# DEVELOPMENT OF THE FRAMEWORK FOR THE INTEGRATION OF BUILDING INFORMATION MODELING TO HIGHER EDUCATION IN MALAYSIA

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# DEVELOPMENT OF THE FRAMEWORK FOR THE INTEGRATION OF BUILDING INFORMATION MODELING TO HIGHER EDUCATION IN MALAYSIA

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Architecture)

Faculty of Built Environment
Universiti Teknologi Malaysia

JANUARY 2018

**All Glory and Dedication to ALLAH the Lord of Universe**

This thesis is dedicated to my beloved wife Nana-Amina and my children, Imam-Yusuf, AbdulRahman, and Ummu-Khadijah for their perseverance and understanding; also to my daughter Amiral-Kauthra for her patience throughout my long absence from home (Nigeria).

*"Thank you for your sacrifices during this PhD journey"*

# ACKNOWLEDGEMENT

**Alhamdulilllahi Rabbil Al'Aamin,** for granting me good health, strength, wisdom and the completion of this thesis. This piece of work could not have been completed without the spiritual guidance and protection and material provision from the Almighty Allah. In addition, I wish to express my sincere appreciation to my wonderful supervisors, Assoc. Prof. Dr. Muhamed Rashid Embi and Assoc. Prof. Dr. Kherun Nita Ali for their guidance, motivation and inspiration for which without it the journey would not have been accomplished.

I am obligated to Prof. Kabir Bala for his motivations and efforts in securing for me the study fellowship. Thanks also to Dr. Yakubu Aminu Dodo for his help in securing for me the admission that have taken me this far. Also worth of mention is Dr. Anthony Adjai-Twuw (Ghanaian) for taking me through on qualitative analysis software (Maxqda-12), I'm indeed grateful. Thanks also goes to many friends and well-wishers that I cannot mention their individual names, who have contributed to the realisation of this PhD journey.

My special thanks go to my academic colleagues in the Department of Architecture, Ahmadu Bello University (ABU), Zaria-Nigeria, who held forth for me while I was away. My appreciation goes to the Tertiary Education Trust Fund (TETFUND) and ABU-Zaria authority for granting me study fellowship. Worth of note, were lots of people that took part in my PhD academic journey with their immeasurable supports, mentioning names here will be impossible due to space limitation. I'm indeed grateful to you all. I also appreciates Prof. Ahmed Ibrahim Dokko and Assoc. Prof. AbdulAzeez Darudas for their sincerity in keeping my back in Nigeria.

My warmest appreciation goes to my immediate family whose tolerance, support and prayers made it possible to pursue my PhD in Malaysia. Such as: my wife Nana Amina, and my children: Imam-Yusuf, AbdulRahman and Ummul Khadijah, they all deserve special recognition for their patients and sacrifices. Also in this category is my eldest daughter Amiral-Kauthra for her patient and understanding during my long absence from home. Wishing you all Allah's blessing, mercy, protection, guidance and breakthrough in all your worldly quest and encounters. I sincerely appreciate you all. I also pray that the PhD knowledge acquired would be beneficial to me, my family, my schools both ABU-Zaria Nigeria and UTM-Johor Malaysia and the entire humanity. **Aamin Ya Allah.**

# ABSTRACT

Building Information Modeling (BIM) is a new project delivery process in the construction industry that has a growing need for competent workforce and its production. The literature confirms that, only a small fraction of stakeholders in the construction industry in Malaysia are aware of BIM, and are willing to adopt its culture, despite its relevance and benefits. This is due to non-availability of adequate BIM competent workforce for employment in the industry. In order to have a constant supply of adequate BIM workforce for the construction industry, knowledge and skills on BIM must be integrated into higher education academic programs. Hence, the study developed a framework to facilitate BIM knowledge and skills integration into the construction related academic departments in Higher Education Institutions (HEIs) in Malaysia. The methodology adopted was a mixed method approach, where qualitative data was collected through interviews of thirteen practicing professionals, whilst the quantitative data was gathered using online questionnaire survey distributed to four hundred and eighty seven educators of HEIs. Sixty three educators from six public universities and three private universities responded to the online survey. Thematic content analysis was adopted to analyse the qualitative data using MAXQDA-12, while descriptive analysis was used to analyse the quantitative data. Furthermore, the study confirmed the workmanship is a crucial problem besides the lack of BIM knowledge and skills being the most critical ones. The study made use of the summation of findings to develop a BIM Education Integration Framework (BIMEIF) for BIM to be integrated into higher education. This framework consists of four stages that run through three developmental phases and the whole process is iterated. BIMEIF has been validated by thirteen experts in BIM knowledge and skills to ascertain the applicability of the framework. The validation result positively showed that the experts are in agreement that the framework is applicable as a guide for the integration of BIM into higher education academic programs in Malaysia. The framework would enhance the collaboration between academic and industry for BIM competence workforce development. As a conclusion, BIM is a technology as well as a process that facilitates collaboration, share of information, remove rework, and reduction of cost and time overruns. These are expected to stimulate Malaysia's construction industry towards global standards and best practices.

