TECHNOLOGY ACCEPTANCE MODEL (TAM) FOR ADOPTION OF BUILDING INFORMATION MODEL (BIM)

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ABSTRACT

The deployment of Building Information Model (BIM) in Architectural, Engineering and Construction (AEC) industry can make different phases throughout the construction life cycle more efficient, effective, flexible and innovative. However the adoption of BIM has been lower than expected and the way adoption is taking place is little known while the stakes of massive BIM adoption are high.

This study aimed to identify and determine factors related with the adoption of BIM based on the Technology Acceptance Model (TAM). A questionnaire was designed by adapting items from relevant literature and included perceived ease of use, perceived usefulness, attitude toward usage, and behavioral intention to use of TAM as the data collection approach.

The results of this study indicated gender is linked to the actual usage of BIM and confirmed there are statistically significant differences of perceived usefulness and perceived ease of use between the user and non-user groups of BIM. The findings also confirmed the validity of the TAM model in explaining the differences in attitude toward usage of BIM and showed evidence that the TAM model is applicable for predicting the actual usage between user and non-user groups. However, several limitations to this research were highlighted.

Keywords: Building Information Modelling (BIM), Technology Acceptance Model (TAM), User and Non User Groups

INTRODUCTION

Building Information Model (BIM) is an innovation approach in Architectural, Engineering and Construction (AEC) industry as a modelling technology which involves applying and maintaining an integrated digital representation of different information across various phases of the construction life cycle to promote productivity and the quality of design, construction, and maintenance of a building. Although the potential benefits of the technologies may seem evident and the AEC industry throughout the world is attempting to adopt BIM as the future standard for building design, construction, and operation, Walasek & Barszcz (2017) noted the adoption rates of this technology have been lower than expected and Ademci & Gundes (2018) highlighted that there are a plethora of barriers hindering the adoption of BIM. Likewise, Hochscheid & Halin (2018) commented that the way adoption is taking place is little known while the stakes of massive BIM adoption are high.

Based on an extensive review of literature, Wang, Xue & Li (2013) proposed applying the Technology Acceptance Model (TAM) to understand the user acceptance of BIM and later, based on the theory of the TAM, Yuan, Yang & Xue (2019) explained BIM adoption

behaviors by investigating how different factors and elements impact individuals' perceptions of usefulness and ease of use of BIM in an empirical study.

The objective of this study was to gain better understanding of the adoption of BIM by applying descriptive and correlation analysis of the various constructs of TAM.

Technology Acceptance Model (Tam)

Over the decades, a variety of theories and models have been developed to address the process and determinants of technology adoption and diffusion. Davis (1989) proposed TAM to explain and predict user's behavior to use a technological innovation which has empirically been proven to have high validity. The TAM, as shown in Figure 1, suggested the intention to use the system is determined by two core constructs. "Perceived Usefulness (PU) is the degree to which a person believes that using a particular system would enhance his or her job performance" and "Perceived Ease of Use (PEOU) is the degree to which a person believes that using a particular system would be free of effort" (Davis 1989).

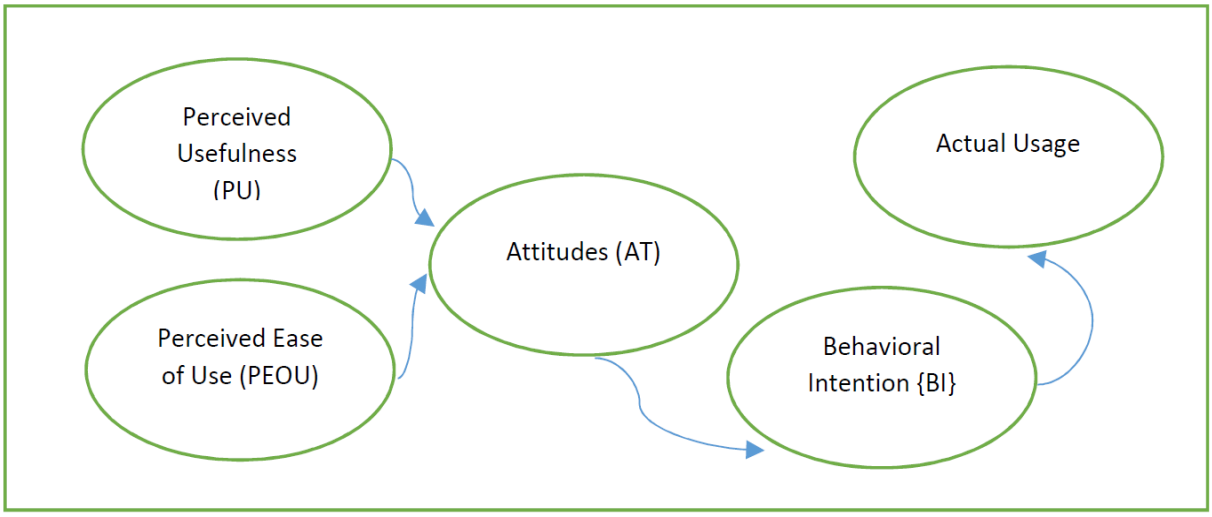

Figure 1. Technology Acceptance Model (TAM)

METHODOLOGY AND HYPOTHESIS

Aiming at identifying and determining factors related with the adoption of BIM, this study was quantitative in nature and employed a TAM questionnaire as a data collection approach with descriptive and correlation analysis to test hypotheses about relationships among various constructs of Technology Acceptance Model (TAM).

