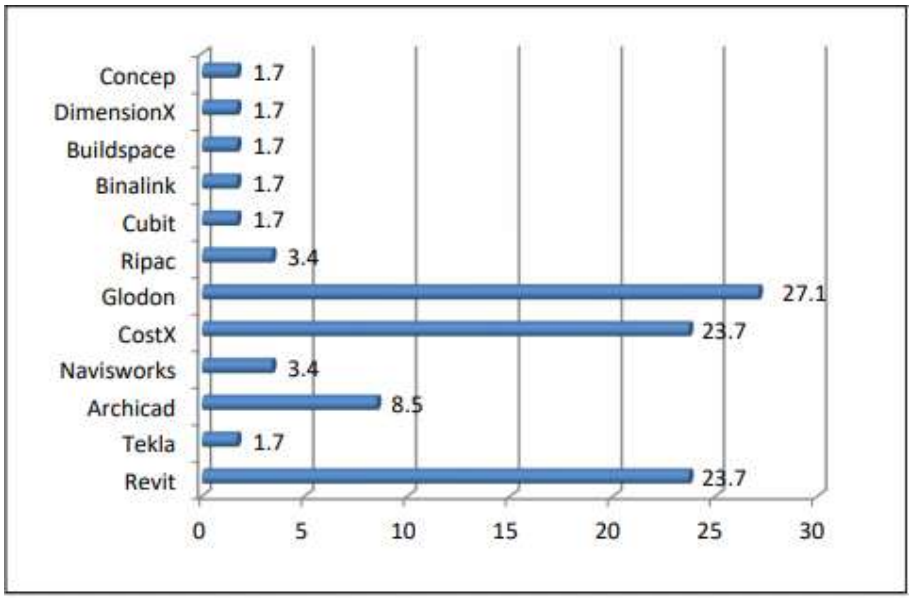

Figure 2.7: Percentage of BIM Software Types Used by QS in Malaysia

(Source: Ismail, Adnan and Bakhary, 2019)

According to Loh (2018), Cubicost which developed by Glodon has become a new trademark within local and international construction industry market. In addition, Cubicost is considered as a tool that is used for carrying out

QS duty and being accepted worldwide. Apart from carrying out quantity take off precisely and efficiently, it also serves as a platform that store big data for the entire lifecycle of a construction project. Several types of Cubicost is available and each of them has their own unique functions. For example, Cubicost Take-off for Architecture and Structure (TAS), Cubicost Take-off for Rebar (TRB), Cubicost Take-off for Mechanical and Electrical (TME) and Cubicost Tender Series for Bill of Quantities (TBQ). TAS and TRB function as BIM-based quantity take off software which enable model-based quantity take off of buildings. TAS is used for measuring architecture and structure works while TRB is to measure rebar. For TME, it is used for measuring quantities for mechanical and electrical works and TBQ serves as the final platform where quantities are imported from TAS, TRB and TBQ and generate BQs. Besides, data and models from Cubicost can be shared among other software. In brief, Cubicost are digging out the maximum productivity of QS with minimum waste of effort.

2.5 User Satisfaction

User satisfaction is defined as the extent to which users believe the goods or services acquired are able fulfil their expectation (Ives, Olson and Baroudi, 1983). According to Cambridge dictionary, satisfaction is a pleasant emotion, when the expectations or needs are fulfilled or there is nothing to complaint about. A great satisfaction level towards goods and services produces a greater effectiveness and productivity of a person. Au, Ngai and Cheng (2008) highlighted that there are a lot of factors affecting the user satisfaction toward using a software. Thus, BIM user satisfaction is referring BIM users' extent of expectation toward a set of influencing factors which is related to their expecting experience they can obtained while adopting BIM software.

Nowadays, measuring user satisfaction level is crucial for performance improvement as people or organization will only adopt and use things that able to reach their expectation. Besides, once the goods or services able to reach the satisfy level of a person or an organization, then only the goods or services is promoted to others and widening its market value. On the other hand, by examine the user satisfaction level and getting feedbacks from the user, the producer of the goods or services then able to improvise or modify their goods

or services, which means the user able to see the changes made by the producer and willingly promote to others. People tend to trust words from another instead of learning the products or services from advertisement on Internet which means words of promoting from a person is able to reach to many others. For example, one person promotes the goods or services to ten persons, then the ten persons will be telling another hundred person and many more. This is a chaining effect of promoting.

2.6 Criteria in Measuring Satisfaction Level of Quantity Surveyors Using BIM Software

There are various criteria identified from literature review for measuring the satisfaction level of QS using BIM software. There are the BIM features, cost for implementing BIM software, the extent of user friendly, software vendors, quality of BIM software, and the interoperability and compatibility of BIM software.

2.6.1 BIM Software Features

Nowadays, BIM modelling is able to function to an *n*th dimension of work and its usage can vary through wide scope of works (Gray et al., 2013). For instance, BIM is able to facilitate the analysis of design, provide assistance during design process, examine the construability, planning for site and its usage, project scheduling, work sequencing, and cost planning. All these functions are affecting the satisfaction level of users as they expect the BIM software is able to provide all these functions. In addition, users are expecting all these functions are useful to them. The term useful is pointing toward the capability of BIM software ease up their job, time saving and precisely deliver the information to other parties. In brief, the satisfaction of BIM software users is depending on the functions of the BIM software itself.

2.6.2 Cost

According to Hoffer (2016), there are three types of BIM investments. First is the start-up cost to guarantee implementation of the technology is successful. In term of monetary, the price of BIM software is high and most of the small or medium QS firms are unable to afford it. Besides of the purchasing cost,

investment of staff training will also cost a lot to a QS firm. The staff must be able get familiar using the BIM software and it takes times for the staff to adapt to it or else it is only a waste. Second cost is the costs to tailor BIM to a project. Additional labour investment is a must to tailor BIM to the process of the firm such as adding a manager that expertise in BIM or more IT support. Third cost is the longer term outlays. In a QS firm, changes of internal process such as integrating or incorporating information or data in the model earlier in the design phase and continually using BIM software must be considered as to build a complete investment calculation.

The cost of implementing BIM software is high and it is highlighted by Yaakob et al. (2018) as implementing BIM required larger investment cost to update both software and hardware, it is costly to train staff and changing of the workflow and work progress, and investor would only invest if the software able to contribute long term benefits. Pursuant to Latiffi, Mohamad and Rakiman (2016), the cost of implementing BIM software within a construction firm could goes up to RM 15,000 to RM 90,000.00 which only affordable for larger organization. To reach higher satisfaction of QS using BIM software, the cost of investment in BIM software must be reaching the expectation of user as the software cost their money and time in order to acquire and adapt to the function of the software.

2.6.3 User Friendly

Since BIM software are created to increase productivity with minimum waste of effort, therefore, BIM software purchasers are expecting the software to be simple and easy to use. According to Loh (2018), the highlighted term of developing a software is that it must be achieve minimum difficulties when using it. Besides, the information created within the software shall be shareable among relevant parties with high reliability and accuracy level. A successful construction project will only be achieved when all relevant parties work together within a same platform and BIM software is the platform that boost the collaboration among them.

On the other hand, an easy understanding user manual and software tutorial must be provided as users are expecting they can learn quickly in using the software and tend to guide new users with minimum effort. Libraries and

contents in the software must be achieve completeness and the software should enable users to add their own unique libraries and software into it. If the BIM software cannot achieve user friendly, then for sure the user satisfaction towards BIM is low and they rather purchase other software to replace it.

2.6.4 Software Vendors

When it comes to purchasing decision, client tends to select vendor that give the best offer to them. For BIM software purchasing decision, the vendors should offer services like warranty, training, support and post-purchase follow up programme together with the software package. BIM software purchasers are expecting to receive proper services from the vendor. On behalf of BIM software purchaser, they have invested their capital to acquire the software and they are deserved to get these services from the vendor.

Firstly, warranty is a must to the BIM software purchaser because the software might appear certain bug or unable to function well, or it might be different from what the vendor described when promoting to them. Latiffi, Mohamad and Rakiman (2016) stated that training or guideline for BIM software is important as the implementation process of BIM software could be false without proper guideline from software vendor and it will cause failure in obtaining the benefits of BIM software implementation. Thus, training shall be included as majority of the purchaser are unfamiliar towards the BIM technology and expertise who demonstrate the features inside the software are needed. On the other hand, the reason vendor should include the post-sales follow up programme is to help client to solve the problems faced when using the BIM software and at the same time collect feedbacks for software improvement. According to Yung and Yung (2009), the satisfaction level of purchaser tends to be higher when assistance is readily available, therefore responsiveness may affect satisfaction level. On the other hand, there is chance of losing current, potential and future customers if the customer services provided by vendors are not appropriate. Kulli (2017) signified that bad customer services provided would cause vendors to lose even the most merciful customers. In brief, the greater the quality of post-purchase services acquired, the higher the satisfaction level of the BIM software user.

2.6.5 Quality

A BIM software is categorized as good quality software when there is various type of selection criteria can be chosen from its library contents. Besides, the BIM software must include smart object in the object library as it helps to maintain associability and connectivity between objects. BIM libraries are essential in every BIM software and buyers are choosing the software based on the libraries attribute. For example, libraries within Cubicost which developed by Glodon are specify in doing estimating work while AutoCAD libraries are for designing purpose. On the other hand, a good quality BIM software shall allow manual adding of new libraries and can be stored for future reference. According to Yang et al. (2013), the embedded libraries shall be able to show semantic information to the operators.

Apart from libraries, a good quality BIM software must also support documentation such as estimated quantities in Cubicost can be export into Microsoft Excel or BQ template which ease up QS job as they are not required to manually key in the estimated quantities. This feature has increased the accuracy of data and achieve time saving. In brief, high user satisfaction level can be achieved once the BIM software quality is able to reach their expectation and provide good quality of work.

2.6.6 Interoperability and Compatibility

Ozturk (2020) explained that collaboration from different parties are essential due to multiple construction project processes. Currently, the number of software that is able handle all information produced from each process is considered as none. Therefore, interoperability applications are required to solve the problem. Compatibility is also an important factor that affect user satisfaction. Shirowzhan et al. (2020) mentioned that the compatibility effect which arises from differences in the format of information extract from virtual and real object are affecting the interpretation of data. Hence, BIM software should be able to compatible with different format such as DWG format, PDF format, etc.

With the purpose of raising the satisfaction level of BIM software user, the software shall be able to perform these two attributes in the perfect manner. For instance, once architect has done modelling the building using Architecture

software, they should be able to transfer the created model to QS to perform estimating task through accessible formatting. Lacking either one of these features will be affecting the satisfaction level of the users. This is because the higher the interoperability and compatibility level of the software, the greater the efficiency of users.