# ABSTRAK

Pemodelan Maklumat Bangunan (BIM) merupakan proses penyerahan projek baru dalam industri pembinaan yang memerlukan peningkatan tenaga kerja yang kompeten dalam pengeluarannya. Kajian lepas mengesahkan bahawa hanya segelintir pihak yang berkepentingan dalam industri pembinaan di Malaysia yang mengetahui tentang BIM, dan sanggup mengadaptasi budayanya, walaupun mempunyai kaitan dan manfaat sendiri. Ini disebabkan oleh tidak adanya BIM yang mencukupi bagi tenaga kerja dalam industri pekerjaan. Untuk memiliki sumber tenaga kerja BIM yang mencukupi bagi industri pembinaan, pengetahuan dan kemahiran BIM mesti diintegrasikan ke dalam program pendidikan tinggi akademik. Oleh yang demikian, kajian ini membangunkan rangka kerja untuk memudahkan pengetahuan dalam BIM dan integrasi kemahiran ke dalam bahagian akademik yang berkaitan dengan bidang pembinaan di Institusi Pengajian Tinggi (IPT) di Malaysia. Kaedah yang digunakan adalah kaedah pendekatan campuran, di mana data kualitatif dikumpul melalui temubual dengan tiga belas ahli profesional, manakala data kuantitatif dikumpul menggunakan soal selidik dalam talian yang diedarkan kepada 477 tenaga pengajar IPT. 63 tenaga pengajar dari enam universiti awam dan tiga universiti swasta telah menjawab kaji selidik dalam talian. Analisis kandungan tematik telah digunakan untuk menganalisis data kualitatif menggunakan MAXQDA-12, manakala analisis deskriptif digunakan untuk menganalisis data kuantitatif. Tambahan pula, kajian mengesahkan bahawa mutu kerja merupakan masalah paling utama selain dari kurangnya pengetahuan dan kemahiran BIM yang menjadi masalah yang paling penting. Kajian ini menggunakan ringkasan dapatan untuk membangunkan Rangka Kerja Integrasi Pendidikan BIM (BIMEIF) untuk BIM disepadukan ke pendidikan tinggi. Rangka kerja ini terdiri daripada empat peringkat yang dilaksanakan melalui tiga fasa pembangunan dan keseluruhan proses pengulangan. BIMEIF telah disahkan oleh tiga belas pakar dalam bidang pengetahuan dan kemahiran BIM bagi menentukan kebolehgunaan rangka kerja tersebut. Hasil pengesahan secara positif menunjukkan bahawa pakar telah bersetuju agar rangka kerja ini dijadikan sebagai panduan untuk penyatuan BIM ke dalam program akademik pendidikan tinggi di Malaysia. Rangka kerja ini akan meningkatkan kerjasama antara bidang akademik dan industri untuk pembangunan tenaga kerja BIM yang kompeten. Kesimpulannya, BIM adalah teknologi serta proses yang memudahkan kerjasama, perkongsian maklumat, penyingkiran, pengulangan kerja, dan pengurangan kos dan masa yang terlalu banyak. Ini diharapkan dapat merangsang industri pembinaan di Malaysia ke arah piawaian dan amalan terbaik secara global.

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## LIST OF SYMBOLS

| | | |
|---|---|---|
| AEC | - | Architectural, Engineering, Construction |
| AECO | - | Architectural, Engineering, Construction and Operations |
| AGC | - | Associated General Contractors |
| AM | - | Asset Managements |
| BAF | - | BIM Academic Forum (UK) |
| BDS | - | Building Description Systems |
| BIM | - | Building Information modeling |
| BPMs | - | Building Product Models |
| BRE | - | Building Research Establishment |
| CAQDAS | - | Computer Assisted Qualitative Data Analysis Software |
| CDE | - | Common Data Environment |
| CIC | - | Construction Industry Council |
| CIDB | - | Construction Industry Development Board (Malaysia) |
| CIMP | - | Construction Industry Master Plan (Malaysia) |
| CITP | - | Construction Industry Transformation Programme |
| CKB | - | Competency Knowledge Base |
| COBie | - | Construction Operations Building Information Exchange |
| CORENET | - | Construction and Real Estate NETwork |
| CSFs | | Critical Success Factors ) |
| DCO | - | Design Construction and Operations |

| | | |
|---|---|---|
| DT | - | Didactic Transposition |
| EIR | - | Employer's Information Requirements |
| FM | - | Facilities Managements |
| GSA | - | General Services Administration (US) |
| HVAC | - | Heating Ventilation and Air Conditioning |
| ICT | - | Information and Communication Technology |
| IPC | - | Integrated Plan Checking |
| HEIs | - | Higher Education Institutions |
| IPM | - | Integrated Project management |
| IPR | - | Intellectual Property Rights |
| ISS | - | Integrated Submission Systems |
| IT | - | Information Technology |
| JKR | - | Jabatan Kerja Raja |
| MOHE | - | Ministry of Higher Education |
| OACIS | - | One-stop Access to Construction Information Services |
| OSSC | - | One-Stop Submission Centre |
| PBL | - | Problem Based Learning |
| PBS | - | Public Building Services |
| ROI | - | Returns on investment |
| SIM | - | Standard Intellectual Maturity |
| ZPD | - | Zone of Proximal Development |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

The importance of education to humans and resource development cannot be over emphasised. According to Montessori (1976) education plays essential roles in the process of human resources development and it is located within the realm of human activities. Moreover, Ulrich *et al.* (1995) also notes that the role and responsibility of human resources in the professional development have changed dramatically from the traditional approach and the competencies needed to fulfil a successful human resources development is knowledge and training. Thus, the inadequacy or lack of knowledge and skills are challenges that must be tackled for a successful competence optimisation in any professional, business organisation, and at national level for economy benefits (Jajri and Ismail, 2007).

Building Information modeling (BIM) is the digital documentation process consisting of holistic data about the sequential phases of construction project at the stages of design, construction planning, construction, facility management and operations. These processes are beneficial for estimating, scheduling and design coordination as well as operational visualization (Kumar and Mukherjee, 2009). BIM has become the yardstick and an international benchmark for measuring efficiency in Architectural, Engineering, and Construction (AEC), and host of other building services. BIM is a collaborative platform that bring together all professionals in the industry. Ibrahim and Krawczyk (2003), affirm that every professional practice have particular task needs to achieving a successful BIM platform. This chapter opens the discussion to this study and it is structured into sections which form the bases on which the research is built.

