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Building Information Modelling (BIM) and Job Performance: An Empirical Analysis in Public Sector Project Management

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Abstract
The construction sector often faces various problems especially related to time, rising costs, project delays, waste and errors that can hinder the economic development. In order to overcome the problems, application of Building Information Modeling (BIM) in construction project is actively implemented in improving work efficiency and performance among industry practitioners especially in developed countries. Nonetheless, the ability of BIM towards highlighting its productivity and performance cannot be seen in the construction industry in Malaysia and faces several challenges that affected the job performance. Therefore, this study examines the relationship between various critical success factors and job performance among professionals who have used BIM applications in construction of project management. The stratified sampling method with the population of 345 professionals who practice the use of BIM applications in construction project management are applied in the study. The total population was collected from a preliminary study of the number of pre-contract stages in PWDs that had implemented BIM. Two models were constructed to be analyzed for multiple regression analysis. Findings revealed that four factors (collaborative synergy, ICT utilization, commitment and knowledge, culture orientation) have a significant positive relationship with job performance. While, external factor (collaborative synergy) has the most significant influence on job performance among those involved with the use of BIM applications. The findings of the study also have highlighted two major weaknesses that limit the effectiveness of the use of BIM applications are related to digital skills among staff and lack of support from management. These elements of weaknesses are seen to have affected the work performance in Malaysian construction sector. In the future research, to get more comprehensive view it is suggested several other factors especially external factors such as government policy and legislation, BIM guidelines and standards are to be considered in the study.
Keywords: Building Information Modeling, Construction, Job Performance, Collaborative Synergy, ICT Utilization, Commitment and Knowledge, Culture Orientation

Introduction

The construction sector is one of the main contributors to a country's economic development. The sector has a role to drive development and be able to stimulate the growth momentum of key sectors, namely agriculture, manufacturing, services and mining. In Malaysia, the importance of the sector can be seen in terms of contribution to Gross Domestic Product (GDP), employment, capital formation, and socio-economic development (Khan et al., 2014). Although the sector's contribution to GDP recorded negative growth in 2020 (-19.4%) and 2021 (-0.8%) as a result of the Covid-19 outbreak, its contribution is projected to increase to 11.5% in 2022 (Ministry of Finance, 2022). In order to drive economic development, the construction sector often faces various problems especially related to time, rising costs, project delays, waste and errors (Samimpay & Saghatforoush 2020) rework, delays, and low quality (Mohd Nawi et al., 2009) and productivity (Nawi et al., 2009; Gardezi, et al., 2014).

In line with the development of technology in the construction sector, in 2007 the Public Works Department (PWD) which is the largest technical agency in Malaysia has introduced the application of Building Information Modeling (BIM) in construction project management. BIM is a system that contains a graphical representation of building structural information that is useful for the entire project life cycle from the design phase to the construction, operation and demolition phases (Eadie et. al., 2013). It is a virtual process that combines all aspects, disciplines and systems that allows stakeholders including owners, architects, engineers, contractors, subcontractors and supplies to collaborate and integrate with more precise systems towards higher efficiency and harmony (Azhar, 2011). The National BIM Steering Committee defines BIM as "... a modeling technology with a set of tools and related processes to produce, communicate, analyze and use digital information throughout the construction life cycle" (CIDB, 2015).

In general, the role of BIM in the construction industry is divided into four stages, namely the planning stage, design stage, construction stage, and operational stage (Fadeyi, 2017). There are three features of BIM that include buildability, investigation, and quantity release (Diaz, 2016). In addition, BIM can be considered as a useful mechanism that can be used for the purposes of visualization, generation and fabrication of store drawings, code review for authorities, cost estimation, construction sequencing, conflict, interface and collision detection, forensic analysis and facilities management (Azhar, 2011). BIM is also used to increase lifetime value for customers, improve design quality, design health and safety in the construction process, improve communication as well as cost and time savings (Eadie et al., 2013). In conclusion, BIM is a technology that has been introduced to increase productivity and performance of construction projects (Jamal et al., 2019).

