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The Effect of Technology Acceptance Model (TAM) Challenges in Building Information Modelling (BIM) Implementation in Relation to Malaysian Government Mandate

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ABSTRACT

Technology Acceptance Model (TAM) is essential to the field of Building Information Modelling (BIM) implementation especially in the construction industry since the government mandate, it has become the key towards this perception as an obstacle of success. While innumerable studies focus on the way contractors, consultants and stakeholder acceptance towards BIM, therefore, it becomes a method for improvisation. However, up until present, limitation have been found for government staffs and perceptions regarding this manner. As to affirm, the government as well as its organization are the backbone of BIM utilization for every country. Research has shown that BIM is also influenced by the one who holds the authority by government mandating its usage strategies, and that representations are generally more effective than appeals from other users. Thus, this study aims and focuses on examines the emerging role of government organizations in the context of perceptions and acceptance towards BIM as well as the readiness of government mandate in facing challenges for Building Information Modelling (BIM) implementation in Malaysia. In this study, an online survey was distributed to government staffs that currently uses BIM across Malaysia. The obtained data were analyzed by statistical tools of IBM SPSS 28 to empirically test the correlation and impact of the proposed variable. The results showed that the TAM for BIM and well-structured government mandate will affect the challenges in BIM implementation. This paper has been organised in the following way. Starts with introduction, literature review, methodology, results and discussions. Finished with conclusions accordingly. Additionally, acceptance of BIM technology would initiate of minimizing the challenges faced by government staffs in Malaysia that involve in BIM. Good obtained values for TAM and government mandate variables in explanatory power, concluded this study. Further research is needed in this area of study to identify well-planned roadmap and proper guideline for government staffs in strengthening the effectiveness of BIM implementation in the future.

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1. Introduction

A significant turning point in the development of the construction sector was the invention of Building Information Modelling (BIM). As the first technology designed for construction industry's needs, BIM was a ground breaking new integrated tool. Thus, Datuk Ahmad Asri Abdul Hamid, the previous CEO of Construction Industry Development Board (CIDB), announced that "property developers in Malaysia, will be mandated to adopt BIM by 2020 for their construction operations." [1]. As an outcome, the potential of BIM for a variety of facilities and applications to enhance performance in the construction sector has lately raised the government's interest in the development of BIM for the industry. The primary causes of the high BIM adoption rate have been found as early as BIM adoption and a mandate for the implementation of BIM in 2016 [2]. Hence, this urges that government plays a vital role in initiating the usage of BIM in Malaysia.

Significant to the situation, the Ministry of Works *(KKR)* through CIDB, and in collaboration with parties with interests in the construction industry are in the midst of developing a Construction Strategy Plan 4.0 (2021 – 2050) to help the construction industry through the changes [2]. The Construction Strategy Plan 4.0 has also determined 12 main technologies also known as "disruptive technologies" which will change the future of construction landscape, and the first and main point, included Building Information Modelling (BIM) [2].

A BIM is a centralised repository of information that contains data about a facility that can be used as a solid foundation for choices over the course of the facility's life cycle, which is defined as existing from earliest conception and ending with demolition [3]. Using BIM improves decision-making, enables more sustainable strategies, and reduces costs for Architecture, Engineering and Construction (AEC) projects [35]. Achieving greater coordination and collaboration can also speed up decision-making, limit errors and potential rework, early conflict identification, and increase the cost saving are the short-listed benefits of BIM from numerous researched done previously [36-37]. The application of BIM used as visually computer aided software, serve more than its purpose than merely for designing. BIM not only provide practical benefits, but also helped change the cultural acceptance and new perspectives of more than just a design tool.

Malaysian adoption rate of BIM found that only 17% of respondents utilised BIM in their construction projects in 2016, so far, there has been an improvement in 2019, with roughly 49% of respondents using it in their projects [2]. Hence, demand towards its applicability and acceptability in Malaysia showing a positive trend, thus this study is important in discovering challenges specifically for government organisations in implementing BIM.

In New Zealand for an instance, for the industry group, as shown in Figure 1, BIM used has broadened throughout all phases of the project lifecycle (use of BIM throughout project lifecycle) [4]. Due to that, its acceptance should be tackled in order the benefits could be gained by all users in construction industry specifically in Malaysia.

