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BIM'S CONTRIBUTION AS A SUSTAINABLE CONSTRUCTION ACCELERATOR

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ABSTRACT

Building Information Modeling (BIM) is a technological tool used in the sustainable construction process, beginning with the planning phase and continuing through the construction and post-construction phases. BIM has excellent capabilities and is being adopted by construction service providers in the process of implementing sustainable construction. However, many barriers remain in the adoption process, particularly with regard to the intention to use it. The purpose of this study was to determine the intention to implement BIM based on the variables of benefits and barriers. In order to parse the phenomena that occur in research, this study employed a quantitative method. Survey data in the form of a questionnaire were collected from the Special Region of Yogyakarta using a purposive sampling method for this study. Questionnaires were distributed via Google Form to respondents from the construction sector (Civil & Architectural Engineering) and BIM application users (students, workers). The findings of this study have provided an overview of the challenges and benefits of implementing BIM in sustainable construction. The barriers presented are financial, technological, and policy barriers, depending on the company's classification, while the benefits presented are environmental benefits and innovation.

Keywords: BIM; Barriers; Benefits; Sustainable construction

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1. INTRODUCTION

Construction industry plays an important role in economic development in a country, due to its role in infrastructure development that facilitates investment activities (James & Matipa, 2004), increasing economic growth and GDP (Alaloul et al., 2021; Musarat et al., 2021; Nguyen, 2020; Sui Pheng & Shing Hou, n.d.), creating capital formation(Sui Pheng & Shing Hou, n.d.), and making job opportunities (Wibowo, 2003). However, apart from the important role, the construction industry also has various challenges and negative impacts, one of which is a high-risk sector (Guerra & Leite, 2021) and generates high environmental impact (largest CO2 emission) (Ramya & Ramadasan, 2016). These difficulties and negative consequences prompted initiatives to make the construction industry more environmentally friendly. As a result, the concept of sustainable construction was launched in 1994 (Hill & Bowen, 2010) which began with the concept of sustainable development as stated in the UN Conference on Environment and Development: Agenda 21 in 1992 (*UN Conference on Environment and Development: AGENDA 21*, 1992). Sustainable construction is an application of sustainable development to the construction industry (Baloi, 2003).

The sustainable construction dimension encompasses all phases of the architecture-engineering-construction (AEC) industry, from upstream to downstream. The phases of the construction process begin with planning (pre-construction), and continue through development (construction phase) and construction operation (post-construction). This process necessitates the use of more efficient and responsible resources, ensuring that the construction process has a low environmental impact and promotes economic equity (Plessis, 2006). The era of sustainable construction will also inffluence the choices and proactive actions of construction service actors to increase efficiency throughout the construction process, such as energy conservation, efficient use of water and other resources, and proper waste minimization (Thomas E. Glavinich, D.E., 2008). To handle this complex process, ecosystem support and technology are required. Building Information Modeling (BIM) is one technology that can aid in this process. BIM was created with the goal of assisting in the effective and efficient implementation of the construction process throughout all phases (Aryani et al., 2014).

The contribution of BIM to the concept of sustainable construction has benefited its implementation. According to a case study conducted in China, behavior intention, behavior attitude, and actual behavior of BIM users and construction project owners in implementing BIM had a significant effect on the implementation of sustainable construction (Zhang et al., 2020). Findings from other case studies also revealed that the use of BIM-based applications has an effect on reducing energy consumption, thermal discomfort, CO2 emissions, and construction costs (Mytafides et al., 2017),(Migilinskas et al., 2016). Aside from the positive contribution to BIM application, research with case studies in Indonesia found that there were implementation barriers such as technical and capability barriers (low ability to operate BIM and flexibility), infrastructure barriers (limited hardware to support BIM-based software operations), management barriers (high license fees and difficulties in data management), and collaboration barriers (limited collaboration and its supporting components) (Primasetra et al., 2022).