BIM is also can be seen as a technology that is capable of enhancing capabilities in quality aspects and will lead to improve quality of work, products, and buildability (Memon et al., 2014; Gardezi et al., 2014; Samimpay & Saghatforoush, 2020; Fadeyi, 2007). Since the time factor is one of the most frequently associated issues in the construction industry, BIM is seen as a mechanism that can help in reducing working hours as well as increase efficiency (Memon et al., 2014; Samimpay & Saghatforoush, 2020; Nawi et al., 2009). It is capable of helping organizations to comply with the quantity of work that needs to be completed as targeted (Gardezi et al., 2014). The use of BIM applications coordinates several problems such as delays, rework, miscommunication, and other related issues that affect project success (Ismail et al., 2017). The features provided by BIM are equivalent to the current construction industry needs in improving efficiency, effectiveness, productivity, project quality, and reducing project cost and delivery time (Ghavamimoghaddam & Hemmati, 2017).

In developed countries, BIM is actively implemented and have become a key approach in improving work efficiency and performance among industry practitioners (Zainon et al., 2016; Wong et al., 2014). However, the ability of BIM towards highlighting its productivity and performance cannot be seen in the construction industry in Malaysia (Kong et al., 2020; Othman et al., 2020; Gardezi et al., 2014). The implementation of BIM in Malaysia faces several issues and challenges that include aspects of human capital, technology, policies and processes and they need to be addressed by all parties involved (Jamal et al., 2019). According to Othman et al (2020) among the constraints encountered in the implementation of BIM applications are low level of knowledge, financial constraints, lack of awareness, difficulty in adapting new technologies, absence of clear guidelines from the organization, policy weaknesses, lack of allocation and financial incentives, lack of investment particularly in the provision of hardware and software. In addition, there are several issues among professionals involved in this technology including willingness to change, lack of digital skills, lack of training and awareness programs, and lack of enforcement by local authorities are some of the issues in the implementation of BIM in Malaysia (Jamal et al., 2019).

Most of the previous studies on BIM focuses more on the analysis of critical success factors in the implementation of BIM (Amuda-Yusof, 2018; Gong et al., 2021) Barriers and Challenges (Yasir & Ismail, 2019) and adoption (Rogers et al., 2015). Although the ability of BIM to drive efficiency in the construction sector has been proven in developed countries yet the implementation of BIM in Malaysia is considered very far from the target by the government (Gardezi et al., 2014; Kong et al., 2020).

- Therefore, the main objective of this paper is to examines a direct analysis of the relationships between various critical success factors and job performance among professionals who have used BIM applications in construction of project management.

Literature Review and Hypotheses

Previous studies have highlighted that there are various factors influence the effectiveness of BIM implementation. The success factors in BIM implementation can be divided into two which are internal aspects involving software and hardware, management, and leadership while the external aspects are collaborative synergy factors. Liu, et al (2010) linked several internal factors such as management support, financial aspects, staff readiness, training, and external factors such as competitive strength, influence of various stakeholders, and competitors are factors that have significant influence on the effectiveness of BIM application implementation. Amuda-Yusof (2018) analyzed on five factors, namely commitment and knowledge, technology adaptation, organizational support, culture orientation and collaborative synergy which are seen as critical success in influencing the implementation of BIM applications. Critical success factor in the implementation of BIM is clearly related to the theory of Resource Based View (RBV) which relates owned resources as important factor that can determine the level of comparative advantage and firm performance. The role of management is important in ensuring that the strategic resources owned can be fully utilized (Rumelt, 1984) to ensure the effectiveness of BIM implementation.

Commitment and Knowledge

One of the success factors in implementation of BIM is the willingness of participants to share knowledge (Won et al., 2013). Popov et al (2010) asserts that BIM implementation facilitates the creation, communication and sharing of knowledge throughout a building's entire life-cycle, while Kymmel (2008) opines that early collaboration among project participants significantly influences BIM implementation. According to Crooty (2012) poor standard of knowledge is the main issue of poor performance in the construction industry. Therefore, the improvement of information quality between stakeholders should be of the highest possible standard to ensure the effective performance of the construction industry. The importance of commitment and knowledge in improving the job performance aspect are important criteria that need to be improved in this industry (Sunil et al., 2017). Apart from improving the aspect of competency towards increasing the understanding of this technology, the knowledge aspect is important as BIM is a complicated system that involves generic tools, techniques, and features that need to be handled and managed and leads to improvement of overall performance. Knowledge aspect regarding this technology is very crucial where the level of knowledge among the respondents regarding BIM concepts is very poor and could not improve their skills (Abd Hamid et al., 2018). Thus, there is a need to improve the knowledge aspect among the professionals as BIM can help interior design for schematic design, calculating quantities, and interior documentation. Many empirical studies found a positive impact of knowledge and competency (Babatunde et al. 2020; Roslan et al. 2019; Saka & Chan, 2020). Given the impact of commitment and knowledge on job performance, a hypothesis can be stated as follows:

H1: Commitment and knowledge is positively related to the job performance.

