

**AN EMPIRICAL STUDY OF A DOMINANT
LEARNING STYLE ON BUILDING
INFORMATION MODELING (BIM) ADOPTION**

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INFORMATION MODELING (BIM) ADOPTION**

by

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LIST OF ABBREVIATIONS

AC	Abstract Conceptualization
AE	Active Experimentation
AECO	Architecture, Engineering, Construction, and Operation
ANOVA	Analysis of Variance
ASSIST	Approaches and Study Skills Inventory for Students
AVE	Average Variance Extracted
BCE	Before Common Era
BIM	Building Information Modelling
BIM-CO	Compatibility attribute of BIM adoption
BIM-EU	Ease of Use attribute of BIM adoption
BIM-RA	Relative Advantage attribute of BIM adoption
BIM-TR	Trialability attribute of BIM adoption
BIM-VS	Visibility attributes of BIM adoption
CAD	Computer-Aided Design
CAI	Computer Assisted Instruction
CB	Covariance-Based
CE	Concrete Experience
CEO	Chief Executive Officer
CFA	Confirmatory factor analysis
CIDB	Construction Industry Development Board
CITC	Corrected Item-To-Total Correlation
CMV	Common Method Variance
CR	Composite Reliability
D	Dimensional
DV	Dependent Variable
ELT	Experiential Learning Theory

ETE	Employee Training Experience
F value	F statistic test
FOC	First Order Component
FSLSM	Felder-Silverman Learning Style Model
F-Square	Effect Size
GDP	Gross Domestic Product
GoF	Goodness of Fit
HCM	Hierarchical Component Model
HR	Human Resources
ICT	Information and Communication Technology
IDT	Innovation diffusion theory
ILS	Inventory of Learning Styles
IMF	International Monetary Fund
IT	Information Technology
IV	Independent Variable
KLS-ACC.	Accommodating Learning Style
KLS-ASS.	Assimilating Learning style
KLS-CON.	Converging Learning style
KLS-DIV.	Diverging Learning style
KLSI	Kolb Learning Style Inventory
KLSI 4.0	The Nine Kolb Learning Style Inventory-Version 4.0
LSI	Learning Styles Inventory
LVS	latent variable scores
LVs	Latent Variables
MV	Mediator Variable
NCEC	National Centre for Engineering Consultancy
OFF-JT	Off-the-Job Training

ON-JT	On-the-Job Training
PLS	Partial Least Squares
Q-Square	Predictive Relevance
R -Square	Coefficient of Determination
RO	Reflective Observation
ROI	Return on Investment
SEM	Structural Equation Modelling
SMEs	Small- and Medium-sized Enterprises
SOC	Second Order Component
SPSS	Statistical Package for the Social Sciences
US	United States of America
VAK	Visual, Auditory, and Kinaesthetic
VAKT	Visual, Auditory, Kinaesthetic, and Tactile

KAJIAN EMPIRIKAL GAYA PEMBELAJARAN DOMINAN TERHADAP PENERIMAGUNAAN PEMODELAN MAKLUMAT BANGUNAN (BIM)

ABSTRAK

Industri seni bina, kejuruteraan, pembinaan dan operasi (AECO) merupakan kunci utama dalam pembangunan ekonomi Iraq. Sumbangan sektor ini kepada Keluaran Dalam Negara Kasar (KDNK) negara tersebut adalah 23.5% pada tahun 2014. Pada masa kini, industri AECO memberi tumpuan kepada peningkatan kualiti dan keuntungan, serta penghapusan sisa dan ketidakcekapan. Pemodelan maklumat bangunan [building information modelling (BIM)] menawarkan pertukaran maklumat yang boleh dipercayai dan tepat pada masanya, dengan faedah seperti mempromosikan penciptaan awal data penting yang diperlukan untuk mereka bentuk, pemerincian, penjimatan sumber, peningkatan produktiviti dan penambahbaikan kualiti. Para penyelidik mendapati bahawa kekurangan latihan dan pembelajaran serta daya tahan terhadap perubahan merupakan halangan utama kepada penerapan BIM di negara-negara lain. Latihan dapat menambah baik hasil penerapan BIM melalui simulasi maya yang menggambarkan kerja sebenar. Oleh sebab individu-individu yang menerapkan BIM mempunyai tahap kebolehan, fleksibiliti dan pemikiran logik yang berbeza, penentuan gaya pembelajaran mereka dalam latihan BIM adalah penting untuk memastikan keberkesanan penerapan BIM. Oleh itu, kajian ini bertujuan mengenal pasti gaya pembelajaran pekerja yang dominan (yang menjadi pilihan) dan mengkaji kesan gaya pembelajaran ke atas sikap pekerja terhadap BIM di Pusat Perundingan Kejuruteraan Kebangsaan [National Centre for Engineering Consultancy (NCEC)] di Iraq. Tambahan pula, kajian ini mengkaji peranan pengalaman semasa