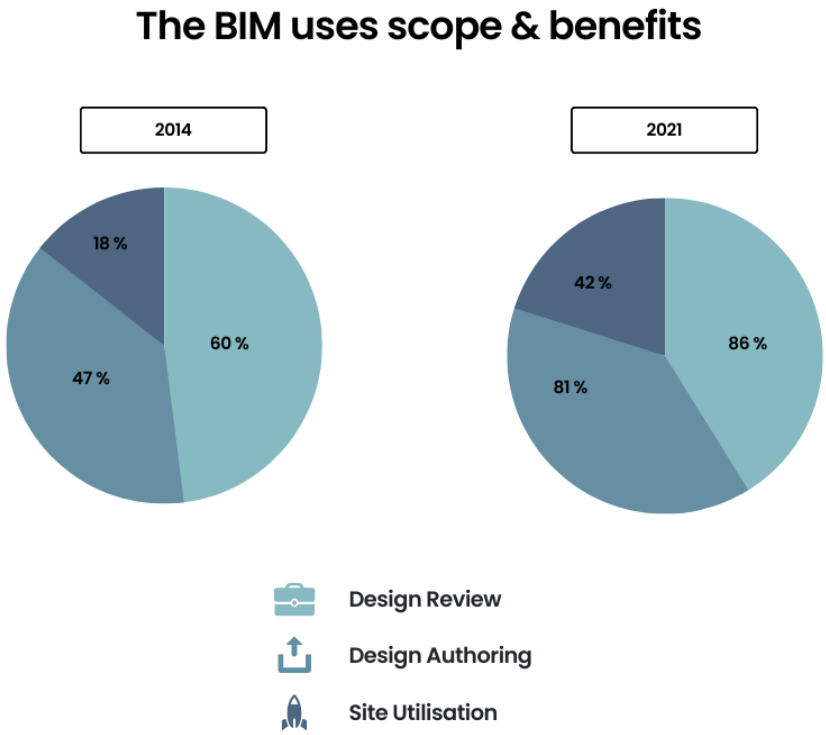

Fig. 1. BIM survey in New Zealand (Source: [4])

In terms of BIM acceptance, numerous scholars have examined the BIM acceptance mechanism using Technology Acceptance Model (TAM). The theoretical of TAM was proposed by Davis [5], who believes Perceived Usefulness (PU) and Perceived Eased of Usefulness (PEU) to be the deciding variables for the adoption of interpretive technology, influencing Behavioural Intention (BI) in this order. Recently, various study done by previous researches uses this theoretical method in BIM acceptance mechanism [6-8]. Yet, as shown in Figure 2 below the current study adopted a survey to explore the acceptance mechanism of BIM in Malaysia. The result in this study could be slightly different from previous association TAM with BIM by integrating government staff perception and behaviour in using the modelling with regards of government mandate external pressure.

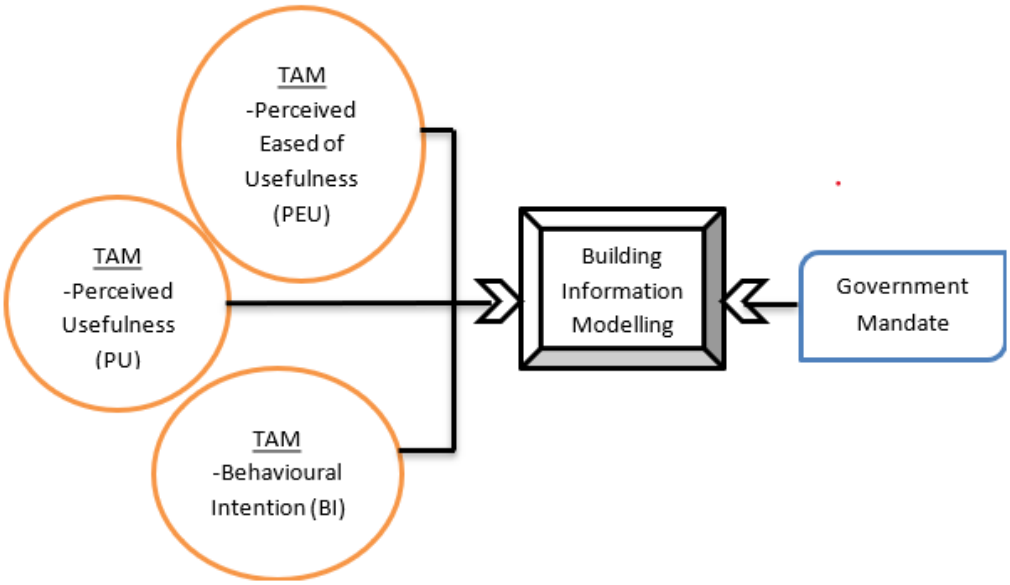

Fig. 2. Research Framework

A study by Eadie *et al.,* [9] highlighted an importance on the government's emphasis and influence of national investors for BIM adoption. Even though BIM is widening with strong applicability through each and various countries, Malaysia is still facing challenges in its implementation. Additionally, in construction industry, there is a slow pace that value technology invention in general, BIM was particularly stigmatized with the lack of acceptance as well as limited government mandating was a significant challenge for its implementation. According to a study by Yang & Chou [10] reports that there are less participants from public sector organisations utilising BIM in Malaysia than from the private sector. In terms of Building Information Modelling-Facility Management Integration (BIM-FM), a study also identified that when it comes to the perception of BIM-FM integration, users have a moderate level of awareness especially in the early stage for the BIM process [40]. The idea of BIM was not entirely new, but conventional methods based on 2D application and usage, cause lack of integrating for BIM interoperability were difficult to learn and use. Information naturally loses value when it is unobtainable, no longer relevant, or incorrect, just as with any other business system [11]. Thus, this study is critical as it investigate users' acceptance that directly involves Technology Acceptance Model (TAM) with BIM, specifically for government staffs, as its limitation of study were found in this case. Furthermore, adaptability of BIM usage due to government mandate is also determined in this study. As both, may affect the level of challenges faced specifically for government organization for the usage of BIM.

