Available online at www.sciencedirect.com

ScienceDirect

International Journal of Project Management 35 (2017) 107 – 120

International Journal of Project Management

www.elsevier.com/locate/ijproman

Addressing individual perceptions: An application of the unified theory of acceptance and use of technology to building information modelling

Robert Howard *, Luis Restrepo, Chen-Yu Chang

Bartlett School of Construction and Project Management, University College London, 2nd Floor 1-19 Torrington Place, London, WC1E 7HB

Received 22 December 2015; received in revised form 6 September 2016; accepted 24 October 2016
Available online 15 November 2016

Abstract

Building Information Modelling (BIM) is a technology with the potential to transform the construction industry, yet its proliferation remains stagnant. Existing research on BIM diffusion focuses on the industry, company, and project levels while disregarding the impact of perceptions at the individual level. This research aims to extend the Unified Theory of Acceptance and Use Technology (UTAUT) model to understand the perceptions that individuals have towards working with BIM. A survey was completed by 84 industry stakeholders and the results analysed against a modified UTAUT model that adds the variable of Attitude and employs moderators of Experience and Voluntariness. The results reveal that Performance Expectancy does not directly affect Behavioural Intention, signifying that BIM is perceived as an unrewarded addition to existing work processes. These findings evince the need to redefine strategies, policies, and incentive schemes in order to advance the acceptance of BIM in the U.K. and worldwide.

Keywords: Building information modelling (BIM); Unified theory of acceptance and use of technology (UTAUT); Diffusion of innovations; Construction; Technology adoption

1. Introduction

In recent years, Building information modelling (BIM) has been promoted as the ultimate solution for the coordination problems that plague construction supply chains. Yet despite a great deal of attention within academia and industry, BIM's diffusion remains slow. In a definition provided by the National Institute of Building Sciences (2007), a BIM model:

> *…utilizes cutting edge digital technology to establish a computable representation of all the physical and functional characteristics of a facility and its related project/lifecycle information, and is intended to be a repository of information for the facility owner/operator to use and maintain throughout the life-cycle of a facility.*

The critical items within this definition are BIM's role as a central repository for information, and that it covers the entire lifecycle of a facility, meaning from its earliest conception up through its demolition. In this role, a BIM model allows the structure to be built virtually, thereby detecting clashes and informing upon optimal sequencing in a way that is simply not possible using paper-based representations. Where BIM truly

Abbreviations: AECO, Architecture, Engineering, Construction, and Operations; AT, Attitude; BI, Behavioural Intention; BIM, Building Information Modelling; CFA, Confirmatory Factor Analysis; CFI, Comparative Fit Index; EE, Effort Expectancy; ERP, Enterprise Resource Planning; FC, Facilitating Conditions; GFI, Goodness of Fit Index; IDT, Innovation Diffusion Theory; IS, Information System; PE, Performance Expectancy; RMSEA, Root Mean Square of Error Approximation; SEM, Structural Equation Modelling; SI, Social Influence; TAM, Technology Acceptance Model; TPB, Theory of Planned Behaviour; TRA, Theory of Reasoned Action; UB, User Behaviour; UTAUT, Unified Theory of Acceptance and Use of Technology.

* Corresponding author.
E-mail addresses: robert.howard.09@ucl.ac.uk (R. Howard), luis.restrepo.13@alumni.ucl.ac.uk (L. Restrepo), chen-yu.chang@ucl.ac.uk (C.-Y. Chang).

http://dx.doi.org/10.1016/j.ijproman.2016.10.012
0263-7863/00/

shines, however, is in its augmentation of the three dimensional space with the additional dimensions of cost, time and facilities management.

With such incredible benefits, it is widely recognized that BIM has the potential to transform the AECO industry. As a result, the U.K. Government has developed a strategy to promote the adoption of BIM within industry by seeking to achieve the implementation of fully collaborative BIM in all public sector projects by 2016 (BIM Task Group, 2013). Despite this charge, the diffusion of BIM across the AECO industry has been protracted. According to a survey of 70 major U.K. construction organizations by law firm Pinsent Masons, the majority of respondents (64%) predict that the U.K. government's goal is not achievable. This result begs the questions as to what factors are impeding the adoption of BIM within industry.