latihan sebagai pengantara antara gaya pembelajaran pekerja yang dominan AECO dengan penerapan BIM di NCEC. Kaedah penyelidikan kualitatif dan kuantitatif dicadangkan untuk digunakan dalam kajian ini. Analisis kandungan data kualitatif memberikan gambaran yang jelas mengenai masalah serta mengesahkan data kuantitatif yang diperoleh melalui soal selidik. Berdasarkan teori pembelajaran berasaskan pengalaman dan teori difusi inovasi, satu model konseptual dibangunkan dan diuji dengan menggunakan 245 sampel di seluruh NCEC. Analisis Ujian Varians dan Analisis Pemodelan Persamaan Struktur digunakan untuk mencatatkan dapatan daripada data kuantitatif tersebut. Dapatan kajian menunjukkan bahawa gaya pembelajaran jenis pemusatan (convergent) adalah gaya pembelajaran pekerja yang dominan dan mempunyai kesan purata yang positif ke atas sikap mereka terhadap penerapan BIM. Dapatan kajian ini juga mengesahkan bahawa pengalaman semasa latihan menjadi pengantara antara gaya pembelajaran yang dominan dan penerapan BIM. Di samping itu, kajian ini mengesyorkan kerjasama antara organisasi AECO awam dengan swasta dan kolej teknologi untuk mengatasi halangan utama kepada penerapan BIM. Penemuan juga mengesahkan bahawa pengalaman dalam latihan mempunyai hubungan pengantara bagi gaya pembelajaran yang dominan dan penerimgunaan BIM. Kerjasama di kalangan organisasi AECO awam dan swasta dan kolej teknikal untuk mengatasi halangan utama untuk penggunaan BIM telah dicadangkan. Kajian masa depan harus membincangkan batasan kajian dan jenis latihan lain untuk memastikan hasil yang tepat. Penyelidikan lanjut boleh menyiasat kesan dimensi BIM dan gaya pembelajaran dan penemuan harus dibandingkan dengan teliti.

AN EMPIRICAL STUDY OF A DOMINANT LEARNING STYLE ON BUILDING INFORMATION MODELING (BIM) ADOPTION

ABSTRACT

The Architecture, Engineering, Construction and Operation (AECO) industry is a key player in the economic development of Iraq. At present, the AECO industry focuses on eliminating waste and inefficiency to improve quality and profitability. Building Information Modelling (BIM) enables a reliable and timely exchange of information with benefits such as promoting the early creation of pivotal data necessary for designing, detailing, resource saving, productivity enhancement, and quality improvement. Accordingly, BIM adoption has become a necessity for the AECO industry to achieve the aims of the industry, ensure sustainable practices, and enhance performance and profitability. Researchers found that the main barriers to the BIM adoption in different countries are lack of training and learning, as well as resistance to change. The BIM adopters have different levels of aptitude, flexibility, and logical thinking, their learning styles in BIM training should be considered to ensure the effectiveness of BIM adoption. Therefore, this study aims to identify the dominant (preferred) learning style of employees and investigate the effects of this learning style on the employees' attitudes towards BIM at the National Centre for Engineering Consultancy (NCEC) in Iraq. Furthermore, this study examines the mediating role of training experience between the dominant learning style of the BIM adopters and the BIM adoption at the NCEC. Preliminary investigation and a quantitative research method were applied in this study. The thematic analysis of the preliminary interview data presented a clear picture of the problem and validated the

quantitative data, which were obtained through questionnaires. Based on the theories of experiential learning and innovation diffusion, a conceptual model was developed and tested using 245 samples across the NCEC in Iraq. An analysis of variance test and structural equation modelling analysis were conducted to obtain the results of the quantitative data. The findings revealed that convergent learning is the employees' dominant learning style, which has a highly positive effect on their attitudes towards BIM adoption. The findings also confirmed that training experience mediated the relationship between the dominant learning style and BIM adoption. Cooperation amongst public and private AECO organisations and technical colleges to overcome the main barriers to BIM adoption was recommended. Future studies should address the limitations of this study and other types of training to ensure accurate results. Further research can investigate the moderate effect on BIM dimensions and learning styles and findings should be thoroughly compared.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter provides background information about the topic of the study in section 1.2. The location and economy of the study area, the case study, and the population of study are provided in sections 1.3, 1.4, and 1.5, respectively. The statement of the problem is presented in section 1.6. The research objectives and the research questions of the study are provided in sections 1.7 and 1.8, respectively. The significance of the study is presented and discussed in section 1.9. This chapter concludes with the organisation of the thesis and definitions of key terms in sections 1.10 and Section 1.11, respectively.

1.2 Research Background

The Architecture, Engineering, Construction and Operation (AECO) industry has continuously grown in terms of complexity and the ability to cope with the environment in which it operates, and to do so, it must rely heavily on the available information, paper-based, and computer-generated alike, for its decisions (Forbes & Ahmed, 2011; Melorose, Perroy, & Careas, 2015). Effectiveness and timeliness of communication and information exchange between teams determine the success of an AECO project, an AECO company and, ultimately, the entire AECO industry.

Currently, Building Information Modelling (BIM) is considered an important information and communication technology innovation because of its activities in providing information effectively and efficiently regardless of distance and time (Ruddock, 2006). Being the most vital element of the construction process, BIM

creates a channel allowing all parties involved in a project to identify and resolve potential problems prior to construction. It also provides a channel for reliable and timely exchange of information between project participants so that the key data needed for designing and detailing can be generated (Ashcraft, 2008). As a collaborative tool, BIM can be attributed to the use of the data embedded in a three-dimension (3D) model with the aim of optimising outcomes of the overall project (Eastman, Teicholz, Sacks, & Liston, 2011). The emergence of BIM has ushered in a new paradigm in the AECO industry (Shelden, 2008). The information exchange between design and construction teams through a digital or virtual representation of the building process has achieved advantages of BIM such as reducing project cost, enhancing productivity and quality, and expediting project delivery (Baba, 2010; Hergunsel, 2011). Therefore, BIM has been recently considered one of the most promising AECO innovations (Azhar, 2011). BIM has attracted the interest of many developing countries owing to its wide range of benefits, which covered various project phases (i.e., planning, design, construction, and maintenance) (Eastman et al., 2011). It allows for resource savings, productivity enhancements (Azhar, 2011), and quality improvement (Ashcraft, 2008; Chen & Luo, 2014).