## 1.2 Problem Statement

In any capital development, human resources are believed to be important if not the most important factor, and the quality of this variable depends on the level of awareness of the society (Van Manen, 2015; Riel, 1998). Human resources can only be ascertained by the quality of education and training (Jajri and Ismail, 2007). Furtherance to that, Freeman and Foray (1992) believe that an overall level of education and in particular technical education is essential for the design and productive use of new technologies (Castells, 1999). The ability to adopt and practice new ICT technology largely depends on the capacity of the whole society to be educated, assimilate and process complex information. The only avenue for this to be achieved is by starting with the education system, from the bottom up, that is, from the primary education through to the university (Castells, 1999).

From the works of Enegbuma and Ali (2011c), Malaysia government is aware of the importance of BIM as an emerging technology that is revolutionizing the entire building industry, it is at this instance that the government establishments such as Jabatan Kerja Raya (JKR), CIDB and other professional bodies, were propelled to came up with Construction Industry Master Plan (CIMP) 2006-2015 and in its Seven Strategic Thrusts, the number fourth and fifth of these thrusts was to develop human resources, encourage innovative research and development, and encourage the use of modern technology for building project delivery. Besides these, CIDB have been organizing awareness talk among construction industry players. As a step further, JKR is now having a BIM unit that is responsible for the implementation of building projects using BIM (Enegbuma and Ali, 2011a).

Another major step forward was building on the success of the CIMP by putting in place Construction Industry Transformation Programme (CITP) which was established for an era of unprecedented progress and growth in the industry. CITP is poised for an advanced and a highly productive construction industry that will be of international standards and be a major contributor towards Malaysia's economy by 2020 (MOW and CIDB, 2015; CIDB, 2017). CITP have a set of four strategic thrusts that was designed to take Malaysia's construction industry to the next level. The strategic thrusts are: 1) Quality, Safety & Professionalism; 2) Environmental Sustainability; 3) Productivity and 4) Internationalisation. Table 1.1 indicated the milestone achievement recorded for CITP on each strategic thrusts. Though, this was made possible by the background work laid by CIMP and the collaborative efforts of the stakeholders. Looking at the strategic thrusts 2 and 3, Malaysia government have singed Memorandum of Understandings (MOUs) with a number HEIs to conduct and promote Research and development (R&D). Also about 800 personnel have been trained on BIM, while a total number of 100,348 trained personnel have been certified in construction related occupations (CIDB, 2017).

**Table 1.1:** Construction Industry Transformation Programme (CITP) as at October 2017 (CIDB, 2017)

| Strategic Thrust | Notable Achievements |
|---|---|
| **1.<br>Quality, Safety & Professionalism** | • **Quality**: 63% of 449 projects assessed achieved Quality Assessment System in Construction (QLASSIC) score of 70%<br>• **Safety**: 824 Safety & Health Officers and 1,350 Site Safety Supervisors trained<br>• **Professionalism:** 43 Facility Management Contractors registered under F01 and F02<br>**Current Thrust Progress: 96%** |
| **2.<br>Environmental Sustainability** | • **Sustainable Infrastructure Rating Tool:** 2 infrastructure pilot projects had been assessed using Civil Engineering Environmental Quality Assessment and Award Scheme (CEEQUAL) to test the viability of CEEQUAL in Malaysia<br>• **MyCREST:** 30 Malaysian Carbon Reduction and Environmental Sustainability Tool (MyCREST) |

| | |
|---|---|
| | assessors have been certified; 27 are from the public sector and 3 are from the private sector<br>• **R&D in Sustainability:** 3 MoUs have been signed with Universiti Teknologi Malaysia (UTM), Universiti Sains Malaysia (USM) and Universiti Kebangsaan Malaysia (UKM) to conduct and promote R&D in sustainability practices.<br>**Current Thrust Progress: 95%** |
| **3. Productivity** | • **Training:** 100,348 construction personnel trained and certified (3 categories of skill, supervisory & management and Continuing Professional Development training)<br>• **Accreditation:** Amended Schedule 3 of Act 520 on accreditation of skilled workers has been gazetted<br>• **IBS:** 46 new Industrialised Building System (IBS) manufacturers registered since 2016<br>• B**IM Training:** 800 Building Information Modelling (BIM) personnel trained via MyBIM Centre & BIM Satellites<br>• **N3C Portal:** National Construction Cost Centre (N3C) Portal completed with 8000 users registered and 40 prototype cost models developed covering 8 categories of building and infrastructure<br>• **NCIIC Portal**: Project manager and vendor has been appointed to develop the National Construction Industry Information Centre (NCIIC) Portal with 16 head of contents.<br>• **Bumiputera FM Contractors:** 321 Bumiputera contractors has been trained for Facility Management (FM)<br>**Current Thrust Progress: 96%** |

**Table 1.1:** Construction Industry Transformation Programme (CITP) as at October 2017 (CIDB, 2017) (Cont'd)

| | |
|---|---|
| **4. Internationalisation** | • **MSCESSM:** 80% progress in converting Malaysian Civil Engineering Standard Method of Measurement (MyCESMM) to a Malaysian Standard (MSCESMM)<br>• **Verification Officers**: 87/50 material verification officers trained and accredited based on category and products.<br>• **Overseas Projects:** RM 2.7 / RM 2.0 billion won through 79 overseas projects.<br>• **Financing Study:** 85% completion of Study on Strengthening Access to Financing for Malaysian Champions Going Abroad<br>**Current Thrust Progress: 99%** |

Taylor and Bernstein (2009), suggested that BIM should be made more important in the training of architects and other professionals in the construction industry, they warned that failure to embrace this trend at our education institutions may connotes a fundamental setback. Wu and Issa (2013a) acknowledge that both the academia and the professionals are aware of the fact that university education is critical for quickening the learning and recruitment of BIM professional for the industry and because the wide existing gap between the industry expectations and university turn-out graduates. This explains why most often companies recruit fresh graduate for jobs opening dedicated to BIM (Wu and Issa, 2013a). In another study, Sacks and Barak (2009), revealed that lack of BIM knowledge is a significant constraint retarding use of the technology in the construction industry.