The benefits and challenges of implementing BIM described in the background are the reason for this research. The study will investigate how the benefits and barriers influence the intention to implement BIM. The study's measurable goal is to identify and quantify a number of variables related to the benefits and barriers to implementing BIM in sustainable construction in Indonesia (particularly in the Special Region of Yogyakarta - DIY) and their influence on implementation intentions. Reasons for choosing DIY province as a research sampling location is based on data and facts sourced from the Central Bureau of Statistics (BPS) and the BIM Committee of Ministry of Public Works and Public Housing (BIM PUPR Committee). DIY province has a convincing statistic on the employment rate and the percentage of experts working in the construction industry sector, which is 6.81 at the employment rate and has a percentage of experts of 3.67% which makes DIY into the top 5 and top 10 provinces with an employment rate and the highest percentage of the number of experts in Indonesia (Badan Pusat Statistik, 2022). This is a concern for researchers in analyzing further about how far the contribution and implementation of BIM in the construction industry sector of DIY province. Moreover, in 2018 the Ministry of Public Works and Public Housing has promoted BIM training in DIY Province as a step in the realization of the BIM roadmap that was launched in the previous year which aims to support the acceleration of BIM implementation in the Special Region of Yogyakarta (BIM PUPR, 2018). The study's findings are expected to provide benefits in the form of a contribution to increasing the level of BIM implementation in the construction industry by more specifically identifying the barriers and benefits of BIM.

According to Volk et al (2014), BIM is a technology or methodology that enables information integration and collaboration in the design and building life cycle (Volk et al., 2014). Besides, Santos (2019) stated that BIM is a process that involves various parties exchanging information about the project's life cycle, which is then projected into a digital model (Santos et al., 2019). BIM is one of the technologies that arose from the green technology concept (Khan, n.d.; Kim, 2019; Timothy O. Olawumi, Daniel W.M. Chan, Johnny K.W. Wong, 2018) and is an innovation in the construction industry that has made advantages. Study conducted by Ahankoob (2022), presented several findings in previous studies regarding the advantages of BIM (Ahankoob et al., 2022): (1) allowing better integration of all construction phases (design phase and construction phase) (Kalantari et al., 2017); (2) visualization from BIM improves understanding of construction details and their implementation methods (Chen & Lu, 2019); (3) construction simulation capabilities that can provide an indepth understanding of the complexities of the construction process (Tulke, 2018), and (4) can improve the accuracy of the information (Monteiro & Poças Martins, 2013).

Several previous studies have discussed the benefits and barriers of implementing BIM. (Chan et al., 2019; Durdyev et al., 2021; Georgiadou, 2019; Ullah et al., 2019), financial and technological benefits and barriers, policy barriers, environmental benefits, and innovation benefits. A comparison study of Construction Waste Management using the BIM method revealed that it can reduce costs by up to 52% when compared to conventional methods (Zoghi & Kim, 2020). In a case study of a railroad project in South Korea, through Benefit-Cost Analysis the adoption of BIM proved to be more profitable in overcoming errors that occurred in the project (Shin et al., 2018). However, in other studies, BIM also had several financial barriers in its implementation, including the high initial initiation costs (Gerges et al., 2017; Ismail et al., 2017; Telaga, 2018), high cost of training (Sun et al., 2017) (Georgiadou, 2019), as well as the high cost of hardware in operation (Ahmad Jamal et al., 2019).

The advantages of BIM's technological side in its implementation include ease of operation, (Gledson & Greenwood, 2017; Putri & Kresnanto, 2021; G. Wang & Song, 2017), visualization ability (Badi & Diamantidou, 2017; Foufou & Eds, 2016; Ghaffarianhoseini et al., 2017), and the acceleration of design process (Dakhil & Alshawi, 2014; Ku & Taiebat, 2011; Lee et al., 2012). Meanwhile, the technological barriers to implementing BIM include, among other things, user resistance, as many people are still hesitant to switch to the BIM method (Gardezi et al., 2014), so this correlates to the lack of experts who master BIM (Khosrowshahi & Arayici, 2012; Mcauley et al., 2019; Sun et al., 2017). Meanwhile, in BIM itself, there are several problems such as BIM being inadequate in terms of interoperability (Abanda et al., 2015; Chan et al., 2019; John et al., 2015; Torkhani et al., 2019), the lack of standardization (Mcauley et al., 2019), (Gerges et al., 2017; Sun et al., 2017), and lack of flexibility in reading and editing files (can only be operated from 1 software)(Ghaffarianhoseini et al., 2017; Rodgers et al., 2015).