Based on the Innovation Diffusion Theory (IDT) of Roger (Rogers, 2003), relative advantage, compatibility, trialability, and observability are perceived by members of so-called ‘social system’ to be positively related to the rate of adoption. By contrast, the complexity of an innovation is perceived to be negatively related to the rate of adoption. The BIM’s attributes (e.g., relative advantage, compatibility, trialability, and observability) that significantly influence the extensive application of BIM in the AECO industry, human resources with diverse skill sets are required to perform a wide array of tasks and meet project requirements. Moreover, AECO

companies are competing for the labour force and offering training or continuing education programs for their employees (Joseph, 2011; McGraw-Hill, 2013). Unfortunately, the shortage of talented employees with adequate BIM training considerably limits BIM adoption (McGraw-Hill, 2013; Sacks & Barak, 2009). This problem can be solved by establishing a pool of new, well-trained engineering employees. These solutions can address the need for BIM-trained engineers (Angel, 2016). However, the long-term solution to ensure sustainable development and facilitate the diffusion of BIM is educating the next-generation of the labour force (McGraw Hill Construction, 2009; Smith & Tardif, 2009).

Also, the adopter plays a key role in BIM adoption. The BIM adopter is the member, who adopts new ideas earlier than other members of the social system. Clearly, the members of a social system differ. Similarly, in the social system within the AECO industry, employees and students in construction institutions differ, especially in their learning styles (Enegbuma et al., 2014). For example, professionals require a learning environment that is different from the university system (Kahl, 2014). A learning style can be defined as the individual's preferred mode of learning depending on his/her attitudes and behaviours (Honey & Mumford, 2006). In light of the differences in learners' learning styles, educators should know how to present the same content in various ways (Oh, Ishizaki, Gross, & Yi-Luen Do, 2013).

Experiential learning theory (ELT) asserts that adult development occurs through learning from experience. It provides a holistic model of the experiential learning process as its foundation is supported by the theories of notable twentieth-century scholars, who placed experience at the core of human learning and development, namely John Dewey, Mary Parker Follett, Paulo Freire, William James,

Carl Jung, Kurt Lewin, Jean Piaget, Carl Rogers, and Lev Vygotsky (Farooq et al., 2011). ELT depicts the experiential learning cycle to be an actual learning spiral. This experiential learning spiral represents the actual learning process in which richer, broader, and deeper experience is gained after being enriched by reflection, made meaningful by thinking, and transformed by action. Subsequently, learning cycles extend to experiences in other contexts such as when learning is integrated with multidisciplinary knowledge and generalised to other contexts. Ultimately, this learning process leads to higher levels of adult development. Regarding the definitions of key terms in section 1.10 of this chapter, these definitions are drawn from the existing literature and related studies. Although precise definitions of the terms are provided by other sources, the definitions given in section 1.10 provide a basic understanding of these terms, which are used in this study.

1.3 Study Area (Location and Economy)

Iraq, officially ‘the Republic of Iraq’ (in Arabic, *جُمْهُورِيَّةُ الْعِرَاق*, which is literally transliterated as ‘*Jumhuriyyat al-Iraq*’) is a country in the Western Asian continent, it is bordered by Turkey to the north, Iran to the east, Kuwait to the southeast, Saudi Arabia to the south, Jordan to the southwest, and Syria to the west. Baghdad, the capital of Iraq and the largest city lies between the two great rivers of Tigris and Euphrates. They are historically known as Mesopotamia, which is referred to as the cradle of civilization, where mankind first began to read, write, and create laws. The ancient people of Mesopotamia lived in cities under an organised government called *Uruk*, from which the name ‘Iraq’ is derived. Numerous civilizations inhabited this land since the sixth millennium Before Common Era (BCE). Iraq covers a land area of 437,367 square kilometres, and its bodies of water

cover a total area of 950 square kilometres, making it the 59th-largest country in the world. Iraq was under the administration of the United Kingdom and was then known as the British Mandate of Mesopotamia. In 1921, a monarchy was established, and in 1932, the Kingdom of Iraq gained independence from Britain. The population of Iraq was estimated to be 31,129,225 million in 2012. Oil is the dominant sector in Iraq, accounting for the largest proportion of the country's gross domestic product (GDP). Regardless of whether domestic consumption or investment increases, an increase in oil prices or exported volume has resulted in an increase in the nominal GDP.

The AECO industry is a key player in the economic development of Iraq and is a major contributor to the country's GDP. For example, the government of Iraq granted the private sector and foreign investors lands that are suitable for housing to remedy the problem of residential slums and to promote the manufacture of construction materials.

In 2012, the contribution of the AECO industry to the GDP in the fixed prices was approximately 5.8%. From 2009 to 2011, the contribution rate of the sector to the country's GDP was 23.5% in 2014. However, since the mid-2014, the terrorist organisations' insurgency and the oil price plunge have negatively impacted the economy. The non-oil economy experienced a slump because of the war against terrorist organisations and fiscal consolidation. Therefore, the Iraqi government has implemented reforms to stabilise the economy, protect social spending, and public service delivery. In 2015, around 2 million housing units were constructed based on the average growth of the Iraqi population. In 2016, the country was reinvigorated with the simultaneous enhancement of oil production, investments, implementation of structural reforms, and the International Monetary Fund (IMF) program and security.

