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Higher Education Students' Readiness Towards Building Information Modelling (BIM) Adoption: A Conceptual Model Based on Extended Technology Acceptance Model

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Abstract: The main goals of this study is to develop a conceptual model for evaluating students' readiness and acceptance for building information modelling (BIM) adoption. The theory was based on a technology acceptance model (TAM) that had been extended. The suggested model, in particular, extends the Technology Adoption Model (TAM) by adding the readiness element as an external variable. A thorough knowledge of this model would provide important insights into the factors that influence the adoption or resistance of BIM by intended users, as well as opportunities for future research into technological acceptance.

Keywords: *technology acceptance model, building information modelling, student readiness, student acceptance.*

1. Introduction

In Malaysia's architectural, engineering, and construction (AEC) industry, building information modeling (BIM) has become a major trend. Although BIM has been used in developed countries for some time, construction companies in Malaysia have only recently begun to use it in their projects after becoming aware of its benefits (Haron, Harun, & Raja Soh, 2017). This technology is currently used by 17% of Malaysian AEC stakeholder (Ahmad Jamal, Mohammad, Hashim, Mohamed, & Ramli, 2019). Furthermore, during a pandemic, BIM is incredibly useful and advantageous to the AEC industry.

The strategy for encouraging architecture firms to use BIM in Malaysia is to train graduates with the necessary skills. Delivering new technology to graduates with the capabilities is one factor that must be stressed on while deploying new technologies. That means the Higher Education Institute (HEI) has a direct influence on the country's technical development to some extent (Grant & Mohd-Nor, 2014). The readiness of students must be investigated in order to improve BIM adoption in the AEC industry (Othman, Al-Ashmori, Rahmawati, Mugahed Amran, & Al-Bared, 2020). In Malaysia, BIM integration is crucial for meeting the needs of the industry. Without the active participation of students in higher education, the success of BIM's adoption will be impossible. The acceptance of BIM's adoption is greatly influenced by the students' perception (Zou, Xu, Jin, Painting, & Li, 2019).

The aims of this paper are to present a conceptual model of BIM that incorporated from the Technology Acceptance Model (TAM) and to identify the most common external factors of BIM adoption. Furthermore, understanding these characteristics is intended to aid decision-makers in recognizing the benefits and drawbacks of BIM education, as well as assist students in achieving higher levels of acceptance in BIM. TAM is one of the most often used theory for analyzing the adoption of new technology, as it is a concise and powerful theory in the information systems world. TAM's key limitation, according to several scholars, is its unable to explain the external variables that are heavily reliant on technology, consumers, and application sectors (Son, Lee, Hwang, & Kim, 2014)(Agoras, 2018). This study improved TAM by integrating the readiness factor, which influences the student's PU and PEU as well as their BIM adoption status.

2. Literature Review

2.1 Building Information Modelling (BIM)

Building Information Modelling (BIM) has been defined in a variety of ways, depending on the definer's area of expertise or the aim of the defining factor. BIM is defined in Malaysia as technology modeling and related processes for generating, communicating, and evaluating digital knowledge models throughout the construction life cycle (CIDB, 2016). The modelling technology, digital information model, and building project life-cycle are the three primary components of this. The modeling software used to create BIM models is referred to as modeling technology. The digital information model, on the other hand, refers to a smart 3D model that contains specific building information. The construction process that begins with the design, development, and management of the building or infrastructure during the specified timeline is referred to as the project's life cycle. Figure 1 depicts the most basic BIM diagram in Malaysian terms.