Digital Skill

It is essential that people working in the industry enhance their *digital skills*. Digitalisation skills are one of the major challenges that the construction industry has to overcome in order to improve the human capital in the sector. Digital skills are defined as a range of abilities in using digital devices, communication applications and also network in accessing and managing information. The application of these skills was also mentioned by UNESCO (2018) as it will bring people to create and share digital content, communicate, collaborate, and solve problems. In the aspect of BIM, adequate digital skills may improve the BIM implementation in the construction project where lack of training and appropriate skills may hinder the advancement of BIM (Gu & London, 2010). Many empirical studies have proven that digital skills by employees are crucial for job performance such as delivery aspect (Mahamadu et al., 2019), quality of work deliver and on technical aspect (Zainon et al., 2016), and. One of the five topmost factors of ERP implementation success is effective training in improving the aspect of skills where it was highlighted as being able to contribute to the success of a project by completion within the allocated cost, time, and expected quality and performance. Therefore, there is a need for consultants and professionals equipped with the skills and expertise to ensure the success of BIM implementation. If the industry players were equipped with the skills and expertise, BIM can yield a better job performance in systemizing the project coordination aspect, a more sustainable output, and reducing the time delivery process for preparing BQ, cost estimation, cost update, and tendering process. This leads to the following hypothesis

H2: Digital skill is positively related to the job performance.

Culture Orientation

Culture is a complex whole, customs, and other abilities, as well as habits acquired by humans as those which contain science, belief, art, morality, law, members of society (Ranjabar, 2006). Culture orientation is one of the critical success factors in implementing BIM (Amuda-Yusof, 2017; Tai et al., 2020; Chen et al., 2018) and job performance (Javeria et al., 2015). The culture orientation aspect provides a basis in explaining the most significant factors that industry stakeholders should focus their attention on for a successful implementation of BIM. Amuda-Yusof (2017); Chen et al (2018) revealed that the culture in a BIM project can be perceived in terms of the coordination's and integrations within the project delivery process performed by the people and the interactions between themselves through patterns of attitudes, values, beliefs, and behaviours shared. Even though culture is a recurring area in the extant BIM literature, existing BIM-based literature reviews do not provide in-depth discussions to reveal the significance of culture in BIM context (Babatunde et al., 2020; Eadie et al., 2013; Abdul Ghafar & Ibrahim, 2018; Olugboyega et al., 2020). However, some studies describe professional and industry culture as significant in BIM adoption (Ahuja et al., 2018). Numerous attempts in the BIM research explain culture as a critical factor affecting and being affected by BIM. Furthermore, culture also be considered as source of success and failure in BIM implementation. Therefore, the hypothesis can be made as;

H3: Culture orientation is positively related to the job performance.

Management Support

Challenges in innovation diffusion in the construction industry as a complex social system are derived not only from the distinct organizational and structural characteristics of construction firms (Shibeika & Harty, 2015) but also from governmental supports. To reduce the resistance from people to change, support from top management is very crucial (Giligan & Kunz, 2007) because during the migration to a new technology, the role of top management is very important to formulate the strategies and direction of the organisation in adopting new technology (Rogers et al., 2015). Julian et al (2015) stated that organisation factor describes the characteristics and resources of the organisation which includes networking structures between employees, intra-firm communication processes, firm size, and the amount of slack resources. Organisation factor can be described by various features such as top management support, organisation structure, organisation's readiness, perceived risks, and training. In contrast, Juliane et al (2016) stated that organisational factor is important to be considered as one of the factors that affect the BIM adoption behaviour of an organisation as there is a large amount of Architectural-Engineering-Construction (AEC) industry available. Top management support is important in adopting new technology such as providing training, practice and skilled person to increase perceptions of the technology is easier to use. It is stated that top management support will increase persons' support of a new technology usefulness. Many scholars have discussed and highlighted the aspect of management support and its relationship with job performance (Purvis et al., 2001; Amuda-Yusof, 2018; Chen et al., 2018). In respect to BIM, management support is seen as a key dynamic capacity for the design companies towards identifying the changes that happened in the competitive environment and to react in the most efficient and effective way (Manzanares et al., 2020; Roslan et al., 2019). This suggests the hypothesis

H4: Management support is positively related to the job performance.

