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

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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"

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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.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

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

LIST OF APPENDICES

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. Quality, Safety & Professionalism	• **Quality**: 63% of 449 projects assessed achieved Quality Assessment System in Construction (QLASSIC) score of 70% • **Safety**: 824 Safety & Health Officers and 1,350 Site Safety Supervisors trained • **Professionalism:** 43 Facility Management Contractors registered under F01 and F02 **Current Thrust Progress: 96%**
2. 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 • **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 • **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. **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) • **Accreditation:** Amended Schedule 3 of Act 520 on accreditation of skilled workers has been gazetted • **IBS:** 46 new Industrialised Building System (IBS) manufacturers registered since 2016 • B**IM Training:** 800 Building Information Modelling (BIM) personnel trained via MyBIM Centre & BIM Satellites • **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 • **NCIIC Portal**: Project manager and vendor has been appointed to develop the National Construction Industry Information Centre (NCIIC) Portal with 16 head of contents. • **Bumiputera FM Contractors:** 321 Bumiputera contractors has been trained for Facility Management (FM) **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) • **Verification Officers**: 87/50 material verification officers trained and accredited based on category and products. • **Overseas Projects:** RM 2.7 / RM 2.0 billion won through 79 overseas projects. • **Financing Study:** 85% completion of Study on Strengthening Access to Financing for Malaysian Champions Going Abroad **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.

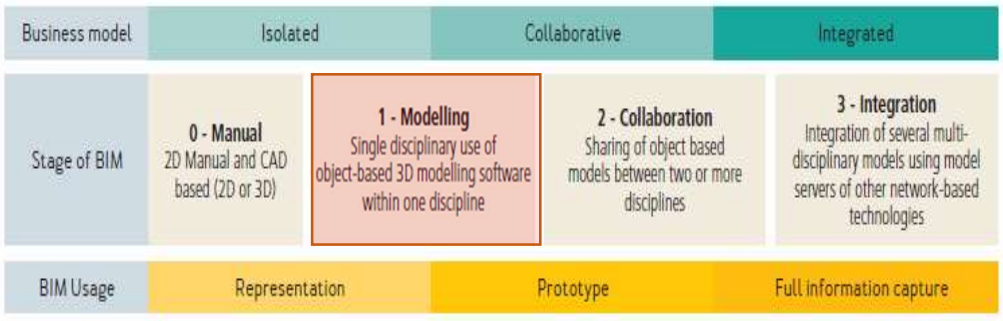

Figure 1.1: Stages of BIM Adoption (MOW and CIDB, 2015)

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).

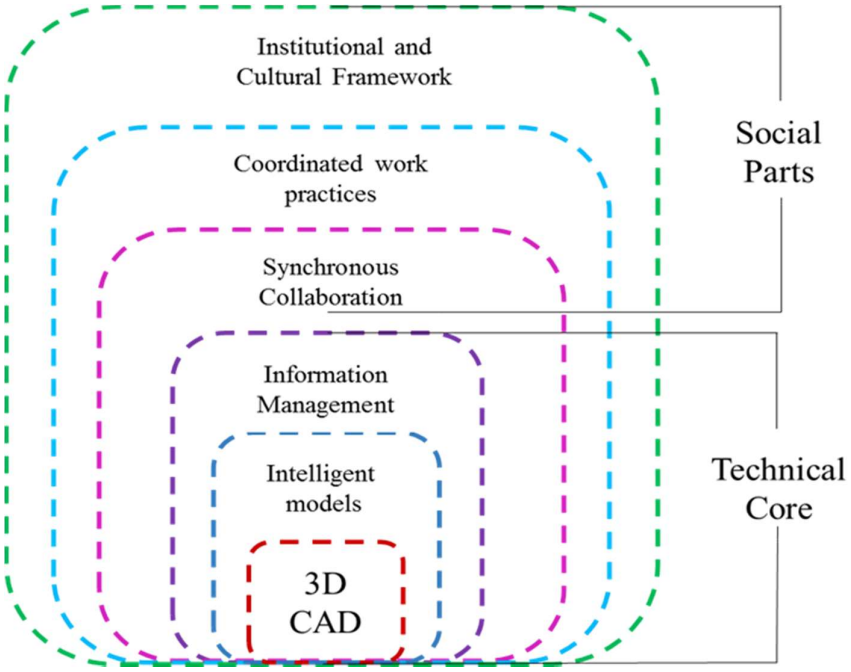

Figure 1.2: BIM as a Socio-Technical System for construction industry transformation and business approach (Henttinen, 2010)

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.

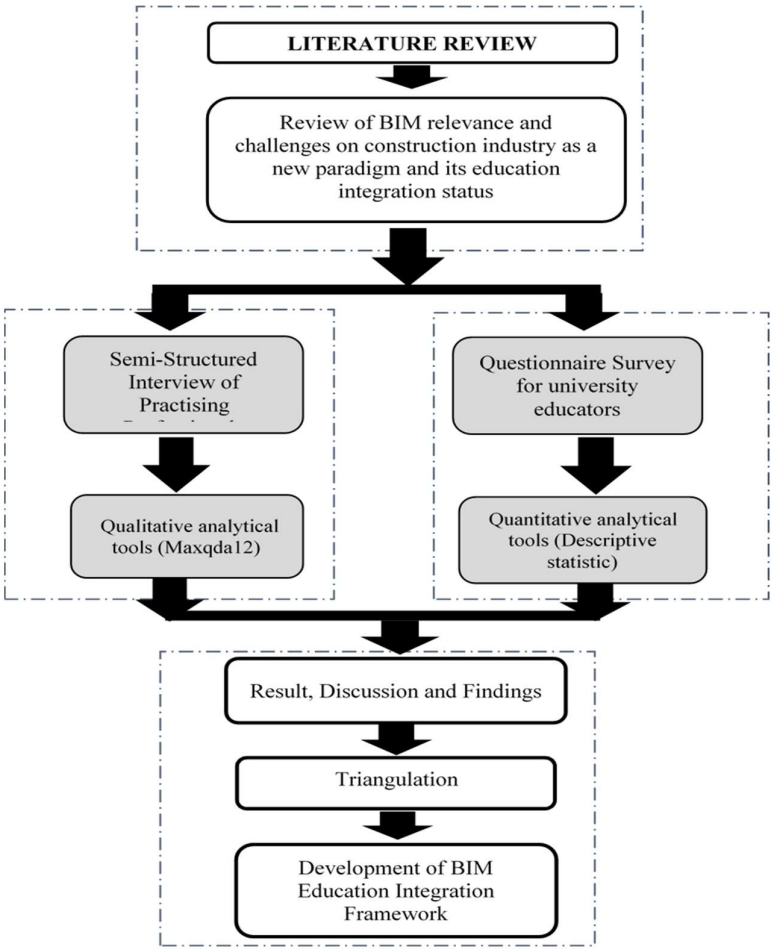

Figure 1.3: Research methodology Flowchart

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.

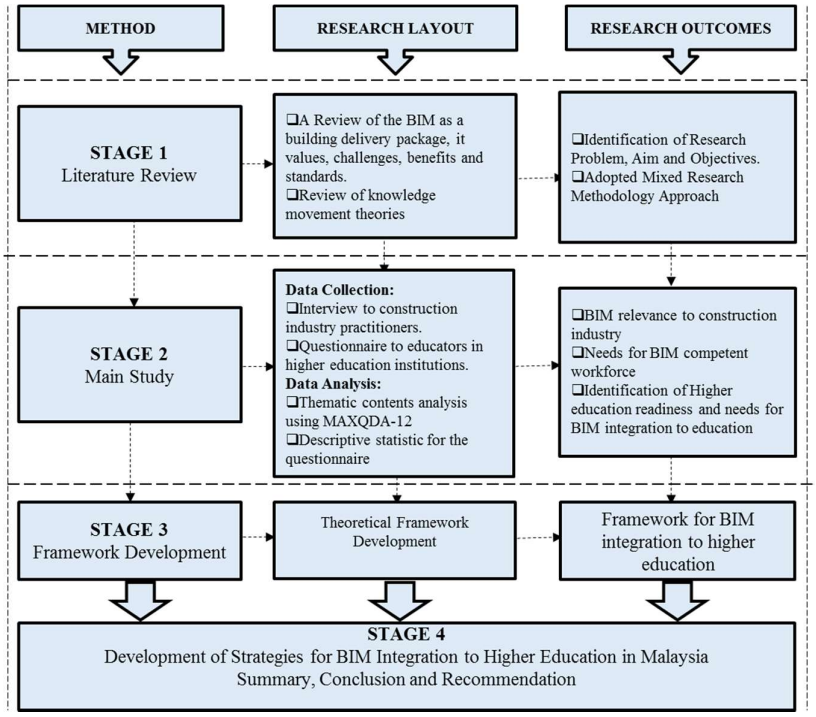

Figure 1.4: Research Operational Framework

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.

REFERENCES

Abanda, F.H., C., V., A.H., O. and J.H.M., T. (2015). A critical analysis of Building Information Modelling systems used in construction projects.

Abbas, A., Din, Z.U. and Farooqui, R. (2016). Integration of BIM in Construction Management Education: An Overview of Pakistani Engineering Universities. *Procedia Engineering.* 145**,** 151-157.