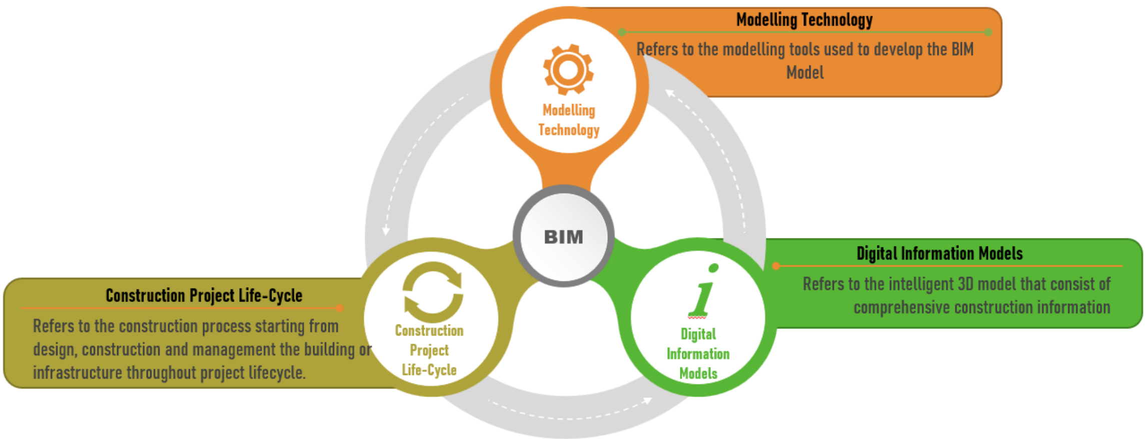

Figure 1: Building Information Modelling (BIM) major parts (CIDB, n.d.)

2.2 BIM in Higher Education

The importance of ICT in AEC education has shifted as a result of recent developments. Students in the construction management field, for example, have significantly improved their perception of reality through a combination of their ability to understand the nature of construction materials and associated processes by looking at the natural world enhanced by computer-generated knowledge layers. However, there is a lack of documentation and study on how the anticipated benefits of BIM and its applications in AEC practices could be integrated into BIM education.

In Malaysia, the director of the Department of Public Works (PWD) introduced BIM in 2009. Stakeholders should be prepared to launch BIM in Malaysia if they are aware of the technology. As a result, the training provider is the most crucial party in ensuring BIM's success in Malaysia. BIM training is divided into two categories: stand-alone courses and integrated courses (Puolitaival & Forsythe, 2016).

The first technique, known as the stand-alone or single-course approach, is a teaching style in which BIM is taught as a BIM course with no additional courses in the institution's curriculum. It essentially teaches or rather covers the entire range of BIM capabilities, including BIM software use, BIM model development, implementation, and learning. The second method is to use an integrated or interdisciplinary approach — BIM is taught using this methodology by modeling a real-world project in which students from different institutions, such as Construction Management and Architecture, collaborate to complete a project using BIM. This method facilitates the closing of the gap between action and theory. (Jin et al., 2018)(Puolitaival, Zealand, Kestle, & Zealand, 2018).

In Malaysia, most of HEi integrated the BIM subject in their curriculum as one of the required subjects. In a training center like Akademi Binaan Malaysia (ABM) or another training company, the stand-alone approach is used.

2.3 Technology Acceptance Model

Researchers employed the Technology Acceptance Model (TAM) to explore the acceptance and readiness of technology. The technology acceptance model (TAM) framework is shown in Figure 2.