The vital economy and the dynamic sector of the AECO industry made the market a complex competitive environment in Iraq and in other countries around the globe. Likewise, the AECO industry focuses on eliminating waste and inefficiency to improve quality and profitability. The advanced innovations of technology have provided many solutions to these focus areas. One of the most powerful of these innovations of technology is BIM. BIM adoption fosters a more reliable and timely exchange of information among project stakeholders, which accordingly promotes earlier creation of pivotal data necessary for designing and detailing (Ashcraft, 2008). Accordingly, BIM adoption has become a necessity for the AECO industry to achieve the industry's objectives, ensure sustainable practices, and enhance performance and profitability (Mehran, 2016).

1.4 Research Case Study

The case study of this research implicitly rests on the existence of a micro-macro link in social behaviour. It is a form of cross-level inference. Sometimes, in-depth knowledge of an individual example is more helpful than fleeting knowledge about a larger number of examples. We gain a better understanding of the whole by focusing on a key part.

BIM carries all information related to a building or facility, including its functional and physical characteristics, as well as the project life cycle in a series of smart objects (Forbes & Ahmed, 2011) and the implementation of BIM presents various benefits (Bryde, Broquetas, & Volm, 2013). However, the success of BIM implementation depends on the BIM skills of project managers (Fox & Hietanen, 2007; Gu & London, 2010; Singh, Gu, & Wang, 2011), who also contribute to the success of construction projects (Chan, Scott, & Chan, 2004; Pheng & Chuan, 2006;

Sanvido, Grobler, Parfitt, Guvenis, & Coyle, 1992). The individual's mastery of BIM implementation can be enhanced through BIM training, which is provided for employees (McGraw-Hill, 2008). Accordingly, several questions regarding BIM training and BIM adoption in the AECO organizations in Iraq should be addressed in order to eliminate any obstacles that may hamper the BIM labour force development (Paper, 2016). Addressing these questions through a case study provides important insights into the entire process of BIM adoption in the AECO organizations in Iraq, not only in the case study but also by focusing on a key part. Moreover, answering these questions can provide useful insights into the way of designing and customising their BIM courses according to the needs of the case study.

In the context of the present study, the National Centre for Engineering Consultancy (NCEC) of Iraq represents the investigated case study. NCEC was established in July 2003 because of the merging of two centres of the Ministry of Construction and Housing: the AL-Qawmiu Centre for Engineering Consultancy (established in 1973) and the AL-Drissi Centre for Engineering Consultancy (established in 1987). Backed by the experiences of these two organisations, NCEC is the top specialised centre for an engineering consultancy in Iraq. NCEC aims to: 1) provides engineering consultancy services, 2) develops designs, and 3) supervises the implementation of projects. NCEC has established partnerships with scientific organisations (i.e., universities and specialised institutions) for knowledge exchange and scientific interaction, which upgraded the engineering consultancy profession. The centre has a total of 560 employees, including technicians, administrators, engineers, and craftsmen, who work in various departments of the centre.

The NCEC's mission involves providing the best designs for projects and all engineering areas through modern technology applications. In February 2015, the NCEC offered the first BIM course for all engineering practitioners involved in the preparation of designs and schedules of quantities and pricing (Juma, 2015). According to the NCEC's efforts, a complete project was designed using the Revit software and was entered in the architectural competition of the Housing Fund in the United States (US). The application of BIM has, therefore, allowed the NCEC to deliver ideas on design rapidly and creatively. As a result, the project won the competition and was implemented in an Iraqi governorate. However, the real dimensions of the facility were not used in BIM due to several training and learning issues (Juma, 2015).

1.5 Population of the Study

Sekaran and Bougie (2016) defined a population as the entire group of events, things or people a researcher plans to investigate, whereas sample as the part of the population that the researcher aims to study. The population in a study includes the individual components, items or objects whose characteristics are being studied. 'Target population' is another name for the population being studied (Ross, 2017). According to the data provided by NCEC, the centre has a human capacity of 564 employees as engineers, technicians, administrators, and craftsmen, who work in various NCEC departments including Planning, Architecture, Civil Engineering, Service Engineering, Project Management, Administrative and Financial Divisions, and Internal Control). The NCEC has four levels of management, namely chief executive officer (CEO), assistant director general, 10 department managers, and 36

regional managers. Table 1.1 shows NCEC 10 departments and the number of BIM adopters

Table 1.1 Number of BIM adopters at NCEC

Department	No. of Employees
Planning and Studies	80
Project Management	74
ICT	64
Civil Engineering	64
Architecture and Urban Planning	58
Internal Control	52
Sustainability and Services	52
Human Resource Management	48
Financial Affairs	38
Legal Affairs	34
Total	564

Source: (NCEC Statistics Report, 2017)

This study focused on the entire construction faculty and the departments responsible for AECO activities at NCEC. The employees of these departments play a crucial role in providing the AECO industry with information as to who fits the requirements.

1.6 Problem Statement

Recently, there has been an increase in the number of building projects in Iraq, which made many new players enter the Iraqi construction market. Joint ventures between foreign companies and local companies have started using BIM in their respective projects. The AECO sector in the developed economies has observed a

growing interest in using BIM due to the myriad of benefits found through its implementation (Wang, 2012). For project planning, design, construction, and maintenance phases. The extent to which BIM has permeated the AECO industry varies significantly among different countries as argued by (Gu & London, 2010).