Abdul Rahman, I., Memon, A.H., Karim, A. and Tarmizi, A. (2013). Significant factors causing cost overruns in large construction projects in Malaysia. *Journal of Applied Science.* 13(2)**,** 286-293.

Achiam, M. (2014). Didactic Transposition; From Theoretical Notion to Research Programme. *In:* Copenhagen, U. O. (ed.) *ESERA Summerschool.*

Adegbehingbe, V.O. (2012). Evaluation of Involvement of Built Environment Professionals in Housing Transformation Processes in Three Government Housing Estates in Southwestern, Nigeria. *4th West Africa Built Environment Research (WABER) Conference*. buja, Nigeria,.

Ahmed, E.M. (2016). ICT and Human Capital Spillover Effects in Achieving Sustainable East Asian Knowledge-Based Economies. *Journal of the Knowledge Economy.* 8(3)**,** 1086-1112.

Ahmi, A., Saidin, S.Z., Abdullah, A., Ahmad, A.C. and Ismail, N.A. (2016). State of Information Technology Adoption by Internal Audit Department in Malaysian Public Sector. *International Journal of Economics and Financial Issues.* (Special Issue for "International Soft Science Conference (ISSC 2016))**,** 103 - 108.

Ahn, E. and Kim, M. (2016). BIM Awareness and Acceptance by Architecture Students in Asia. *Journal of Asian Architecture and Building Engineering.* 15(3)**,** 419-424.

Aibinu, A. and Venkatesh, S. (2014). Status of BIM Adoption and the BIM Experience of Cost Consultants in Australia. *Journal of Professional Issues in Engineering Education and Practice.* 140(3)**,** 04013021.

Ajagbe, A.M., Sholanke, A.B., Isiavwe, D.T. and Oke, A.O. (2015). Qualitative Inquiry for social sciences.

Aksamija, A. and Ali, M.M. (2008). Information Technology and Architectural Practice. *Proceedings of AIA IL Conference: Breaking New Ground, Moline, IL, .*

Aksamija, A.Z. and Ali, M.M. (2007). Emerging Technologies and Sustainability Practices in Architecture: Aiming for Zero-Energy Buildings. *Emerging Technologies and Sustainability Practices in Architecture*.

Ali, K.N. (2015). BIM Educational Framework for the Quantity Surveying Students: The Malaysian Perspective. *9th BIM Academic Symposium & Job Task Analysis Review*. Washington, D. C.

Ali, K.N., Mustaffa, N.E., Keat, Q.J. and Enegbuma, W.I. (2016). Building Information Modelling (BIM) Educational Framework for Quantity Surveying Students: The Malaysian Perspective. *Journal of Information Technology in Construction.* 21**,** 140-151.

Alliance, B. (2012). National BIM Standard - United States Version 2. USA: National Institute of Building Sciences buildingSMART allianc.

Altbach, P.G. (2004). Globalisation and the university: Myths and realities in an unequal world. *Tertiary Education & Management.* 10(1)**,** 3-25.

Anderson, T. (2013). Research Paradigms: Ontology's,Epistemologies & Methods.

Andersson, N. (2013). BIM Adoption in the University Teaching Program - Swedish case Study. *CITA BIM Gathering*, November 14th -15th 2013.

Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C. and O'reilly, K. (2011). Technology adoption in the BIM implementation for lean architectural practice. *Automation in Construction.* 20(2)**,** 189-195.

Autodesk (2014). New analysis tools for the Revit ecosystem advance the democratization of sustainable building design. *In:* Autodesk, I. (ed.) *Autodesk Sustainability Solutions: High performance design – empowered by simulation.* Autodesk, Inc.

Autodesk, I. (2011). Realizing the Benefits of BIM. *Autodesk® Building Information Modeling.*

Awang, H. (2004). Human Capital and Technology Development in Malaysia. *International Education Journal.* 5(2).

Azhar, S. (2011). Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering.* 11(3)**,** 241-252.

Azhar, S. and Brown, J. (2009). BIM for Sustainability Analyses. *International Journal of Construction Education and Research.* 5(4)**,** 276-292.

Azhar, S., Brown, J. and Farooqui, R. (2009). BIM-based sustainability analysis: An evaluation of building performance analysis software. *Proceedings of the 45th ASC annual conference*.

Azhar, S., Hein, M. and Sketo, B. (2008a). Building Information Modeling (BIM): Benefits, Risks and Challenges.

Azhar, S., Khalfan, M. and Maqsood, T. (2012). Building information modelling (BIM): now and beyond. *Australasian Journal of Construction Economics and Building.* 12(4)**,** 15-28.

Azhar, S., Nadeem, A., Mok, J.N.Y. and Leung, B.H.Y. (2008b). Building Information Modeling (BIM) A new paradigm for visual interactive modeling and stimulation for construction projects. *Advancing and Integrating Construction Education, Research & Practice.* 12.

Azhar, S., Nadeem, A., Mok, J.Y. and Leung, B.H. (2008c). Building Information Modeling (BIM): A new paradigm for visual interactive modeling and simulation for construction projects. *Proc., First International Conference on Construction in Developing Countries*. 435-446.

Badiru, Y.Y., Ali, K.N. and Embi, M.R. (2016). Building Information Modeling as a Process of Systemic Changes for Collaborative Education in Higher Education. *ScienceDirect.* 219**,** 820-827.

Baki, I.A. (2017). Panduan Pelaksanaan Pendidikan Abad Ke-21. *In:* Ministry of Education, M. (ed.). Malaysia: Institut Aminuddin Baki

Kementerian Pendidikan Malaysia.

Ballesty, S., Mitchell, J., Drogemuller, R., Schevers, H., Linning, C., Singh, G. and Marchant, D. (2007). Adopting BIM for facilities management: Solutions for

managing the Sydney Opera House. *Cooperative Research Centre (CRC) for Construction Innovation, Brisbane, Australia.*

Barison, M.B. and Santos, E.T. (2010a). BIM teaching strategies- an overview of the current approaches. *International Conference on Computing in Civil and Building Engineering*.

Barison, M.B. and Santos, E.T. (2010b). An overview of BIM specialists. *International Conference on Computing in Civil and Building Engineering*. Nottingham UK.

Barison, M.B. and Santos, E.T. (2010c). Proceedings of the - Review and Analysis of Current Strategies for Planning A BIM Curriculum. *CIB W*. Egypt.

Bartels, L. and Beil, J. 2017. *What is Problem-Based Learning (PBL)?* [Online]. Southern Illinois University Edwardsville: Center for Faculty Development and Innovation. Available: http://www.siue.edu/facultycenter/services_resources/teaching/pbl.shtml [Accessed 29 December, 2017 2017].

Bataw, A. (2013). Making BIM A Realistic Paradigm Rather than Just Another Fad. *ARCOM Doctoral Workshop, BIM Management and Interoperability*. Birmingham B4 7XG, United Kingdom.

Bataw, A., Kirkham, R. and Lou, E. (2016). The Issues and Considerations Associated with BIM Integration. *MATEC Web of Conferences*. 00005.

Bauer, J. and Kenton, J. (2005a). Toward technology integration in the schools: Why it isn't happening. *Journal of technology and teacher education.* 13(4)**,** 519.

Bauer, J. and Kenton, J. (2005b). Toward Technology Integration in the Schools: Why It Isn't Happening. *Jl. of Technology and Teacher Education.* 13(4)**,** 28.

Bayliss, R., Cheung, S.-O., Suen, H.C. and Wong, S.-P. (2004). Effective partnering tools in construction: a case study on MTRC TKE contract 604 in Hong Kong. *International Journal of Project Management.* 22(3)**,** 253-263.

Bazeley, P. (2009). Analysing qualitative data: More than 'identifying themes'. *Malaysian Journal of Qualitative Research.* 2(2)**,** 6-22.

Bazjanac, V. (2004). Virtual building environments (VBE)-applying information modeling to buildings. *eWork and eBusiness in Architecture, Engineering and Construction: Proceedings of the 5th European Conference on Product and*

Process Modelling in the Building and Construction Industry-ECPPM 2004, 8-10 September 2004, Istanbul, Turkey. 58.

Becerik-Gerber, B., Gerber, D.J. and Ku, K. (2011). The pace of technological innovation in architecture, engineering, and construction education: integrating recent trends into the curricula. *Journal of Information Technology in Construction.* 16**,** 411-432.

Bell, S. (2010). Project-Based Learning for the 21st Century: Skills for the Future. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas.* 83(2)**,** 39-43.

Berg, B.L., Lune, H. and Lune, H. (2004). *Qualitative research methods for the social sciences.* Pearson Boston, MA.

Blernackl, P. and Waldorf, D. (1981). *Snowball Sampling*. *Sociological Methods & Research.* (pp.: Sage.

Blumenfeld, P.C., Soloway, E., Marx, R.W., Krajcik, J.S., Guzdial, M. and Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational psychologist.* 26(3-4)**,** 369-398.

Bolpagni, M. (2013). The implementation of BIM within the public procurement: . *In:* Centre, V. T. R. (ed.) *A model-based approach for the construction industry.* VTT Technology 130: Julkaisija – Utgivare – Publisher.

Bosch, M. and Gascón, J. (2006). Twenty-five years of the didactic transposition. *ICMI Bulletin.* 58**,** 51-65.