Government regulations are one of the most important factors in the successful implementation of BIM. (Ahuja et al., 2020; Liu et al., 2015; Zhou et al., 2019). The lack of government involvement in developing policies that directly regulate the concept of BIM will be one of the impediments to BIM adoption and implementation in the industrial sector, particularly in developing countries (Babatunde et al., 2021; Belay et al., 2021; Bui et al., 2016; Van Roy & Firdaus, 2020). Additionally, a literature review on the adoption and application of BIM by the government in Indonesia was provided in great detail (Sopaheluwakan & Adi, 2020). Despite the fact that there have been regulations governing the implementation of BIM in Indonesia, namely Ministerial Regulation No. 22/PRT/M/2018 concerning the Construction of State Buildings, several previous studies continue to identify the 'government policy' factor as one of the barriers to the adoption and implementation of BIM in Indonesia (Mieslenna & Wibowo, 2019; Sriyolja et al., 2021; Van Roy & Firdaus, 2020).

BIM, an innovation in the construction industry, is expected to have a positive impact on the environment. Researchers' findings based on previous studies about the environmental impact of using BIM include, among other things, the efficiency of energy use in BIM implementation (Abanda & Byers, 2016; Beazley et al., 2017; Mahiwal et al., 2021), BIM contributes to reducing emissions (Bonenberg & Wei, 2015; B. Cheng et al., 2020; Mohammed et al., 2022) and establishing a warm environment nyaman (Gan et al., 2021; B. Wang et al., 2021; Wei et al., 2021).

According to recent studies, the use of cloud computing in the construction industry was still relatively new, with numerous opportunities to capitalize on (Bello et al., 2021). More specifically, it was revealed in several previous studies regarding the use of cloud computing in BIM operations (Sirimal et al., 2019). The inclusion of virtual reality into BIM operations is one of the benefits of implementation innovation. Several previous studies have mentioned the use of virtual reality. (Lin et al., 2018;Azhar, 2017; Natephra et al., 2017). The use of 3D, 4D, and 5D BIM in construction today is extremely beneficial to consultants/contractors in terms of reducing claims to service providers. Previous research by the researchers have revealed relevant findings (Noviani et al., 2022;J. C. P. Cheng et al., 2017).

Individual interest plays a role in the successful implementation of BIM at work. Previous research on individual intentions to adopt and implement BIM is included in the Technology Acceptance Model (TAM) concept (Elshafey et al., 2020; Hong & J H Yu, 2018; Putri & Kresnanto, 2021). According to the study, two factors influenced a person's interest in using BIM: perceived usefulness and perceived ease of use. Individual beliefs that BIM can increase effectiveness, productivity, and performance at work are factors that influence individual interest in using BIM on perceived usefulness. Furthermore, factors such as perceived ease of use, ease of job control, and BIM that does not drain the mind can influence individual interest in using BIM.

2. METHODS

2.1 Research Plot

The study was carried out in the manner depicted in Figure 1. The study began with a review of the literature on the benefits and challenges of implementing BIM. This literature review's findings identified a number of research variables that would be used. Data was collected by interviewing several selected respondents, and the results of the interviews were processed using statistical testing tools.