However, the Iraqi construction industry does not have abundant knowledge and skills, which promote the adoption and implementation of the BIM technology within a short period of time. Specifically, the number of BIM experts remains small, project stakeholders lack the necessary skills and knowledge, as well as the costs of software, hardware and training are high. According to a recent survey (Al-Zwainy, Mohammed, & Raheem, 2016), 92% of site engineers in Iraqi companies do not hold professional certificates, which indicates that they have insufficient knowledge and experience in managing construction projects. To address this problem, a qualitative approach was, therefore, used in this study through interviews so that a clear picture of the study problem is obtained based on the interview results as shown in the summary of the preliminary study results in section 4.2.6.

In Iraq, the main reason behind the relatively low-profile implementation of BIM in many organizations is the mega barriers to diffusing knowledge, benefits, and BIM application. According to the results of Hatem, Abd and Abbas (2018), the barriers can be classified into two types. The first type of barriers involves the accompaniment barriers of diffusing knowledge (e.g., resistance to change for adopters, poor training submitted, the high cost of training, and application requirements). The second type of barriers that face BIM diffusion involves the weakness of the government's support or the absence of national standards that regulate and apply BIM. The BIM adoption barriers in Iraq were congruent with many

researchers' results in other countries to varying degrees (e.g., Aboushady & Elbarkouky, 2015; Abubakar, Ibrahim, Kado, & Bala, 2014; Bin Zakaria, Mohamed Ali, Tarmizi Haron, Marshall-Ponting, & Abd Hamid, 2013; Chan, 2014; Gu & London, 2010; Kassem, Brogden, & Dawood, 2012; Mehran, 2016; Nanajkar & Gao, 2014)).

The demand for BIM applications in the AECO projects necessitates appropriate solutions to overcome the accompaniment barriers of BIM knowledge adoption. However, human resources for diverse AECO skill sets are required to perform a wide range of tasks and meet the BIM and AECO industry requirements inside AECO companies, which are competing for the labour force and offering training or continuing education programs to their employees by employing BIM trained to establish a pool of new BIM well-trained adopters. Employee training plays an essential role in improving the AECO sector, as well as increasing productivity. Training is related to performance improvement by developing employees' knowledge, skills, abilities, competencies, and behaviours (Nassazi, 2013; Tabassi, Ramli, & Bakar, 2012). Therefore, training has become a mechanism to increase performance, and the outcome expectancy of that training is clear through a good relationship with AECO organizations' goals.

Evidence of the existing relationship between training and BIM adoption is clear based on a previous study by (Pena, 2011). Despite the promotion of BIM training experience, learning, and considerable investment in AECO organisations (Ruddock, 2006; Van Oortmerssen, 2014), the industry still has to ensure that the learning process in training can provide practitioners with the skills that are necessary to function effectively in a dynamic and information-bombarded environment

(Eastman et al., 2011; Iroha & Ekwueme, 2003). According to Wodi and Dokubo (2008), training can enhance the outcome of the persuasion of BIM adoption by providing opportunities for practical investigation or a virtual alternative to real practical work through simulations, in which a model is explored and decisions are made by using a computerised representation of the phenomenon under study.

Effective training of employees is based on compatibility between training approaches and the understanding of adopters' capabilities. Also, adopters of different levels of aptitude differ in flexibility and logical thinking (Oh et al., 2013). Each adopter has a separate learning style like a fingerprint. Therefore, it is necessary to identify the learning style's preferences of the AECO adopter when using BIM training. It is even more important to remember that each adopter has a different learning style. Therefore, training approaches need to be built on appropriate learning styles of various adopters.

BIM instructors should consider the adopters' learning style to maximise the integration of theory and practice (Milton-Wildey, Kenny, Parmenter, & Hall, 2014). The training experience should provide learners with simple, fast, meaningful and interesting learning experiences. To enhance classroom instruction, realistic and concrete experiences should be provided, information processing should be easy, efficient and fun, scientific inquiry, and scientific literacy should be developed (Meadati & Irizarry, 2010).

It has become a crucial point for employees to understand their own learning styles to enable them to benefit from the learning process. Once the employees distinguish and realise their own learning styles, they can find suitable activities that suit their learning preference, which will enhance their performance in the BIM

adoption. In addition, if employees fail to identify their preferred or compatible learning styles, they might lose interest in learning BIM as they fail to find suitable activities that can boost their learning interest.

The learning styles have been a popular area of investigation all around the world. However, only a few studies were carried out on the effect of BIM adoption. Also, there are not many published studies on employees' training experience as a mediator between BIM adoption attributes and learning styles. Therefore, this study aims to tackle this gap by examining the effect of learning styles and employees' training in addition to the assisting role of employees' training in producing high quality of BIM adopters' employees.

1.7 Research Questions

This study aims to answer the following questions:

1. What is the dominant learning style of BIM adopters in NCEC?
2. What are the effects of learning styles on the attitudes towards BIM adoption?
3. Does training experience mediate the relationship between the dominant learning style of the BIM adopters in NCEC and BIM adoption attributes?

1.8 Research Objectives

This study aims to substantiate that a specific learning style influences the adoption of BIM and the training experience outcome. This is because BIM diffusion is accompanied by changes and challenges arising from learning style differences. This study uses Kolb's Learning Style Inventory and the attributes that affect innovation diffusion, which was developed by Rogers (2003) (i.e., relative advantage,

compatibility, complexity, trialability, and observability). Furthermore, training experience and BIM adoption should boost the capacity and willingness of adopters from different categories to acquire and apply new knowledge and skills. Moreover, this study aims to establish the link between training to enhance the attributes of BIM as an innovation for adoption and training to address the dominant learning styles of different adopter categories (BIM adopters in NCEC). Therefore, this study aims to achieve the following objectives:

1. To identify the dominant learning style of BIM adopters.
2. To investigate the effects of learning styles on the attitudes towards BIM adoption.
3. To investigate the mediating role of training experience between the dominant learning style of the BIM adopters and BIM adoption attributes.