Botchwey, N.D., Hobson, S.E., Dannenberg, A.L., Mumford, K.G., Contant, C.K., Mcmillan, T.E., Jackson, R.J., Lopez, R. and Winkle, C. (2009). A model curriculum for a course on the built environment and public health: training for an interdisciplinary workforce. *Am J Prev Med.* 36(2 Suppl)**,** S63-71.

Bowling, A. (2014). *Research methods in health: investigating health and health services.* McGraw-Hill Education (UK).

Braun, V. and Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology.* 3(2)**,** 77-101.

Brown, N.C. and Peña, R. (2009). Teaching BIM: Best Practices for Integrating BIM into Architectural Curriculum? *Autodesk University, Learn.Connect. Explore.*

Bryman, A. and Burgess, B. (2002). *Analyzing qualitative data.* Routledge.

Buildingsmart (2015). BuildingSmart Alliance Council Charter. *National Institute of Building Sciences.*

Caires, B. E. A. (2013). *BIM as a tool to support the collaborative project between the Structural Engineer and the Architect BIM execution plan, education and promotional initiatives.* Msc Universidade do Minho, Escola de Engenharia.

Castells, M. (1999). Information Technology, Globalization and Social Development. *United Nations Research Institute for Social Development.* No. 114.

Catanzaro, M. (1988). Using qualitative analytical techniques. *Nursing research: Theory and practice.* 437-456.

Chaiklin, S. (2003a). *The zone of proximal development in Vygotsky's analysis of learning and instruction*. In: Kozulin, A., Gindis, B., Ageyev, V. and Miller, S. (Ed.) *Vygotsky's educational theory and practice in cultural context.* (pp. Cambridge:: Cambridge University Press.

Chaiklin, S. (2003b). The zone of proximal development in Vygotsky's analysis of learning and instruction. *Vygotsky's educational theory in cultural context.* 1**,** 39-64.

Chandrasekaran, B., Josephson, J.R. and Benjamins, V.R. (1999). What Are Ontologies, and Why Do We Need Them? *IEEE Intelligent Systems.* (1094-7167/99).

Charmaz, K. and Smith, J. (2003). Grounded theory. *Qualitative psychology: A practical guide to research methods.* 81-110.

Cheng, J.C. and Ma, L.Y. (2013). A BIM-based system for demolition and renovation waste estimation and planning. *Waste management.* 33(6)**,** 1539-1551.

Chevallard, Y. (1988). On didactic transposition theory: Some introductory notes. *International Symposium on Research and Development in Mathematics, Bratislava, Czechoslavakia*.

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

Cho, J. and Trent, A. (2006). Validity in qualitative research revisited. *Qualitative research.* 6(3)**,** 319-340.

Chong, H.-Y., Preece, C. and Rogers, J. (2014). BIM update 2013: A mixed review approach from academia and industry. *Trends and Development in Management Studies.* 3(1)**,** 1-21.

Christopoulos, D. (2010). Peer Esteem Snowballing: A methodology for expert surveys.

Chuang, T.-H., Lee, B.-C. and Wu, I.-C. (2011). Applying cloud computing technology to BIM visualization and manipulation. *28th International Symposium on Automation and Robotics in Construction*. 144-149.

Chynoweth, P. (2009). The built environment: disciplinary knowledge base and implications for educators. *RICS COBRA Research Conference*. University of Cape Town, 1475-1486.

Cidb (2017). Construction-Industry-Transformation-Programme-on-track-to-reach-KPIs-and-outcomes. *In:* Cidb (ed.) *96.5% of Current CITP Targets Achieved through National Blue Ocean Strategy.* Kuala Lumpur, Malaysia: CIDB.

Ciribini, A. (2013). Level of Detail and Level of Development: Commissioning processes and Information Modelling. *TECHNE-Journal of Technology for Architecture and Environment.* (6)**,** 90-99.

Clevenger, C., Glick, S. and Del Puerto, C.L. (2012). Interoperable Learning Leveraging Building Information Modeling (BIM) in Construction Education. *International Journal of Construction Education and Research.* 8(2)**,** 101-118.

Clevenger, C.M., Ozbek, M., Glick, S. and Porter, D. (2010). Integrating BIM into construction management education. *Proc., The BIM--Related Academic Workshop*.

Coates, P., Arayici, Y., Koskela, K., Kagioglou, M., Usher, C. and O'reilly, K. (2010). The key performance indicators of the BIM implementation process.

Corbin, J. and Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory.* Sage publications.

Corbin, J.M. and Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative sociology.* 13(1)**,** 3-21.

Cream (2014). Bim Seminar Workshop For Malaysia Construction Industry. *In:* Ismail, M. H., Abd. Hamid, Z., Kamar, K. a. M., Mohd Zain, M. Z., Takim, R., Ahmad, N., Roslan, A. F., Nasir, R. A., Dzulkalnine, N. and Ibrahim, I. (eds.)

Construction Research Institute of Malaysia (CREAM). Kuala Lumpur, Malaysia: Construction Research Institute of Malaysia (CREAM).

Creswell, J.W. (2012a). *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research.* 4th ed. Boston.

Creswell, J.W. (2012b). *Planning, Conducting, and Evaluating Quantitative and Qualitative Research.* Fourth Edition ed. Boston.

Creswell, J.W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches.* Sage publications.

Creswell, J.W. and Clark, V.L.P. (2007). Designing and conducting mixed methods research.

Crumpton, A., Miller, B., Organizers, P. and Participants, P. (2008). Building Information Modeling: State of the A&D Industry and BIM integration into design education. *Proceedings of the Interior Design Educator's Conference, Montreal, Quebec, Canada*.

Darius, M., Vladimir, P., Virgaudas, J. and Leonas, U. (2013). The Benefits, Obstacles and Problems of Practical Bim Implementation. *11th International Conference on Modern Building Materials, Structures and Techniques, MBMST 2013*.

David, F. (2002). Understanding and doing research: A handbook for beginners. *Iloilo City, Philippines: Panorama Printing Inc.*

Davies, R.S. and West, R.E. (2014). *Technology integration in schools*. *Handbook of research on educational communications and technology.* (pp. 841-853). Springer.

Dean, R. (2007). Building Information Modeling (BIM): Should Auburn University Teach BIM to Building Science Students. *Graduate Capstone, Department of Building Science, Auburn University.*

Dede, C. (1998). *Learning with Technology. 1998 ASCD Yearbook.* ERIC.

Dede, C. (2009). Comparing Frameworks for "21st Century Skills".

Dede, C. (2010a). Comparing frameworks for 21st century skills. *21st century skills: Rethinking how students learn.* 20**,** 51-76.

Dede, C. (2010b). Comparing frameworks for 21st century skills. *21st century skills: Rethinking how students learn.* 51-76.

Denzer, A. (2009). Long Distance multidisplinary collaboration, some lessions learned.

Denzer, A. and Hedges, K. (2008). From CAD to BIM: Educational strategies for the coming paradigm shift. *AEI.*

Denzin, N.K. (1973). *The research act: A theoretical introduction to sociological methods.* Transaction publishers.

Denzin, N.K. (2010). Moments, Mixed Methods, and Paradigm Dialogs. *Qualitative Inquiry.* 16(6)**,** 419-427.

Dey, I. (2005). *Qualitative Data Analysis A User-friendly Guide for Social Scientists.* London, Routledge, Taylor & Francies Group.

Dobelis, M. (2013). Drawbacks of BIM concept adoption. *the 12th International Conference on Engineering Graphics, BALTGRAF*. 5-7.

Draganidis, F., Chamopoulou, P. and Mentzas, G. (2006). An Ontology Based Tool for Competency Management and Learning Paths.

Duit, R. (2014). *Teaching and learning the physics energy concept*. *Teaching and Learning of Energy in K–12 Education.* (pp. 67-85). Springer.

Duit, R., Gropengießer, H., Kattmann, U., Komorek, M. and Parchmann, I. (2012). *The Model of Educational Reconstruction–a Framework for Improving Teaching and Learning Science1*. *Science education research and practice in Europe.* (pp. 13-37). Springer.

Earle W. Kennett (2010). The VA-BIM-Guide. *In:* Stubbs, S. (ed.) *Department of Veterans Affairs.*

Eastman, C., Eastman, C.M., Teicholz, P. and Sacks, R. (2011a). *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors.* John Wiley & Sons.

Eastman, C., Teicholz, P. and Sacks, R. (2011b). *BIM Handbook.* Canada, WILEY.

Eastman, C., Teicholz, P., Sacks, R. and Liston, K. (2008). *A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors.* New Jersey, John Wiley & Sons, Inc.

Eastman, C., Teicholz, P., Sacks, R. and Liston, K. (2011c). *BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors.* John Wiley & Sons.

Eastman, C.M. (1999). *Building product models: computer environments, supporting design and construction.* CRC press.

Eddy, D.M., Hollingworth, W., Caro, J.J., Tsevat, J., Mcdonald, K.M. and Wong, J.B. (2012). Model transparency and validation: a report of the ISPOR-SMDM Modeling Good Research Practices Task Force–7. *Medical Decision Making.* 32(5)**,** 733-743.

Edelson, D.C., Gordin, D.N. and Pea, R.D. (1999). Addressing the challenges of inquiry-based learning through technology and curriculum design. *Journal of the learning sciences.* 8(3-4)**,** 391-450.