ICT Utilization

BIM technology can enhance the performance of work aspect including more efficient quality of work on time and cost aspect in delivering of the requirements and needs from the stakeholders and other construction players. The implications of digitalisation and automation, by utilising various technologies and processes, such as the Internet of Things (IoT), cloud computing and artificial intelligence (AI) have been the main concern of experts in the manufacturing (Lu, 2017) and Architecture, Engineering, Construction, and Operations industries in terms of Industry 4.0 principles. BIM technology is considered as a new platform for delivering construction project (He et al. 2017). ICT utilization is defined by the Vision 2040 National Planning Authority Manual as the capacity of the building in the aspect of human resources application development regarding access to information and knowledge. The ICT influence business skills and appear to be a force towards changes in improving the concept of life (Mohamed, 2003). The ICT aspect is including computers, the internet, and other delivery systems like radio, television, and projector (Fu, 2013). In the BIM aspect, the utilization of ICT including the use of computers towards various processes as well as improving the quality of works to enable the construction process from the design stage to the construction stage which allows immediate access to the project among team members and will improve the information flows (Svalestuen et al., 2017). The use of ICT in construction projects helps to manage projects in productive and effective ways (Yuan et al. 2019 and Abd Hamid et al.,2018). ICT has introduced BIM as a tool to manage construction projects effectively (Sundaraj, 2006). It was created as a result of integrating ICT in the construction industry processes (Roslan et al., 2019; Tai et al., 2020). This leads to the hypothesis of;

H5: ICT utilization is positively related to the job performance.

Collaborative Synergy

In today's global economy, companies are trying to re-invent their businesses and maintain their competitive advantage through collaboration. Collaborative practices, such as supply chains, value chains, extended enterprises, virtual enterprises and clusters, are becoming commonplace. Through collaboration, companies aim to share resources, share and exchange information, reduce risks, reduce cost, reduce time-to-market, reduce delivery-time, increase market-share, increase asset-utilisation, increase skills and knowledge, and increase customer services (Lewis, 1990; Kanter, 1994; Huxham, 1996; Parker, 2000; McLaren et al., 2002; Sahay, 2003). Effective undertaking of BIM as a systemic innovation requires tighter collaboration among multiple stakeholders and supply chain partners and entails a culture change. However, obtaining a high degree of collaboration is difficult given the nature of construction projects with diverse supply chains and stakeholders involved in a project. Several scholars also had discussed and highlighted the collaborative synergy and its relationship with job performance. This collaborative aspect is an external process of collaborative working that includes informal networks, alliances, or partnering to full integration of fixed length of time also in forming permanent arrangement (Eadie et al., 2013). The collaborative synergy includes four key resources which are people, process, technology, and data (Amuda-Yusof, 2018, Liu et al., 2017; Ibrahim et al., 2019). Amuda-Yusof (2018) highlighted that the collaborative synergy in BIM is in respect to the process between two or more parties in achieving any aim of the organizations and can give maximum benefit in using

BIM. The understanding in the collaboration process can improve the overall performance including the quality, quantity, and time aspect that may lead to promote expected collaborative outcomes by reducing the times of drafting and related works, improving the design quality, improving the design communication, and information quality aspect. Thus, the relationship between collaborative synergy and job performance can be stated as;
H6: Collaborative synergy is positively related to the job performance.

Research Method

Sample

In this study, population involved was a total of 345 professionals who practice the use of BIM applications in construction project management. The total population was collected from a preliminary study of the number of pre-contract stages in PWDs that had implemented BIM. The study population was divided into three professional groups (engineers, architects and quantity surveyors). Based on the total population, Krejcie and Morgan (1970) suggested that the appropriate sample size was 182 respondents. Stratified sampling method was used for sampling purposes. Based on the list obtained, questionnaires were emailed to those involved.
A total of 242 respondents (70.14%) out of 345 targeted respondents, responded to the questionnaire emailed to them. That number exceeds the sample recommended by Krejcie and Morgan (1970). Details of population numbers and sampling are shown in Table I.