2.7 Framework of Criteria That Affect Satisfaction Level of Quantity Surveyors Using BIM Software

After reviewing various previous studies, there are six criteria that are affecting the satisfaction level of QS using BIM software. They are the BIM features, cost for implementing BIM software, user friendly, software vendors, quality of BIM software, and the interoperability and compatibility of BIM software. A framework of how these criteria affecting the satisfaction level of QS in using BIM software is proposed as shown in Figure 2.8.

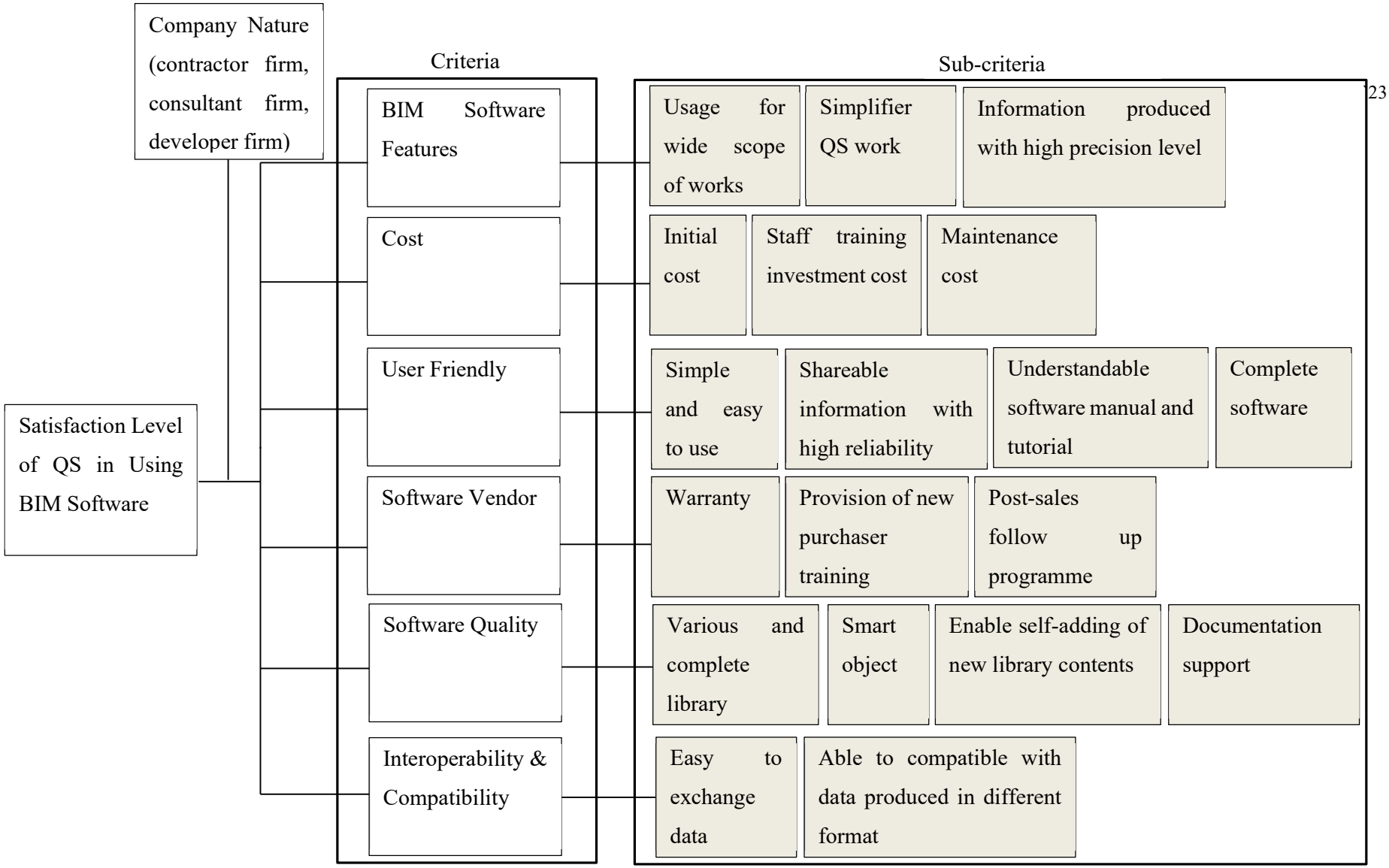

Figure 2.8: Criteria Affecting Satisfaction Level of QS in Using BIM Software

2.8 The Usage of BIM Software for Different Nature of Companies

There are different natures of companies such as architectural firms, developer firms, consultant firms, contractor firms and many others in the construction industry. The common things about all these companies is the employment of QSs, but the tasks to be performed by the QSs are varies. Therefore, the usage of BIM software by QS is depending on the nature of company and different nature of business would have different consideration or expectation in using the BIM software. Thus, there will be a different on the satisfaction level of QS in using BIM software which require to be investigated further in this study.

2.8.1 The Use of BIM software in Contractor Firms

The main task given to a contractor is to engage construction workers and manage the construction work. Therefore, building information models act as the basis for the contractor to carry out the construction works accordingly. In contractor firm, QS are using BIM tools to perform the estimating task, coordinating of resources, planning for construction work, prefabricating components and many others. There are numerous types of estimating performed by QS in contractor firm such as estimate construction work for tendering purpose, estimate work done for claiming payment, estimate for variation order and many others. They are expecting BIM tools adopted are able to assist them and increase their efficiency in estimating work as using traditional method would cost longer time.

Besides, QSs in contractor firm are in charge of coordinating the trading of materials based on the construction plan and schedule generated using BIM tools and ordering prefabricated components based on the information within building information models. Thus, they are expecting the construction plan which is generated according to the requirement and information given by project owner and design team is reliable and accurate. On the other hand, manufacturers are expecting contractor QS to provide specification of the prefabricating components in the form of BIM modelling and compatible with the BIM software adopted by manufacturers. In contractor firm, the measuring of satisfaction level of QS in using BIM software is emphasized on how BIM software could assist them in winning the contract, complete the work within time allowed and reduce the wastage of resources.

2.8.2 The Use of BIM software in Consultant Firms

In construction industry, QS who work within a consultant firm are responsible for validation and monitoring the project cost. Consultant QSs are required to execute broader specialist QS services which included pre-contract, contract, and post contract (Mbachu, 2015). In the early stage of a project, consultant QSs are hired to give advice on procurement, produce initial cost plans and BQs and appoint contractors. Sometimes, design team only produces 2D drawings and consultants are required to develop building information models by referring the 2D drawings. Consultant QSs should build up the 3D building information model based on the architect and engineer CAD drawings in Internal Foundation Class (IFC) format as to minimize software and communication constraints (Soon et al., 2017). Besides, building information models have enabled the visualization of the construction work for project owner and stakeholders and they are shareable to those interested contractor. Consultant QSs are required to prepare pre-tender estimate (PTE) and BQs before inviting contractors to submit their tender. The accuracy of PTE is important as it is used to check and compare contractors' cost estimation to avoid selecting the overpriced contractor.

In the meanwhile, when the project is running, the consultant QSs are required to liaise with contractor's QSs to verify and authorise the interim payment for work done. Normally, contractor's QSs would first estimate the work done and generate as-built drawings using BIM tools and then submit to consultant QSs, then consultant QSs would check is there any changes on design. If there are no changes, the consultant QSs would go for inspection and estimate the work done by contractor then compare with their clamming amount. With the usage of BIM software, consultant QSs are expecting time for measurement and producing BQ are shorten. Besides that, the precision of measurement work is expected to be boosted to a higher level and the information of building information models are more complete and reliable compare to the usage of 2D paper drawings.

2.8.3 The Use of BIM software in Developer Firms

In developer firm, BIM tools contributed in leading the construction project to be delivered in the most efficient and reliable method. Furthermore, the strategic goal of QSs in developer firm is to attain high satisfaction level of end-users by minimizing the life-cycle cost of the development (Lilavivat, 2013). They are also required to conduct feasibility study before the commencement of a project. Thus, they are expecting the usage of parametric models and BIM-based planning are able save time to market as the time to market would greatly impact the project's return on investment (ROI) and detail planning of the project is more reliable.

Besides, the precise nature of building information models acts as a reliable source for QS in developer firm to carry out measurements and estimating work and give immediate reply regarding the cost based on the changes of design. QSs are expecting the usage of BIM software is able to minimize the chances of cost overrun. Furthermore, QSs are using the visualization function within BIM software enable them to carry out design assessment as it is important ensure the design of the product are following the requirement of stakeholders. In short, QS in developer firm are expecting the adoption of BIM software within a construction project are able to assist them in preparing feasibility study, budgeting, cost controlling and time saving.

2.9 Summary of Chapter

This chapter firstly introduced BIM in construction industry follow by how BIM technology assisting QS jobs. After that, BIM software and user satisfaction are being discussed. There are a lot of criteria affecting the satisfaction level of QS in using BIM software and there are also different nature of company adopting BIM software. At the end of this chapter, a framework of criteria that affecting satisfaction level of QS in using BIM software is being proposed.

CHAPTER 3

METHODOLOGY AND WORK PLAN

3.1 Introduction

The research method and data collection procedures that adopted to carry out this research is being determined and explanation is made within this chapter. First of all, the chapter discusses and make comparison regarding the characteristic of qualitative method and quantitative method. After that, selection among the two methods are made and being justified. Furthermore, this chapter also describes the research design and the method used to analyse the collected data regarding satisfaction level of quantity surveyor (QS) using Building Information Modeling (BIM) software. Lastly, summary of chapter which represented an overview of this chapter is being provided.

3.2 Research Method

According to Walliman (2011), the term 'research' is being applied on any kind of investigation that intended to uncover or explore new facts or problems. Besides, research is also described as a process that included gather, analyse and interpret the data or information to answer questions (Goundar, 2013). Research method is the method by which the research is conducted into a topic or a subject through experiments, tests, surveys, etc. According to Davies and Hughes (2014), if the research is related to people's opinions, feelings, experiences or behaviours, then there are two distinct methods can be chosen or choose both at the same time which are quantitative method and qualitative method. Quantitative method is more toward scientific tradition where qualitative method is more focus on individual's experience. Both are able to deliver reliable result when they are welly conducted by the researcher.

3.2.1 Quantitative Research

Pursuant to Aliaga and Gunderson (2005), the nature of quantitative research is answering of questions by gathering data which is presented in numerical form and analysed the data with the statistical method. It is a systematic type of research and it is being adopted to investigate scientific research problem.