On the basis of the literature review, the following hypotheses are proposed for testing in the empirical study of behavior intention and actual usage of BIM

i. There is no significant difference between the Perceived Usefulness (PU) of user and non-user groups of BIM.
ii. There is no significant difference between the Perceived Ease of Use (PEOU) of user and non-user groups of BIM.
iii. There is no significant difference between the Attitude (AT) of user and non-user groups of BIM.
iv. There is no significant difference between the Behavioral Intention (BI) of user and non-user groups of BIM.

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The questionnaire for the study was designed by adapting items from relevant literature using a 5 point Likert's scale and included perceived ease of use (6 items), perceived usefulness (6 items), attitude toward usage (3items), and behavioral intention to use (3 items) of the Technology Acceptance Model (TAM).

FINDINGS AND DISCUSSION

As shown in the sample description (see Table 1), the participants comprised 29 (46%) females and 34 (54%) males. The majority of participants were between 20 and 49 years, with 40% from 20 to 29, 29% from 30 to 39, 16% from 40 to 49, and 13% from 50 to 59, with a low minority (3%) above 60. The rest of the figures and information are presented in the following table.

Table 1. Participants; Demographic Information

Variables	Scale	Frequency	Percentage
Gender	Female	29	46%
	Male	34	54%
Age	20-29	25	40%
	30-39	18	29%
	40-49	10	16%
	50-59	8	13%
	60 and above	2	3%
Education	Diploma	6	10%
	Bachelor	29	46%
	Master	21	33%
	Ph.D.	7	11%
Profession by Training	Architect	1	2%
	Civil Engineer	29	46%
	Quantity Surveyor	28	44%
	Others	5	8%

To verify the internal consistency of the questionnaire, Table 2 presents the Cronbach's Alpha coefficients. As can be observed, high value of Cronbach's Alpha was obtained for all constructs of TAM in the questionnaire; as such, it is concluded that there is a coherent and systematic relationship among responses to questions and satisfactory internal consistency of the questionnaire exists.

Table 2. Cronbach's Alpha for Internal Consistency

Constructs of TAM	Numbers of Item	Cronbach's Alpha
Perceived Usefulness (PU)	6	0.8875
Perceived Ease of Use (PEOU)	6	0.9124
Attitude(AT)	3	0.8996
Behavioral Intention(BI)	3	0.8965

The following table shows that the correlations between the PU, PEOU AT and BI are positive and significant. This confirmed the original hypothesis made in the literature concerning the Technology Acceptance Model.

Table 3. Correlation Analysis

	PU	PEOU	AT	BI
PU	1			
PEOU	0.41**	1		
AT	0.41**	0.75**	1	
BI	0.33**	0.61**	0.57**	1
Note: ** p-value <0 .01, * < 0.05				

Actual usage is the core of this study for which a user group and a non-user group were identified based on respondents' answers to the question "I use BIM frequently?"

The survey sample included 63 respondents of which 26 (41%) use BIM frequently and 37 (59%) are non-users. The following table illustrates the gender difference of users and non-users of BIM. The relationship among the variables were analyzed by means of the chi-square independence test.

Table 4. Difference in Actual Usage of BIM by Gender

Gender	User		Non User		Chi Square	Sig
	n	%	n	%		
Male	18	28.6	16	25.4	4.151	0.0416*
Female	8	12.7	21	33.3		
Note: ** p-value <0 .01, * < 0.05						

In this case $p < 0.05$, so this result indicated gender is linked to the actual usage which is consistent with the prior research that suggests demographic factors such as gender influence acceptance of information technologies (Venkatesh et al., 2012).

Table 5. t-test Result for Actual Usage of BIM

Constructs	User (n=26)		Non User (n=37)		T	P
	Mean	Std	Mean	Std		
PU	4.43	0.6437	3.91	0.8299	2.677	0.0095**
PEOU	3.79	0.9572	3.28	0.8432	2.235	0.0291*
AT	4.65	0.4788	4.14	0.8652	2.723	0.0084**
BI	3.85	0.9165	4.46	0.5742	-3.247	0.0019**
Note: ** p-value <0 .01, * < 0.05						

As it can be seen from the above table that there is a consistent pattern of the mean values of various TAM constructs obtained by user and non-user groups. These outcomes further illustrated that there are statistically significant differences of perceived usefulness (PU) and perceived ease of use (PEOU) between the user and non-user groups towards BIM, so the null hypotheses, "There is no significant difference between the Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) of user and non-user groups of BIM" are rejected. Furthermore, consistent with prior research, the results depicted that user group have higher mean value of AT as compared with the non-user group which means more positive attitude

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toward adoption of BIM. However, as users are currently using BIM the higher mean value of BI of the non-user group may imply non-users wish and intend to adopt BIM in the future.

CONCLUSIONS

This research attempted to explore factors that influence user adoption of BIM. Consistent with prior research (Davis, 1989), perceived usefulness and perceived ease of use were found to have significant relationships with users' attitude and intention.

The findings also confirmed the validity of the TAM model in explaining the differences in attitude toward usage of BIM and showed evidence that the TAM model is applicable for predicting the actual usage between user and non-user groups.

There are however several limitations to this research. First, this research only looks at the basic TAM model and not the extended TAM. Another limitation is that although the variables (i.e. PU and PEOU) included may explain the variation in intention to use, there are other variables that may also influence intention to use that have been left out; for example, personality traits of users and non-users as well as the technical support and characteristics of the work environment. So, further research needs to be undertaken in the future.

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