Smart Construction Using Building Information Modelling (BIM)

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Abstract: Smart construction is the application of advanced technologies and digital tools in the construction industry to enhance productivity, efficiency, and collaboration throughout the construction process. One of the key technologies used in smart construction is Building Information Modelling (BIM), a digital representation of a building or infrastructure project encompassing its physical and functional characteristics. This study investigates the factors influencing BIM implementation in Indonesia's construction industry. The study surveyed 175 engineers in Indonesian construction companies and used SmartPLS to analyze the data. The findings indicate that performance expectancy, effort expectancy, and social influence significantly impact behavioral intentions to use BIM, which, in turn, positively correlates with individual user behaviors when using BIM in Indonesian construction companies.

Keywords: Smart Construction, Building Information Modelling (BIM), Construction Industry, Project Management, Indonesia.

1 Introduction

Smart construction is a rapidly growing field that leverages innovative technologies and digital tools to improve productivity, efficiency, and collaboration across the entire construction lifecycle. One of the foundational technologies underpinning smart construction is Building Information Modeling (BIM), which provides a digital representation of a building or infrastructure project, encompassing its physical and functional characteristics. [1]. BIM involves creating, managing, and sharing digital models containing detailed information about various elements of a construction project, including architectural, structural, mechanical, electrical, and plumbing components [2]. However, the researchers have noted several research gaps as follows [3] [4]

(1) The competence of Indonesian engineers in adopting BIM still needs to improve. Therefore, assessing the factors influencing BIM implementation in Indonesia's construction industry is important.
(2) While technology like BIM is being adopted in Indonesia, perceptual challenges hinder its optimal use. Specifically, there are concerns about the actual benefits of

BIM, the effort required for its implementation, and the need for a solid social push within companies for its comprehensive application.

(3) There is a gap in understanding and communicating BIM's full potential and benefits beyond 3D visualization.

2 Theoretical foundations

BIM implementation requires a high investment cost and experienced human resources, and its advantages still need to be clearly described [5]. Inspired by the Unified Theory of Acceptance and Use of Technology (UTAUT) offered by Venkatesh et al., the researchers incorporated several concepts from the model into their own technology acceptance model. [6] to facilitate the successful implementation of BIM in Indonesia

Unlike the Technology Acceptance Model (TAM), the Unified Theory of Acceptance and Use of Technology (UTAUT) incorporates social influence, which is the degree to which an individual perceives that others believe they should use a method or system. UTAUT has also been demonstrated to be the most reliable model for predicting technological adoption in multicultural settings, such as Indonesia. Due to its variables, such as performance expectancy, effort expectancy, and social influence, UTAUT is a more suitable model for assessing technological acceptance in multicultural workplaces than other acceptance models [7].

3 Literature Review

3.1 Building Information Modelling

BIM is a collaborative repository of digital data about a building or infrastructure project that provides a reliable foundation for decision-making throughout its lifecycle, from conception to demolition [8]. BIM was intended to capture all information and aspects of a facility's design and construction; therefore, it is typically used for operation and maintenance [8]. BIM goes beyond just geometry, and it covers all aspects of dimension integration, the brightness of each room model, contour image, and detail quantity with the specification of building items [9].

3.2. Unified Theory of Acceptance and Use of Technology (UTAUT)

Researchers developed the UTAUT model by combining previous technology models [10]. To construct the UTAUT model, researchers tested all these theories and combined the results to form a set of determinant factors that affect behavioral intention and user behavior towards an information system [6]. UTAUT can be used to predict how the following factors, among other things, affect behavioral choice toward an information system:

- Performance expectancy: The perceived degree to which using a system will improve job performance.
- Effort expectancy: The perceived difficulty of using a system.

- Social influence: The perceived pressure from others to use a system [11].

3.3 Behavior Intention

Behavioral intention is the likelihood that an individual will adopt and use a new system on an ongoing basis, given the opportunity [6] [12]. It is also defined as the consumer's readiness and likelihood to use a particular technology [13] [14]. Behavioral intention, which is influenced by performance expectancy, social influence, and effort expectancy, is a mediating variable in the UTAUT model [15].

3.4 User Behavior

User behavior can be defined as how often an individual uses a new system. The use of a new system or technology will be driven by the individual's interest in the experience so that the quality and efficiency of their work can be improved [15]. Understanding individual user behavior in BIM utilization requires a multi-dimensional perspective encompassing technological, organizational, and personal factors.

4 Hypothesis Development

4.1 Performance Expectancy with Behavioural Intentions

No and Kim [16] studied the effect of performance expectancy on smartphone usage. The study found that users are more likely to adopt and use smartphones if they perceive that they will receive more benefits. This statement is supported by Shara and Widodo [17], who found that performance expectancy positively correlates with user acceptance of smartphone usage.