The deferred adoption has certainly not gone unnoticed by academia. That said, the focus of current research has focused solely on the aggregate (industry, company or project) level. In such studies, several impediments to BIM adoption have been identified, including: low awareness, lack of training, fragmentation of the industry, difficulties in changing traditional work processes, nebulous roles and responsibilities in deploying BIM within organizations, and software interoperability issues. From the perspective of technology diffusion, there is one type of inhibitor that has not been investigated: the perception of BIM by users. A survey of 375 organizations indicated that individual user resistance is the top-ranked challenge for the implementation of large-scale information technologies (ITtoolbox, 2004). Since BIM is at its heart an information technology, it would stand to reason that it be impacted by the same forces; namely, the perceptions of individuals. The research problem thus becomes how BIM is perceived by individual users and how those perceptions influence BIM's application on a project.

It is recognized that people who do not fully accept an innovation could delay, hinder, underutilize or even disrupt its implementation (Brown et al., 2002). Since acceptance is an individual act based on personal perceptions, philosophically the current research is guided by the need to identify what perceptions influence behaviour (ie. acceptance) so that the aggregate benefits of project-level acceptance can be realized. In short, this research contends that users' perceptions towards collaborative BIM plays a pivotal role in its current low rate of adoption.

The significance of this factor for the case of BIM adoption remains an empirical issue, in response to which this research aims to provide an apposite empirical analysis. The empirical model is based on the unified theory of acceptance and use of technology (UTAUT) developed by Venkatesh et al. (2003). Built upon the highly influential TAM model (Davis, 1989), Venkatesh et al. (2003) refines, integrates, and validates the constructs of eight previous technology acceptance methodologies into a single model, making UTAUT a robust basis for exploring a wide range of technology diffusion issues (Wu et al., 2007; Keong et al., 2012; Oh and Yoon, 2014). Seven hypotheses were derived through the modification of UTAUT and tested through a survey employing structural equation modelling (SEM).

The findings of this study should be of special interest to policymakers, companies, and organizations interested in the diffusion of BIM with important insights on policies, incentives, work strategies, and role structuring potentially stemming from the research. The study also investigates the UTAUT model and its robustness for predicting the diffusion of BIM, enhancing academic research on technology and innovation acceptance.

2. Literature review

2.1. Prior studies on BIM adoption

Given the potential impact of BIM on the AECO industry, the topic of BIM adoption has spawned a vast amount of literature, but as noted previously the focus is overwhelmingly on the industry, project, and company levels. For example, Becerik-Gerber and Rice (2010) utilized surveys to test the perceived value of BIM in the USA's building industry at the project level while Bryde et al. (2013) focused on the project level to address the benefits of BIM from a project management perspective.

Some recent research identified the barriers to successful BIM adoption taken from case study reviews of BIM-enabled projects. Conversely, others employed surveys to present the same issue. Panuwatwanich and Peansupap (2013) applied Everett Rodgers' innovation diffusion theory (IDT) to study factors affecting the diffusion of BIM at the project level. Among others, Azhar (2011) used online surveys to identify common barriers to BIM implementation throughout the U.S. construction industry and Gu and London (2010) applied information from the Australian construction industry to study the technical and non-technical issues that require consideration in implementing BIM.

It has been noted that overcoming barriers to BIM has a direct connection with the performance of individuals in their jobs, which goes to the core of the research question. For example, learning curves in training and education can be optimized if employees learn more quickly, as changes in work processes can be imposed with greater ease, less cost, etc. (Fishbein and Ajzen, 1975; Kleinbeck, 1987). As proven by a large body of empirical research documented in the literature of organizational psychology, Kleinbeck (1987, p. 261) explains that "motivation influences goal directed action and is an essential characteristic of job-performance." Therefore, it is important to discover whether individuals in the AECO industry perceive that using BIM will in fact translate into benefits for themselves as practitioners.

While it may seem as if the benefits and factors identified within literature also apply to the individual level, this is not the case. For instance, classifying productivity as an individual level benefit can prove problematic because achieving the same work in less time may result in fewer paid hours. This same dilemma exists with many other aggregate level benefits, meaning that the individual level may be inversely affected by benefits at the project or company levels. Existing literature does not yet address the personal benefits of BIM for practitioners at the individual level; a research gap this study aims to fill.