Egan, S.J. (1998). Rethinking Construction. *The Report of the Construction Task Force.* Department of Trade and Industry.

Eisenhardt, K.M. and Santos, F.M. (2002). Knowledge-based view: A new theory of strategy. *Handbook of strategy and management.* 1**,** 139-164.

Ellis, B.A. (2006). Building information modeling: an informational tool for stakeholders. *Government/Industry Forum by the Federal Facilities Council*. 1-5.

Elo, S., Kääriäinen, M., Kanste, O., Pölkki, T., Utriainen, K. and Kyngäs, H. (2014). Qualitative content analysis. *Sage Open.* 4(1)**,** 2158244014522633.

Elo, S. and Kyngas, H. (2008). The qualitative content analysis process. *J Adv Nurs.* 62(1)**,** 107-15.

Elo, S. and Kyngäs, H. (2008). The qualitative content analysis process. *Journal of advanced nursing.* 62(1)**,** 107-115.

Emmitt, S. and Ruikar, K. (2013). *Collaborative design management.* Routledge.

Enegbuma, W. and Ali, K. (2011a). A Preliminary Study on Building Information Modeling (BIM) Implementation in Malaysia. *Proceedings of 3rd International Postgraduate Conference on Infrastructure and Environment (IPCIE2011). Hong Kong*.

Enegbuma, W.I. and Ali, K.N. (2011b). A Preliminary Critical Success Factor (Csfs) Analysis Of Building Information Modelling (Bim) Implementation In Malaysia. *Asia Conference on Real Estate (ACRE2011)*. Thistle Johor Bahru , Malaysia.

Enegbuma, W.I. and Ali, K.N. (2011c). A Preliminary Study On Bim Implementation In Malaysia. *Proceedings of 2011 3rd International Post Graduate Conference in Engineering* 11TH-12TH July 2011. University. Vol 2. 399-407. 11th – 12th July, Hong Kong., 6.

Enegbuma, W.I., Dodo, Y.A. and Ali, K.N.C. (2013). Dimensions to Building Information Modelling Penetration in Malaysia. *Technology, Education, and Science International Conference*

Ertmer, P.A. (1999). Addressing first-and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development.* 47(4)**,** 47-61.

Felker, G., Jomo, K. and Rasiah, R. (2013). *Industrial technology development in Malaysia: industry and firm studies.* Routledge.

Fellows, R.F. and Liu, A.M. (2015). *Research methods for construction.* John Wiley & Sons.

Ferguson, E. and Cox, T. (1993). Exploratory factor analysis: A users' guide. *International Journal of Selection and Assessment.* 1(2)**,** 84-94.

Fields, C.R.I.O., Dimaggio, P. and Powell, W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review.* 48(2)**,** 147-160.

Fillingham, V., Radosavljevic, M., Gulliver, S., Malone, A. and Rajabdeen, S. (2013). Sustainable BIM-driven Design through to Post-Occupancy Evaluation of Buildings.

Fisher, C., Dwyer, D.C. and Yocam, K. (1996). *Education & Technology: Reflections on Computing in Classrooms.* ERIC.

Flanagan, L. and Jacobsen, M. (2003). Technology leadership for the twenty-first century principal. *Journal of educational administration.* 41(2)**,** 124-142.

Fombad, M.C., Boon, J.A. and Boon, J.A. (2009). Strategies for knowledge management in law firms in Botswana. *Peer Reviewed Article.* 11(2)**,** 16.

Fombad, M.C., Boon, J.A. and Bothma, T.J.D. (2009). Strategies for knowledge management in law firms in Botswana. *South African Journal of Information Management.* 11(2)**,** 1-16.

Foo Sing, T. and Zhong, Q. (2001). Construction and real estate NETwork (CORENET). *Facilities.* 19(11/12)**,** 419-428.

Ford, S., Aouad, G., Kirkham, J., Brandon, P., Brown, F., Child, T., Cooper, G., Oxman, R. and Young, B. (1995). An information engineering approach to modelling building design. *Automation in Construction.* 4(1)**,** 5-15.

Frechtling, J. (2002). The 2002 User-Friendly Handbook for Project Evaluation. *In:* Foundation, N. S. (ed.). Arlington: National Science Foundation.

Freeman, C. and Foray, D. (1992). Technology and the wealth of nations. *London: Pinter.*

Fuggetta, A. and Di Nitto, E. (2014). Software process. 1-12.

Gardner, J.C., Hosseini, M.R., Rameezdeen, R. and Chileshe, N. (2015). Building Information Modelling (BIM) Education in South Australia: Industry Needs.

Gardner, J.C.H., Hosseini, M.R., Rameezdeen, R. and Chileshe, N. (2014). Building Information Modelling (BIM) Education in South Australia: Industry Needs. *International Conference On Engineering, Project, And Production Management*. Port Elizabeth 6031, South Africa, 293-302.

Garson, G.D. (2006). *Public information technology and e-governance: Managing the virtual state.* Jones & Bartlett Learning.

Gelder, J.E. (2015). The design and development of a classification system for BIM. 1**,** 477-491.

Gersting, J. and Young, F.H. (1997). Content+ experiences= curriculum. *ACM SIGCSE Bulletin.* 29(1)**,** 325-329.

Gilligan, B. and Kunz, J. (2007). VDC use in 2007: significant value, dramatic growth, and apparent business opportunity. *Center for Integrated Facility Engineering Report, Stanford University, Stanford, CA, USA.*

Glanz, K. (2013). Social and Behavioral Theories. *e-source Behavioral and Social Sciences Research.* National Institutes of Health.

Goedert, J.D. and Meadati, P. (2008). Integrating construction process documentation into building information modeling. *Journal of construction engineering and management.* 134(7)**,** 509-516.

Goerger, S.R., Mcginnis, M.L. and Darken, R.P. (2005). A Validation Methodology for Human Behavior Representation Models. *JDMS.* 2(1)**,** 5-17.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The qualitative report.* 8(4)**,** 597-606.

Golding, C. (2013). Blinkered conceptions of academic development. *International Journal for Academic Development.* 19(2)**,** 150-152.

Goucher, D. and Thurairajah, N. (2012). Advantages and challenges of using BIM: A cost consultant's perspective. *49th ASC Annual International Conference,*

California Polytechnic State University (Cal Poly), San Luis Obispo, California.

Grapragasem, S., Krishnan, A. and Mansor, A.N. (2014). Current Trends in Malaysian Higher Education and the Effect on Education Policy and Practice: An Overview. *International Journal of Higher Education.* 3(1).

Gray, M., Gray, J., Teo, M., Chi, S. and Cheung, Y.F. (2013). Building Information Modelling: An International survey. *CIB 2013 World Congress*.

Grove, S. and Burns, N. (2005). The practice of nursing research: Conduct, critique, & utilization. St. Louis, Missouri: Elsevier Saunders.

Gruber, T. (2009). Ontology. *Encyclopedia of database systems.* 1963-1965.

Gu, N. and London, K. (2010). Understanding and facilitating BIM adoption in the AEC industry.

Guion, L.A., Diehl, D.C. and Mcdonald, D. (2011). Triangulation: Establishing the Validity of Qualitative Studies. *In:* Studies1, T. E. T. V. O. Q. (ed.) *Youth and Community Sciences,.* University of Florida; Gainesville: University of Florida, IFAS Extension.

Gummadi, K.P., Dunn, R.J., Saroiu, S., Gribble, S.D., Levy, H.M. and Zahorjan, J. (2003). Measurement, modeling, and analysis of a peer-to-peer file-sharing workload. *ACM SIGOPS Operating Systems Review*. 314-329.

Hadzaman, N.a.H., Takim, R. and Nawawi, A.H. BIM Roadmap Strategic Implementation Plan: Lesson Learnt from Australia, Singapore and Hong Kong.

Hadzaman, N.a.H., Takim, R. and Nawawi, A.H. (2015). BIM Roadmap Strategic Implementation Plan: Lesson Learnt from Australia, Singapore and Hong Kong. *Procs 31st Annual ARCOM Conference*. Lincoln, UK,.

Häkkinen, T. and Kiviniemi, A. (2008). Sustainable building and BIM. *Proceedings of SB08 Conference Melbourne*. 21-25.

Halpin, D. and Troyna, B. (1995). The politics of education policy borrowing. *Comparative Education.* 31(3)**,** 303-310.

Handcock, M.S. and Gile, K.J. (2016). On the Concept of Snowball Sampling. *eScholarship.*

Hargreaves, A. (1996). Transforming knowledge: Blurring the boundaries between research, policy, and practice. *Educational evaluation and policy analysis.* 18(2)**,** 105-122.

Harona, A.T., Marshall-Pontingb, A.J., Zakariac, Z., Nasrun, M., Nawid, M., Hamide, Z.A. and Kamarf, K.a.M. (2015). An Industrial Report on the Malaysian Building Information Modelling (BIM) Taskforce: Issues and Recommendations.