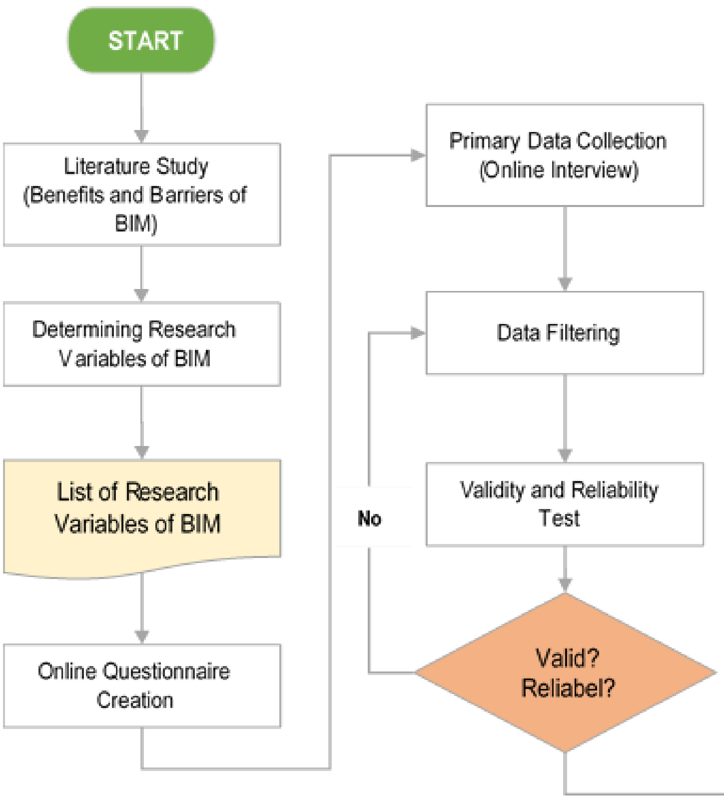

Figure 1. Research Plot

2.2 Sample Size

In describing the problems and testing the hypotheses proposed in the research, this study employed a quantitative approach. This study's population included construction/architectural workers as well as students enrolled in related study programs (civil/architecture) in DIY. The research data came from 121 respondents who completed a questionnaire using a random purposive sampling method that is suitable for quantitative research that does not generalize (Sugiyono, 2016). Therefore, although the selection of respondents is carried out randomly, but must go through certain considerations, in this case, the appropriate individuals to be respondents are individuals who have or are using BIM-based software. Because there was no data on the exact number of BIM users in DIY, the researchers used the Cochran formula (Sugiyono, 2017) to decide sample size, based on the following formula:

$$n = \frac{Z^2 pq}{e^2} \quad (1)$$

n = sample size
Z = The curve value is 95% confidence level (5% deviation), then the value is 1.96
p = 50% chance of being correct
q = 50% chance of being wrong
e = margin error *10%*

Thus, the sample size is:

$$n = \frac{(1{,}96^2)(0{,}5)(0{,}5)}{(0{,}1)^2} = 96{,}04 \quad (2)$$

By rounding up, the minimum number of respondents required is 97 people.

2.3 The Variables and Hypothesis of Study

The variables tested in this study were financial barriers (FB), technological barriers (TB), policy barriers (PB), innovation benefits (IB) and environmental benefits (EB). The number of variable measurements is based on previous research models and findings in the form of research gaps found in several previous studies summarized in Table 1. All of these variables will be tested to find out how much these variables affect individual interest in implementing BIM so that they can become a benchmark for BIM's contribution as an accelerator of sustainable construction. The variables used were based on several previous studies discussing the implementation of BIM and sustainable construction. Tables 1 and 2 show the specifics.

Table 1. Variables, Number of Measurements, and Hypothesis

Variables	Measurement	Research Hypothesis	Reference
Financial Barriers	6 statements	H1: Financial barriers had a negative effect on the intention to implement BIM	(Gang et al., 2018), (Gerges et al., 2017; Ismail et al., 2017; Telaga, 2018), (Durdyev et al., 2021)
Technological Barriers	5 statements	H2: Technological barriers had a negative effect on the intention to implement BIM	(Timothy O. Olawumi, Daniel W.M. Chan, Johnny K.W. Wong, 2018), (Chan et al., 2019; Gardezi et al., 2014; Khosrowshahi & Arayici, 2012)
Policy Barriers	3 statements	H3: Policy barriers had a negative effect on the intention to implement BIM	(Gang et al., 2018), (Bui et al., 2016; Van Roy & Firdaus, 2020), (Ullah et al., 2019)
Environment Barriers	3 statements	H4: Environmental benefits had a positive effect on the intention to implement BIM	(Kresnanto & Putri, 2017), (Beazley et al., 2017; Bonenberg & Wei, 2015)
Innovation Benefits	2 statements	H5: The benefits of innovation have a positive effect on the intention to implement BIM	(Dobson et al., 2013),

Table 2. Measurement Indicators (Statements) of Each Variable

Variable	Measurement Indicators (Statement)	Code
Financial Barriers	BIM implementation has an impact on increasing investment costs.	HF1
	BIM implementation has not been rewarded in the form of adequate incentives.	HF2
	BIM implementation disrupts the smooth flow of construction work cashflow.	HF3