This study furthers the body of work discussed above by focussing on the objectives, which are to investigate the effect of Technology Acceptance Model (TAM) of Building Information Modelling (BIM) on challenges for its implementation and to determine the relation of government mandate with challenges for BIM implementation. As these may directly give positive influence for the field of BIM in construction industry as its benefits.

2. Literature Review

2.1 BIM Technologies

Munianday *et al.,* [12] study examined the trend that in the Middle East and North Africa (MENA) region still has a poor adoption rate, which puts it at great risk of falling behind. The study comes to the conclusion that the biggest obstacles to BIM adoption are time and financial constraints. In terms of education and teaching, findings showed a general absence of BIM teaching and diffusion in higher education in Cambodia, with students having relatively low self-rated knowledge of BIM and considerably lower awareness and familiarity with IFC [13]. Meanwhile, in adoption of Artificial Intelligence (AI)-BIM, the construction industry's widespread implementation for BIM environments is insufficient to enable effective exploitation of the data they contain or to fully realise the potential of AI in this manner [14].

Thus, these claims that in all aspect of BIM is still slow in adoption recently. There has been substantial agreement up to this point over the manner in which BIM deployment is progressing slow across all sectors of the global construction industry. There are issues with the universality of much of the published research on the topic. As a result, this study highlights the need to identify what is causing the implementation of BIM in the government sector to be so challenging in terms of Technology Acceptance Model (TAM) for government staffs and the weaknesses of existing government mandate in providing plan for the usage of BIM.

Moreover, previous researchers have investigated the benefits of BIM in wider aspects. In terms of project management, using BIM software can greatly increase risk management by up to 13% and communication management by a significant amount by up to 17% [15]. Other than design, a study by [16] found that BIM is a tool for information management with broad uses. Life Cycle Assessment

(LCA) could also be used in methodology and tool called Building Information Modelling (BIM), enabling it to be performed at each step of a project, which could aid the construction sector in achieving environmental goals [17]. Due to this, the efficiency of BIM implementation and the efficiency of the construction process are strongly correlated if using BIM [18]. In order to combat the existing reactive traditional measures that are inefficient in decreasing the effects of uncertainties that occur in refurbishment projects, this article highlights the actual benefits of adopting BIM [19]. Based on the BIM parametric modelling process findings by [20] more controlled utilisation of technical and human resources is made possible by the higher level of assertiveness and the quality of design and construction planning, which can be obtain by BIM. Somehow, according to prior studies, Malaysia's building sector uses BIM remarkably little [38-39]. Thus, the usage of BIM factually provides endless benefits in construction industry. So, its challenges need to be solved in order for its interoperability could be maintained and sustained in the future.

2.2 BIM with Technology Acceptance Model (TAM)

Uncertainty about technological change and inadequate information are cognitive challenges that the introduction of BIM directly exposes to stakeholders [21]. The two primary elements that correspond with resistance to implementing BIM are rational decision-making (uncertainty costs) and psychological commitment (sunk costs) [22]. Moreover, findings also represented the resultant thought that abstaining from adopting modernity's (the international style's) is the identity and collective memory of peoples with using BIM [23]. However, positive findings of the study shows that Indonesia's construction industry is capable of embracing BIM technology [24]. Due to that, Yang & Chou [25], highlighted that client's BIM education and training are crucial for successful BIM implementation with benefits that can be attained. There are also challenges from the point of view of the users of the BIM-to-XR in the AEC industry, including the level of acceptance / engagement of stakeholders, their awareness of XR, the usability of the model, and their acceptance to bear additional costs for hardware, software, and training [26].

Technology Acceptance Model (TAM) is a key theoretical matter that has dominated the technology industry for many years. Due to that, its relation also occurs in BIM adoption for the construction industry. In terms of acceptance, BIM needs to be overviewed its benefits as well as mitigating its challenges. So that, users would not being burden by its existence. As for researchers, this study needed as it could improvise the mentality and acceptance of BIM and its challenges of implementation could be minimized. Specifically for government organisations.

2.3 Government Towards BIM Implementation

The use of government policy and public procurement procedures is advised as effective means of encouraging this BIM sector-wide utilisation. As for example, in Singapore, by public sector taking the lead means, the Building and Construction Authority of Singapore (BCA) decided to cooperate with government procurement entities (GPE) to use BIM on public projects in Singapore [27]. Government and BIM formed the central focus of a study by Zhao *et al.,* [28] study that the government BIM policy and organisational support have an impact on how well BIM technology is accepted. Somehow, in Nigeria, it shows that Nigeria's government does not have any policies in place to promote the utilisation of BIM [29]. This might cause an issue because in China it can be found that six main obstacles to the adoption of BIM in China were identified: an insufficient government leadership or direction, organisational concerns, legal problems, high implementation costs, opposition to a shift in thinking, and a lack of external encouragement [30].