Quantitative data are normally collected in numeric form through surveys or other measurement techniques. Besides, this research method focuses on larger scale and representative sets of data (Goundar, 2013). According to Walliman (2011), the analysed data by using quantitative data analysis is for the purpose of measure, compare, examine relationships, explore, built-up concept and theories, etc. On the other hand, this research method is able to effectively and easily transfer the collected data into quantifiable charts and graphs which simplify the process of data analysis.

This research method has its own strength and limitation. For example, precise data are obtainable through quantitative and reliable measurement, the use of controlled experiments which enable production of causality statement and able to target the right group of respondents. Besides, quantitative is a standardised and systematic approach. It produces a consistent conclusion and helps the researchers in attaining an objective conclusion, testing of hypothesis and determining the issues of causality (Goundar, 2012). The limitation of quantitative research is that due to the uniqueness of personal experience, it is a complicated task to exclude or control all the uncertainties. Besides, this validity and reliability of the research depend on the measurement instruments used for the study (Almeida, Faria and Queiros, 2017).

3.2.2 Qualitative Research

The nature of qualitative research is that only words and language are involved (Cropley, 2019). Numbers and numerical data are excluded as the main focus of this research approach is about an individual's thinking of 'how' and 'why' things happened, and the analysed data shall be able to present an in-depth picture to readers. Qualitative research is used to deal with smaller sample size as compared with quantitative research. It is highly subjective research discipline, designed to understand human behaviour such as opinions, impressions and viewpoints (Goundar, 2013).

Collection of qualitative data is separated into few types such as open-ended interviews, direct observation and written documents. The information obtained from interviews included direct quotation from interviewee about their thinking, feelings and experiences. Direct observation provides data regarding the description of program activities, target groups' behaviour and action, etc.

In addition, written documents provide data in the form of records, correspondence, official reports and open-ended surveys. The validity and reliability of collected data are depending on evaluator skill of observing and recording data.

Qualitative research is more towards descriptive and narrative approach which help evaluator to gain new insight when analysing the qualitative data. It also allows researchers to obtain a more realistic feel of the world that cannot be experienced in the numerical data and statistical analysis used in quantitative research. Besides, it is flexible to perform data collection, subsequent analysis, and interpretation of collected information (Rahman, 2016). In contrast, the generalization of this approach to a large population is not possible and the findings from this approach are dependent on the experience of interviewees which shows its lack of statistical representation (Gaille, 2017). For instance, interviewing with 10 QSs with the experiences of using BIM software in Klang Valley, and the results obtained could not represent all the QSs within Klang Valley area.

3.3 Justification of Selection

Goundar (2013) highlighted that there are two critical elements need to consider when deciding which type of research method. The first consideration is the type of data needed for the research, and the second will be the type of format used to analyse and report the research findings. In this research, large scale of data is needed as to represent the QS community. In addition, the data should be analysed in the method where the most influential criteria that affecting the satisfaction level of QS in using BIM software can be figured out. Therefore, in order to conduct this research, quantitative research approach had been selected. The objectives for this research are to identify the criteria in measuring the satisfaction level of QS when utilizing BIM software, evaluate extent of satisfaction of QS when utilizing BIM software and compare satisfaction level of QS from different nature of company in using BIM software. Once the objectives are achieved, the criteria which greatly impact the satisfaction level of QS in using BIM software are determined and improvement are made accordingly to enhance BIM software adoption within construction industry. In order to determine those criteria, a great number of respondents are needed to

measure the satisfaction level of QS in using BIM software. Therefore, quantitative approach is suitable to adopt as compared to qualitative approach.

The reason of choosing quantitative method is because quantitative method yields large scale of respondents while qualitative method only yields a small scale of respondents. If qualitative approach is adopted, the number of interviewees selected is limited which cannot represent the whole QS population as compare to quantitative research. Besides, in order to measure satisfaction level of a software used, feedback from large scale of customers or users are required. Therefore, quantitative approach is more appropriate for the purpose of fulfilling the objectives of this research through distributing questionnaires within the QS population. The results acquired can represent the whole QS population.

3.4 Research Design

According to Akhtar (2016), research design acts as the structure of research where it combines all the important elements within the research project. Research design helps to ensure all the information and data collected can be accurately and correctly addressed to the aim of the research. A good research design is when it minimizes bias and yields maximum information with minimum unnecessary information. In short, a research design is necessary as it act as a plan for the proposed research work. Figure 3.1 shows the research flow chart for this study.

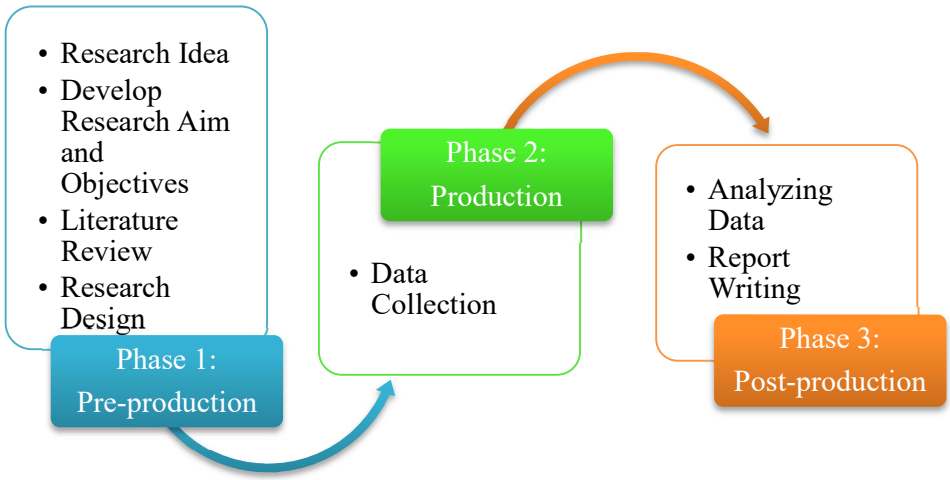

Figure 3.1: Research Flow Chart

There are three phases of research methodology process. Phase one is the pre-production phase. This is a phase where research idea is produced followed by research problem being defined and formulated. After that, research aim, and objectives are being developed. Currently, research regarding measurement of satisfaction level of QS in using BIM software is very limited. Thus, within this research, those criteria used to measure satisfaction level of QS using BIM software must be identified, QS satisfaction level in using BIM software has to be evaluated, and comparison of satisfaction level between QS from different nature of company in using BIM software must be made. Arshed and Danson (2015) highlighted that literature review is defined as a tool to educate oneself to understand the topic area and literature before forming an argument or justification. In order to present a good literature review about BIM and its software, there are various sources of information such as journals, articles, books, previous studies, etc. can be use as references. Then, research design is determined. It is a framework that related to the collection and analyzation of data. Suitable research method is decided when the forming the research design framework.

Data collection is focused on the second phase which is the production phase. Two kind of data are found, and they are defined as primary data and secondary data. For primary data, it is obtained from the distributed questionnaire and the secondary data is obtained from the previous studies. For sources of primary data, the targeted population must be properly chosen as the reliability and accuracy of data are depending on the respondents.

Lastly, the third phase is post-production phase where data analysis is conducted, analysed and then written into a report format. Relevant software or tests are chosen and applied during data analysis and the result is presented in the form of charts or graphs. Previous studies are used to strengthen and justify the result of the research. Lastly, the results are presented with the report format.

3.5 Literature Review

Bolderston (2008) mentioned that literature review helps to determine the known and unknown within the topic area, the area of controversy or debate, and assist in formulating questions that required more research. During the writing process of literature review, researchers are able to identify the principal

concepts, arguments and discussion regarding the research topic area. Literature review acts as the secondary data within a research. Therefore, the data sources of literature review play an important role as it need high reliability and accuracy level in order to produce high quality literature review.

The keywords 'BIM', 'BIM cost management software', 'construction', and 'user satisfaction' are used when searching the relevant study materials. After that, in order to effective study the materials found, skim through and filter are being done and those central to the topic are being focused. In this research, journals, articles, books and internet are being used during the data searching process. The written literature review of this research is related to BIM theories, BIM application in QS practise, BIM software implementation in various country included Malaysia, user satisfaction, criteria in measuring satisfaction level of QS in using BIM software and BIM software adoption in different nature of company.

3.6 Quantitative Data Collection

According to Kabir (2016), collection of data is a process for information gathering and measuring in an established systematic way as to respond to the research questions, test hypotheses and evaluate the outcomes. The nature of quantitative data is in 'number' and the data can be mathematically computed. There is different type of scale while measuring quantitative data such as nominal scale, ordinal scale, interval scale and ratio scale.

The collected quantitative data from survey questionnaire is categorized as the primary data. The collected data is named as the first-hand experience or data that has not been release in the public before which are more reliable, authentic and objective; and data that has not been altered by people. Thus, the primary data is way more valid compare to secondary data.

Secondary data is data collected from a published source. In any research, the writing of literature review is referring to the secondary data. Secondary data has played an important role within a research as sometimes primary data is hard to be obtained due to respondents' unwillingness to reveal it or sometimes primary data might be created by the researcher in order to ease up his data analysis work.

Survey questionnaire are adopted for this research in order to collect quantitative data as the results are easy to summarize, compare and generalize. Questions are prepared and disseminated to the targeted populations. After that, data and information obtained from the survey forms are being analysed and discuss in chapter 4.

3.6.1 Questionnaire Design

A questionnaire is a list of questions that distributed to targeted population in order to obtain their opinions regarding the research topic. In order obtain useful and relevant information, careful consideration is essential during the process of designing the questionnaire. Besides, effort and thought are required for a well-designed questionnaire and a few stages of planning must be followed such as initial consideration, follow by developing the question content, phrasing and response format, then planning for question sequencing and its layout, go through pre-test and revision, and lastly final questionnaire.

There are four different type of questionnaire designing for a survey such as contingency questions, matrix questions, closed-ended questions and open-ended question. The questionnaire is separated into two section and all of the question are prepared in closed-ended questions form. Three type of closed-ended questions are prepared which is Yes or No question, multiple choice question and scaled question.

For first section, questions regarding respondents' general background are prepared. The respondents are required to provide information about the years of working experience as QS, their position in company and which BIM software is adopted in their company. Besides, questions regarding which criteria are affecting satisfaction level of QS in using BIM software are prepared in order to accomplish the first objective of this research. Respondents are given the chance to write their opinion or alternative answer.

For section two, the prepared questionnaires are aimed to achieve objective two and three. The respondents are required to rate their satisfaction level in using BIM software based on the six criteria such as BIM features, cost for implementing BIM software, the extent of user friendly, software vendors, quality of BIM software, and the interoperability and compatibility of BIM software. The 5-points Likert scale is being utilized in this section, ranged from

very satisfied to unsatisfied. It is used to allow the respondents to express the level of satisfaction on a particular statement. A sample of survey questionnaire is appended at Appendix.