	BIM implementation makes the price of construction services higher and less competitive.	HF4
	New BIM implementations can be marketed to certain consumers.	HF5
	The cost of paying for a BIM-based software platform license for sustainable construction is quite high.	HF6
Policy Barriers	BIM implementation lacks policy/regulation support from the government.	HK1
	The current policies/regulations regarding the implementation of BIM are inadequate.	HK2
	Policies/regulations regarding the implementation of BIM are considered not too important to be regulated in more detail.	HK3
Technological Barriers	Lack of knowledge on the availability of BIM-based software platforms.	HT1
	There are still difficulties in using BIM-based software that integrates construction work in one platform.	HT2
	There are still difficulties in measuring the parameters of sustainable construction with the available technology	HT3
	There is still a lack of experience in using technology, knowledge and skills in using BIM-based technology in construction work environments.	HT4
	The adaptation of BIM-based technologies takes a long time	HT5
Environmental Benefits	BIM implementation will save energy and resources (water, other natural resources)	ML1
	BIM implementation will be more environmentally friendly (more focused on avoiding pollution that endangers human safety)	ML2
	BIM implementation will contribute more to creating a healthy and comfortable environment to live in	ML3
Innovation Benefits	The construction work database can be stored in the cloud and accessed flexibly and safely from anywhere and anytime, making it easier for construction workers to implement BIM.	MI1
	BIM implementation encourages the practice of implementing construction work to be of higher quality in terms of method, performance, and optimizing the use of construction products.	MI2
Intention towards BIM adoption and implementation	Even though there were financial barriers, they did not prevent me from implementing BIM.	BI1
	Even though there are still policy obstacles, I am still interested in implementing BIM.	BI2
	Even though there are technological barriers, I will still use BIM as a tool for my work.	BI3
	I really feel the benefits of being environmentally friendly when using BIM.	BI4
	BIM brings new technological benefits, so I am interested in implementing BIM in my work.	BI5

2.4 Method of Data Analysis

The data will be analyzed using the SPSS 26.0 software and the Multiple Linear Regression test. The Validity Test and Reliability Test will be used to verify that the data is reliable and reproducible, and that the results are correct while the Classical Assumption Test, T Test, and R2 Test will be used to carry out the testing. In validity test, the parameter R Count > R Table was utilized to indicate that the data is valid while in reliability test, Cronbach alpha value >0.6 was utilized as a criterion to indicate that the data is reliable (Ghozali, 2006; Hair et al., 2010; Sugiyono, 2017). The T-test was used to test the research hypothesis about the effect of each independent variable on the dependent variable. Furthermore, the results of the research instruments' validity and reliability tests, as well as descriptive statistics about the respondent's profile, will be displayed.

3. RESULTS AND DISCUSSION

3.1 Respondents Profiles

Figure 2 depicts the profiles of research respondents based on research data. The majority of respondents (54%) were workers in construction services aged 20-24 years (and 22% were 25-29 years). According to their most latest education, the majority of respondents (54%) had SMA/K education and 43% had a Bachelor's degree. Meanwhile, the number of respondents was balanced based on gender and socioeconomic status.