1.9 Significance of the Study

Misled by strong marketing campaigns, many members of the AECO industry have the misconception that BIM is invented and patented by certain BIM software vendors, and that by buying the vendors' software, their company is automatically 'doing BIM'. There is no single person, however, can claim to have invented BIM even if Eastman (Yessios, 2004) is credited for coining the term. BIM is a process-driven technology, which does not depend on a single software program, a single building model or a single database. Instead, BIM is most aptly described as a series of interconnected models and databases. Certain major changes in the AECO industry can be attributed to the intensified adoption of BIM. Indeed, BIM is becoming a standard component of the undergraduate AECO curricula in many countries. In response to this change, educators have been testing pedagogical approaches to

develop industry-required knowledge, skills, and abilities in BIM implementation. According to the existing literature, the focus of BIM education has shifted to project execution and management from traditional software skills training. In view of this trend, project-based learning has been widely adopted (Wu & Hyatt, 2016). This study contributes to the literature on BIM by encouraging new employees to adopt BIM and eventually provide a reference in creating policies that promote BIM adoption.

Furthermore, this study provides a basis for overcoming the problems that restrict BIM development and adoption. Currently, an increasing number of universities have been incorporating BIM in college curricula (Barison & Santos, 2010; Sabongi & Arch, 2009; Wu & Issa, 2013) notwithstanding the presence of barriers and the lack of standards (Clevenger, Ozbek, Glick, & Porter, 2010; Sacks & Pikas, 2013; Woo, 2006). The technological aspects of BIM were highlighted. However, the focus has recently shifted to the implementation and the value of BIM (Sacks & Pikas, 2013).

To cope with the growing demand for BIM-trained workforce, universities offer continuously increasing academic programs (Sacks & Pikas, 2013). Educational institutions adopt various pedagogical models and methods for BIM instruction. However, no standard pedagogical strategy for teaching BIM in AECO curricula has been formalised (Woo, 2006). Furthermore, 90% of the educational platforms are developed on a single architecture or engineering platform although BIM is considered as multidisciplinary (Barison & Santos, 2010). Clearly, both the uncertainty and the absence of a consensus on how to best equip employees and students with the required BIM skills to ensure career success in the AECO fields reinforced the need for improved pedagogical strategies.

1.10 Organisation of the Thesis

This thesis is organized into six chapters. The study presented and discussed the process of identifying the effect of learning styles and training experience on BIM application, which provides an opportunity to optimise the use of BIM, enhances decision making, and confirms the profitability of BIM in the AECO industry in NECE. The chapters of this study are organised as follows:

Chapter 1 provides the background of the study, the study area location, and economy, the research case study, the population, the statement of the problem. The research questions and objectives are provided in this chapter. The significance of the study is presented. The chapter concludes with the organisation of the thesis and definitions of key terms.

Chapter 2 comprehensively reviews the existing literature on BIM adoption, which was presented and thoroughly discussed. The learning style, the evolution of learning style inventories, classical models of learning style, and the adopted learning style inventory in this study, are provided in the chapter. The learning styles' models are presented and discussed. Moreover, the relationship between learning styles and BIM adoption is examined. The chapter discusses employee training experience, particularly the types of training provided by NCEC in Iraq for AECO employees. Related studies by other scholars are reviewed. In addition, previous studies, which investigated how learning through various styles can enhance BIM adoption, are highlighted in this chapter.

Chapter 3 describes the methodology used in the study. It also discusses the conceptual framework, research hypotheses, and research variables. Moreover, it provides an in-depth discussion of the research design of the study, including the measures, questionnaire design (survey instrument), units of analysis, sampling method, and the pilot testing. The survey instrument is presented in this chapter in detail with relevant references in the literature. The quantitative method, which is employed in the study is discussed by introducing the research variables. The study population, the sample frame, and sample size are also presented in the chapter. The questionnaire design, the measures employed, and the data analysis techniques adopted are provided in this chapter. Validity and reliability of the measurement model and the structural model are presented and discussed in the chapter.

Chapter 4 presents the results of the study, discusses the analysis of the quantitative data, and provides the findings of the study. The relationships between the study variables (i.e., independent, mediator, and dependent variables) are presented and discussed. The constructs are validated through the factor analysis of the research findings and the empirical analysis of the theoretical models.

Chapter 5 provides a discussion of the research findings and the results of the hypotheses testing. The direct relations are presented, followed by the indirect relations of the mediation effect.

Finally, chapter 6 provides answers to the research questions of the study. It presents and discusses the hypotheses testing results. The study contribution, including the theoretical contribution and the practical contribution, as well as the limitations of the study, recommendations, and concluding remarks are provided in this chapter.

1.11 Definitions of Key Terms

Table 1.2 operationally defines the key terms that are used in this study. The definitions are drawn from the review of the literature and related studies. Although precise definitions of the terms are provided in other sources, the definitions that are given in Table 1.2 provide a basic understanding of these terms as they are used in the context of this study.