3.6.2 Sampling Determination

Due to the difficulties to measure the whole populations, the selection of which sample must be the representative of the population in order to ensure the findings from the research sample can be generalised to the huge population. The targeted respondents for this research are QSs working in contractor firm, consultant firm and developer firm within the Klang Valley area who have experiences in using BIM software. Due to the difficulties to identify QSs who have experience in using BIM software, the central limit theorem (CLT) is selected to be adopted.

Chang, Huang and Wu (2006) highlighted that application of CLT is important for some statistical applications. When the research required a large sample size, CLT enables the researcher to come out with inferences regarding the population mean. Frost (2020) mentioned that the application of CLT to a large sample size, a sample size of 30 is sufficient. According to Kwak and Kim (2017), the process of collecting all responses from the population requires a lot effort and it is nearly not possible. Therefore, to make such inferences, the population need to be categorized carefully.

In order to subset the population correctly, the purposive sampling method is being adopted in this study. Purposive sampling method is the selection of the participants for the research based on their knowledge of the related field (Etikan, Musa and Alkassim, 2016). For this research, QSs who have the experience in using BIM software and have been working in contractor firms, consultant firms and developer firms are being targeted. The combination of CLT and purposive sampling method conclude that the research needs to collect data from 30 respondents for each type of firm.

3.6.3 Questionnaire Distribution

In this research, the questionnaire is prepared by using online google form. The survey forms prepared are being distributed to the respondents through electronic mail. For contractor firm, the email addresses are obtained from the

Construction Industry Development Board (CIDB) website. Companies that are certified with G7 license are being prioritised as they tend to utilize BIM software as compared with those lower grade firm. The email addresses for consultant firms are obtained from BQSM while the email addresses for developer firms are obtained from the Real Estate and Housing Developers' Association (REHDA). The e-survey link is being distributed through email to these companies and the period of distribution is 5 weeks after the questionnaire is well prepared.

3.7 Data Analysis

Interpretation of the collection data is carried out by referring the objectives of the research. The Statistical Package for Social Science Version 23.0 Software and Microsoft Excel are used for inputting the collected data. SPSS software help to ease up the job of analysing data and keep the data within a tidy format. For instance, SPSS software can automatically arrange the data based on the user set up such as variable names, variable types, titles, etc. After that, the data are analysed with statistical analysis and the results are obtained. The methods adopted to perform data analysis for this research are Cronbach's Alpha Reliability Test, Arithmetic Mean and Kruskal-Wallis Test.

3.7.1 Cronbach's Alpha Reliability Test

The internal consistency and reliability of the data are measured using this test. Internal consistency and reliability of data must be measured before the data can be used for research as to ensure validity. Table 3.1 shows the rule of thumb for alpha result.

Table 3.1: Rule of Thumb of Cronbach's Alpha

Cronbach's Alpha	Internal Consistency
$0.9 \leq \alpha$	Excellent
$0.8 \leq \alpha < 0.9$	Good
$0.7 \leq \alpha < 0.8$	Acceptable
$0.6 \leq \alpha < 0.7$	Questionable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

(Source: Stephanie, 2014)

The results Cronbach's Alpha are ranged from zero to one. Based on Table 3.1, the greater the Cronbach's Alpha, the higher the internal consistency. When the result is above 0.7, it is considered good enough and it is proven from the Likert scale that the data is dependable.

3.7.2 Arithmetic Mean

One of the various kinds method to evaluate the central tendency of data is the arithmetic mean. Manikandan (2011) mentioned that central tendency is the statistical measure that use a single value to represent the entire distribution. In short, it is the average value. All the collected data set are used to calculate the mean value, so, this is a good and effective method to let a single value representing all the research data. The repeated samples collected from the same population produce the same mean value. Therefore, fluctuation between different samples are avoided by using the arithmetic mean method. The arithmetic mean formula is:

$$\bar{x} = \frac{\sum x}{n}$$

Where,

$\bar{x}$ = mean of an item

$\sum x$ = sum of an item

n = total number of observations

In this research, the mean represented every single criterion that is making impact on the extent of satisfaction of QS when utilizing BIM software while the sum of an item represents the score for each criterion. The Likert scale for this research ranged from 1 to 5 which is from 'unsatisfied' to 'very satisfied'. The mean value is used to determine the satisfaction level of QSs as which criteria they evaluate satisfied or dissatisfied. The highest mean value represented as satisfied while lowest represented dissatisfied. For instance, the criteria with the greatest mean value is representing the most satisfied criteria when QSs use BIM software.

3.7.3 Kruskal-Wallis Test

The Kruskal-Wallis test is used to determine whether there have significant differences between two or more groups of independent variables on ordinal or continuous dependent variables. Besides, the evaluation of the graded scores for every sample together with the mean of is performed using this test. The calculation of H-value is based on this formula:

$$H = \left[\frac{12}{n_T\,(n_T+1)}\sum_{i-1}^{k}\frac{R_i^2}{n_i}\right]$$

Where,

K = number of attributes samples

n_i = number of responses in sample i

n_T = total number of responses in all sample

R_i = sum of ranks for sample

After calculated the H-value, it is used to do comparison with critical chi-square value. In case the H-value is lesser compared to critical chi-square value, then H_0 is considered failed to reject. In contrast, in case the H-value is higher compared to the critical chi-square value, then acceptance is made on the alternative hypothesis. The critical chi-square value is obtainable based on the degree of freedom and alpha value (p). Table 3.2 shows the chi-square table. In this research, Kruskal-Wallis test is adopted to determine the present of any

significance difference of QS from different nature of company towards their satisfaction level of using BIM software.

For the purpose of detecting the significance difference among the groups, two hypotheses are formed for this study as follows:

- H_0 (null hypothesis): There is no significant difference in satisfaction level of using BIM software between different natures of QSs companies.
- H_1 (alternative hypothesis): There is a significant difference in satisfaction level of using BIM software between different natures of QSs companies.

Table 3.2: Chi-Square Table

Degree of Freedom	P-value			
	0.10	0.05	0.025	0.01
1	2.706	3.841	5.024	6.635
2	4.605	5.991	7.378	9.210
3	6.251	7.815	9.348	11.345
4	7.779	9.488	11.143	13.277
5	9.236	11.070	12.832	15.086
6	10.645	12.592	14.449	16.812

(Source: Vaughan, 2009)

3.8 Summary of Chapter

Quantitative research approach is adopted for this research. Questionnaire survey is prepared, and literature review is written based on previous studies. The questionnaire survey is distributed through electronic mail. Data analysis is performing by utilizing the Cronbach's Alpha Reliability Test, Arithmetic Mean and Kruskal-Wallis Test.

CHAPTER 4

RESULT AND DISCUSSIONS

4.1 Introduction

This chapter discusses the analysed results obtained from the respondents and presented the discussion regarding the findings. There are three main parts within this chapter. The first part emphasized on the respondents' rate while the second part summarized the general information of the respondents. The analysed data such as the results of the evaluation of satisfaction level of QS in using BIM software and the comparison of satisfaction level between QSs from different nature of companies in using BIM software.

4.2 Response Rate

A total of 160 sets of questionnaires had been distributed during the process of data collection. All of the questionnaires were distributed through electronic mail in the form of Google form as the social media channel was chosen which can convenient the researcher to collect data. A total of 105 responses was collected from 160 sets of questionnaires that had been distributed. However, there is only 97 responses are analyzed as 8 respondents mentioned that they had no experiences in using BIM software. Thus, the survey response rate for this study was 60.63% and have been summarized in the table 4.1.

Table 4.1: Questionnaire Response Rate

	Total number of questionnaires distributed, n	Total number of responded questionnaire, n	Response rate, %
Google Form	160	97	60.63

4.3 Respondent's General Background

The general background information of the respondents is analysed in this section which are the information of nature of QS Company, respondent's job position in the company, year of working experience in construction industry are discussed. Table 4.3 illustrated the demographic profile of the respondents.

Table 4.2: Demographic Profile

Demographics Data	Categories	*n*	%
Nature of QS Company	Contractor Firm	32	33.0
	Consultant Firm	34	35.1
	Developer Firm	31	32.0
Respondent's Job Position in the Company	Director	1	1.0
	Technical Director	3	3.1
	Contract Manager	13	13.4
	Contract Executive	27	27.8
	Assistant Quantity Surveyor	38	39.2
	Team Leader	5	5.2
	BIM Coordinator	1	1.0
	Project Manager	4	4.1
	Project Executive	5	5.2
Year of Working Experience in Construction Industry	Less than 6 years	57	58.8
	6 – 10 years	23	23.7
	11 – 15 years	10	10.3
	16 – 20 years	5	5.2
	More than 20 years	2	2.1

Based on Table 4.2, 34 respondents were from consultant firm, 32 respondents were from contractor firm while 31 respondents were from developer firm.

Regarding the job position of respondents in their company, majority of the respondents (38 respondents) are assistant quantity surveyor. There are 27

respondents are contract executive, 13 respondents are contract manager while only 1 respondent each response as director and BIM coordinator.

In term of year of experiences, 57 respondents are having less than 6 years of working experience in construction industry, 23 respondents are having 6 to 10 years of working experience and only 2 respondents have 20 years in construction industry.

4.4 Respondents' BIM Software Background

The respondents' experience in using BIM software are analysed and discussed. Table 4.3 displayed the respondents' experience in using BIM software.

Table 4.3: Respondents' BIM Software Background

BIM Software Background	Categories	*n*	%
Type of BIM Software Used in Respondent's Company	Glodon Cubicost	82	84.5
	CostX	36	37.1
	Autodesk Revit	23	23.7
	Autodesk Navisworks	19	19.6
Duration in Using BIM Software	Less than 2 years	44	45.4
	2 – 4 years	41	42.3
	5 – 7 years	11	11.3
	8 – 10 years	0	0
	More than 10 years	1	1.0
Type of Task Carried Out by Using BIM Software	Measurement / Take Off	82	84.5
	Prepare Bill of Quantity	70	72.2
	Estimating	68	70.1
	Monitor the Work Progress	49	50.5
	Prepare Cost Appraisal	41	42.3
	Resource Coordination	26	26.8
	Schedule Planning	25	25.8

Table 4.3 (continued)

	Design Assessment	14	14.4
Criteria for Selecting BIM Software	The Features Provided by the BIM Software	88	90.7
	The Quality of the BIM Software	83	85.6
	Whether the BIM Software is User Friendly	79	81.4
	The Cost of Investing in the Current BIM Software	51	52.6
	The Extent of Interoperability and Compatibility of the BIM Software	47	48.5
	The Assistance Acquired from the Software Vendors	43	44.3

Various types of BIM software were used in different companies which are Glodon Cubicost, Autodesk Navisworks, Autodesk Revit and CostX. Some companies were using more than one type of the BIM software. A total of 84.5% of respondents claimed that their company are using Glodon Cubicost, while 37.1% of respondents responded that their company are using CostX. This finding is in accordance with Ismail, Adnan and Bakhary (2019) highlighted that Cubicost which developed by Glodon is being adopted widely in Malaysia followed by CostX as the second widest adopted BIM software in Malaysia.