Table I
Population and Sample of Research

(Professional)	Population (N)	Sample (n) (recommended)*	Actual sample (n)
Engineer	119	63	85
Quantity surveyor (QS)	60	32	45
Architect	166	87	112
Total	**345**	**182**	**242**

*Notes: Based on the Krejcie and Morgan (1970)
Source: Based on the sample survey

Before the data analysis was performed, several statistical tests were conducted for the purpose of determining the suitability of the hypothesis testing method. Table II and Table III show that Cronbach's α values for all variables are above 0.7 which explains that they are reliable for analysis in the model. Besides that, factor loading explains the correlation coefficient for the variable (items). The higher the loading factor value, indicating the stronger the relationship that exists between variable on that particular factor. Pallant (2007) explained where factor loadings indicate how much a factor explains a variable. Overall, the loading factor for each item is high, which explains that the factor strongly influences the variable.

Table II
BIM Implementation Influence Factors

	Construct/measure	Cronbach's α	Mean	SD	Factor Loading
	Commitment and Knowledge	*0.857*			
CK1	The current work process is analyzed first to suit BIM		5.893	1.080	0.626
CK2	Requires the involvement of all stakeholders		6.050	1.137	0.544
CK3	Give emphasis on aspects of education and training among staff		6.322	0.974	0.558
CK4	Management needs to provide clear information on the use and importance of BIM applications		6.393	0.849	0.625
CK5	Organizations should constantly strive to improve BIM skills among staff		6.496	0.790	0.612
CK6	The organization is able to transfer the right knowledge to the staff		6.029	1.052	0.578
	Digital Skill	*0.872*			
DS1	Organizations need to ensure appropriate software for the widespread implementation of BIM applications		6.446	0.794	0.608
DS2	Organizations have a high ability to use applications		5.554	1.332	0.637
DS3	There is a high awareness among end-users on the use of BIM applications in work processes		5.227	1.467	0.579
DS4	Have BIM skills among staff (interpersonal skills)		5.657	1.257	0.691
DS5	Organizational structuring has been made towards the use of BIM in work processes		5.306	1.369	0.662
DS6	BIM applications can meet the needs of users		5.765	1.122	0.810
	Culture Orientation	*0.827*			
CO1	The digital infrastructure in the organization is capable of supporting the implementation of BIM		5.558	1.316	0.683
CO2	Organizations have positive management commitment and resources to deal with change		5.459	1.259	0.727
CO3	Have confidence that BIM can be fully implemented in the organization		5.533	1.223	0.728
CO4	The use of BIM applications can provide a large return on investment		5.707	1.361	0,808

	Management Support	*0.912*			
MS1	Get strong support from management		5.674	1.264	0.745
MS2	Management places great emphasis on the competent development of staff		5.607	1.281	0.770
MS3	The organization has a clear plan for the implementation of BIM		5.471	1.250	0.775
MS4	Often hold in house training to improve staff efficiency		5.496	1.394	0.664
MS5	There is a substantial financial allocation to ensure the effectiveness of BIM implementation		5.831	1.035	0.797
	ICT Utilization	*0.816*			
IU1	The use of BIM applications can save operating costs		5.475	1.400	0.612
IU2	BIM is able to build collaborations with various stakeholders		5.897	1.007	0.769
IU3	BIM is able to complete the work process more efficiently		5.996	0.975	0.715
IU4	The use of BIM can reduce the risk of project management failure		5.661	1.243	0.728
IU5	The organization has an adequate ICT support system		4.620	1.701	0.678
	Collaborative Synergy	*0.795*			
CS1	Improving the efficiency of the use of BIM is highly dependent on outsourcing		4.934	1.433	0.471
CS2	The output of the organization will determine their ability to use BIM		5.612	1.069	0.781
CS3	Ensure that all parties involved can benefit to the maximum		5.851	0.987	0.801
CS4	Establish clearer communication with all stakeholders		5.855	1.006	0.777

Notes: All factor loadings significant $p < 0.01$
Source: Based on a sample survey

Table III
Job Performance Criteria

	Construct	**Cronbach's α**	**Mean**	**SD**	**Factor Loading**
	Job Performance	0.954	5.4670	0.941	
	Job Quality	0.942			
JP1	Tasks are performed attentively and correctly		5.798	0.949	0.734