Hartmann, T. and Fischer, M. (2008). Applications of BIM and hurdles for widespread adoption of BIM. *2007 AISC-ACCL eConstruction Roundtable Event Rep.*

Hashimov, E. (2015). Qualitative Data Analysis: A Methods Sourcebook and The Coding Manual for Qualitative Researchers: Matthew B. Miles, A. Michael Huberman, and Johnny Saldaña. Thousand Oaks, CA: SAGE, 2014. 381 pp. Johnny Saldaña. Thousand Oaks, CA: SAGE, 2013. 303 pp. *Technical Communication Quarterly.* 24(1)**,** 109-112.

Hazzan, O., Dubinsky, Y. and Meerbaum-Salant, O. (2010a). Didactic Transposition in Computer Science Education. *standard articles.* 1(4).

Hazzan, O., Dubinsky, Y. and Meerbaum-Salant, O. (2010b). Didactic transposition in computer science education. *ACM Inroads.* 1(4)**,** 33-37.

Heckathorn, D.D. (2011). Snowball Versus Respondent-Driven Sampling. *Sociol Methodol.* 41(1)**,** 355-366.

Hedges, K.E., Denzer, A.S., Livingston, C. and Hoistad, M. (2008). Socially responsible collaborative models for green building design. *Proc., AIA Research for Practice Program Grant.*

Henttinen, T. (2010). BIM in Finland.

Mehmet F. Hergunsel (2011). *Benefits of Building Information Modeling for Construction Managers and BIM Based Scheduling.* Master of Science, Worcester Polytechnic Institute.

Hesse-Biber, S.N. and Leavy, P. (2006). *Emergent methods in social research.* Sage.

Hietanen, J. and Drogemuller, R. (2008). Approaches to university level BIM education. *IABSE Symposium Report*. 24-28.

Hon, C.K., Utiome, E., Drogemuller, R., Owen, R., Beazley, S., Nepal, M., Gray, J. and Coffey, V. (2016). An evaluation of learning and teaching initiatives for BIM education at Queensland University of Technology (QUT).

Howell, I. and Batcheler, B. (2013). BIM Two Years Later- Huge Potential, Some success and Several limitations.

Hsieh, H.-F. and Shannon, S.E. (2005). Three approaches to qualitative content analysis. *Qualitative health research.* 15(9)**,** 1277-1288.

Huber, R. (2012). New Zealand National BIM Survey 2012. *Masterspec - Construction Information Limited.*

Ibrahim, M. and Krawczyk, R. (2003). The level of knoledge of CAD objects within the Building Informatiom model. *ACADIA22 ; Connecting Crossroads of Digital Discourse.*

Issa, R.R. and Suermann, P. (2009). Evaluating industry perceptions of building information modeling (BIM) impact on construction. *J. Inf. Technol. Constr.* 14**,** 574-594.

Jacelon, C.S. and O'dell, K.K. (2005). Analyzing qualitative data. *Urologic Nursing.* 25(3)**,** 217.

Jajri, I. and Ismail, R. (2007). Technical Efficiency, Technological Change and Total Factor Productivity Growth in Malaysian Manufacturing Sector. *The Icfai Journal of Industrial Economics.* 4(4).

James, W. (1975). *Pragmatism.* Harvard University Press.

Johnson, R.B. and Onwuegbuzie, A.J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational researcher.* 33(7)**,** 14-26.

Jones, A.C. and Wilcox, R.K. (2008). Finite element analysis of the spine: towards a framework of verification, validation and sensitivity analysis. *Med Eng Phys.* 30(10)**,** 1287-304.

Jonker, J. and Pennink, B. (2010). *The Essence of Research Methodology AConcise Guide for Master and PhD Students in Management Science.* Heidelberg, Germany, Springer.

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

Kamal, E.M., Haron, S.H., Ulang, N.M. and Baharum, F. (2012). The critical review on the Malaysian construction industry. *Journal of Economics and Sustainable Development.* 3(13)**,** 81-87.

Kamar, K.a.M., Alshawi, M. and Hamid, Z. (2009). Barriers To Industrialized Building System (Ibs): The Case Of Malaysia

International Postgraduate Research Conference (IPGRC 2009), . 29 –30th January, 2009. The University of Salford, Salford, United Kingdom.

Kane, C.D. (2012). *Productivity Roadmap.* Building and Construction Sector, Productivity Partnership.

Kelly, M., O'connor, J., Costello, M. and Nicholson, G. (2015). A Collaborative Academia-Industry Approach to Programme-Wide Implementation of Building Information Modelling Processes using a Reciprocal Learning Framework.

Khan, A.A. (2014). Qualitative Research: A Case for a Multi-Angle View to Enhance 'Validity'. *International Journal of Business and Management.* 9(9).

Khemlani, L. (2004). Autodesk Revit: implementation in practice. *White paper, Autodesk.*

Khosrowshahi, F. and Arayici, Y. (2012a). Roadmap for implementation of BIM in the UK construction industry. *Engineering, Construction and Architectural Management.* 19(6)**,** 610-635.

Khosrowshahi, F. and Arayici, Y. (2012b). Roadmap for implementation of BIM in the UK construction industry. *Engineering, Construction and Architectural Management.* 19(6)**,** pp. 610-635.

Kim, C., Kim, M.K., Lee, C., Spector, J.M. and Demeester, K. (2013). Teacher beliefs and technology integration. *Teaching and Teacher Education.* 29**,** 76-85.

Kiviniemi, A. (2013). Challenges and opportunities in the BIM education: How to include BIM in the future curricula of AEC professionals?

Kjartansdóttir I. B. (2011). *BIM adoption in Iceland and its relation to lean construction.* M.Sc Master of Science in Construction Management, Reykjavík University.

Kolarevic, B. and Malkawi, A. (2005). *Performative Architecture.* Routledge.

Kopcha, T.J. (2012). Teachers' perceptions of the barriers to technology integration and practices with technology under situated professional development. *Computers & Education.* 59(4)**,** 1109-1121.

Kouider, T. and Paterson, G.J. (2013). Architectural Technology and The BIM Acronym: Critical Perspectives of Evangelical and Evolutionary Paradigms for Technical Design. *Procedding of the International Congress of Architectural Technology*. Sheffield.

Kreider, R.G. and Messner, J.I. (2013). The Uses of BIM: Classifying and Selecting BIM Uses. *State College-Pennsylvania.*

Kriengsak, P., Wong, M.L., Doh, J.H., Stewart, R.A. and Mccarthy, T.J. (2013). Integrating building information modelling (BIM) into Engineering education: an exploratory study of industry perceptions using social network data. *University of Wollongong, Research Online.*

Krippendorff, K. (2012). *Content analysis: An introduction to its methodology.* Sage.

Kumar, J.V. and Mukherjee, M. (2009). Scope of Building Information Modeling (BIM) in India. *Journal of Engineering Science and Technology Review.* 2 (1).

Kumar, V. and Jain, P. (2003). Commercialization of new technologies in India: an empirical study of perceptions of technology institutions. *Technovation.* 23(2)**,** 113-120.

Labaree, R.V. (2017). Organizing Your Social Sciences Research Paper: Purpose of Guide. *Research Guides.* USC Libraries, University of Southern California: USC Libraries.

Lavy, S. and Jawadekar, S. (2014). A case study of using BIM and COBie for facility management. *International Journal of Facility Management.* 5(2).

Lea, H. (2012). What Is Building Information Modelling. *CIBSE BIM Update Conference.*

Lee, C.C. and Hogg, K. (2009). Early career training of quantity surveying professionals. *The Construction and Building Research Conference of the Royal Institution of Chartered Surveyors*. University of Cape Town.

Lee, M.N. (1999). Education in Malaysia: towards vision 2020. *School effectiveness and school improvement.* 10(1)**,** 86-98.

Lee, M.N. (2004a). *Restructuring higher education in Malaysia.* School of Educational Studies, Universiti Sains Malaysia Penang.

Lee, M.N.N. (2004b). Global Trends, National Policies and Institutional Responses: Restructuring Higher Education in Malaysia. *Educational Research for Policy and Practice.* 3(1)**,** 31-46.

Lee, N. and Hollar, D.A. (2013). Probing BIM education in construction engineering and management programs using industry perceptions. *49th ASC Annual Int. Conf. Proc., California Polytechnic State Univ., San Luis Obispo, CA*.

Lefroy, J., Thomas, A., Harrison, C., Williams, S., O'mahony, F., Gay, S., Kinston, R. and Mckinley, R.K. (2013). Development and face validation of strategies for improving consultation skills. *Adv in Health Sci Educ.* 19**,** 661–685.

Lewins, A. and Silver, C. (2007). *Using software in qualitative research: A step-by-step guide.* Sage.

Lewis, P., Thornhill, A. and Saunders, M. (2007). *Research methods for business students.* Pearson Education UK.

Lichtman, M. (2013). *Qualitative research for the social sciences.* Sage Publications.

Liu, S., Joy, M. and Griffit, N. (2008). An Exploration of Correlative Elements to Support Cognitive Advancement in the Design

of Collaborative Learning Tools. *The Warwick Research Archive Portal (WRAP).*

Lu, N. and Korman, T. (2010). Implementation of building information modeling (BIM) in modular construction: Benefits and challenges. *Construction Research Congress 2010: Innovation for Reshaping Construction Practice*. 1136-1145.

Lu, W.W.S. and Li, H. (2011). Building information modeling and changing construction practices. *Automation in Construction.* 20(2)**,** 99-100.