For the duration in using BIM software, 45.4% of respondents stated that they were using BIM software for less than 2 years. 42.3% of respondents claimed that they were using BIM software for 2 to 4 years. These data showed that BIM software is still on the track of entering Malaysia construction market as currently, a lot of QS had only get exposed to BIM software for not more than 5 years.

Respondents were using BIM software to carry out different tasks which assigned by their company. 84.5% of the respondents were using BIM software in completing task of measurement or take off. It followed by 72.2% of respondents were using BIM software to prepare bill of quantity while 70.1%

of respondents were doing task of estimating by using BIM software. It shows that most of the respondents who adopted Glodon Cubicost and CostX are utilizing them to perform QS's task. According to Loh (2018), Glodon Cubicost is a tool that being accepted worldwide for performing QS duty such as measurement or take off, prepare BQ and estimating.

Different criteria are taken into consideration by the respondents to select the use of BIM software. Most of the respondent (90.7% of respondents) claimed that features of BIM software were the most importance criteria. On the other hand, 85.6% of the respondents stated that they focused on the quality of BIM software. The consideration regarding the assistance acquired from the software vendors is the least selected consideration by the respondents.

4.5 Cronbach's Alpha Reliability Coefficient

Cronbach's Alpha Reliability Coefficient was carried out to test the reliability of this study. A total number of 97 respondents were taking part to give response on the questionnaire in this survey. The result is shown in the table 4.4.

Table 4.4: Reliability Statistics of Measurement of Satisfaction Level Towards the QS in Using BIM Software

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.819	0.822	19

Table 4.4 illustrates the Cronbach's Alpha value for the 19 items in measuring the satisfaction level towards quantity surveyor in using BIM software is 0.819 which is lies between the range of $0.9 > a \geq 0.8$. Thus, the result is considered good in reliability in term of internal consistency and shall be accepted.

4.6 Satisfaction Level of QS in Using BIM Software

The objective of this study is to evaluate the satisfaction level of quantity surveyor in using BIM software. In this section, respondents need to rate their satisfaction level towards the six criteria in using BIM software.

4.6.1 Mean Ranking

The mean values obtained from the overall rating scale ranked by respondents in a manner of proposing their level of satisfaction towards the utilization of BIM software.

4.6.2 Main Criteria that Affect the Satisfaction Level of QS in Using BIM Software

Table 4.5 tabulates the data into the result in the form of mean value which emphasized on the main criteria that affect the satisfaction level of QS in using BIM software. The highest overall mean value of 4.48 recorded by respondents which they were satisfied with the features provided by BIM software. Software quality ranked the second with the overall mean value of 4.34. The lowest mean ranking is cost category with mean value of 3.50. Apart from overall mean ranking, the satisfaction level of QS from contractor firm, consultant firm and developer firm in using BIM software are also being evaluated and analysed. For contractor firm and developer firm, the most satisfied main criteria are same with the overall satisfied criteria while the consultant firm is more satisfied with the software quality. Furthermore, the QSs from contractor firm have ranked software quality as the second most satisfied criteria which is also similar with ranking of overall satisfied criteria while interoperability and compatibility of BIM software is rated as top two by QSs in developer firm. For consultant firm, the second most satisfied criterion is the features provided in BIM software. On the other hand, software vendor and cost have brought the least satisfaction to all type of companies.

Pursuant to Ives, Olson and Baroudi (1983), user satisfaction is a measurement of the extent to which users believe the goods or services acquired are able to fulfil their expectation. Out of the six main criteria, BIM software features had met the nearest expectation of the QS in using BIM software as there are various type of features provided and the function of all features are designated to assist QS to fulfil their duty of work. Thus, most of them are satisfied with it.

Besides, respondents are also satisfied with the software quality as currently, most of the embedded libraries in BIM software are able to show semantic information to the operators and provided the documentation support

such as allow the exportation of estimated quantities in Glodon Cubicost into Microsoft Excel and BQ template. Yang et al. (2013) highlighted that the embedded libraries in BIM software shall be able to show semantic information to the operators and fulfilling this feature signified that there is certain level of quality in the BIM software.

Based on Table 4.5, the software vendor is rated as the second lowest satisfied criteria by majority of the respondents with the mean value of 3.66. This signified that this criterion does not fulfil the expectation of purchaser and improvement should be made. During the purchasing process of BIM software, purchaser would prioritize those vendors who provide the most beneficial supports. Besides, it is signified by Yung and Yung (2009), the satisfaction level of purchaser is depending on the availability of readily assistance from vendors as vendors' responsiveness may affect the satisfaction level. In addition, the quality of supports or services from vendors is also being considered and it is highlighted by Kulli (2017) that bad customer services provided by vendors would actually chase away customers.

The satisfaction level toward the cost of BIM software is the lowest with the mean value of 3.50. Hoffer (2016) highlighted that there are three types of BIM investment which included the start-up cost, costs to tailor BIM to a project and the maintenance cost. In term of satisfaction level, the cost of investing BIM software is unable to par with the expectation of purchaser. It is emphasized by Yaakob et al. (2018) that implementing BIM software is costly as it required large investment cost in updating software and hardware, staff training, changing of workflow and procedure and it is highlighted that investors would only purchase BIM software if long term benefits is perceived.

Table 4.5: Mean Ranking of Main Criteria for Evaluating Satisfaction Level of QS in Using BIM Software

		Overall		Contractor Firm		Consultant Firm		Developer Firm	
Code	Main criteria	Mean	Ranking	Mean	Ranking	Mean	Ranking	Mean	Ranking
A	BIM Software Features	4.48	1	4.60	1	4.05	2	4.83	1
E	Software Quality	4.34	2	4.35	2	4.12	1	4.58	3
C	User Friendly	4.23	3	4.34	3	3.98	3	4.38	4
F	Interoperability and Compatibility	4.19	4	4.19	4	3.78	4	4.63	2
D	Software Vendor	3.66	5	3.61	5	3.52	5	3.86	5
B	Cost	3.50	6	3.58	6	3.32	6	3.60	6

4.6.3 Sub-criteria that Affect the Satisfaction Level of QS in Using BIM Software

Table 4.6: Mean Ranking of Sub-criteria for Evaluating Satisfaction Level of QS in Using BIM Software

		Overall		Contractor Firm		Consultant Firm		Developer Firm	
Code	Sub-criteria	Mean	Ranking	Mean	Ranking	Mean	Ranking	Mean	Ranking
A1	Usage for wide scope of work	4.56	1	4.78	1	4.12	3	4.81	2
A3	Information produced with high precision level	4.49	2	4.56	2	4.09	6	4.87	1
A2	Simplifier QS work	4.39	3	4.47	4	3.94	9	4.81	2
E1	Various and complete library	4.38	4	4.38	5	4.26	1	4.52	8
E2	Smart Object	4.35	5	4.31	9	4.12	3	4.65	4
C1	Simple and easy to use	4.33	6	4.34	7	4.24	2	4.42	11
E3	Enable self-adding of new library contents	4.33	6	4.38	5	4.12	3	4.52	8
E4	Documentation support	4.30	8	4.34	7	3.97	8	4.61	6
C2	Shareable information with high reliability	4.29	9	4.50	3	3.91	10	4.48	10
C4	Complete software	4.25	10	4.28	10	4.09	6	4.39	12
F1	Easy to exchange data	4.25	10	4.22	12	3.91	10	4.65	4

Table 4.6 (continued)

F2	Able to compatible with data produced in different format	4.12	12	4.16	13	3.65	13	4.61	6
C3	Understandable software manual and tutorial	4.04	13	4.25	11	3.68	12	4.23	13
D1	Warranty	3.84	14	3.78	14	3.56	14	4.19	14
B1	Initial cost	3.60	15	3.50	19	3.32	18	4.00	15
D3	Post-sales follow up programme	3.59	16	3.53	17	3.50	15	3.74	16
D2	Provision of new purchaser training	3.56	17	3.53	17	3.50	15	3.65	17
B3	Maintenance cost	3.46	18	3.59	16	3.41	17	3.39	18
B2	Staff training investment cost	3.43	19	3.66	15	3.24	19	3.42	19

Table 4.6 illustrates the measurement of satisfaction level towards the sub-criteria that affect the satisfaction level of QS in using BIM software. The main criteria A which is the BIM software features is the most impactful criteria and it consist of 3 sub-criteria which is A1 = "Usage for wide scope of works", A2 = "Simplifier QS work", and A3 = "Information produced with high precision level". From these three sub-criteria, A1 has scored the highest mean value of 4.56 and also the highest overall scoring among other sub-criteria. Besides, this sub-criterion also scored the highest mean score of 4.78 for QS who working in contractor firm. There are a lot of tasks need to be performed by QS in contractor firm such as measurement, preparing bill of quantities, estimating, cost appraisal, etc. According to Gray et al. (2013), the usage of BIM modelling can vary through wide scope of work and users are expecting the fully utilization of BIM modelling able to assist them to perform wide scope of work. Therefore, QS in contractor firm would feel satisfied if the adopted BIM software is able to perform 'one software, multiple usage' as they are expecting the BIM software able to assist to complete various task and increase their work efficiency. For consultant firm and developer firm, the A1 sub-criteria also have scored quite high level of satisfaction level which is 4.12 and 4.81 respectively and these two scores is in top 3 in consultant firm and top 2 in developer firm.

Besides that, the sub-criteria A3 is ranked as the top 2 (mean value = 4.49) for overall scoring among other sub-criteria. In addition, QSs in developer firm have rated it as the most satisfied criteria with a mean score of 4.87 as QSs in developer firm need to perform feasibility study before the commencement of a project, so, the precision level of the produced information is the key factor for them to rate their satisfaction level toward the adopted BIM software. For contractor firm, this sub-criterion is placed as the top 2 while for consultant firm, it is rated as the top 6 of the satisfied sub-criteria. QSs in contractor firm are in charge for resource coordination based on construction plan and schedule while QSs in consultant firm are in charge for validation and monitoring the project cost and their duties are depending on the precision level of data generated. Therefore, the higher the precision level of information produced, the higher the satisfaction level they would rate for the adopted BIM software.