In the field of integrated BIM usage, the government should also set more specific policies and standards to promote prefabricated construction-BIM and offer owners incentive programmes in order to do it effectively [31]. As well as from contractor's perspectives, the major conclusion of this study confirms that government policy (rules and regulations) plays a moderating role between individual elements influencing contractors' risk attitudes in Malaysian construction enterprises [32]. Somehow, in a few cases, mixed approach could be enhanced in supporting BIM. As for example, Taiwan is a good observation of where a mixed method (industry- and government-driven) is used for utilising BIM [10]. Hence, it is fascinating to observe that, the government and the owners, software vendors and academia are still the important stakeholders as well. These parties are frequently ignored in prior study and in application [31].

From that point of view, despite the fact that numerous studies have focused on the government mandate and support for the adoption of BIM. Somehow, very limited study done for this workability and perception of BIM towards government's staffs itself, which are the one mainly involving to urge BIM. As they were the backbone of BIM adaptability could be spread in construction industry, thus, their role should never being underestimate in these cases.

3. Methodology

Based on Figure 3 below, this study adopts a few phases to empirically understand the specific mechanism of how government mandate and Technology Acceptance Model (TAM) can support the Building Information Modelling (BIM) implementation in spite its challenges faced throughout its accessibility and interoperability. Numerous research method such as an expert review and questionnaires dissemination that was proven by statistical analysis has been accomplished in this study. First, the root of the problem is the government mandate for BIM implementation. As well as conceptual model based on Technology Acceptance Model (TAM) with Building Information Modelling (BIM) for government organizations, theoretical issue was developed in order to collect data. Second, questionnaire distribution was carried out for government's staffs that already implement BIM to obtain data on government mandate for its implementation and TAM for BIM as well as challenges faced by them. Third, the obtained data were analyzed by statistical method of SPSS 28 to empirically test the correlation and impact of the proposed variable.

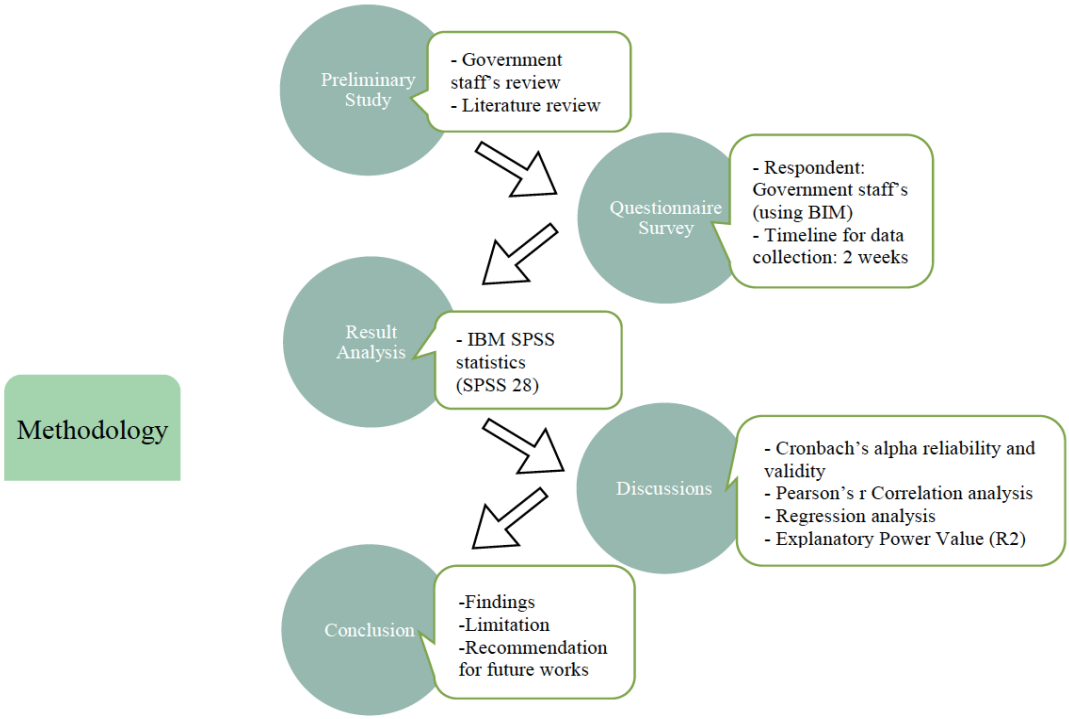

Fig. 3. The methodology of the current study

Conceptually, an extensive literature review was done to determine gap for the root of challenges that may cause BIM implementation to be comprehensively done in Malaysia. As a result, limitations of previous studies which only focused on consumer-based perceptions and not client-based perceptions. In comparison, this study focuses on the government organizations. Thus, for the preliminary study phase, observation on trends for the usage of BIM were done by reporting from NGO's, government and consumer's perspective. Then, numerous previous studies were identified on its scope of studies and reviewed on its conclusion, therefore it may be used for an extension of study in this research.