Furthermore, Gilligan and Kunz (2007) also identify that it is not the difficulties inherent in the BIM technology but rather it was due to the lack of training and availability of qualified staff, because of the existing challenges in educating staff to be competent with the technology. Given consideration to effective inclusion of BIM into education curriculum and its critical value in the preparation of future employable professionals for the construction industry. Clevenger *et al.* (2010) observe that the responsibility of higher education institutions to take up the challenges of introducing and leverage BIM into existing or future coursework are still lacking. This clearly indicates that insufficient training of BIM or lack of it is an issue affecting BIM adoption in the construction industry globally. From the report presented by Mills *et al.* (2013), maintains that education is critical to enhance the relevant abilities of graduates of architecture and other construction disciplines, and that BIM technical skills and collaboration requirements should be included in Higher education disciplines.

Zuhairi *et al.* (2014), further revealed that the main barriers for the implementation of BIM in Malaysia are largely due to lack of knowledge, reluctance to the adoption of the new technology and lack of incentive to motivate the stakeholders to adopt or use BIM for their project implementation. The same study also identifies factors that can enhance the speedup of the implementation of BIM such as: support and enforcement from the government; promote BIM training and education and promotional efforts of the different professional bodies in the industry.

They also noted that effort and support from government will go a long way to yield good effects on the activities of BIM in Malaysia (Zahrizan *et al.*, 2013b).

Based on the globalization of BIM in construction industry; the growing potential needs of competent workforce and the mandatory adoption for governments and corporate organizations construction projects; thus, the need for BIM education integration to higher education clearly appears to be non-negotiable. Many construction instruction establishment in Malaysia are willing to adopt BIM for the delivery of their professional engagement (Yusuf *et al.*, 2015b). But due to non-availability of BIM competent workforce for employment has been a serious challenge (Badiru *et al.*, 2016; Yusuf *et al.*, 2017). Also due to HEIs poor response to the adoption of technology innovation and academic bureaucracy, the BIM competent workforce supply have been too few to cater for the market need. It is on this premise that the research therefore, set to identify possible resources and strategies for the integration of BIM into university education in Malaysia. This is to create a balance between the potential market needs and the higher institutions career development of the upcoming professionals for construction industry and in order to keep alive the government vision of making Malaysia to be become a fully developed country by the year 2020.

MOW and CIDB (2015) observe that construction industry in Malaysia are still facing some challenges that is responsible for it low productivities across sectors and its standards below international benchmark. Besides, at present BIM adoption in Malaysia is at stage-1and to step up construction actives to match global benchmark, CITP commends that BIM adoption in Malaysia should move beyond stage-1 to stage-2 (MOW and CIDB, 2015). Stages of BIM adoption presented in Figure 1.2 show that Malaysia's BIM adoption (stage 1) is still at single disciplinary use of object-based 3D modelling software within one discipline with little business model collaboration and poor usage prototype (MOW and CIDB, 2015). The training of BIM experts for Malaysian's construction industry is mainly by BIM business education centres anchored by software vendors. Based on the record presented by CITP, about 800 Building Information Modelling (BIM) personnel were trained via MyBIM Centre & BIM Satellites. Also, memorandum of understanding (MoUs) have been signed with three universities to set-up research and development (R&D) in the area of BIM and its related applications (MOW and CIDB, 2015). However, many universities are still at the preparation stage for BIM integration into their curriculum. Though, some university have ventured into collaboration with government agencies by the signing of memorandum of understanding (MoU), but the effects are yet to be felt in BIM competent delivery to the industry.

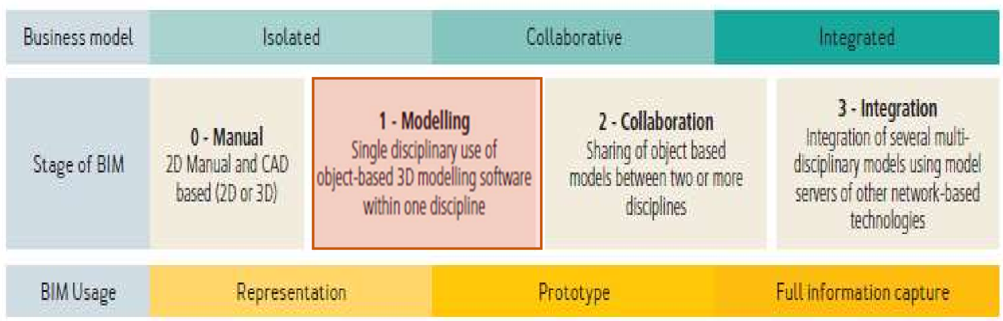


**Figure 1.1:** Stages of BIM Adoption (MOW and CIDB, 2015)

## 1.3 Research Question

Awareness is defined as process by which knowledge and understanding of ideal is developed in a person(s), but the rate of understanding reduces when individuals are working or learning in isolation, whereas, social interaction increases understanding, better output and pave way for development (Seng, 2001). Gersting and Young (1997) note that it is important to take cognizance of experiences and more recent content evaluation in designing new curricula or revising existing one. Also identified by Zuhairi *et al.* (2014) that the intense promotion of BIM education, skills and training is one of the major factors that is needed to enhance the speedup of the implementation of BIM in Malaysia's construction industry with the believes that it will boost production of manpower for the potential BIM market in a very near future.