Based on table 4.5, the top 2 highest of main criterion is the criterion E ("Software Quality") and its sub-criteria consist of E1 = "Various and complete

library", E2 = "Smart object", E3 = "Enable self-adding of new library contents" and E4 = "Documentation support". The criterion E1 is ranked as the top 4 overall sub-criteria while rated as top 1 by QSs in consultant firm which contained mean value of 4.26. Besides that, E1 is also placed at top 5 by QSs in contractor firm and top 8 in developer firm. The mean values are above 4 which signified that QSs in contractor firm and developer firm are satisfied with this sub-criterion. Within BIM software, the libraries are essential, and each type of BIM software consist of different attributes. The BIM software licence purchasers are buying them based on their needs. As highlighted by Yang et al. (2013), the embedded libraries shall be able to show semantic information to the operators. QSs that work in consultant firm are required to prepare pre-tender estimate (PTE) and BQ which is depending on the semantic information in the embedded libraries to increase their efficiency and quality of work. Thus, BIM software that provide various and complete library tend to satisfy the QSs who working in consultant firm more as compare to contractor firm and developer firm.

The third highest ranked of main criteria is criteria C ("User Friendly") and its sub-criteria is C1 = "Simple and easy to use", C2 = "Shareable information with high reliability", C3 = "Understandable software manual and tutorial" and C4 = "Complete software". The sub-criterion C1 is rated as top 6 among the overall sub-criteria as tabulated in Table 4.6. As mentioned by Loh (2018), the highlighted term of developing a software is that it must be achieve minimum difficulties when using it. QSs in consultant firm rated this sub-criterion as top 2 which signified that they are satisfied with the simplicity and easiness of the usage of BIM software. There are a lot of fresh graduate QS tends to enter consultant firm in order to learn contractual knowledge and acquired basic knowledge of BIM software. Therefore, the characteristic of simple and easy to use of BIM software is important for new user to adapt to it.

Based on Table 4.6, criteria D ("Software Vendor") is rated as the second lowest main criteria and its sub-criteria include D1 = "Warranty", D2 = "Provision of new purchaser training" and D3 = "Post sales follow-up programme". The result stated that D2 is the least satisfied sub-criterion as compared to the other two sub-criteria. According to Latiffi, Mohamad and Rakiman (2016), proper training and guideline provided by software vendors is

one of the crucial factors to secure the benefits of implementing BIM software can be successfully attained by the users. Thus, the satisfaction level of BIM user is dependent on the services provided by the software vendors. However, most of the respondents are dissatisfied on this criterion.

The lowest ranked of main criteria is criteria B ("Cost") and it consists of 3 sub-criteria which is B1 = "Initial cost", B2 = "Staff training investment cost" and B3 = "Maintenance cost". Among the 19 sub-criteria, B2 is the most not satisfied sub-criteria with mean score of 3.43 and similarly to the consultant firm and developer firm who also rated it the lowest satisfaction level. On the other hand, QSs in contractor firm has rate B1 as the least satisfied sub-criterion. This signified that the cost for implementing BIM software is too high. This statement is highlighted by Yaakob et al. (2008), and Latiffi, Mohamad and Rakiman (2016) that the implementation of BIM software which consist of initial purchasing cost, software and hardware upgrading cost, staff training cost and cost of changing workflow and procedure is too high and mostly only large organization can afford it. As a result, majority of the respondents are not satisfied in term of cost of the software.

4.7 Kruskal-Wallis Test

In this study, Kruskal-Wallis test is being conducted to examine whether there has significant difference in satisfaction level of using BIM software between different natures of QS companies. The p-value for this test is 0.05 and the calculation of the degree of freedom (df) is by subtracting the number of groups by one. Chi-Square table (Vaughan, 2009) is used to determine the critical value as shown in Table 4.7. Two hypotheses are defined in order to detect the existence of significant difference of QS from different nature of company towards their satisfaction level of using BIM software. The hypotheses are defined as follow:

- H_0 (null hypothesis): There is no significant difference in satisfaction level of using BIM software between different natures of QSs companies.
- H_1 (alternative hypothesis): There is a significant difference in satisfaction level of using BIM software between different natures of QSs companies.

Table 4.7: Chi-Square Table

Degree of Freedom	P-value			
	0.10	0.05	0.025	0.01
1	2.706	3.841	5.024	6.635
2	4.605	5.991	7.378	9.210
3	6.251	7.815	9.348	11.345
4	7.779	9.488	11.143	13.277
5	9.236	11.070	12.832	15.086
6	10.645	12.592	14.449	16.812

(Source: Vaughan, 2009)

4.7.1 Kruskal-Wallis Test on Different Nature of QS Companies

There are three different types of QS company which are “Contractor firm”, “Consultant firm” and “Developer firm”. P-value of 0.05 is used and the degree of freedom (df) is the number of different type of QS company deduct by one and based on the Table 4.7, the critical value is equal to 5.991. Hence, when H value is less than 5.991, there will be no significant difference in satisfaction level of using BIM software between different natures of QSs companies, vice versa. Table 4.8 illustrated the result of Kruskal-Wallis test for different nature of QS companies toward the satisfaction level of using BIM software. It is proven that there is significant difference in satisfaction level of using BIM software between different natures of QSs companies.

Table 4.8: Results of Kruskal-Wallis Test

Code	Chi-Square	Asymp. Sig.
A: BIM Software Features		
A1	**9.621**	**0.008***
A2	**21.146**	**0***
A3	**19.937**	**0***
B: Cost		
B1	**10.143**	**0.006***
B2	4.031	0.133

Table 4.8 (continued)

B3	1.800	0.407
C: User Friendly		
C1	0.643	0.725
C2	**9.759**	**0.008***
C3	**6.929**	**0.031***
C4	1.203	0.548
D: Software Vendor		
D1	**9.611**	**0.008***
D2	0.691	0.708
D3	1.769	0.413
E: Software Quality		
E1	1.571	0.456
E2	**7.166**	**0.028***
E3	4.339	0.114
E4	**11.158**	**0.004***
F: Interoperability and Compatibility		
F1	**13.686**	**0.001***
F2	**16.938**	**0***

Note: * specify the significant value, $p<0.05$

The total amount sub-criteria that are having chi-square value exceed the critical value of 5.991 is 11. This signified that the null hypothesis, H_0 is rejected by the 11 sub-criteria which included A1 = "Usage for wide scope of work", A2 = "Simplifier QS work", A3 = "Information produced with high precision level", B1 = "Initial cost", C2 = "Shareable information with high reliability", C3 = "Understandable software manual and tutorial", D1 = "Warranty", E2 = "Smart Object", E4 = "Documentation support", F1 = "Easy to exchange data", and F2 = "Able to compatible with data produced in different format". In brief, every main criterion has shown that there is a significant different in satisfaction level of using BIM software between different nature of QSs companies.

Table 4.9: Mean Ranking of QSs from Different Nature of Companies Rated Their Satisfaction Level of Using BIM Software

Code	Sub-criteria	Nature of Company	N	Mean Rank
A1	Usage for wide scope of work	Contractor Firm	32	53.66
		Consultant Firm	34	39.34
		Developer Firm	31	54.79
A2	Simplifier QS work	Contractor Firm	32	48.56
		Consultant Firm	34	35.65
		Developer Firm	31	64.10
A3	Information produced with high precision level	Contractor Firm	32	49.09
		Consultant Firm	34	36.03
		Developer Firm	31	63.13
B1	Initial cost	Contractor Firm	32	46.72
		Consultant Firm	34	40.29
		Developer Firm	31	60.90
C2	Shareable information with high reliability	Contractor Firm	32	54.94
		Consultant Firm	34	38.00
		Developer Firm	31	54.94
C3	Understandable software manual and tutorial	Contractor Firm	32	53.91
		Consultant Firm	34	39.72
		Developer Firm	31	54.11
D1	Warranty	Contractor Firm	32	47.45
		Consultant Firm	34	40.34
		Developer Firm	31	60.10
E2	Smart Object	Contractor Firm	32	44.39
		Consultant Firm	34	44.18
		Developer Firm	31	59.05

Table 4.9 (continued)

E4	Documentation support	Contractor Firm	32	49.38
		Consultant Firm	34	38.71
		Developer Firm	31	59.90
F1	Easy to exchange data	Contractor Firm	32	47.28
		Consultant Firm	34	38.54
		Developer Firm	31	62.24
F2	Able to compatible with data produced in different format	Contractor Firm	32	47.44
		Consultant Firm	34	37.06
		Developer Firm	31	63.71

Based on Table 4.9, it highlighted that QSs from developer firm have the higher mean rank for all the 11 sub-criteria as compared to contractor firm and consultant firm. In term of BIM software features, all the sub-criteria are included as the category of rejecting null hypothesis, H_0. This signified that QSs in developer firm are more satisfied with this main criterion A ("BIM Software Features") as they are required to manage projects from the starting stage of projects which is pre-tender stage until the end of projects which included post contract activities. Therefore, utilizing BIM software would assist them by providing handy features which enable the usage of BIM software for various type of job while simplifier their tasks and producing high precision level of information.

Besides, QSs in developer firm tend to more satisfied with the sub-criterion B1 ("Initial cost") with mean rank of 60.90 than QSs in contractor and consultant firm. By implementing BIM software, it required high initial cost and mostly only large organization can afford (Yaakob et al., 2008, Latiffi, Mohamad and Rakiman, 2016). As an investor, developer firm especially big established firms are more willing to invest their money in software usage in order to perceive the long-term benefits from BIM software usage. Hence, they are more satisfied with the initial cost of BIM software as compared to other natures of companies.

Within main criterion C ("User Friendly"), the sub-criteria C2 ("Shareable information with high reliability") and C3 ("Understandable software manual

and tutorial") have accepted the alternative hypothesis, H_1. For sub-criterion C2, contractor firm and developer firm have scored similar mean rank, which is 54.94 while for sub-criterion C3, developer firm achieved higher mean rank (54.11) than contractor and consultant firm. QSs in developer firm and contractor firm are relying on shareable information with high reliability to carry out their dy. On behalf of QSs in consultant firm, their working style required them to work under imminent deadline which is set by the client. In addition, they should be providing wider specialist QS services (Mbachu, 2015). During tendering stage of a project, consultant QS need to prepare pre-tender estimate (PTE) and BQ within limited time while the occurrence of changes of design required them to inform and discuss with relevant parties immediately before proceeding to documentation tasks. Hence, QSs in consultant firm has limited time for exploring the BIM software manual and tutorial as compared to QSs in developer firm and this symbolized that they do not perceive sub-criteria C3 as user friendly.

Furthermore, the sub-criterion D1 ("Warranty") provided by the software vendor has attained the highest mean rank (60.10) from QSs in developer firm. Warranty is essential for every goods or services as it acted as a protection to the purchaser. Every type of software has their own kind bug and sometimes, even the creator or technical team members could not figure it out. One of the strategic goals needed to be achieved by QSs in developer firm is satisfying the end-users by minimizing the life-cycle cost of the development (Lilavivat, 2013). The intention of developer firm adopting BIM software is for managing the whole life cycle of the projects unlike contractor firm and consultant firm who only use BIM software to manage projects for certain period. Thus, warranty is perceived as the necessary service provided by software vendor.