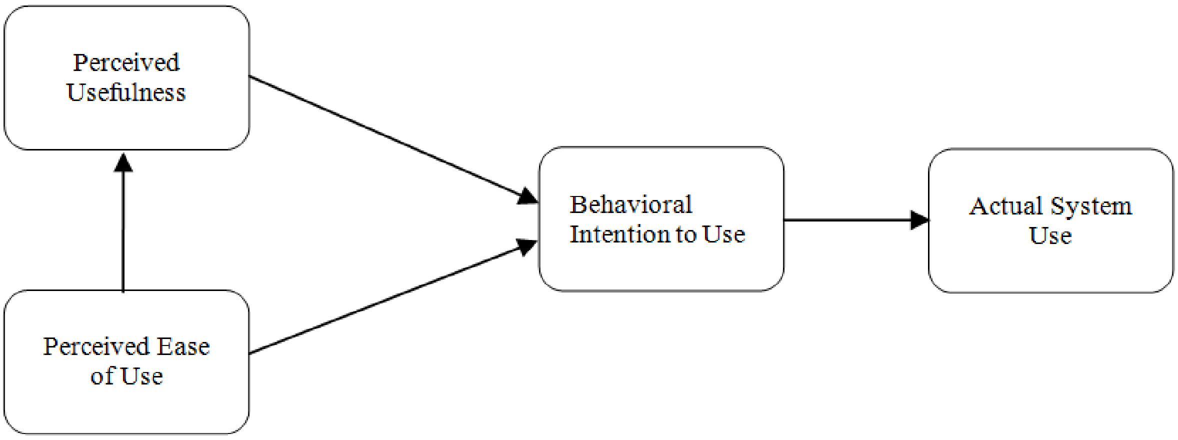

Figure 2: Technology Acceptance Model (Davis, 1989)

Researchers' systematic use of the Technology Acceptance Model (TAM) to learn about the acceptance of technology and the use of information systems demonstrates the model's success (Straub, Keil, & Brenner, 1997). Davis (1989), a popular choice among academics, proposed the Technology Acceptance Model (TAM) to study the acceptance of any new technology, owing to its robustness and efficiency. Several academics who looked into BIM acceptance among students used TAM as a starting point for their research (Iqbal & Bhatti, 2015). According to the TAM, people's attitudes toward new technology are influenced by their perceptions of how easy it is to use (perceived ease of use-PEU), and adoption leads to better productivity (perceived usefulness-PU). This suggest, PEU has a positif relationship towards PU.

Perceived Usefulness (PU) is one of the most important prior considerations for the use and implementation of technology. The degree of confidence in a program created by people that can boost work performance is referred to as PU (Venkatesh & Davis, 2000). The degree to which people believe that utilizing a system is simple known as perceived ease of use (PEU). The PEU was the most important factor in deciding to employ the method. In many contexts and technology implementations, there was a positive relationship between perceived ease of use and technology use (Kripanont, 2007).

3. The Conceptual Model

The purpose of this study is to discuss a variety of aspects that may influence the adoption and implementation of BIM in various fields. Researchers intend to investigate the creation of the proposed conceptual model for future research by outlining the main components in greater depth. The suggested paradigm aims to gain a complete grasp of the setting under examination, which necessitates some rationality compromise (Taylor & Todd, 1995b). The proposed model allows potential researchers to hypothesize and assess the correlations between the defined constructs in order to determine whether the theoretical model is accurate or not (Sekaran & Bougie, 2011). The best answer, on the other hand, to identify specific constructions relevant to the context of BIM, based on the fact that prior models of technology acceptance and adoption had some limits.

Two categories of variables would be included in the suggested study model. The primary determinants (independent variables) that may influence behavioural intention (BI) and attitude toward usage (AU) of the framework for BIM adoption are discussed in the first section. These constructs are student readiness, perceived ease of use (PEU), and perceived usefulness (PU). In the second category, there are two dependent variables: BI and AU. In this study, BI is expected to have an impact on the AU. Figure 3 depicts the suggested conceptual model, and the subsequent sections of this research provide a full discussion of each category.