However, it is apparent that the BIM education, skills and training is central and critical to BIM implementation and adoption in the construction industry. Though, the awareness campaigns for BIM for building delivery method is growing rapidly and widely, while BIM education, skills and training remain low in higher education institutions (Macdonald, 2012b). It is against this background that this research is in the attempt to proffer answers to the under listed mind boggling questions and to postulating a framework for the integration of BIM into Higher education through a pedagogy shift process. The research questions the research seeks to answer are:

i. How relevant to construction industry is the integration of BIM into higher education institutions in Malaysia?
ii. Of what need is BIM competent graduates to the construction industry in Malaysia?
iii. How ready are the higher education institutions in Malaysia to integrate BIM into education programs?
iv. How can BIM be integrated to higher education institutions in Malaysia?

## 1.4 Research Aim and Objectives

The aim of this study is to establish a framework implementation plans necessary for BIM integration into construction industry academic programs of higher education institutions in Malaysia for a smooth paradigm shift. The research therefore addresses the following specific objectives:

i. To identify relevance of BIM adoption in the construction industry in Malaysia.
ii. To assess the need for competent BIM workforce (competent graduates) to construction industry in Malaysia.
iii. To determine the academic readiness for BIM integration into higher education.

iv. To develop a framework for the integration of BIM to education programs of higher education institutions in Malaysia

## 1.5 Background of the Study

The concept of BIM has long been around since about 33years ago in the manufacturing and aerospace industries, though it was not known as BIM. In 2002, Phil Bernstein of Autodesk coined the word Building Information modeling (BIM) which marks the beginning of its introduction into the construction industry. However, this technology has changed the traditional paper-based 2D drawings to information-rich, architectural 3D modeling and electronic design (Robins, 2011), BIM is a new approach to project delivery which has changed the way professionals handle building design, construction and management of construction projects (Khemlani, 2004). Though, its implementation are facing challenges globally, largely due to lack of understanding of BIM and the approach for its integration into the various professional disciplines of the construction industry (Goucher and Thurairajah, 2012)

At this age of Information Technology (IT) revolution (of which BIM belongs), Riel (1998) warns that effort should be made not to reduce BIM education to an uncoordinated activity that lack uniform standards of project execution due to the absence of knowledge and learning skills that needed for project delivery in construction industry. He further emphasises that, education still remains a formal and an organised entity; it integrates learning into larger intellectual frameworks which equip the learner (practitioners, stakeholders and students) in immediate and multiplicative contexts. Therefore, this call for collaboration and interactions of an integrated knowledge and skill, which should be structured to take into account the forces of economy, academy and the national interest (Riel, 1998). Nonetheless, BIM as a new field of technology currently poses significant challenges to educators. This is basically due to its resourcefulness and the influences of BIM on project delivery and on the construction processes. It is also noted that, these challenges have created a niche on the university level education, where the focus should be shifted from teaching how to use tools, to actual using of the tools, for the current and future generations (Hietanen and Drogemuller, 2008).

It almost goes without saying that education has been facing unprecedented changes in the 21st century due technological innovations**.** Bauer and Kenton (2005b), claims that, though computer technology is the current means that aid and widened the educational opportunities, but educators (trainers) are not fully disposed to it usage as an institutional delivery system nor widely incorporate the technology into the academic curriculum (Riel, 1998)**.** Macdonald (2013), also retraces that due to the inadequacies in the construction industry, such as low levels of trust and poor information sharing, disputes resolution among project team members cost more money than amount spent on Research and Development (R&D). Though the construction industry is expressly in need of competent skilled graduates with collaborative design tendencies of BIM, but due to occupational roles partition and professional silo culture, which also extended to teaching of students, have remain a serious challenge (Macdonald, 2013).

Conventionally, the teaching and training of professionals in the construction industry have always been the responsibility of universities that offers the related courses. However, the university education has scarcely adopted BIM education into their training due to limitation of awareness and knowledge of BIM among educators (Macdonald, 2012a). For university educators to adopt BIM into curriculum, they need awareness, knowledge and training skills to support BIM education (Hon *et al.*, 2016). In addition, it is difficult for a sudden change of teaching habit and approach for the new BIM technology while the technology is also rapidly changing, thus, making it a challenge for academics to catch up (Macdonald, 2012a).

BIM is a technology that revolves around three base components: people, process and digital technology, absence of any of these does not make it complete. The interrelationships of these elements make up BIM system and this explains the collaborative characteristic of BIM (Kiviniemi, 2013). Henttinen (2010), further elaborate that BIM is a socio-technical system with ability to transform the design and construction industry, and business approach with maximum benefits to all the stakeholders in the industry, as illustrated in Figure 1.1. The widely referred BIM definition is that of Autodesk incorporation which state that "*Building Information Modeling (BIM) is a process involving the generation and management of a digital representation of physical and functional characteristics of a facility. The resulting building information model becomes a shared knowledge resource to support decision-making about a facility from earliest conceptual stages, through design and construction, then through its operational life before its eventual demolition*" (Lea, 2012).