A questionnaire survey was distributed to government staffs' who are currently involved in the BIM usage. Various method was used to reached the organizations including by email, texting and google link. A total of 10 replies were collected at the end of the data collecting timeline for it to be analyzed. The time period took approximately 2 weeks for the data collections, started from April 3 to April 14, 2023. This data was analyzed based on close-ended questionnaire as a research instrument. Multiple choice responses for the challenges faced in implementing BIM and five-point Likert scale for government staff's perception towards government mandate as well as technology acceptance behavior in implementing BIM that appropriate for this study.

As for data analysis, three steps were involved continuously. First, evaluating each and every detail of the variable questionnaire validity and reliability for it to be used for further analysis is Cronbach's alpha reliability and validity test. Second, to find the correlation between variables by using Pearson's correlation analysis. Next, regression analysis and lastly by determining R^2 value to find the efficacy of the relevant variable with the assumptions.

4. Results and Discussions

Data were analyzed using IBM SPSS statistics (SPSS) 28 for reliability and validity, Pearson's correlation analysis, regression analysis and determination of an explanatory power for variables involved. For reliability and validity, the items were examined by the variables of challenges for

Building Information Modelling (BIM) implementation, government mandate and Technology Acceptance Model (TAM). The Cronbach's Alpha coefficient and composite reliability were thoroughly analyzed in this study to verify the reliability and validity of the questionnaire for each variable. Statistically, Cronbach's alpha value which ranges from 0 to 1 were measured. However, it is still standard procedure in science education to regard alpha as an adequate indicator of an instrument's dependability or internal consistency when it reaches the relatively arbitrary number of 0.70 [33]. Hence, if the value is more than 0.7, it is regarded acceptable its variable for further research. As shown in Table 1, the variables value of Cronbach's Alpha obtained its reliability and validity for this research.

Table 1
Reliability Analysis on Cronbach Alpha Coefficient

No.	Variables	Number of Items	Cronbach Alpha
a.	Challenges for BIM implementation	6	0.832
b.	Government Mandate	7	0.719
c.	Technology Acceptance Model (TAM)	17	0.915

Pearson's correlation result in Table 2 revealed the value of correlation coefficient to clarify the trend or relationship between the variables of both government mandate and Technology Acceptance Model (TAM) towards the challenges faced in implementing BIM. In an absolute correlation, where a change in one variable accurately predicts changes in the other, the coefficient is either 1.0 or -1.0. A Pearson's data analysis revealed a negative moderate correlation, r = -0.652. Thus, it specifies that more challenges faced for BIM implementation if fewer government mandate urge by its usage. For TAM relation, a Pearson's data analysis revealed a negative moderate correlation, r = -0.657. Thus, it can be stipulate that low level of acceptance for BIM in daily's usage '(TAM)' causing more challenges faced for BIM implementation.

Table 2
Pearson's correlation Coefficient Analysis

		Government Mandate	Technology Acceptance Model (TAM)	Challenges for BIM implementation
Government Mandate	Pearson correlation	1	0.473	-0.652
	Sig. (2-tailed)		0.168	0.41
	N	10	10	10
Technology Acceptance Model (TAM)	Pearson correlation	0.473	1	-0.657
	Sig. (2-tailed)	0.168		0.039
	N	10	10	10
Challenges for BIM implementation	Pearson correlation	-0.652	-0.657	1
	Sig. (2-tailed)	0.41	0.039	
	N	10	10	10

Note: *Correlation is significant at the 0.05 level (2-tailed)

Based on the objectives of the study, the regression analysis was done. Regression analysis was conducted to explore the impact of challenges face by BIM implementation for government organization by analyzing the relationship between government mandate and Technology Acceptance Model of BIM. Hence, the dependent variable of Challenges for BIM implementation was regressed on predicting variable of government mandate and Technology Acceptance Model (TAM) for BIM implementation. As shown in Table 3, government mandate significantly predicted Challenges for BIM implementation, p = 0.024, which is less than 0.05. Thus, this indicates that the

government mandate can play a significant role in shaping challenges for BIM implementation (b = -0.378, p < 0.05). These results clearly direct the negative affect of the challenges for BIM implementation. An increase in the government mandate urge of implementing BIM, a decrease effect of challenges faced for its implementation in government organization.

For Technology Acceptance Model of BIM variable with the dependent variable of challenges faced for BIM implementation, TAM of BIM significantly predicted challenges for BIM implementation, p = 0.015, which is less than 0.05. Thus, this indicates that TAM of BIM has significant impact with challenges for BIM implementation (b = -0.464, p < 0.05). These results clearly direct the negative affect of the challenges for BIM implementation. A decrease of challenges faced for BIM implementation is due to an increment of Technology Acceptance Model in this study specifically is by using BIM in government organization.