Besides that, two of the sub-criteria (E2 = "Smart object" and E4 = "Documentation support") from main criteria E ("Software Quality") has rejected the null hypothesis, H_0. The highest mean rank of 59.05 and 59.90 is obtained from the responses from QSs in developer firm. In order to perform auto-quantification and documentation support by utilizing building information model, QSs in consultant firm are required to model the architectural and structural CAD drawing into building information model which indicated that the frequency of consultant QSs of using BIM software for

measurement and documentation are more than developer firm's QSs (Soon et al., 2017). Therefore, the smart object and documentation support of BIM software tends to assist more towards QSs in developer firm perhaps they are unfamiliar with this kind of specialist QS duties.

The main criteria F ("Interoperability and Compatibility") has shown rejection to the null hypothesis, H_0. Sub-criteria F1 ("Easy to exchange data") and F2 ("Able to compatible with data produced in different format") are rated highest by QSs in developer firm. This indicated that respondents from developer firm are paying more attention in how easily the data can be transfer to others and whether the data from different file format can be compatible with current BIM software. These two considerations are not crucial for QSs in consultant firm as they are loaded with various types of information and the information received from relevant parties might be difficult to convert. In addition, some relevant parties are not be adopting BIM software or different type of BIM software is adopted. Thus, this main criterion F is providing high level of convenience to QSs in developer firm as they are receiving those done processing and converted information from the consultant QSs.

4.8 Framework of Criteria That Affect Satisfaction Level of Quantity Surveyors Using BIM Software

Figure 4.1 illustrated the framework of criteria that affecting the satisfaction level of QS from different nature of company in using BIM software. The six main criteria are arranged accordingly which is from the most satisfied criteria (A = "BIM Software Features") to the least satisfied criteria (B = "Cost"). The sub-criteria are also arranged horizontally which is from the left side (most satisfied sub-criteria) to the right side (least satisfied sub-criteria) based on the overall mean rank. Due to different natures of companies consist of different job scope, there are different ranking of satisfaction level in using BIM software which rated by QSs from different natures of companies such as contractor firms, consultant firms and developer firms. The QSs from contractor firm have ranked the main criterion E ("Software Quality) as the second, but it is ranked as top one by QSs in consultant firm and QSs from developer firm considered it as the third satisfied main criterion. The results are tabulated in Table 4.5 and Table 4.6 while the framework is arranged based on the overall mean rank.

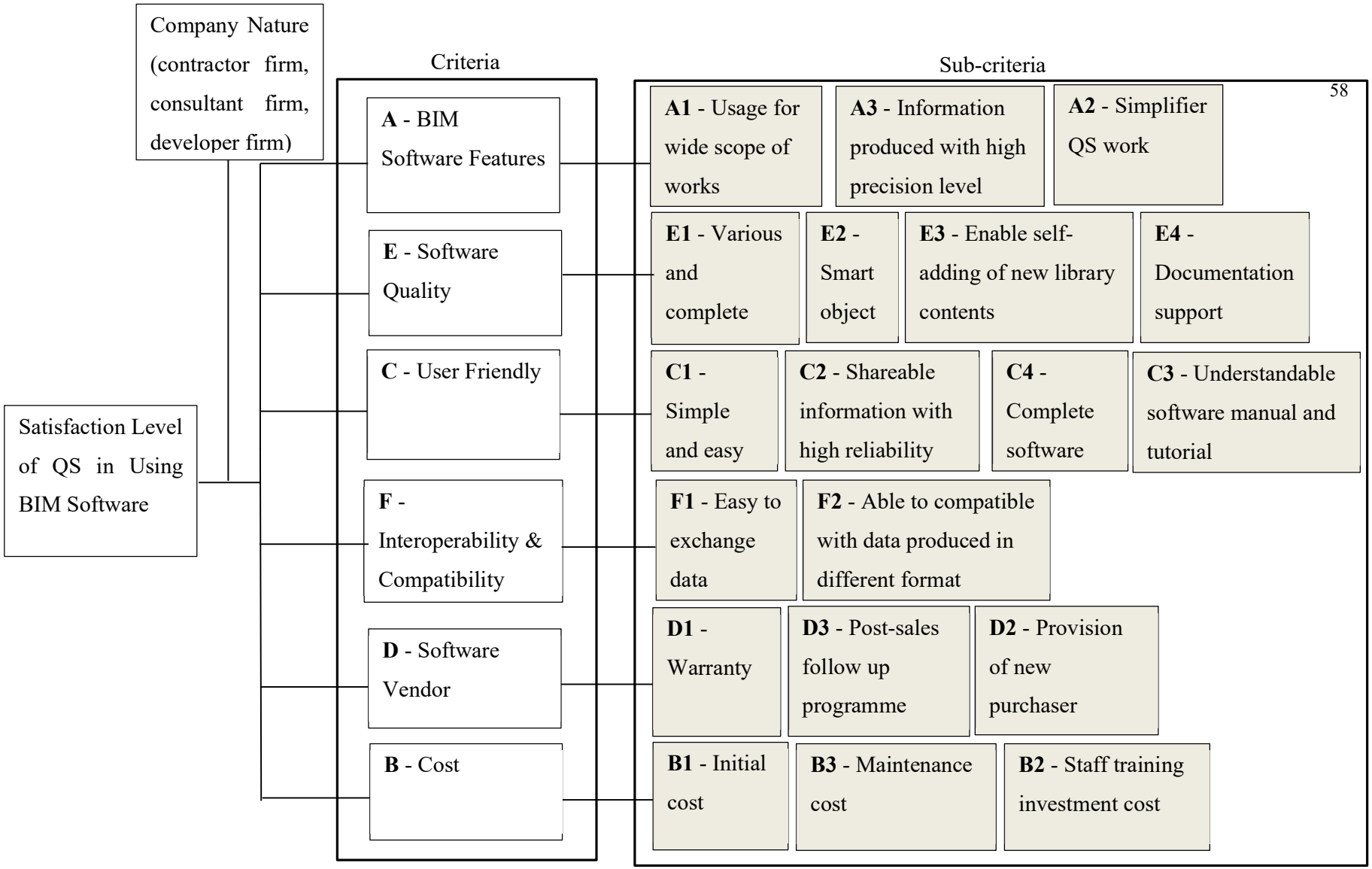

Figure 4.1: Criteria Affecting Satisfaction Level of QS in Using BIM Software

4.9 Summary of Chapter

In this chapter, the results for the criteria that affecting satisfaction of QS in using BIM software are explained detailly. Total of 97 responses are collected, and the data are analysed by using three statistical method which is Cronbach's Alpha Reliability Coefficient, Arithmetic Mean and Kruskal-Wallis Test.

In addition, the demographic data of respondents are discussed and tabulated in Section A while the discussion of respondents' BIM software background are located at Section B. In section C, Cronbach's Alpha value is acquired, and it show good reliability as within the internal consistency. This indicated that the outcome is acceptable.

The Arithmetic mean is being utilized and the ranking of main criteria and sub-criteria that affecting the satisfaction level of QS in using BIM software is arranged. Besides, the framework regarding the criteria that affecting satisfaction level of QS in using BIM is refined and sequenced from the highest mean to the lowest mean. In addition, the mean obtained for contractor firm, consultant firm and developer firm are also written in the framework.

Kruskal-Wallis test was conducted to figure out whether there is a significant difference in satisfaction level of using BIM software between different nature of QSs companies. The results signified that among 19 sub-criteria, 11 sub-criteria had accepted the alternative hypothesis, H_1 while the remaining accepted the null hypothesis, H_0. The findings of this test is tabulated and discussed in Section E.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter has summarized the whole research. At first section, the chapter summaries for each chapter is discussed and the findings and results of this research are concluded according to the research aim and research objectives. In addition, the limitation of this conducted research is being emphasized and recommendations are suggested for the improvement to be done in the future similar research topics. Besides, the discussion on the significance of this research to the society is being summarized in this chapter.

5.2 Accomplishment of Research Objectives

In Malaysia, the implementation of BIM technology is still growing. For this research, the problem statement is stated that the user satisfaction in using BIM software is less emphasized from previous studies especially for quantity surveyors (QSs). A lot of researches which conducted previously were focusing on benefits and barriers of BIM usage, challenges of implementing BIM, adoption rate of BIM, and implementation of BIM on different type of building work. Therefore, this research is conducted to evaluate the satisfaction level of QS in using BIM software.

The research aim of this study is to seek to evaluate the satisfaction level of QSs in using BIM software as to improve BIM adoption in the construction industry. Three research objectives need to be achieved which is to identify the criteria in measuring the satisfaction level of QS in using BIM software, evaluate the satisfaction level of QS when using BIM software and do comparison on the satisfaction level of QS from different nature of company in using BIM software. The accomplishment of each objectives is discussed in details in the next section.

5.2.1 Objective 1: To Identify the Criteria in Measuring the Satisfaction Level of Quantity Surveyors in Using BIM Software

First research objective is achieved by gathering and reviewing the secondary sources of information which relevant to the criteria that affecting the satisfaction level of QSs in using BIM software. Journal, articles, report, and internet are the source of information to identify those criteria. A total of 6 criteria is identified after reviewing previous researches which are BIM software features, cost, user friendly, software vendor, software quality, and interoperability and compatibility. Besides, every main criterion consists of a few sub-criteria which are used to evaluate the satisfaction level of QSs from different natures of company in using BIM software. Table 5.1 tabulated the main criteria and sub-criteria to evaluate satisfaction level of using BIM software which are extracted out from the literature reviews.

Table 5.1: List of Main criteria and Sub-criteria to Evaluate Satisfaction Level of Using BIM Software

Main Criteria	Sub-criteria
A) Software BIM Features	A1) Usage for wide scope of work A2) Simplifier QS work A3) Information produced with high precision level
B) Cost	B1) Initial cost B2) Staff training investment cost B3) Staff training investment cost
C) User Friendly	C1) Simple and easy to use C2) Shareable information with high reliability C3) Understandable software manual and tutorial C4) Complete software
D) Software Vendor	D1) Warranty D2) Provision of new purchaser training D3) Post-sales follow up programme

Table 5.1 (continued)

E) Software Quality	E1) Various and complete library E2) Smart Object E3) Enable self-adding of new library contents E4) Documentation support
F) Interoperability and Compatibility	F1) Easy to exchange data F2) Able to compatible with data produced in different format

5.2.2 Objective 2: To Evaluate the Satisfaction Level of Quantity Surveyors in Using BIM Software

The second objective was achieved by questionnaire survey collection and interpreting data based on rating of the satisfaction level of QS in using BIM software. After collecting data, arithmetic mean test was conducted to evaluate the ranking of mean value of main criteria and sub-criteria. From overall perception, the top three main criteria that the respondents were satisfied are "BIM software features", "software quality" and "user friendly" while the least satisfied main criteria are the "software vendor" and "cost" of BIM software. On the other hand, among the 19 sub-criteria, the three highest rated sub-criteria that the respondents were satisfied are "usage for wide scope of work", "information produced with high precision level" and "simplifier QS work". Three lowest rated sub-criteria that the respondents were not satisfied are "provision of new purchaser training", "maintenance cost", and "staff training investment cost".