Lucas, J., Thabet, W. and Bowman, D. (2009). Analyzing capacity of BIM tools to support data use across project lifecycle. *Managing IT in construction/managing construction for tomorrow.* 26**,** 11-18.

Macal, C.M. (2005). Model verification and validation. *Workshop on" Threat Anticipation: Social Science Methods and Models*.

Macdonald, J. (2011a). BIM-Adding value by assisting collaboration.

Macdonald, J. 2013. *C'mon C'mon Let's Work Together...Educating for a Collaborative Future* [Online]. Available: http://buildingsmart.org.au/cmon-cmon-lets-work-together-educating-for-a-collaborative-future/#.WGJ8u1ykHd4 [Accessed 27/12/2016].

Macdonald, J.A. (2011b). Bim – Adding Value By Assisting Collaboration.

Macdonald, J.A. (2012a). A Framework For Collaborative Bim Education Acros The Aec Disciplines.

Macdonald, J.A. (2012b). A framework for collaborative BIM education across the AEC disciplines. *37th Annual Conference of Australasian University Building Educators Association (AUBEA)*. 4-6.

Mahidin, M.U.B. (2017). Current Population Estimates, Malaysia, 2016-2017. *In:* Malaysia, D. O. S. (ed.). Malaysia: Department Of Statistics Malaysia.

Malaysia, C. (2007). Construction Industry Master Plan Malaysia 2006-2015. *Kuala Lumpur. Construction Industry Development Board Malaysia.*

Malaysia, M. (2012). Malaysian Education Blueprint 2013-2020. *In:* Ministry of Education, M. (ed.).

Mamter, S., Salleh, N.M. and Mamat, M.E. (2014). Building Information Modeling (BIM) awareness among higher education Institution students.

Mandhar, M. and Mandhar, M. (2013). BIMing the architectural curricula: integrating Building Information Modelling (BIM) in architectural education. *International Journal of Architecture.* 1(1)**,** 1-20.

Mathews, M. (2015). Defining Job Titles and Career Paths in BIM.

Mazlan, J.M. (1998). Malaysian fisheries policy beyond 2000. *Fisheries and the Environment: Beyond 2000.* 15-20.

Mcauley, B., Hore, A. and West, R. (2016). BICP Global BIM Study.

Mcgraw-Hill (2012). The Business Value of BIM in North America Multi-Year Trend Analysis and User Ratings (2007–2012). *In:* Report, S. (ed.).

Meadati, P. and Irizarry, J. (2010). BIM–a knowledge repository. *Proceedings of the 46th Annual International Conference of the Associated Schools of Construction, Retrieved November*. 2010.

Merriam, S.B. and Simpson, E.L. (1995). *A guide to research for educators and trainers of adults.* ERIC.

Miles, M.B. and Huberman, A.M. (1994). *Qualitative Data Analysis.* London, Sage Publications, Inc.

Miles, M.B., Huberman, A.M. and Saldaña, J. (2013). *Qualitative data analysis: A methods sourcebook.* SAGE Publications, Incorporated.

Miller, G., Sharma, S., Donald, C. and Amor, R. (2013a). *Developing a Building Information Modelling Educational Framework for the Tertiary Sector in New Zealand*. *Product Lifecycle Management for Society.* (pp. 606-618). Springer.

Miller, G., Sharma, S., Donald, C. and Amor, R. (2013b). Developing a Building Information Modelling Educational Framework for the Tertiary Sector in New Zealand. *IFIP International Conference on Product Lifecycle Management*. 606-618.

Miller, H. (2006). Paradigm Shift, How Higher Education is Improving Learning. *Herman Miller Inc.*

Mills, J., Tran, A., Parks, A. and Macdonald, J. (2013). Collaborative building design education using Building Information Modelling (CodeBIM). *Office for Learning and Teaching, Department of Education Sydney, Australia< Retrieved August.* 21**,** 2014.

Ministry of Education, M. (2013). Malaysia Education Blueprint 2013-2025. *In:* Education, M. O. (ed.) *Ministry of Education, Malaysia.*

Miyazoe, T. and Anderson, T. (2015). Empirical Research on Learners' Perceptions: Interaction Equivalency

Theorem in Blended Learning. *European Journal of Open, Distance and E-Learning (EUROL).*

Moe. 2015. *The Malaysian Higher Education System - An Overview* [Online]. StudyMalaysia.com. Available: https://www.studymalaysia.com/education/higher-education-in-malaysia/the-malaysian-higher-education-system-an-overview [Accessed 23th August, 2016 2016].

Mohammad, H.I. (2015). Strategic Implementation Of BIM In The Malaysian Construction Industry. *Architecture Malaysia.* 27(3)**,** 78-81.

Mokhtar, S.A. (2005). Academic Computing Components in Malaysian Higher Education. *Proceedings of the Postgraduate Annual Research Seminar*.

Monson, C. Student Collaboration As The Foundation For Learning Bim Software: Ideas From A Project-Based Introduction. *Building Construction Science Program.*

Monteiro, A. and Martins, J.P. (2013). A survey on modeling guidelines for quantity takeoff-oriented BIM-based design. *Automation in Construction.* 35**,** 238-253.

Monteiro, A. and Martins, J.P.P. (2012). SIGABIM: a framework for BIM application. *XXXVIII IAHS World Congress*.

Montessori, M.M. (1976). *Education for Human Development: Understanding Montessori.* New York, Schocken Books.

Morse, J.M. (1995). The significance of saturation. *Qualitative health research.* 5(2)**,** 147-149.

Mow and Cidb (2015). Construction Industry Transformation Programme (CITP) 2016-2020

Driving Construction Excellence Together. *In:* Cidb, M. O. W. M. A. (ed.). Kuala Lumpur, Malaysia: Construction Industry Development Board (CIDB) Malaysia.

Mustafa Kamal, E. and Flanagan, R. (2012). Understanding absorptive capacity in Malaysian small and medium sized (SME) construction companies. *Journal of Engineering, Design and Technology.* 10(2)**,** 180-198.

Nawi, M.N.M., Lee, A. and Nor, K.M. (2011). Barriers to Implementation of the Industrialised Building System in Malaysia. *The Built & Human Environment Review.* 4.

Neuman, W.L. (2005). *Social research methods: Quantitative and qualitative approaches.* Allyn and Bacon Boston.

Ngai, S.C., Drew, D.S., Lo, H.P. and Skitmore, M. (2002). A theoretical framework for determining the minimum number of bidders in construction bidding competitions. *Construction Management and Economics.* 20(6)**,** 473-482.

Nielsen, D., Fleming, M. and Kumarasuriyar, A.C. (2009). An innovative learning model for teaching architectural technology using building information modelling: a Queensland University of Technology perspective.

Noor, K.B.M. (2008). Case study: A strategic research methodology. *American journal of applied sciences.* 5(11)**,** 1602-1604.

Noss, R. (2012). 21st Century Learning for 21st Century Skills: What Does It Mean, and How Do We Do It? *7th European Conference onTechnologyEnhancedLearning,EC-TEL2012*. Saarbrücken, Germany.

O'banion, T. (1997). Creating More Learning-Centered Community Colleges.

Ofori, G. (2000). Globalization and construction industry development: research opportunities. *Construction Management & Economics.* 18(3)**,** 257-262.

Ofori, G. (2007). Construction in Developing Countries. *Construction Management and Economics.* 25(1)**,** 1-6.

Osborne, J.F. (1996). Beyond constructivism. *Science education.* 80(1)**,** 53-82.

Patton, M.Q. (1990). *Qualitative evaluation and research methods.* SAGE Publications, inc.

Patton, M.Q. and Cochran, M. (2007). A Guide to Using Qualitative Research Methodology. *In:* Medicine, L. S. O. H. a. T. (ed.) *Research Unit,* . London: Medecins Sans Frontieres.

Peel, D. (2009). EmbracingScholarshipin the Built Environment. *Journal for Education in the Built Environment.* 4(2)**,** 1-8.

Plume, J. and Mitchell, J. (2007). Collaborative design using a shared IFC building model—Learning from experience. *Automation in Construction.* 16(1)**,** 28-36.

Poerschke, U., Holland, R.J., Messner, J.I. and Pihlak, M. (2010). BIM collaboration across six disciplines. *Proc., Int. Conf. on Computing in Civil and Building Engineering*. 575-671.

Polit, D.F. and Beck, C.T. (2010). Generalization in quantitative and qualitative research: myths and strategies. *International journal of nursing studies.* 47(11)**,** 1451-1458.

Rand, A. (1988). *The Ayn Rand lexicon: objectivism from A to Z.* Penguin.

Rattray, J. and Jones, M.C. (2007). Essential elements of questionnaire design and development. *J Clin Nurs.* 16(2)**,** 234-43.

Razak, M.F.R. and Sani, A. (2015). The Preferences of Using BIM Software by Architectural Students in University of Malaya–An Exploratory Pilot Study. *Journal of Design and Built Environment.*

Riel, M. (1998). Education in the 21st century: Just-in-time learning or learning communities. *Fourth Annual Conference of the Emirates Center for Strategic Studies and Research, Abu Dhabi*.

Ritchie, D. and Wiburg, K. (1994). Educational variables influencing technology integration. *Journal of Technology and Teacher Education.* 2(2)**,** 143-153.