Table 3
Results of Regression Analysis on Challenges for BIM implementation

Model	Unstandardized coefficients		Standardized coefficients	t.	Sig.
	B	Std. Error	Beta		
Constant	3.618	1.196		3.025	0.019
Government Mandate	-0.378	0.193	-0.530	-1.962	0.024
Technology Acceptance Model (TAM)	-0.464	0.339	-0.369	-1.368	0.015

Note: Dependent Variable: Challenges for BIM implementation

Moreover, this study has two variable constructs that could demonstrate the R^2 value, as shown in Table 4. the $R^2 = 0.491$ depicts that the finding explains 49.1% of the variance in government mandate towards challenges of BIM implementation in government organization. Meanwhile, for Technology Acceptance Model of BIM with its challenges for the implementation $R^2 = 0.598$ interpret that the results of 59.8% of the variance. If the value is greater than 0.33, then it is significant [34]. As a conclusion, this can be simplified that both R^2 scores for government mandate and TAM for BIM were moderate in explanatory power.

Table 4
Coefficient of Determination (R^2)

Construct	R^2	Explanatory Power
Technology Acceptance Model	0.598	Moderate
Government Mandate	0.491	Moderate

5. Conclusions

According to this study, the government holds big responsibilities in promoting BIM in construction industry. Findings were accomplished to determine the challenges faced in implementing BIM when supports of strong government mandate urge its usage. Furthermore, Technology Acceptance Model for BIM also being studied its impact towards the challenges faced throughout user's perceptions which are government staffs in BIM. Hence, the findings of this study give a comprehensive picture for the current BIM practices in the Malaysian construction sector from the point of view for government's staffs. Due to an unknown perception as well as insufficient concept in mandating BIM towards challenges faced for the implementation of BIM. This study has

provided significant empirical evidence that well-structured government mandate and high level for the acceptance of BIM technology may minimize the challenges faced in BIM usage. Findings also shows that the technology acceptance for BIM would affected more in reducing the challenges for BIM implementation as compared to government mandate. Although current study found the gap that arise for this finding to be determine, hence in the future, it will be crucial to develop a solid roadmap for a well-constructed government mandate, particularly in the use of BIM, and to reassess the challenges that will arise after the roadmap to fill the gap from earlier arise issue. Due to this limitation, can be observed that there are some negative perceptions from government staffs towards the benefits of BIM in construction industry. Their mindset could slow down to spread the interoperability of BIM in construction industry. Hence, more effort should be made to change the acceptance and judgemental perception towards BIM implementation and looking more deeper towards its benefit of adoption.

6. Contributions

This study contributes to a greater comprehension of the diversity, complexity, and acceptance of user's experiences and BIM implementation. This study was brought its idea started from researcher's time working for contractor company. As a site engineer, witnessing difficulties based on-site actual progress with the preliminary planned of progress and detail of specification. Therefore, this study could make a major contribution to research on BIM by discerning the challenges for the implementation of BIM in perspectives of government staffs acceptance in using BIM and critical of current government mandate and policies for BIM. Achieved its accountability in implementing BIM especially in better and clear policy of BIM adoption does also contribute to smoothness of project monitoring. Indirectly, could provide an opportunity to increase the profit of construction industry sector as well as gives returning on investment (ROI) for Malaysia economy sector.

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References
[1] Zainuddin, Mohd Zaky. "Consideration of government in using BIM comprehensively (Kerajaan timbang guna model BIM secara komprehensif)." 2016.
[2] Construction Industry Development Board (CIDB) Malaysia (2020). "CIDB Technical Report Publication No. 208, Malaysia Building Information Modelling Report 2019." Malaysian Construction Industry directories Cidb.
[3] East, E. William. "An Overview of the US National building Information Model Standard (NBIMS)." *Computing in Civil Engineering (2007)* (2007): 59-66. http://dx.doi.org/10.1061/40937(261)8
[4] EBOSS 2021. "BIM in New Zealand – an industry-wide view." 2021 *EBOSS* Wellington
[5] Davis, Fred D. "Perceived usefulness, perceived ease of use, and user acceptance of information technology." *MIS quarterly* (1989): 319-340. https://doi.org/10.2307/249008
[6] Lai, Yin Ling, and Joseph Lee. "Integration of technology readiness index (TRI) into the technology acceptance model (TAM) for explaining behavior in adoption of BIM." *Asian Education Studies* 5, no. 2 (2020): 10. https://doi.org/10.20849/aes.v5i2.816
[7] Ahmad, Julfikar, Chandika Ahir, Kritika Arora, and Jasleen Kathpal. "A critical analysis of technology acceptance model (TAM) towards adopting BIM by architects in India." *ECS Transactions* 107, no. 1 (2022): 6209. https://doi.org/10.1149/10701.6209ecst
[8] Sanchís Pedregosa, Carlos, Juan Manuel Vizcarra Aparicio, and Antonio Luis Leal Rodríguez. "BIM: a technology acceptance model in Peru." *Journal of Information Technology in Construction, 25, 99-108.* (2020). https://doi.org/10.36680/j.itcon.2020.006