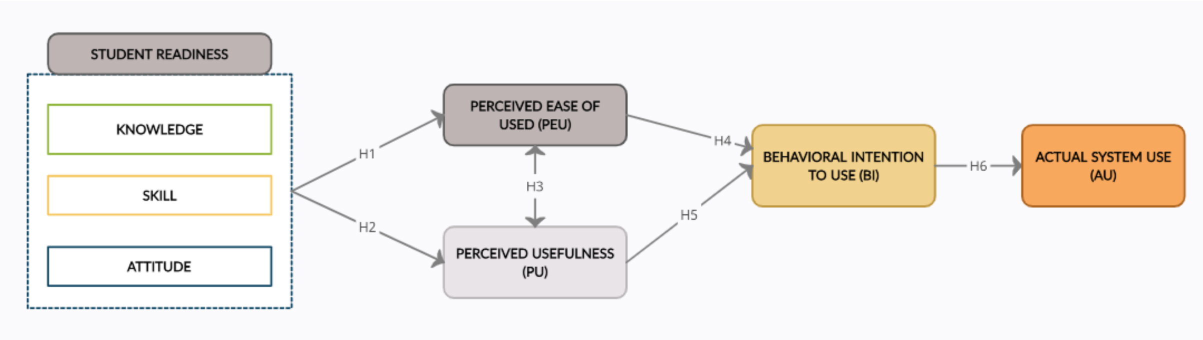

Figure 3: Proposed Conceptual Model

3.1 Student Readiness Factor

Four types of personal attributes for digital technology adoption include technical skills, learning preferences, technology attitudes, and computer self-efficacy. Students who have the appropriate technological skills are more likely to be interested in using emerging technologies than students who lack those skills.

"Readiness" is defined as "willingness or a state of being prepared for something," according to the Cambridge Advanced Learner's Dictionary (2008). Readiness assesses a person's willingness and skill in all of its forms. For the purposes of this study, BIM readiness is defined as the student's willingness to utilize BIM and their capacity to perform in a BIM-enabled environment. As a result, the study intends to assess students' willingness to adopt BIM and their perception that BIM is valuable in their courses, as well as their capacity to work in a BIM-enabled environment that they think to be simple to use.

The focus of this study will be on student readiness in terms of knowledge, skill, and attitude (KSA). Knowledge will look into student BIM knowledge, skill will look into student BIM skills, and attitude will look into student BIM attitudes. Since it is related to bloom taxonomy, which is used in most educational institutions, this KSA in Fig. 3 is the most important aspect in learning.

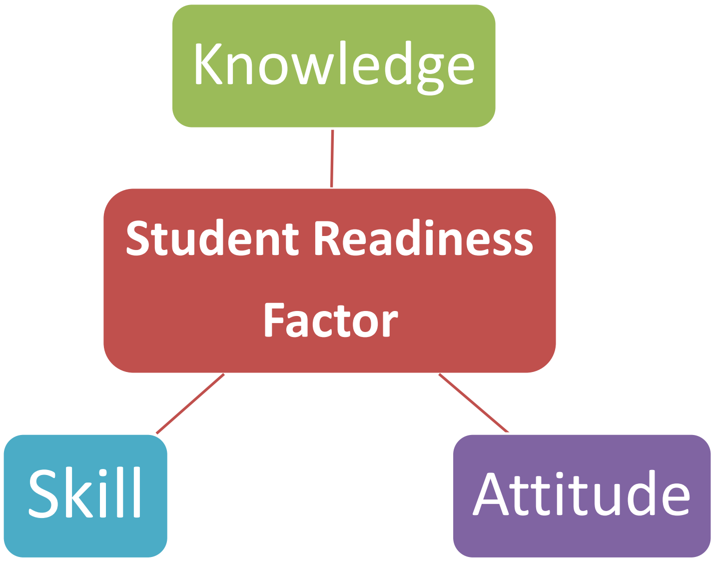

Figure 4: Student Readiness Factor

a. Knowledge

Knowledge is a cognitive domain made up of three learning domains. The cognitive domain includes awareness and the development of intellectual ability (Birlik, 2015). This entails recalling or acknowledging basic facts, procedural patterns, and principles that aid in the development of analytical abilities and skills. According to Safiee, Hanapi, and Sheh's (2019) research, there are four major aspects that influence readiness: knowledge, skills, attitudes, and training. BIM adoption in the AEC industry has been hampered by a lack of BIM understanding and knowledge (Yusuf, 2018). It is critical to determine the level of BIM knowledge among students in order to improve BIM adoption in the industry to fulfill current needs (Mamter & Mamat, 2014). Students might be affected by a lack of knowledge, so BIM education can be examined by measuring BIM understanding rates and student acceptability.