Table 1.2 Definitions of Key Terms Used in the Study

Term	Definition
Innovation	An idea, practice or object considered new by the adopter (Rogers, 2003).
Diffusion	The spread of innovation throughout a social system (Rogers, 2003).
Adoption	Adoption is the acceptance and continued use of an innovation. The adoption process refers to a series of mental and behavioural states that a person passes through leading to the adoption or rejection of an innovation (Rogers, 2003).
Social System	A set of interrelated social units, which may be individuals, informal groups or organisations, engaged in problem-solving to achieve a common goal (Rogers, 2003).
BIM	BIM is the process of generating and managing building data during the life cycle of the building. This technology uses a model linked with a database of project information. The model carries all the information related to a building or facility, including its physical and functional characteristics and project life cycle information, in a series of smart objects (Forbes & Ahmed, 2011).
ICT	This is the general term that covers all related technologies, including devices, services, and applications that enable communication and information sharing through broadcast media, telecommunication systems, and computer systems (Cio, 2016).

Term	Definition
Relative Advantage	It is the first of the five perceived attributes of innovation. It involves the degree to which an innovation is perceived as better than existing innovations (Rogers, 2003).
Compatibility	It is the second of the five perceived attributes of innovation. The degree to which an innovation is consistent with the values, previous experiences, and actual needs of potential adopters (Rogers, 2003).
Complexity	It is the third of the five perceived attributes of innovation. It involves the degree to which an innovation is considered difficult to understand and use compared with others (Rogers, 2003).
Trialability	It is the fourth of the five perceived attributes of innovation. It involves the degree to which an innovation may be experimented with on a limited basis (Rogers, 2003).
Observability	It is the fifth of the five perceived attributes of innovation. It involves the degree to which the results of an innovation are seen by others (Rogers, 2003).
Training Experience	The systematic acquisition of skills, concepts, or attitudes that result in improved performance in another environment (Goldstein, Ford, & Ford, 2001, p. 1).
Experiential Learning Theory (ELT)	The theory that focuses on how a person understands and processes information. This theory presents the four-stage learning cycle: 1) accumulation of concrete experience, 2) reflective observation, 3) abstract conceptualisation, and 4) active experimentation (Kolb, 2015).
Learning Style Inventory (ILS)	The Learning Style Inventory is derived from the Experiential Learning Theory developed by David A. Kolb in 1984. It is a practical self-assessment instrument that can help to assess unique learning styles (Kolb & Kolb, 2005).
Diverging Learning Style (KLS-DIV.)	Individuals with this learning style view things from a different perspective. They prefer watching than doing. They are imaginative, emotional, artistic, group-oriented, open-minded, and receptive to feedback. They have broad interests in different cultures and people. They prefer concrete experience and reflective observation.

Term	Definition
Assimilating Learning Style (KLS-ASS.)	Individuals with this learning style prefer clear information. They can logically format the given information and explore analytical models. They are more interested in concepts and abstracts than in people. They prefer abstract conceptualization and reflective observation.
Converging Learning Style (KLS-CON.)	Individuals with this learning style love to solve problems and apply what they have learned to practical situations. They also prefer technical tasks and experiment with new ideas. They are unemotional and tend to prefer abstract conceptualization and active experimentation.
Accommodating Learning Style (KLS-ACC.)	Individuals with this learning style prefer doing practical things. They are attracted to new challenges and solve problems intuitively. They prefer concrete experience and active experimentation.
Dominant Learning Style	It is the learning style, which is preferred by most employees in the social system. The dominant learning style can be defined as a subset of a set consisting of more than half of the learning styles preferred by the adopters, namely the AECO employees in this study.
Kolb Learning Style Inventory version 4.0	The Kolb Learning Style Inventory version 4.0 replaces the four original learning styles with nine new learning styles, namely initiating, experiencing, imagining, reflecting, analysing, thinking, deciding, acting, and balancing. This inventory aims to help learners understand the impacts of their learning style on problem-solving, teamwork, conflict-handling mode, communication, and career choice, develop learning flexibility, develop their ability to assess group dynamics, and strengthen their overall learning.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The related literature is reviewed in this chapter. The review starts with the BIM innovation model for both diffusion and adoption process focusing on the attributes of BIM that encourage the adoption by the AECO industry according to Rogers' Innovation Diffusion Theory (refer to section 2.2). The literature on the independent variable, which is learning style, is discussed, particularly its general concept (refer to section 2.3), the evolution of learning style inventories in (Section 2.4), the Kolb Learning Style Inventory version 4.0 (Section 2.5). This chapter presents the existing literature on the mediator variable, which is training experience in AECO (Section 2.6) and the methods of employee training experience (Section 2.7). Moreover, this chapter elaborates on the theoretical framework and research hypotheses in section 2.8 and section 2.9, respectively. Related studies by other scholars are reviewed in section 2.10. Finally, the chapter ends with a summary of the chapter in section 2.11.

2.2 BIM Innovation Model

BIM is classified as an innovation (Brewer & Gajendran, 2012; Davies & Harty, 2013). This study aims to investigate the adoption of BIM and the consequent disruption of the existing working practices of an organisation (i.e., NCEC). The attributes of innovation introduced by Rogers (Rogers, 2003), namely relative advantage, compatibility, complexity (i.e., ease of use), trialability, and observability are used to frame the research questions. The definition of attributes of innovation in chapter 1 provides a basic understanding of these terms as they are used in the context

of this study Empirical data are gathered through qualitative interviews and observations during the implementation of BIM.