Ritchie, J. and Spencer, L. (2002). Qualitative data analysis for applied policy research. *The qualitative researcher's companion.* 573**,** 305-329.

Robins, M. 2011. *The Benefits of BIM* [Online]. Available: http://www.metalconstructionnews.com/articles/magazine-features/the-benefits-of-bim.aspx?alttemplate=printtemplate [Accessed 20/12/2016].

Rogers, D.L. (2000). A paradigm shift: Technology integration for higher education in the new millennium. *Educational Technology Review.* 19-27.

Rogers, J., Chong, H.-Y. and Preece, C. (2015). Adoption of building information modelling technology (BIM) perspectives from Malaysian engineering

consulting services firms. *Engineering, Construction and Architectural Management.* 22(4)**,** 424-445.

Rooney, K. (2015). BIM Education-Global Summary 2015 Update Report. Sydney, Australia: NATSPEC Construction Information.

Rorty, R. (1982). *Consequences of pragmatism: Essays, 1972-1980.* U of Minnesota Press.

Roth, W.-M. and Radford, L. (2010). Re/thinking the Zone of Proximal Development (Symmetrically). *Mind, Culture, and Activity.* 17(4)**,** 299-307.

Rundell, R. (2006). 1-2-3 Revit: BIM and Cost Estimating. *Cadalyst.*

Rundell, R. 2007. *BIM and Education (1-2-3 Revit Tutorial): How building information modeling is being used to teach sustainable design.* [Online]. Available:

http://aec.cadalyst.com/aec/Column:+1-2-3+Revit/BIM-and-Education-1-2-3-Revit-Tutorial/ArticleStandard/Article/detail/460799

, [Accessed 03/01/2017].

Ruzek, J.I. and Douglas F. Zatzick, M.D. (2000). Ethical Considerations in Research Participation Among Acutely Injured Trauma Survivors: An Empirical Investigation. *General Hospital Psychiatry.* 22(1)**,** 27-36.

Rwamamara, R., Norberg, H., Olofsson, T. and Lagerqvist, O. (2010). Using visualization technologies for design and planning of a healthy construction workplace. *Construction Innovation.* 10(3)**,** 248-266.

Ryan, A. and Tilbury, T. (2013). Flexible Pedagogies: new pedagogical ideas. *The Higher Education Academy.* 41.

Ryan, A.B. (2006). Post-positivist approaches to research. *Researching and Writing your Thesis: a guide for postgraduate students.* 12-26.

S. Suwal, P. Jäväjä, Md. A. Rahman and Gonzalez, V. (2013). Exploring Bim-Based Education Perspective.

Sabol, L. (2008). Building Information Modeling & Facility Management. *IFMA World Workplace, November 2008.*

Sabongi, F.J. (2009). The Integration of BIM in the Undergraduate Curriculum: an analysis of undergraduate courses. *Proc., 45th Annual Conference of ASC*.

Sacks, R. and Barak, R. (2008). Impact of three-dimensional parametric modeling of buildings on productivity in structural engineering practice. *Automation in Construction.* 17(4)**,** 439-449.

Sacks, R. and Barak, R. (2009). Teaching building information modeling as an integral part of freshman year civil engineering education. *Journal of Professional Issues in Engineering Education and Practice.* 136(1)**,** 30-38.

Sacks, R. and Barak, R. (2010). Teaching Building Information Modeling as an Integral Part of freshman year Civil Engr. Education. *Journal of Professional Issues in Engineering Education and Practice*

Sacks, R., Eastman, C.M. and Lee, G. (2004). Parametric 3D modeling in building construction with examples from precast concrete. *Automation in Construction.* 13(3)**,** 291-312.

Sacks, R. and Pikas, E. (2013). Building information modeling education for construction engineering and management. I: Industry requirements, state of the art, and gap analysis. *Journal of Construction Engineering and Management.* 139(11)**,** 04013016.

Sacks, R., Radosavljevic, M. and Barak, R. (2010). Requirements for building information modeling based lean production management systems for construction. *Automation in Construction.* 19(5)**,** 641-655.

Saldaña, J. (2015). *The coding manual for qualitative researchers.* Sage.

Salleh, I.M. and Meyanathan, S.D. (1993). *Malaysia: growth, equity, and structural transformation.* World Bank Publications.

Sampaio, A.Z. (2015). The Introduction of the BIM Concept in Civil Engineering Curriculum. *International Journal of Engineering Education.* 31(1)**,** 302-315.

Sandelowski, M. and Barroso, J. (2003). Classifying the Findings in Qualitative Studies. *Qualitative Health Research.* 13(7)**,** 905-923.

Sargent, R.G. (1999). Validation and Verification of Simulation Models. *28th Winter Simulation Conference*.

Savenye, W.C. and Robinson, R.S. (2005). Using qualitative research methods in higher education. *Journal of computing in Higher education.* 16(2)**,** 65-95.

Savery, J.R. (2015). Overview of problem-based learning: Definitions and distinctions. *Essential Readings in Problem-Based Learning: Exploring and Extending the Legacy of Howard S. Barrows.* 5.

Schlueter, A. and Thesseling, F. (2009). Building information model based energy/exergy performance assessment in early design stages. *Automation in construction.* 18(2)**,** 153-163.

Seah, E. (2012). BIM Object Libraries and their implications in the preparation of BQ and estimating. *In:* Consultants, G. C. (ed.) *LangdonSeah.*

Seah, E. (2014). Building Information Modelling. *In:* Consultants, G. C. (ed.) *LangdonSeah.* Singapore: Global Construction Consultants.

Selvaratnam, V. (1985). The Higher Education System in Malaysia-Metropolitan, Cross-National, peripherai Or National. *Elsevier Science Publishers.* 14**,** 477-496.

Seng, T.O. (2001). Thinking Skills, Creativity And Problem-Based Learning.

Shamoo, A.E. and Resnik, D.B. (2009). *Responsible conduct of research.* Oxford University Press.

Sharag-Eldin, A. and N., N.O. (2010). BIM in AEC Education. *ASCE Structures Congress*.

Shelbourn, M., Macdonald, J. and Mills, J. (2016). Developing an international framework for BIM education in the HE sector.

Shen, L.Y., Li Hao, J., Tam, V.W.Y. and Yao, H. (2007). A checklist for assessing sustainability performance of construction projects. *Journal of civil engineering and management.* 13(4)**,** 273-281.

Shen, W., Shen, Q. and Sun, Q. (2012). Building Information Modeling-based user activity simulation and evaluation method for improving designer–user communications. *Automation in Construction.* 21**,** 148-160.

Shephard, R.J. (2002). Ethics in exercise science research. *Sports Medicine.* 32(3)**,** 169-183.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard educational review.* 57(1)**,** 1-23.

Silver, C. and Lewins, A. (2014). *Using software in qualitative research: A step-by-step guide.* Sage.

Singh, V., Gu, N. and Wang, X. (2011). A theoretical framework of a BIM-based multi-disciplinary collaboration platform. *Automation in Construction.* 20(2)**,** 134-144.

Succar, B. (2009). Building information modelling framework: A research and delivery foundation for industry stakeholders. *Automation in Construction.* 18(3)**,** 357-375.

Succar, B. (2011). BIM Industrial Transformation in Australia - Handout.

Succar, B. and Sher, W. (2013). A competency knowledge-base for BIM learning. *A Competency knowledge-base for BIM learning', in Australasian Universities Building Education (AUBEA2013), , ,* November 20-22, 2013. Auckland, New Zealand.

Succar, B., Sher, W., Aranda-Mena, G. and Williams, T. A Proposed Framework To Investigate Building Information Modelling Through Knowledge Elicitation And Visual Models.

Succar, B., Sher, W. and Williams, A. (2012). Measuring BIM performance: Five metrics. *Architectural Engineering and Design Management.* 8(2)**,** 120-142.

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

T.H. Nguyen, T. Shehab and Z. Gao (2010). Evaluating Sustainability of Architectural Designs Using BIM. *The Open Construction and Building Technology Journal.* 4(1-8).

Taihairan, R.B.R. and Ismail, Z. (2015). BIM: Integrating Cost Estimates at Initial/Design Stage. *International Journal of Sustainable Construction Engineering & Technology.* 6(1)**,** 13.

Takim, R., Harris, M. and Nawawi, A.H. (2013). Building Information Modeling (BIM): A New Paradigm for Quality of Life Within Architectural, Engineering and Construction (AEC) Industry. *Procedia - Social and Behavioral Sciences.* 101**,** 23-32.

Tamera, M. and Pober, E. BIMSTORM- A Platform Facilitating Integrated Design and Construction Processes.

Tardif, M. (2008). BIM: Reaching Forward, Reaching Back. *AIArchtiect This Week.*

Taylor, J.E., A.M.Asce, A.M. and Bernstein, P.G. (2009). Paradigm Trajectories of Building Information Modeling Practice in Project Networks

Journal Of Management In Engineering 69-76.

Taylor, J.E. and Bernstein, P.G. (2009). Paradigm trajectories of building information modeling practice in project networks. *Journal of Management in Engineering.* 25(2)**,** 69-76.

Thompson, E., Horne, M., Lockley, S. and Cerny, M. (2011a). Towards an Information Rich 3D City Model: Virtual NewcastleGateshead GIS Integration. *Proceedings of 12th International Conference on Computers in Urban Planning and Urban Management, ALBERTA, Canada*.