Based on the literature above, the hypothesis is:

H1: Performance expectancy has a positive relationship with individual behavioral intentions to use BIM in Indonesia.

4.2 Effort Expectancy with Behavioural Intentions

Previous studies on effort expectancy have found that the ease of use of technological advancement positively correlates with the user's attitude toward accepting the technology, especially in the case of smartphone usage [17]. Another study by Park and Ohm [18] found that the ease of use of mobile apps positively impacts their adoption, as it requires less effort to use the apps.

Therefore, the hypothesis of this study can be concluded as follows:

H2: A positive relationship exists between effort expectancy and individual behavioral intentions to use BIM in Indonesia.

4.3 Social Influence with Behavioural Intentions

Previous studies on social influence have found that it positively correlates with user acceptance of smartphone usage [17]. This finding is supported by other studies by Venkatesh, Thong, and Xu [19]

According to Howard et al.[13], social influence is the degree to which people believe that essential people think they should use a system. The most significant influence on behavioral intentions comes from social influence, which correlates significantly with user behavior. This means that the social environment is promoting the use of BIM.

Therefore, the following hypothesis can be concluded for this study:

H3: Social influence has a positive relationship with individual behavioral intentions to use BIM in Indonesia.

4.4 Behavioral Intentions with User Behaviour

Prior research has shown that facilitating conditions and behavioral intention are positively correlated with the use of hospital management applications. Users believe that encouraging the environment to adapt to new technology will help them use it voluntarily [20]. This claim is supported by an earlier study on how students adapt to e-learning websites, which found that when students are more motivated to use a website, they tend to use it more regularly [21].

Based on the findings of this study, the following hypothesis can be drawn:

H4: Behavioral intention has a positive relationship with individual user behavior to use BIM in Indonesia.

5 Methodology

A quantitative method with a causal research design was used in this study. Quantitative methods use data and statistical analysis [22]. To better understand the current state of BIM adoption in the construction industry, the author conducted an exploratory study in Indonesia prior to the main research. The UTAUT model used by Howard et al. [13] served as the basis for the questionnaire's development.

The population of this study is BIM users in Indonesia. This includes employees from both state-owned and private companies. A total of 175 valid surveys were collected and analyzed using SmartPLS software.

6 Result and Discussion

After passing the reliability and validity tests, a path analysis was performed. The resulting analysis is shown in Table 1.

Table 1: Hypothesis Testing

	Original...	Sample...	Standar...	T Statist...	P Values
Behavioral Int. -> Use Behavi...	0.445	0.442	0.130	3.428	**0.000**
Effort Exp. -> Behavioral Int.	0.183	0.194	0.095	1.918	**0.028**
Perf. Exp. -> Behavioral Int.	0.194	0.179	0.092	2.114	**0.017**
Social Inf. -> Behavioral Int.	0.218	0.225	0.122	1.785	**0.037**

The table indicates that all hypotheses are supported, with p-values < 0.05. The next paragraphs discuss the contributions of this research.

The research has adapted UTAUT to Indonesia's specific BIM context. By applying UTAUT in this manner, the study potentially broadens the theory's applicability and offers a nuanced understanding of how the approach operates in the construction domain.

The findings related to performance expectancy, social influence, and effort expectancy provide a deeper theoretical understanding of these constructs within BIM. The study's results challenge or refine the conventional understanding of these UTAUT variables, especially in developing countries like Indonesia.

Furthermore, the article underscores the importance of behavioral intentions in determining BIM adoption. This adds a layer of complexity to the UTAUT theory, suggesting that behavioral intentions may play a more pivotal role in specific contexts than previously assumed.

By applying the UTAUT model to the construction sector in Indonesia, the study potentially expands the theory's geographical and sectoral scope. This can pave the way for further theoretical explorations in similar contexts or industries.

Overall, the article offers valuable theoretical insights into the dynamics of technology acceptance in the construction industry, refines our understanding of UTAUT constructs, and offers a foundation for further theoretical advancements in the domain of BIM and technology adoption.

7 Conclusion

The UTAUT model was found to be a useful framework for understanding the factors that influence BIM adoption in Indonesia. This study revealed that performance expectancy, effort expectancy, and social influence and have a positive relationship with BIM adoption intentions, which in turn have a positive relationship with user behavior.

These findings have implications for both technological designers, developers, and organizations considering adopting BIM. Technical designers and developers could use the UTAUT model to design and develop BIM technologies more likely to be accepted and used by users. For instance, technology developers could focus on developing technologies that are user-friendly and provide clear benefits to users [23].

Organizations could use the UTAUT model to identify factors likely to influence the acceptance and use of BIM within their organization [24]. This could help them to develop strategies to promote the adoption of new technologies.

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