Any form of BIM learning in an organisation represents a certain pedagogical theory and practice that are deemed appropriate to deliver the contents to employees, engage them in the learning process, achieve the expected adopter learning outcomes and eventually develop the BIM knowledge, skills, and abilities that can prepare employees for their future roles in their professional career. The generic BIM learning entails knowledge of concepts, definitions, processes, practices, and skills with technologies and functionalities, analyses and applications for problem-solving in project delivery, evaluation of implementation strategies, and assessment of project outcomes (Lee, Dossick, & Foley, 2013; Sacks & Pikas, 2013). The scope of BIM education necessitates a careful pedagogical design to ensure the progressive development of adopter competency, which can be facilitated with a solid understanding of learning theories and utilisation of established pedagogical models. Exposure to real-world knowledge and implementation of BIM through case studies, guest lectures, and capstone projects are frequently cited as amongst the most effective approaches in curriculum design and adopter learning engagement (Gardner, Hosseini, Rameezdeen, & Chileshe, 2014; Lee et al., 2013; Sacks & Pikas, 2013; Wu & Issa, 2013). Adopters appreciate the business value of BIM not only as a solution to discipline-specific issues but also as a collaborative platform that improves communication amongst members of an intrinsically heterogeneous project team (Becerik-Gerber, Gerber, & Ku, 2011; McGraw-Hill, 2013). The roles and responsibilities played by project participants in domain-specific and organisational (e.g., the team as a temporary organisation) contexts determine that both individual and organisational BIM competencies should be expected from the future workforce.

The pedagogical design of BIM learning should, accordingly, reflect both individualised and team-based learning needs. Experiential, project-based learning, therefore, seems to be a promising option.

2.2.1 BIM Innovation's Diffusion Model

According to Rogers' Innovation Diffusion Theory (IDT) (Rogers, 2003), diffusion models highlight the overall diffusion rate and timing of innovation within a sector, whereas the adoption models concentrate on the characteristics of the adopter (e.g. a person or firm) of the innovation and that entity's decision to adopt. Many studies have shown that innovation acceptance or use is not instantaneous, that is, innovations take time before they are adopted as standard practice (Davies et al., 2015; Edirisinghe, Kalutara, & London, 2016; Kaner, Sacks, Kassian, & Quitt, 2008; Lee & Yun, 2016). The causes of such time delay have been the object of study of many economists and marketing analysts. Innovation adoption is divided into five stages as follows:

- 1) In the knowledge stage, the decision-making unit (individual or firm) becomes aware of the innovation and understands its functions.
- 2) In the persuasion stage, the same unit forms either a favourable or an unfavourable attitude towards the innovation.
- 3) In the decision stage, the unit engages in activities that lead to either the adoption or rejection of the innovation.
- 4) In the implementation stage, the unit uses the innovation.
- 5) In the confirmation stage, the unit attempts to reinforce the innovation-decision it has made. Nevertheless, this decision may still be reversed if the unit encounters conflicting messages about innovation.

Figure 2.1 shows Rogers' model of Innovation Diffusion according to IDT, as proposed by Rogers (Rogers, 2003). Both the diffusion and adoption processes take time even if the adopter is strongly in favour of innovation. The innovation-decision process refers to how an organisation proceeds as follows: 1) initial knowledge about an innovation is acquired, 2) a certain attitude towards the innovation is formed, 3) a decision to adopt or reject is made, 4) the new idea or innovation is implemented and 5) the decision is confirmed. Such a process consists of a series of choices and actions allowing the adopter to evaluate the new idea before deciding whether to integrate the innovation into the current practice. This process may happen when the adopter is uncertain as to whether he/she should integrate or replace an existing idea with a new alternative. Compared with other types of decision making, innovation decision making considers the perceived novelty of innovation and the uncertainty associated with it.

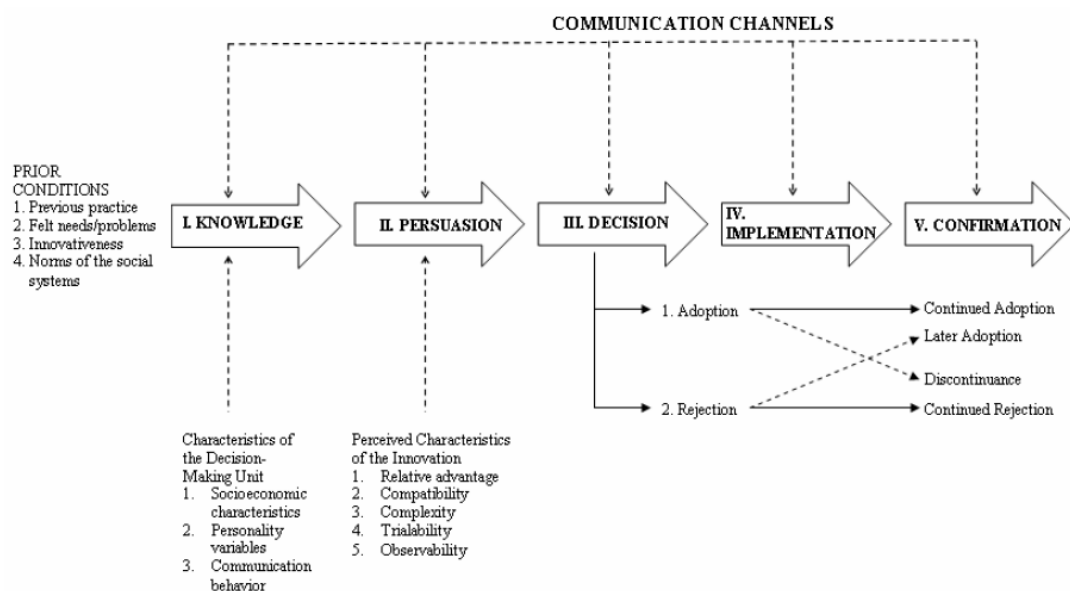


Figure 2.1 Rogers' Model of Innovation Diffusion

Source: (Rogers, 2003).