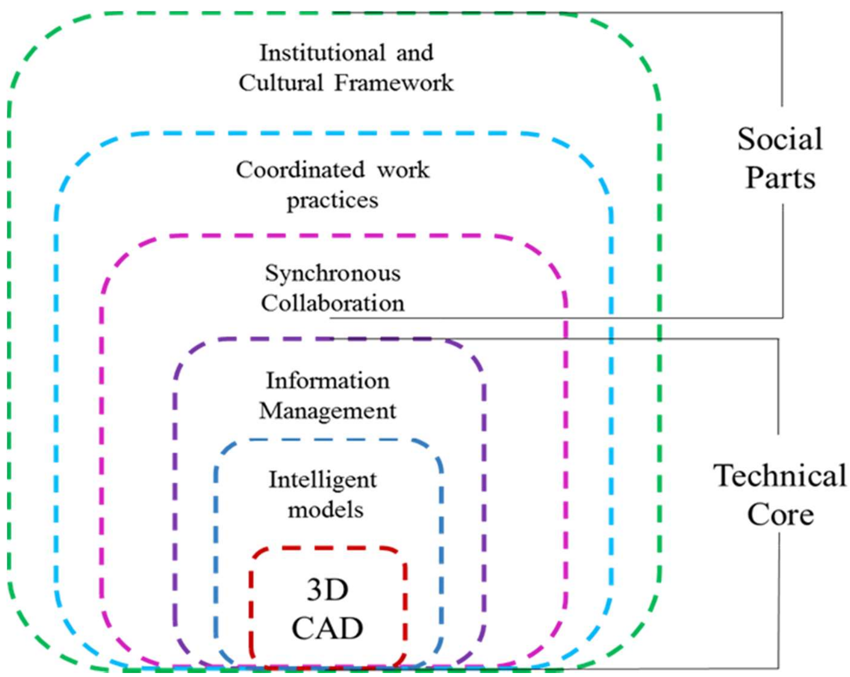


**Figure 1.2:** BIM as a Socio-Technical System for construction industry transformation and business approach (Henttinen, 2010)

Moreover, BIM can be said to be a methodology to manage the building design and project data in digital format throughout a building lifecycle (Succar, 2009), more so it is as a paradigm shift within the industry. Series of study have also revealed that BIM is having the potential to significantly change and improve performance, and documentation in the AEC industry. This would invariably reduce inefficiencies, enhancing productivity, and increasing collaboration and communication (Goedert and Meadati, 2008). It is the expectation that BIM have the ability to reduce project cost and time overruns, improve productivity and quality, and enables free flow of information for easy project delivery and monitoring (Azhar *et al.*, 2008b). Despite the success factor perceived of the BIM and the envisage potential, the embracement and the adoption of these opportunities has remain low (Becerik-Gerber *et al.*, 2011).

Furthermore, BIM is becoming a global trend and governments of most developed countries such as: US, UK, Australia, Hong Kong, Singapore and others; are having a short at BIM as mandatory for the delivery of projects of certain magnitude due to benefits that stands to be achieved. Likewise, the government of Malaysia has put up a vision to become a fully developed country by the year 2020, and to achieve this, there is need for the build-up of industry capacity to withstand global competitiveness and innovation in the industry (Harona *et al.*, 2015). Though, presently BIM is at the early stage of development in Malaysia, but its development still solely rest on robust education and training development that will aid its adequate implementation in Malaysian construction industry; with a suggestion that BIM competence education and training development need to be taken with urgent priority (Mamter *et al.*, 2014).

Clevenger *et al.* (2012) notes that in this era, BIM determines the way construction projects are executed. This emerging practice requires technological know-how in order to achieve significant building efficiency. Also, in order to make BIM knowledge accessible higher education institutions (universities) must embrace the use of BIM as an innovative technology that will pave ways for the acquisition of the new skills by the students in order to prepare them for the competitive global market (Sampaio, 2015). Though, Barison and Santos (2010a) note that, there have been different approaches employed for the introduction of BIM into academic curricula due to facts that most experiences are very recent. This suggest that there is the need for the standardization of BIM curricula among educational institutions. Sampaio (2015), insist that university education is an important driver for the establishment of BIM knowledge, training and practice for the professionals both new and old ones.

Focusing on the Malaysia's readiness for technological development, the study presents a brief background of construction industry in Malaysia and its economic contribution. Construction industry plays an important and vital roles in the socio-economic growth of a country and it contributes significant improvement in the overall GDP and positively influence the quality of life by providing the necessary infrastructure such as housing, roads, hospitals, schools and other basic facilities (Abdul Rahman *et al.*, 2013). Malaysia is a country located in Southeast Asia, it is a country divided into 13 states on the peninsular Malaysia, with Sabah and Sarawak on the island of Borneo and it has a total landmass of 326,847 sq.km put together (Kamal *et al.*, 2012). The population of Malaysia stood at 32.05 million (as at July 2017) accounting for 68.8% Malays, 23.2% Chinese, 7.0% Indians and 1% others people (Mahidin, 2017).

Malaysia is a fast growing developing nation with potentials to match with developed nations. It is a Southeast Asian country located on strategic sea-lane that exposes it to global trade and foreign culture. Malaysia is being referred to as the developing country, but with the seal to imbibe any modern development that will place her at par with global development (Awang, 2004). Furthermore, Malaysia is an ethnically diverse society which has used this opportunity to the best advantage in achieving growth, equity and structural transformation. From the records the Malaysia growth between 1960 and 1990 witnessed a sevenfold increase in GDP, which is about an annual growth rate of 6.8%. This has transformed Malaysia into a modern industrial economy (Salleh and Meyanathan, 1993). This is evident in the early recognition that a trained, skilled and well-educated workforce with information and communication technology (ICT) driven and knowledge based society will undoubtedly fuel high economic performance and sustainable economic growth in Malaysia (Awang, 2004). It is in line with the above believes that the government earnestly developed her seventh Malaysia Plan 1996-2000 and Eighth Malaysia Plan 2001-2005 and placed emphases on the adoption of ICT utilization in the implementation of policies and programs. Furtherance to these, the government established Multimedia Super Corridor (MSC) and the formulation of the National IT Agenda (NITA) and have progressively increased allocation for research and development this area (Ahmed, 2016; Ahmi *et al.*, 2016; Zaremohzzabieh *et al.*, 2016; Awang, 2004).