Thompson, E.M., Horne, M., Lockley, S. and Cerny, M. (2011b). Towards an Information Rich 3D City Model: Virtual NewcastleGateshead GIS Integration.

Tiberghien, A. and Sensevy, G. (2014). *Transposition Didactique*. *Encyclopedia of Science Education.* (pp. 1-4). Springer.

Tondeur, J., Kershaw, L.H., Vanderlinde, R. and Braak, J.V. (2013). Getting inside the black box of technology integration in education: Teachers' stimulated recall of classroom observations. *Australasian Journal of Educational Technology.* 29(3).

Tookey, J.E. (2012). Shaving BIM: Establishing A Framework for Future BIM Research in New Zealand.

Trilling, B. and Fadel, C. (2009). *21st Century Skills- Learning for Life in Our Times.* United States, John Wiley & Sons.

Trochim, W.M. and Donnelly, J.P. (2001). Research methods knowledge base.

Turk, D., France, R. and Rumpe, B. (2005). Assumptions Underlying Agile Software Development Processes. *In: Journal of Database Management.* 16(4)**,** 62-87.

Ulrich, D., Brockbank, W., Yeung, A.K. and Lake, D.G. (1995). Human resource competencies: An empirical assessment. *Human Resource Management.* 34(4)**,** 473-495.

Underwood, J. and Ayoade, O. (2015a). Current Position and Associated Challenges of Bim Education in Uk Higher Education. *In:* Forum, B. A. (ed.) *The Higher Education Academy.*

Underwood, J. and Ayoade, O. (2015b). Current Position and Associated Challenges of BIM Education in UK Higher Education.

Utiome, E., Drogemuller, R. and Docherty, M. (2014). Enriching the" I" in Bim: A BIM-Specifications (Bimspecs) Approach. *Computing in Civil and Building Engineering (2014)*. 97-104.

Vaismoradi, M., Turunen, H. and Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing & health sciences.* 15(3)**,** 398-405.

Van Den Akker, J., Gravemeijer, K., Mckenney, S. and Nieveen, N. (2006). *Educational design research.* Routledge.

Van Gog, T., Paas, F., Savenye, W., Robinson, R., Niemczyk, M., Atkinson, R., Johnson, T.E., O'connor, D.L., Rikers, R.M. and Ayres, P. (2008). Data collection and Analysis. *Handbook of Research on Educational Communications and Technology 3e.* 763-806.

Van Manen, M. (2015). *Researching lived experience: Human science for an action sensitive pedagogy.* Left Coast Press.

Vanier, D.D. (2001). Why industry needs asset management tools. *Journal of computing in civil engineering.* 15(01)**,** 35-43.

Venkatesh, V., Brown, S.A. and Bala, H. (2013). Bridging the qualitative-quantitative divide: Guidelines for conducting mixed methods research in information systems. *MIS quarterly.* 37(1)**,** 21-54.

Voordijk, H., Haan, J.D. and Joosten , G.-J. (2000). Changing governance of supply chains in the building industry: a multiple case study. *European Journal of Purchasing & Supply Management.* 6**,** 217-225.

VOSLOO J. J. (2014). *A sport management programme for educator training in accordance with the diverse needs of South african schools.* PhD, NorthWest University.

Walsh, D. (2015). The countdown to 2016: Your action list to be ready. Design.

Wang, J., Li, J. and Chen, X. (2010). Parametric Design Based on Building Information Modeling for Sustainable Buildings. 236-239.

Wass, R. and Golding, C. (2014). Sharpening a tool for teaching: the zone of proximal development. *Teaching in Higher Education.* 19(6)**,** 671-684.

Weinberg, B.A. (2004). Experience and technology adoption.

Wertsch, J.V. (1984). The Zone of Proximal Development: Some Conceptual Issues.

Wierzbicki, M., De Silva, C.W. and Krug, D.H. (2011). BIM–HISTORY and TRENDS.

Wong, A.K., Wong, F.K. and Nadeem, A. (2011a). Government roles in implementing building information modelling systems: Comparison between Hong Kong and the United States. *Construction Innovation.* 11(1)**,** 61-76.

Wong, A.K.D., Wong, F.K.W. and Nadeem, A. (2011b). Government roles in implementing building information modelling systems: Comparison between Hong Kong and the United States. *Construction Innovation: Information, Process, Management.* 11(1)**,** 61-76.

Wong, A.K.D., Wong, F.K.W. and Nadeem, A. (2013). Attributes of Building Information Modelling and its development in Hong Kong. *The Hong Kong Institution of Engineers Transactions.* 16(2).

Wong, K.-D.A., Wong, F.K. and Nadeem, A. (2011c). Building information modelling for tertiary construction education in Hong Kong. *Journal of information technology in construction.* 16**,** 467-476.

Wong, K.A., Wong, K.F. and Nadeem, A. (2011d). Building Information Modelling For Tertiary Construction Education In Hong Kong. *Journal of Information Technology in Construction.*

Woo, J.H. (2006a). BIM (building information modeling) and pedagogical challenges. *Proceedings of the 43rd ASC National Annual Conference*. 12-14.

Woo, J.H. (2006b). BIM and Pedagogical Challenges. *Proceedings of the 43rd ASC National Annual …,* .

Wood, G. (1999). Interdisciplinary working in built environment education. *Education + Training.* 41(8)**,** 373-380.

Wu, D. (2013). Building Knowledge Modeling: integrating knowledge in BIM.

Wu, W. and Issa, R.R.A. (2013a). BIM-education-for-new-career-options_an-initial-investigation. *BIM Academic Workshop*. Washington, DC.

Wu, W. and Issa, R.R.A. (2013b). BIM Education For New Career Options: An Initial Investigation *BIM Academic Workshop*. Washington, DC.

Wu, W. and Luo, Y. (2016). Pedagogy and assessment of student learning in BIM and sustainable design and construction. *Journal Of Information Technology In Construction.* 21**,** 218-232.

Y. Arayici, P. Coates, Koskela, L. and Kagioglou, M. (2011). BIM adoption and implementation for architectural practices. *Emerald Group Publishing Limited.* 29(1)**,** pp. 7-25.

Yong, Y.C. and Mustaffa, N.E. (2012). Analysis of factors critical to construction project success in Malaysia. *Engineering, Construction and Architectural Management.* 19(5)**,** 543-556.

Young, N., Jones, S., Bernstein, H.M. and Gudgel, J. (2009). The Business Value of BIM-Getting Building Information Modeling to the Bottom Line. *Bedford, MA: McGraw-Hill Construction.*

Yusuf, B.Y., Ali, K.N. and Embi, M.R. (2015a). Building Information Modeling (BIM): A Potential For Effective Building Industry Practice In Malaysia. *Jurnal Teknologi.* 77(15).

Yusuf, B.Y., Ali, K.N. and Embi, M.R. (2015b). Building Information Modeling (BIM): A Potential for Effective Building Industry Practice in Malaysia. *Jurnal Teknologi.* 77(15)**,** 55-62.

Yusuf, B.Y., Embi, M.R. and Ali, K.N. (2017). Academic Readiness for Building Information Modelling (BIM) Integration to Higher Education Institutions (HEIs) in Malaysia. *IEEE.* 3(17).

Zahrizan, Z., Ali, N.M., Haron, A.T., Marshall-Ponting, A. and Abd Hamid, Z. (2013a). Exploring the Adoption of Building Information Modeling in Malaysia Construction Industry- A Qualitative Approach. *International Journal of Research in Engineering and Technology.* 2(8).

Zahrizan, Z., Ali, N.M., Haron, A.T., Ponting, A.M. and Abd Hamid, Z. (2013b). Exploring The Adoption Of Bim Malaysia Construction Industry, A Qualitative Approach. *IJRET: International Journal of Research in Engineering and Technology.* 2(8)**,** 12.

Zahrizan, Z., Nasly, M.A., Ahmad, T.H., Marshall-Ponting, A. and Zuhairi, A.H. (2014). Exploring the barriers and driving factors in implementing building Information Modelling (BIM) in the malaysian construction industry - a preliminary study. *Journal – The Institution of Engineers, Malaysia.* 75(01).

Zaremohzzabieh, Z., Samah, B.A., Muhammad, M., Omar, S.Z., Bolong, J. and Shaffril, H.a.M. (2016). An investigation into factors influencing rural youth

entrepreneurs' intentions to use ICT: a case of Malaysia. *Int. J. Entrepreneurship and Small Business,.* 27(4)**,** 480 - 504.

Zhang, Y. and Wildemuth, B.M. (2009). Qualitative analysis of content. *Applications of social research methods to questions in information and library science.* 308-319.

Zhou, Y., Jiang, J.L., Zeng, K., Cao, X.Y. and Zhang, D.P. (2015). Precursing Application and Promotion of BIM Technology in Construction Phase. *Applied Mechanics and Materials*. 1584-1588.

Zikmund, W.G., Babin, B.J., Carr, J.C. and Griffin, M. (2013). *Business research methods.* Cengage Learning.

Zuhairi, A.H., Marshall-Ponting, A., Ahmad, T.H., Nasly, M.A. and Zahrizan, Z. (2014). Exploring the barriers and driving factors in implementing building Information Modelling (BIM) in the malaysian construction industry-a preliminary study.