JP2	Tasks are completed according to specifications and standards		5.843	0.934	0.775
JP3	The output produced meets the set criteria and standards		5.731	1.005	0.868
JP4	Quality inspection is performed before the output is finalized		5.835	0.945	0.803
JP5	The output produced always meets the needs of the customer		5.682	1.011	0.852
	Job Quantity	0.931			
JP6	The output unit is in line with the number of workers		5.083	1.449	0.751
JP7	The output unit meets the expectations of the organization		5.343	1.206	0.793
JP8	The amount of output is set according to my skills and abilities		5.351	1.217	0.778
JP9	The targeted output quantity is always met		5.438	1.077	0.759
	Job Time	0.919			
JP10	Tasks are usually completed on schedule		5.347	1.331	0.864
JP11	Tasks are completed within a reasonable time		5.070	1.627	0.807
JP12	The production of output is done on time		5.269	1.300	0.844
JP13	Employees achieve time-related organizational goals		5.244	1.289	0.817

Notes: All factor loadings significant p < 0.010.759
Source: Based on a sample survey

Table IV shows the results of the Kolmogorov-Smirnov test which showed that the value was above 0.5 (p> 0.05). This explains that the study data is parametric, which shows that the data is a normal distribution and it is suitable for analysis through multiple regression methods.

Table IV
One Sample Kolmogorov-Smirnov

Construct	Kolmogorov-Smirnov Z	Asymp. Sig (2 tailed)
Commitment and knowledge	1.103	0.172
Digital skills	1.195	0.115
Culture orientation	1.063	0.209
Management support	0.925	0.359
ICT utilization	0.900	0.393
Collaborative synergy	1.293	0.071

Source: Based on a sample survey

Measurement

The dependent variable for this study is job performance. The performance measurement is measured based on Likert scale (seven-point scale) from 1= "really not agree" to 7= "really agree". Na-Nan et al (2018) highlighted that there are 13 criteria in measuring job performance where it had been divided into three criteria which are job quality (Chen et al., 1997; Fynes & Voss, 2001; Gilmore, 1985; Liu & Xu, 2006), job quantity (Cheng & Kalleberg, 1996) and job time (Na-Nan & Chalermthanakij, 2012). The items under job quality include tasks performed attentively and correctly, tasks completed as per specifications and standards, materials and tools meet the set criteria and standards, quality inspection conducted prior to the delivery of goods or services and products or services meet the expectations of customers. Besides that, the items under job quantity involve units of output are in sync with number of employees, output unit meet organizational expectations, output unit under the responsibility correspond to the skills and ability and quantity assignment is always fulfilled. Factors under job time include tasks are normally completed on schedule, tasks carried out within a reasonable amount of time, delivery of goods or services is conducted in a timely fashion and workers achieve time-related organizational goals.

The study involved six independent variables and was categorized into two groups according to internal and external factors. Internal factors involved five constructs: commitment and knowledge, digital skill, culture orientation, management support and ICT utilization. While the external factor only involves one construct, namely collaborative synergy. All these independent variables refer to the CSF of the study presented by (Amuda-Yusof, 2017). There are six items used to measure the construct of commitment and knowledge were analyzed to suit BIM, involvement of all the stakeholders, education and training aspect, clear information on the use of BIM, strive for the BIM staff's skills and the last one is the ability of organization to transfer the right knowledge to the staff. For the digital skill construct, it is measured based on six items, namely organizations need to ensure appropriate software for the widespread implementation of BIM applications, organizations have a high ability to use applications, there is a high awareness among end-users on the use of BIM applications in work processes, interpersonal skills, organizational structuring has been made towards the use of BIM in work processes and BIM applications can meet the needs of users. The culture orientation construct is measured based on four items related to the capability of digital infrastructure in supporting the implementation of BIM, positive management by organization to deal with change, BIM confidence to be implemented in the organization and BIM can provide a large return on investment. The measurement of management support construct is made based on five items, namely strong support from the management, organization has a clear great emphasis from management on the development of staff, organization has a clear plan for the implementation of, conduction of in-house training, and allocation of the financial allocation to ensure the effectiveness of BIM. The ICT utilization construct is measured involving five items, namely the use of BIM application can save operating cost, BIM is able to build collaboration with stakeholders, BIM is able to complete the work process more efficiently, BIM is able to reduce the risk of project management failure, and organization have adequate ICT support systems. For the external factors that is collaborative synergy measurement based on four items; improving the efficiency of the use of BIM is highly dependent on outsourcing, the output of the organization will determine their ability of BIM usage, ensure that all parties involved can benefit to the maximum and establish clearer communication with all stakeholders. All of the independent variables are measured based on Likert scale (seven-point scale) from 1= "really not agree" to 7= "really agree."