b. Skill

The term "psychomotor skill" refers to a skill that is always linked to the psychomotor domain. Physical activity, reflex actions, and interpretive gestures have separate psychomotor priorities. The psychomotor domain (Simpson, 1971) includes physical activity, coordination, and usage motor skills. Skills are one of the primary characteristics that contributed to the level of readiness, according to Safiee, Hanapi, & Sheh, 2019 study. This is because highly skilled graduates are capable of meeting and fulfilling the needs of the industry as well as the country's future. Skills influence students to learn BIM more skillfully and carefully (Mohamad Nizar, Mohd Karim, & Zainudi, 2019). According to Abd Hamid, Embi, Mohd Taib, & Abdul Razak, 2020 study, adoption would be slowed by a lack of skill and knowledge. To ensure smooth progress in the growth of construction and rising BIM usage, student skills should be considered as readiness factor to examine.

c. Attitude

One of the learning domains, affective domains, can be connected with attitude. The affective domain is comprised of our feelings, emotions, and attitudes (Birlik, 2015). The complexity of an innovation will impact how people feel about it before they decide to adopt it (Ahmed & Kassem, 2018). Furthermore, Ahmed and Kassem (2018) claim that individual and group attitudes and perceptions can influence BIM adoption. Therefore, the following hypothesis suggested:

H1: The component of Student Readiness has a clear positive relationship with Perceived Ease of Use (PEU).

H2: The factor of Student Readiness has a clear positive relationship with Perceived Usefulness (PU).

3.2 Perceived Ease of Used

PEU (Perceived Ease of Use) is related to the expectation of effort in UTAUT and is stated as "the degree to which an individual assumes that using a given method will be free of effort" (Venkatesh, Morris, Davis, & Davis, 2003). PEU was proposed as a direct BI determinant in the TAM, TAM2, and DTPB (Yousafzai, Foxall, & Pallister, 2007). Furthermore, a number of studies have discovered evidence for a PU-mediated indirect link between PEU and BI. The importance of the PEU in predicting the BI has been proven by good data (Tarhini, Hone, & Liu, 2014).

The majority of following research on student expectations of using technologies confirms PEU's importance in predicting BI. The significance of the findings in the literature, on the other hand, varied (Ramirez-Anormaliza, Sabaté, & Guevara-Viejo, 2015). For example, Peng, Su, Chou, & Tsai, (2009) discovered that PEU was the strongest determinant of the intention to adopt the system, correlating with Chang & Tung, (2008) findings. However, it was not the most accurate indicator for the BI to use in the system. Cheney, (2006), on the other hand, came to the conclusion that perceived ease of use had no discernible and significant impact on the system's intention to be used.

As a result, the PEU is included to investigate students' expectations that the system will be simple to use and to predict their behavioral intention to systems. It is assumed that if students find the system simple to use, they will accept and use it. As a result, based on many models and past studies that include PEU's direct association with BI as well as indirectly through PU, we propose the following hypothesis:

H3: Perceived Ease of Use (PEU) will have a direct positive significance on Perceived Usefulness (PU) of BIM.

H4: Perceived Ease of Use (PEU) will have a direct positive significance on the Behavioural intention (BI) to use BIM.

3.3 Perceived Usefulness

Perceived Usefulness (PU) is described as "the degree to which a person believes that employing a specific method will improve his or her job performance" (Davis, 1989). PU is comparable to relative advantage in model DOI and success expectancy in UTAUT (Venkatesh et al., 2003). To put it another way, it's the extent to which benefits are considered to outweigh costs. In the TAM, TAM2, and Augmented TAM, PU was proposed as a direct determinant of BI. Davis (1989) discovered that PU had a far stronger relationship with BI than perceived ease of use, and e-learning study revealed the same result (Liu, Chen, Sun, Wible, & Kuo, 2010).