Since independent the Malaysian construction industry has developed from a low-tech, labour intensive, craft-based industry to that of a highly mechanized one with a capacity to deliver advanced buildings and infrastructure projects, such as PETRONAS Twin Towers, Kuala Lumpur International Airport and Sepang Formula 1 circuit (Mustafa Kamal and Flanagan, 2012). It is the government's intention to keep the tempo of the achievement in the construction of these world class monuments, thus making the Malaysian construction industry to be a world class, innovative and knowledgeable solution provider. In addition, through the Construction Industry Development Board (CIDB) in Malaysia have been put efforts to upgrade the level of knowledge and skills among the construction player (Kamal *et al.*, 2012). This has given more encouragement to the government agencies, professional bodies, individual practices organization and education sectors to involve in the BIM awareness campaign. The Malaysia government through CIDB have in place a BIM roadmap which is a strategic plan to ensure a wider adoption of BIM embraced among industry players; though, more is still needed to be achieved in term of capacity, support and value (Hadzaman *et al.,* 2015).

## 1.6 Research Scope

This research identifies and establishes strategic implementation plans necessary for the integration of BIM to construction-based academic departments and faculties of higher education institutions in Malaysia. The study investigates the problems and the prospects of BIM adoption in the construction industry in Malaysia. This was done by interview among construction industry practitioners both in private and public organizations. Similarly at the education sector, the research investigate academic readiness for BIM integration into higher education , the level of awareness, willingness of academia to change for the new paradigm and the current challenges to BIM education take-off and possible way forward. However, the study is limited to the integration of BIM to university education in Malaysia and is here referred to in this thesis as higher education. In the same way Higher Education Institutions (HEIs) refers to universities in Malaysia to which the research is focused. Nevertheless, all other tertiary education institutions are not considered for this study. The study also refers to academic department of universities in Malaysia as those departments that involve in the training and developing workforce for construction industry and it also been referred to as construction-based academic departments. Similarly, the educators in university that are responsible for teaching and lecturing are denoted as faculties of higher education institutions. Hence, the scope is limited to the development of framework for BIM inclusion into academic programs of higher education institutions in Malaysia.

## 1.7 Research Methodology

The research methodology is a step by step procedure employed by the researcher in the execution of the study at hand. The research was executed in four stages. The stage one deals with the review of relevant literature of BIM with focus on its importance, relevance and its influence on construction industry as a new technology. The literature also touches on the need for education and training of the workforce needed for BIM adoption and its integration to higher education institutions' academic programs, which is meant to facilitate the production of BIM competent workforce needed for the construction industry.

The next two stages deals with the adopted data collection methods and the methods for their analysis. A mixed method approach was employed for data collection. The stage two is the qualitative data collection using semi-structured interviews for practitioners in the construction industry and MAXQDA-12 as analysis tools. The stage three involves quantitative approach using questionnaires survey for data from the educators in higher education institutions' departments that are relevant to construction industry and was analysed using descriptive statistic.

The fourth stage deals with data analysis, discussion and findings and the findings from the two approaches were then subjected to triangulation. The study conclude by presenting the report of the study findings and make recommendations for further study and to develop a framework for the BIM integration to higher education institutions in Malaysia. However, Figure 1.2 present the flowchart illustration of the methodology process as adopted for the execution of the study.