Result

Descriptive analysis involving mean values, standard deviation correlation between variables is shown in Table V. The mean values for all variables are high above the moderate level. This explains the tendency of respondents to give assessments towards strongly agreeing for all study constructs. For standard deviation, there were five variables that showed small standard deviation (<1). Only two items have a value greater than 1. The correlation statistics show that the relationship between the variables is moderate with a range between 0.476 to 0.769. Referring to Table VI, the tolerance value for all variables is more than 0.1 and Variance of inflation (VIF) less than 10. This explains that there is no problem of multicollinearity in the study data and it is suitable to be analyzed using multiple regression method.

Table V

Descriptive Statistics and Correlation.

	Variables	Mean	SD	1	2	3	4	5	6
1	Commitment and Knowledge	6.1908	0.7054						
2	Digital Skills	5.6559	0.9276	0.598***					
3	Culture Orientation	5.5647	1.0090	0.570***	0.763***				
4	Management Support	5.5414	1.0444	0.476***	0.682***	0.775***			
5	ICT Utilization	5.5340	0.9504	0.601***	0.663***	0.816***	0.712***		
6	Collaborative Synergy	5.5636	0.8572	0.540***	0.686***	0.748***	0.724***	0.769***	
7	Job Performance	5.4695	0.9408	**0.554*** **	**0.600*** **	**0.722*** **	**0.645*** **	**0.736*** **	**0.731*** **

Notes: N = 242; ***p < .01

Source: Based on a sample survey

The results of multiple regression analysis to explain the five study hypotheses are shown in Table VI. Based on the table, Model 1 shows that the analysis is based on five internal factors (commitment and knowledge, digital skill, culture orientation, management support and ICT utilization). While Model 2 involves external factors (Collaborative Synergy) to estimate the study model. The results of the multiple regression analysis of Model 1 showed that the value of R^2 involving only internal factors was 0.609. The results of multiple regression analysis involving all external and internal factors are explained in Model 2. R^2 value ($\Delta R^2 = 0.031$, $p < 0.01$) and total variance explain 64.0 percent of job performance among professionals involved in BIM implementation. As the objective of the study that evaluates the relationship of factors that influence the success of BIM implementation on job performance clearly shows that there are four factors that have a positive and significant relationship with job performance while two factors show no relationship with job performance. Referring to the findings in Model 2, it is clear that commitment and knowledge have a significant positive relationship with job performance ($\beta = 0.112$, $p < 0.05$), accordingly the study confirms H1.

The analysis of the study in Model 2 also revealed that digital skills did not have a significant relationship with job performance ($\beta = 0.033$, n.s) therefore, the study could not confirm H2.

The results of the analysis in the same table also explained that the culture orientation variable has a significant positive influence on job performance (β = 0.162, $p < 0.1$). However, the influence of these variables on job performance is relatively weak. Based on those values the study confirms H3. Table V also empirically reveals that management support variables do not affect job performance among the professionals involved. Accordingly, the study was unable to confirm H4. Analysis on the relationship of ICT utilization variables with job performance clearly shows that there is a significant positive relationship between the two variables (β = 0.277, $p < 0.01$), therefore the study supports H5. The relationship between collaborative synergy factor with job performance among professionals who practice BIM in project management also shows empirically there is a significant positive relationship (β = 0.309, $p < 0.01$), therefore the study can confirm H6.

Table VI
Result of the Multiple Regression Analysis

Construct	**Tolerance**	**VIF**	**Model 1** Engineer (n = 85)	Architect (n = 112)	QS (n = 45)	Overall (n = 242)	**Model 2** Engineer (n = 85)	Architect (n = 112)	QS (n = 45)	Overall (n = 242)
BIM success factors										
Commitment and knowledge	0.570	1.753	-0.041	0.103	0.202*	0.125**	-0.050	0.107	0.185	0.112**
Digital skill	0.353	2.830	0.125	0.126	0.087	0.019	0.098	0.046	-0.132	-0.033
Culture orientation	0.214	4.664	0.486***	-0.140	0.488***	0.192**	0.440***	-0.145	0.480***	0.162*
Management support	0.340	2.937	-0.235*	0.377***	0.076	0.149**	-0.307**	0.294***	0.038	0.074
ICT utilization	0.259	3.855	0.477***	0.428***	0.224	0.394***	0.421***	0.204*	0.162	0.277***
Collaborative synergy	0.321	3.115					0.225*	0.445***	0.173	0.309***
R^2			0.644	0.632	0.632	0.609	0.660	0.703	0.641	0.640
Adjusted R^2			0.622	0.615	0.585	0.601	0.634	0.686	0.584	0.631
R^2 Change			0.644	0.632	0.632	0.609	0.016	0.071	0.009	0.031
Statistics F			28.636***	36.402***	13.389***	73.623***	25.256***	41.499***	11.298***	69.650***