[9] Eadie, Robert, Mike Browne, Henry Odeyinka, Clare McKeown, and Sean McNiff. "BIM Implementation throughout the UK Construction Project Lifecycle: An Analysis." *Automation in Construction* 36 (2013): 145–51. https://doi.org/10.1016/j.autcon.2013.09.001

[10] Yang, Jyh-Bin, and Hung-Yu Chou. "Mixed Approach to Government BIM Implementation Policy: An Empirical Study of Taiwan." *Journal of Building Engineering* 20 (2018): 337–43. https://doi.org/10.1016/j.jobe.2018.08.007

[11] Shepherd, David. "Managing the Mandate: The BIM Level 2 Environment." *BIM Management Handbook*, July 25, (2019):80–93. https://doi.org/10.4324/9780429347535-6

[12] Munianday, Praveena, Rahimi A. Rahman, and Muneera Esa. "Case Study on Barriers to Building Information Modelling Implementation in Malaysia." *Journal of Facilities Management*, November 22, 2022. https://doi.org/10.1108/jfm-10-2021-0132

[13] Corrado, Riccardo, Meta Soy, and Vichera Heang. "BIM and IFC: Awareness and Self-Assessed Knowledge from the Perspective of Cambodian University Students." *Ain Shams Engineering Journal* 14, no. 2 (2023): 101851. https://doi.org/10.1016/j.asej.2022.101851

[14] Sacks, Rafael, Mark Girolami, and Ioannis Brilakis. "Building Information Modelling, Artificial Intelligence and Construction Tech." *Developments in the Built Environment* 4 (2020): 100011. https://doi.org/10.1016/j.dibe.2020.100011

[15] Shaqour, E.N. "The Role of Implementing BIM Applications in Enhancing Project Management Knowledge Areas in Egypt." *Ain Shams Engineering Journal* 13, no. 1 (2022): 101509. https://doi.org/10.1016/j.asej.2021.05.023

[16] Chen, Shuzhen, Yun Zeng, Ali Majdi, Anas A. Salameh, Tamim Alkhalifah, Fahad Alturise, and H. Elhosiny Ali. "Potential Features of Building Information Modelling for Application of Project Management Knowledge Areas as Advances Modeling Tools." *Advances in Engineering Software* 176 (2023): 103372. https://doi.org/10.1016/j.advengsoft.2022.103372

[17] Fonseca Arenas, Nathalia, and Muhammad Shafique. "Recent Progress on BIM-Based Sustainable Buildings: State of the Art Review." *Developments in the Built Environment* 15 (2023): 100176. https://doi.org/10.1016/j.dibe.2023.100176

[18] Caglayan, Semih, and Beliz Ozorhon. "Determining Building Information Modeling Effectiveness." *Automation in Construction* 151 (2023): 104861. https://doi.org/10.1016/j.autcon.2023.104861

[19] Okakpu, Anthony, Ali GhaffarianHoseini, John Tookey, Jarrod Haar, and Amirhosein Ghaffarian Hoseini. "An Optimisation Process to Motivate Effective Adoption of BIM for Refurbishment of Complex Buildings in New Zealand." *Frontiers of Architectural Research* 8, no. 4 (2019): 646–61. https://doi.org/10.1016/j.foar.2019.06.008

[20] Sampaio, Alcinia Zita, Vitor Fernandes, and Augusto Gomes. "The Use of BIM-Based Tools to Improve Collaborative Building Projects." *Procedia Computer Science* 219 (2023): 2027–34. https://doi.org/10.1016/j.procs.2023.01.504

[21] Chen, Yansheng, Xiaotong Cai, Jie Li, Weiping Zhang, and Zhonghao Liu. "The Values and Barriers of Building Information Modeling (BIM) Implementation Combination Evaluation in Smart Building Energy and Efficiency." *Energy Reports* 8 (2022): 96–111. https://doi.org/10.1016/j.egyr.2022.03.075

[22] Klein, Hans Christian, Aida Stelter, Frederike Marie Oschinsky, and Bjoern Niehaves. "A Status Quo Bias Perspective on User Resistance in Building Information Modeling Adoption – Towards a Taxonomy." *Computers in Industry* 143 (2022): 103760. https://doi.org/10.1016/j.compind.2022.103760

[23] Younus, Iqbal, Wahda Al-Hinkawi, and Sabeeh Lafta. "The Role of Historic Building Information Modeling in the Cultural Resistance of Liberated City." *Ain Shams Engineering Journal* 14, no. 10 (2023): 102191. https://doi.org/10.1016/j.asej.2023.102191

[24] Prihatono, Felix Andrian, and Tri Joko Wahyu Adi. "Building Information Modeling (BIM) Technology Acceptance Analysis Using Technology Acceptance Model (TAM)." *IPTEK Journal of Proceedings Series* 0, no. 1 (2021): 81. https://doi.org/10.12962/j23546026.y2020i1.10854