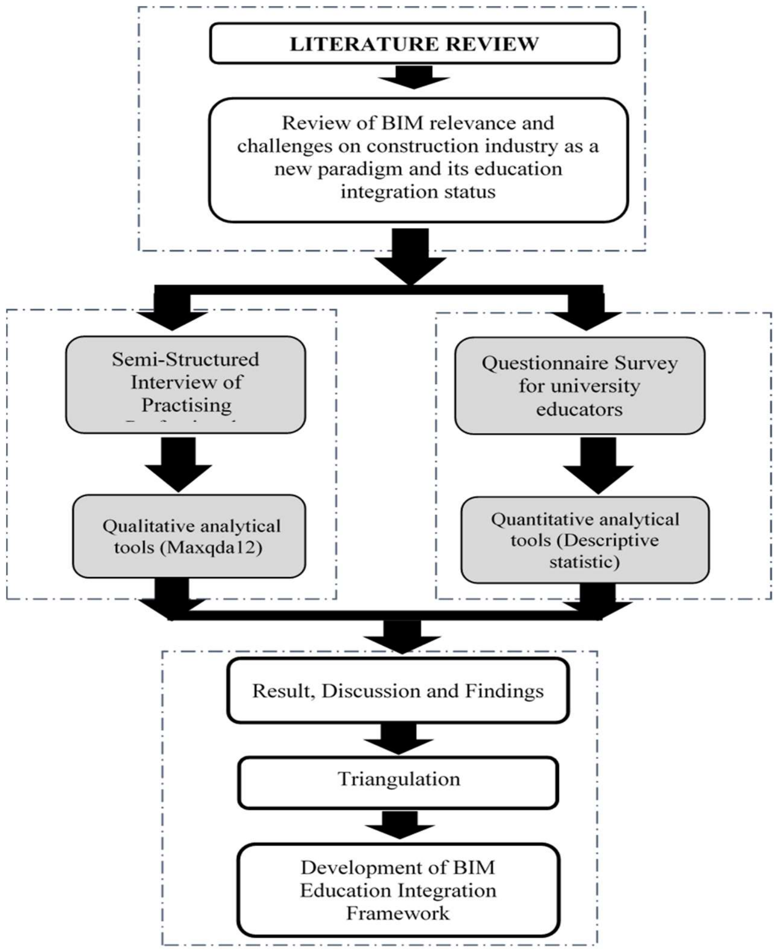


**Figure 1.3:** Research methodology Flowchart

## 1.8 Operational Framework

It is of importance to outline an operational framework that would give a synopsis of this study that has been done throughout the research, hence, the need to source and collect information that would be useful for this research. In other to make sure that all research activities are well composed, articulated, organized and concluded as at when required, a schedule research operational framework is highly needed. This framework is meant to serve as a guide as the research proceeds. It is a form of direction by clarifying the connection and interrelationship between the various activities undertaken or and will be carried out as the research progresses. At initial stage of the research, problem statement was defined, research questions established, and the scope of the study was outlined.

In accordance with the aim and objectives, the research program is to be subdivided into four broad steps as shown in Figure 1.3. Step 1 comprise of review of relevant literature, which guide to production of chapter 1, 2 and 3. Step 2 discussed in detail the main work of the research, while step 3 discusses the development of theoretical framework development. Step 4 presents the framework for integration of Building Information Modeling (BIM) to higher education in Malaysia and then the summary, conclusions, and recommendations of the study.

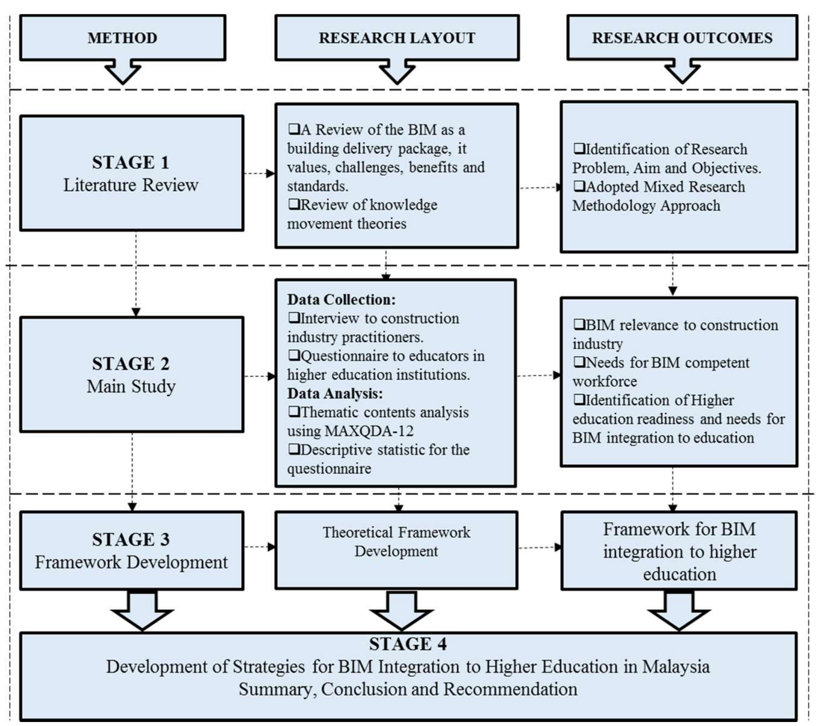


**Figure 1.4:** Research Operational Framework

## 1.9 Structure of the Thesis

This thesis is structured into seven chapters and these chapters can be classified into three main groups. The first group comprise of chapters one to three which discuss introduction, literature review and methodology; the second group includes chapter four to six and they presents discussion, findings and results, while chapter seven presents the development of framework for BIM integration to higher education institutions in Malaysia. The last chapter presents the summary of key findings, contributions and limitations of the study and suggestions area for further studies.

**Chapter one** is the introduction to the study as a whole. It entails the general overview of the research with sections on background of the research; problem statement; research questions, aim as well as the objectives. It presents the research methodology outline and the outline of thesis structures.

**Chapter two** is an overview of BIM technology and global development trends. The chapter discussed the relevant literatures relating to BIM as it concerns it evolution, technology, benefits and challenges. Also discussed is BIM global development trends in some selected developed countries believe to have established BIM usage in their construction industry practises.

**Chapter three** discusses theories and their relevance to BIM education integration. The chapter also discuss BIM adoption and awareness campaigns of BIM education and review of related educational theories.

**Chapter four** is the Research Methodology adopted for the study. The chapter outlines the methodology employed in the study. It explains various parts of the study including philosophy, research approach, design, data collection and data analysis procedures.

**Chapter five** is the qualitative analysis of Building Information modeling adoption in Malaysia. The chapter presents the overviews of findings on BIM as it relates to the relevance and challenges facing the adoption in construction industry in Malaysia.

**Chapter six** discuses BIM Education Integration: it presents finding through the analysis of quantitative data gathered through the online questionnaire survey. The chapter presents discussion and findings on higher education institutions preparedness to integrate BIM into academic program in Malaysia.

**Chapter seven,** this mark the summary and conclusion of the study. The chapter therefore presents, the development of BIM integration framework for BIM integration to higher education in Malaysia, based on the analysis and discussion in chapters 5 and 6. Similarly, the chapter also presents the summary of key findings, contributions to knowledge, study limitations and suggested areas for further studies.

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