5.2.3 Objective 3: To Compare Satisfaction Level of Quantity Surveyors from Different Nature of Companies in Using BIM Software

In order to achieve the third objective, the responses from QSs in contractor firm, consultant firm and developer firm was categorized accordingly. After that, Kruskal-Wallis test was conducted and the result obtained showed there were 11 sub-criteria that rejected the null hypothesis, H_0 which signified that there is

a significant difference in satisfaction level of using BIM software between different natures of QSs companies. The sub-criteria included “usage for wide scope of work”, “simplifier QS work”, “information produced with high precision level”, “initial cost”, “shareable information with high reliability”, “understandable software manual and tutorial”, “warranty”, “smart object”, “documentation support”, “easy to exchange data”, and “able to compatible with data produced in different format”.

5.3 Research Limitation

A few research limitations are found out when conducting this research. First is the response rate of this research. After distributing out 160 questionnaires survey, only 60.63% responses are collected which is low, and the responses are mostly done by BIM users with less than 5 years of experience in using BIM software. This signified that the reliability of their experience in using BIM software is low due to some functions or features within the BIM software might not yet explored by the respondents. On the other hand, during the distribution process, which is done through email, the questionnaires surveys cannot guarantee to have delivered to the targeted population.

The second limitation is that the adoption of quantitative research method which only provides numerical description which is not as detail as information obtained by using qualitative research method. The respondents might have their own satisfied or unsatisfied part on BIM software, but they do not have opportunity to voice out. Thus, the potential of receiving wider opinions is being cut off.

The next limitation is that the targeted population is limited to Klang Valley only. This indicated that the results obtained from the research is unable to represent other QSs who work in different cities or nations. The proposed framework cannot be verified and validated by professional practitioners within construction industry as validating of framework required a few case studies or interview to support it. Thus, it serves a preliminary satisfaction framework.

5.4 Research Recommendations

There are some recommendations are suggested to solve the limitation stated. Firstly, the research scope has to be extended to broader area which is across Malaysia in order to collect more data. The data collected will be more precise as this research is depending on large population. Apart from that, respondents who have more experience in using BIM software must be approach as their responses are more reliable.

Besides, mixed research method is recommended for future research. By combining quantitative research method and qualitative research method, it allows the strengths of one approach to complement the limitations of another. Furthermore, the results acquired will be in wider scope and new perceptions from interviewer on the criteria that affecting satisfaction level of QS in using BIM software are obtained. Case studies or interviews are suggested to be conducted as they provide additional information and supporting findings to the research. It could help to verify, validate and enhance the framework of this study. Furthermore, interview session allows the respondents to further explain the criteria that affecting satisfaction level of QS in using BIM software. Rich data can be obtained as a result.

5.5 Research Contribution

Although there are quite a number of successful implementations of BIM software for construction project, but the BIM software adoption rate is still considered low. In this research, the criteria that affecting satisfaction level of QSs from different natures of companies in using BIM software are identified, evaluated and compared. From the results of the research which ranked the extent of satisfaction of QSs in using BIM software, it is found out that improvement must be made by certain parties in order to boost up the BIM software adoption rate in Malaysia.

In this research, it is found out that the software vendor criteria and costing of BIM software are unable to satisfy the users. First of all, BIM software vendors played an important role in boosting the BIM adoption rate in Malaysia. On behalf of software vendors, acknowledging their own limitations is a way to improve their promoting technique. For instance, after knowing that the

purchasers are unsatisfied with provision of new purchaser training, they should be able to come out with new ideas such as visitation to purchasers' company twice a month at the beginning stage and proceed with once a month after the purchasers get familiar with the software. During the visitation session, meeting and discussion must be carry out and guide them personally in order to solve the issues faced by the purchasers. On the other hand, the period of post-sales follow up programme must be carried out constantly throughout the whole active licence period of the software. If purchasers intend to stop cancel the licence of the software, survey and interview must be done as to figure out the which part of the software or promoting technique need to improve. Thus, this research outcomes are informative for the software vendor to further enhance their services in order to satisfy the users.

In term of costing, this research serves as a good information to the relevant authorities such as Construction Industry Development Board (CIDB), Board of Quantity Surveyors (BQSM), Royal Institution of Surveyors Malaysia (RISM), and local government. BIM software are expensive that most of the medium or small size organization are unable to afford them. Thus, the government should acknowledge this issue and provide assistance to those construction companies who cannot afford to purchase the licence of BIM software. The assistance included rebates when purchase the licence, provides loans with low interest rate while allowing instalment method, and negotiate with the BIM software company to get better promotion. On the other hand, CIDB should provide helps by organizing more training sessions regarding BIM software for free as to promote the adoption of BIM software. In brief, if all these assistances are implemented, the burden of construction companies who intend to adopt BIM will be greatly decrease and adoption rate of BIM in Malaysia will be accelerated.

This research proposes a framework for evaluating satisfaction level of quantity surveyors in using BIM software. This framework serves as a reference for other researchers in other industries or countries. They can adopt and modify this framework based on the local context and practices for measuring the satisfaction level of users in using BIM software in order to accelerate BIM adoption.

5.6 Summary of Chapter

In conclusion, all the findings are concluded in this chapter. The research aim and objectives for this research are achieved. The limitation of conducting this research are stated and suitable recommendation is proposed. In addition, the contributions from this research were identified at the end of this chapter.

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APPENDICES

APPENDIX A: Questionnaire

1. Have you used any BIM software (such as Glodon, CostX, Revit, etc.) before on any construction projects?

   □ If Yes, please continue with the following question.

   □ If No, thank you for your participation.

Section A: General Background

Please tick (√) in the appropriate box.

1. What nature of QS company are you currently working?

   □ Contractor Firm

   □ Consultant Firm

   □ Developer Firm

2. What is your job position in your company?

   □ Director

   □ Technical Director

   □ Contract Manager

   □ Contract Executive

   □ Assistant Quantity Surveyor

   □ Team Leader

   □ BIM coordinator

   □ Project Manager

   □ Project Executive

   □ Other, please specify _____

3. How long have you been working in construction industry?

   □ Less than 6 years

   □ 6 – 10 years

   □ 11 – 15 years

   □ 16 – 20 years

   □ More than 20 years

4. What is the BIM software that your company used in practice? (You may select more than 1 option)

   □ Glodon Cubicost

   □ Autodesk Navisworks

   □ Autodesk Revit

   □ CostX

   □ Other, please specify _____

5. How long have you been using BIM software based on Question 4?

   □ Less than 2 years

   □ 2 – 4 years

   □ 5 – 7 years

   □ 8 – 10 years

   □ More than 10 years

6. What kind of tasks are being carried out when you are using BIM software? (You may select more than 1 option)

   □ Measurement / Take off

   □ Prepare cost appraisal

   □ Resource coordination

   □ Schedule planning

   □ Monitor the work progress

   □ Prepare Bill of Quantity

   □ Estimating

   □ Design assessment

   □ Other, please specify _____

7. What are the criteria is important for you when using BIM software? (You may select more than 1 option)

□ The features provided by the BIM software
□ The cost of investing in the current BIM software
□ Whether the BIM software is user friendly
□ The assistance acquired from the software vendors
□ The quality of the BIM software
□ The extent of interoperability and compatibility of the BIM software

Section B: Satisfaction level of QS in using BIM software

The table below is a list of criteria to measure the satisfaction level of QS in using BIM software. Based on your experience, to what extent of satisfaction would you rate for the following criteria when you are using the BIM software.

1. Please tick (√) one option for each of the following.

Criteria	Very Unsatisfied	Unsatisfied	Moderate	Satisfied	Very Satisfied
A) BIM Software Features					
i. I am satisfied with the features within the BIM software which allow me to execute various type of tasks (rather than manually) such as prepare bill of quantity, prepare cost plan, quantity take off, etc.					
ii. I am satisfied with features within the BIM software which simplify					

various tasks (e.g. the shorten times) such as measurement, estimating, scheduling, etc.	
iii. I am satisfied with the high precision level of information obtained from using the features within BIM software. For example, the quantities generated by the BIM software are accurate.	
B) Cost	
i. I am satisfied with the initial cost of purchasing BIM software.	
ii. I am satisfied with the training cost which assist in getting familiar with the purchased BIM software.	
iii. I am satisfied with the maintenance cost such as upgrading cost which improve the functionality of the BIM software.	

C) User Friendly	
i. I am satisfied with the BIM software because it is easy to use.	
ii. I am satisfied with the extent of user reliability toward the BIM software. For example, the user will not need to worry about the information produced using BIM software as they are complete and accurate.	
iii. I am satisfied with the manual handout and tutorial videos provided by software vendors which are easy to understand.	
iv. I am satisfied with the completeness of the BIM software such as complete libraries and content within the software.	

D) Software Vendors	
i. I am satisfied with the provision of warranty for the newly purchased BIM software.	
ii. I am satisfied with the provision of BIM software training provided by the software vendors which helps to solve problems faced by users.	
iii. I am satisfied with the post-sales follow up programme such as constantly receiving support/ information/ updates from software vendors.	

E) Quality	
i. I am satisfied with the provision of various type of selection criteria such as different type of materials, sizes, attributes, etc. from the library contents within the BIM software.	
ii. I am satisfied with the existence of smart object within the BIM software which helps to maintain the associability and connectivity between objects.	
iii. I am satisfied with the enabling of manual adding of new library contents such as adding of new material type which does not provided in the original libraries.	
iv. I am satisfied with the documentation method provided within the BIM software such as	

	exporting the estimated quantities from BIM software into Microsoft Excel.	
F)	**Interoperability and Compatibility**	
	i. I am satisfied with the extent of how easy the data produced from the BIM software can be exchange seamless between different parties. For example, when the QS finished take off, the measurement or quantity can be shared to other project team members for viewing, checking or conduct other tasks.	
	ii. I am satisfied with the production of compatible data from BIM software which allow the data to be produced in different formats such as DWG format, JPEG or PDF format, etc.	