In the context of this paper, PU will be used to investigate students' perceptions of the potential benefits of adopting technology. In various study investigations, the important principle that PU plays on BI in the use of technology has been highlighted ((Chang & Tung, 2008). They discovered that PU was the most influential component in predicting the intention to use the technology. According to Sanchís-Pedregosa, Vizcarra-Aparicio, & Leal-Rodríguez, (2020), Perceived Usefulness (PU) is more relevant than Perceived Ease of Use (PEU) in predicting Behavioural Intention (BI). As a result, it was hypothesized that PU would have a significant beneficial impact on the intention to use the technology. The researcher then proposed the following hypothesis:

H5: Perceived Usefulness (PU) will have a significant positive effect on the Behavioral intention (BI) to use BIM.

3.4 Behavioral Intention to Use

A stage in which a person has acquired a purposeful intent to commit or not commit future behavior of a certain stated. The presence of Behavioral Intention (BI) in TAM is one of the primary differences from TRA. BI is regarded as an immediate precedent of use behavior and serves as a predictor of the ability of an individu to carry out a given action. According to Ajzen, (1991), "the higher the intention to participate in, the more likely a behavior is to be successful." In TAM, both PU and PEU affect a person's intention to use technology, which in turn affects the individual's purpose to use technology (Davis, 1989). TAM claims that two ideas determine an individual's behavioural intention to utilize a new technology are perceived usefulness and perceived ease of use (Batarseh & Kamardeen, 2018a).

The link between BI and overall usage behavior has been well established in the literature (Taylor & Todd, 1995a, Venkatesh & Davis, 2000). Furthermore, in TAM, DTPB, and TPB, the transition from BI to AU is crucial. The impact of BI on the AU is enormous. It's worth mentioning, too, that the influence of BI on AU is more predictable when people have used the technology before (Taylor & Todd, 1995b).

In the context of information system research, system use has been investigated as a dependent variable and is frequently estimated using only BI, solely AU, or even both BI and AU (Agarwal & Karahanna, 2000,Szajna, 1994). Whether it is motivated or resistant behavior, the readiness level will be reflected in actual BIM usage behavior (Batarseh & Kamardeen, 2018b). BI is predicted to have a direct impact on forecasting how students will accept and use technology in the future. As a result, the researcher presents the following hypotheses:

H6: The Behavioral intention (BI) of the student would have a positive influence on his or her Attitude towards use (ATT) of the BIM usage.

3.5 Attitude Towards Use

The extent to which a person has a positive or negative attitude regarding BIM can be define as attitude (Hussein, 2017). Several studies have revealed that attitude has a direct impact on behavioral intentions (Fathema, Shannon, & Ross, 2015,Deshpande, Bhattacharya, & Yammiyavar, 2012). All of the hypotheses that have been fomulated are showed in Table 1:

Table 1 Summerize of Hypotheses

H1	The component of Student Readiness has a clear positive relationship with Perceived Ease of Use (PEU).
H2	The factor of Student Readiness has a clear positive relationship with Perceived Usefulness (PU).
H3	Perceived Ease of Use (PEU) will have a direct positive significance on Perceived Usefulness (PU) of BIM.
H4	Perceived Ease of Use (PEU) will have a direct positive significance on the Behavioural intention (BI) to use BIM.
H5	Perceived Usefulness (PU) will have a significant positive effect on the Behavioral intention (BI) to use BIM.
H6	The Behavioral intention (BI) of the student would have a positive influence on his or her Attitude towards use (ATT) of the BIM usage

4. Discussion

This study proposed a theoretical framework that could be effective in explaining the various factors that are likely to influence BIM implementation and adoption. The conceptual model is based on well-known technology adoption models and frameworks, such as TAM, TAM2, TRA, DTPB, and UTAUT, which are all applicable to the BIM context. These characteristics include readiness factor, perceived ease of use, perceived usefulness, and behavioral intention and usage, and they represent personal, social, and situational aspects.

As a result, this work develops and examines six direct hypotheses relating to H1 and H6. Extending the TAM to incorporate the readiness element is expected to help understand more of the variance in behavioral intention and actual use, as well as investigate why the model could be better in certain circumstances than others.

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