[25] Yang, Jyh-Bin, and Hung-Yu Chou. "Subjective Benefit Evaluation Model for Immature BIM-Enabled Stakeholders." *Automation in Construction* 106 (2019):102908. https://doi.org/10.1016/j.autcon.2019.102908

[26] Alizadehsalehi, Sepehr, Ahmad Hadavi, and Joseph Chuenhuei Huang. "From BIM to Extended Reality in AEC Industry." *Automation in Construction* 116 (2020): 103254. https://doi.org/10.1016/j.autcon.2020.103254

[27] Jiang, Rui, Chengke Wu, Xiang Lei, Ammar Shemery, Keith D. Hampson, and Peng Wu. "Government Efforts and Roadmaps for Building Information Modeling Implementation: Lessons from Singapore, the UK and the US." *Engineering, Construction and Architectural Management* 29, no. 2 (2021): 782–818. https://doi.org/10.1108/ecam-08-2019-0438

[28] Zhao, Yiwei, Yindong Sun, Qianqian Zhou, Caiyun Cui, and Yong Liu. "How A/E/C Professionals Accept BIM Technologies in China: A Technology Acceptance Model Perspective." *Engineering, Construction and Architectural Management*, 2022. https://doi.org/10.1108/ecam-04-2022-0308

[29] Babatunde, Solomon Olusola, Damilola Ekundayo, Adedayo Opeyemi Adekunle, and Wasiu Bello. "Comparative Analysis of Drivers to BIM Adoption among AEC Firms in Developing Countries." *Journal of Engineering, Design and Technology* 18, no. 6 (2020): 1425–47. https://doi.org/10.1108/jedt-08-2019-0217

[30] Zhou, Yijun, Yu Yang, and Jyh-Bin Yang. "Barriers to BIM Implementation Strategies in China." *Engineering, Construction and Architectural Management* 26, no. 3 (2019): 554–74. https://doi.org/10.1108/ecam-04-2018-0158

[31] Xu, Hongyu, Ruidong Chang, Na Dong, Jian Zuo, and Ronald J. Webber. "Interaction Mechanism of BIM Application Barriers in Prefabricated Construction and Driving Strategies from Stakeholders' Perspectives." *Ain Shams Engineering Journal* 14, no. 1 (2023): 101821. https://doi.org/10.1016/j.asej.2022.101821

[32] Taofeeq, Moshood D., A.Q. Adeleke, and Chia-Kuang LEE. "Government Policy as a Key Moderator to Contractors' Risk Attitudes among Malaysian Construction Companies." *Journal of Engineering, Design and Technology* 18, no. 6 (2020): 1543–69. https://doi.org/10.1108/jedt-08-2019-0192

[33] Taber, Keith S. "The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education." *Research in Science Education* 48, no. 6 (2017): 1273–96. https://doi.org/10.1007/s11165-016-9602-2

[34] Chin, Wynne W., and Peter A. Todd. "On the Use, Usefulness, and Ease of Use of Structural Equation Modeling in MIS Research: A Note of Caution." *MIS Quarterly* 19, no. 2 (1995): 237. https://doi.org/10.2307/249690

[35] Autodesk Inc. "The tipping point has arrived: Industry-wide BIM adoption is accelerating digital transformation", *SMARTMARKET REPORT BACKGROUND: Dodge Data & Analytics*. (2022).

[36] Azhar, Salman. "Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry." *Leadership and management in engineering* 11, no. 3 (2011): 241-252. https://doi.org/10.1061/(ASCE)LM.1943-5630.0000127

[37] Garavaglia, Elsa, Anna Anzani, Fabio Maroldi, and Fabio Vanerio. "Non-invasive identification of vulnerability elements in existing buildings and their visualization in the bim model for better project management: The case study of cuccagna farmhouse." *Applied Sciences* 10, no. 6 (2020): 2119. https://doi.org/10.3390/app10062119

[38] Othman, Idris, Yasser Yahya Al-Ashmori, Yani Rahmawati, YH Mugahed Amran, and Mohammed Ali Mohammed Al-Bared. "The level of building information modelling (BIM) implementation in Malaysia." *Ain Shams Engineering Journal* 12, no. 1 (2021): 455-463. https://doi.org/10.1016/j.asej.2020.04.007

[39] Al-Ashmori, Yasser Yahya, Idris Othman, Yani Rahmawati, YH Mugahed Amran, SH Abo Sabah, Aminu Darda'U. Rafindadi, and Miljan Mikić. "BIM benefits and its influence on the BIM implementation in Malaysia." *Ain Shams Engineering Journal* 11, no. 4 (2020): 1013-1019. https://doi.org/10.1016/j.asej.2020.02.002

[40] Ariffin, Erni Yusnida, Nur Emma Mustafa, and Maimunah Sapri. 2023. "Perspective towards the Perceived Benefits and Challenges on Building Information Modelling - Facility Management (BIM-FM) Integration at an Early Stage of BIM Projects". *International Journal of Real Estate Studies* 17, no. 1:70-82. https://doi.org/10.11113/intrest.v17n1.198