Source: Based on the sample survey (2021)
Significant at: p < .10; ** p < .05; *** p < .0.01

Discussion and Conclusion

This study aims to analyze the relationship between various critical success factors of BIM implementation and job performance. Past studies in developed countries have shown that BIM has a significant positive effect on project productivity and performance (Zainon et al., 2016; Wong et al., 2014). While in Malaysia the effectiveness of the application in the construction sector is still at a less encouraging level (Kong et al., 2020). This is due to several constraints including in terms of human capital, technology, policies and processes (Jamal et al., 2018), level of knowledge and awareness, financial issues, difficulty in adapting new technologies, lack of investment (Othman et al., 2020), poor rule enforcement, willingness to change, lack of training, digital skills issues (Jamal et al., 2018).

Multiple regression analysis on 242 study samples consisting of professionals who practice BIM applications in project management was conducted to clarify some research hypotheses.

The findings of the study found that four factors (collaborative synergy, ICT utilization, commitment and knowledge, culture orientation) have a significant positive relationship with job performance. The findings show that external factors (collaborative synergy) have the most significant influence on job performance among those involved with the use of BIM applications. This explains the external elements such as outsourcing especially in terms of expertise and finance, direct involvement of various stakeholders from outside the organization and clear communication with all parties is very important to ensure the effectiveness of BIM application in the management of a construction project. The same level of importance is explained by the ICT utilization factor on job performance in the implementation of BIM applications. The use of such technology can not only save operating costs and be able to complete projects efficiently and reduce project failures, but also can form a network of cooperation efficiently and effectively with various stakeholders in a construction project. The effective use of BIM also demands a high level of commitment and knowledge, especially among the staff involved. They should clearly understand each work process related to project management involving BIM procedures. Management also needs to improve staff skills through education and training, provide clear information on the advantages of using BIM and ensure that there is always a transfer of knowledge according to technological changes. In terms of culture orientation, organizations not only need to ensure that there is the latest digital infrastructure but also have high resources and commitment to address the technological changes that occur. In addition, all those involved must have positive confidence in the ability of BIM applications to be fully implemented and able to provide a profitable return on investment.

The findings of the study also revealed two major weaknesses that limit the effectiveness of the use of BIM applications are related to digital skills among staff and lack of support from management. Weaknesses in both of these elements are seen to have affected the work performance of those involved. Basic ICT skills among those involved are required to facilitate the transfer of BIM application technology in the work process. The organization also needs to make a correct and clear task structuring to ensure the appropriate software for the implementation of BIM applications widely and effectively. The role of management is very important in making clear plans to ensure the effectiveness of BIM implementation. The available resources need to be optimized, the level of awareness and confidence in the importance of BIM applications in project management needs to be enhanced and financial allocation for the investment of the application. The importance of internal resources and their relationship to performance are consistent with what is explained by Resource Based View (RBV) theory. Staff skills in the use of BIM technology need to be strengthened through various trainings. This relationship between training and performance can be linked to Human Capital Theory (Fernandez et al., 1999). Investment in human capital will have a significant positive impact on business productivity and profitability (Bruwer & Haydam, 1996).

Limitation and Future Research

The scope of use of BIM applications in project management involves all stages of construction in the project lifecycle starting from the design phase to the operation phase. However, in Malaysia, the use of the application is still not widespread and most are used in the early stages. The study sample involves professionals in PWD who manage projects at the pre contract stage which is carried out through conventional methods and does not involve the contractor. The study also involved only six CSFs that were relevant to the implementation of BIM applications. Based on multiple regression analysis, statistical tests show that all these factors explain 64.0% on job performance. To get a more comprehensive picture, several other factors especially external factors such as government policy and legislation (Saka et al., 2019; Olawumi et al., 2018; Liu et al., 2015) and BIM guidelines and standards (Tan et al., 2019; Eadie et al., 2014; Rogers et al., 2015) need to be taken into account.

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