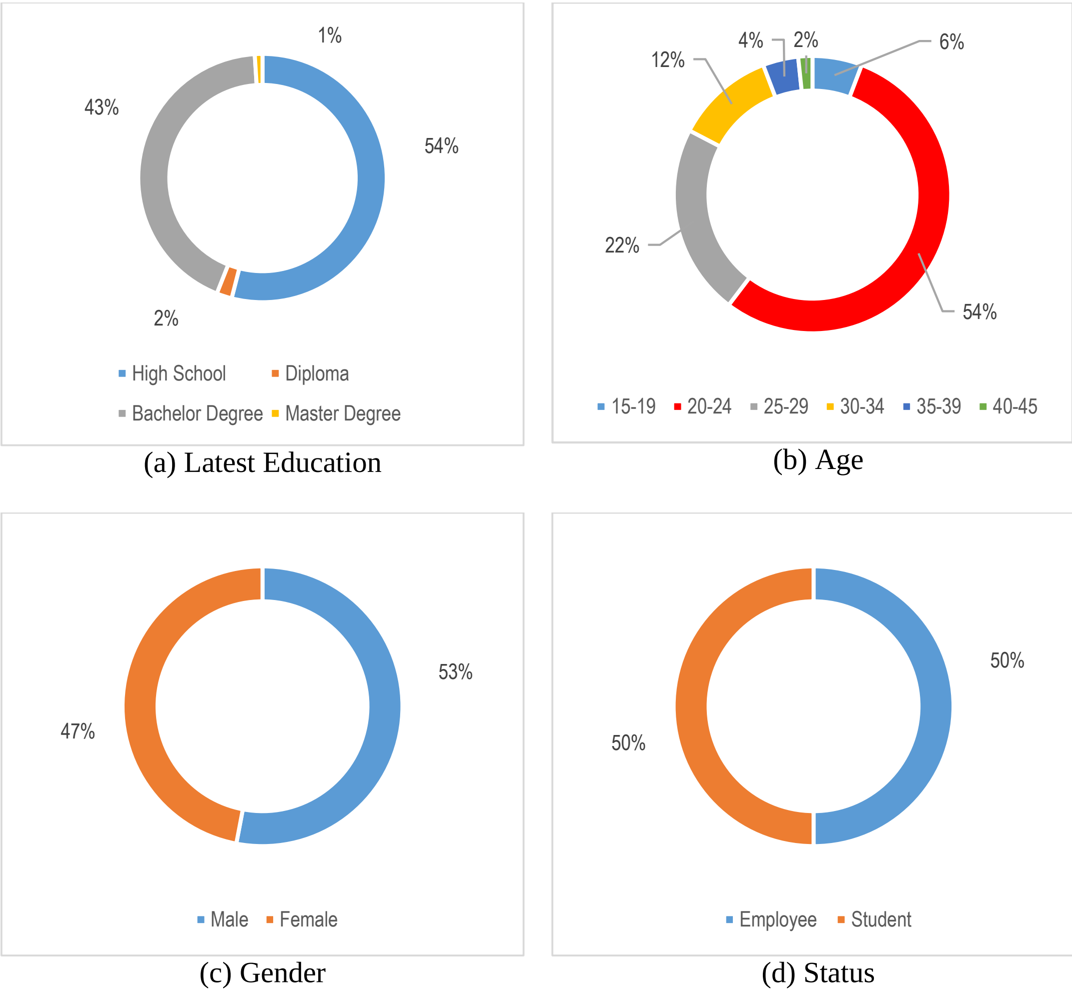

Figure 2 Characteristics of Respondents Based on (a) Education, (b) Age, (c) Gender and (d) Working Status

According to the respondent profiles, BIM users were millennials who are very close to technology, with the most educational backgrounds being undergraduate and high school graduates who were already working or are still studying education.

3.2 Statistical Test Results

3.2.1 Validity and Reliability Test

It is necessary to test the validity and reliability of the data collected through interviews before claiming that it can be used for further tests. To determine the validity of the data, the parameter R Count > R Table was used. The Cronbach alpha value > 0.6 was used as a parameter in the reliability test to indicate that the data is reliable. The study's validity test was conducted in two stages: (1) the first stage used all variables (24 indicators) to determine that there were two invalid variables (I4 and I5); and (2) the second stage used 22 indicators (without I4 and I5). Figure 3 depicts the results of the two-stage validity test. Following the validity test, a two-stage reliability test was performed in accordance with the stages of the validity test. Figure 4 depicts the results of the reliability test.

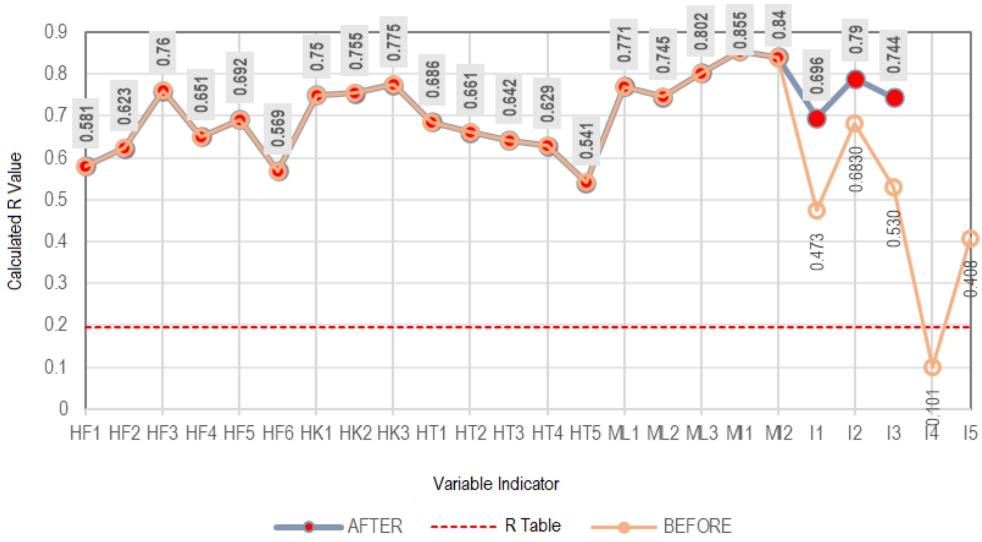

Figure 3. Graph of Validity Test Results Before and After Filtering Data

The validity and reliability tests showed that the two intention variables (I4 and I5) did not meet the valid and reliable requirements and cannot be used for further analysis.

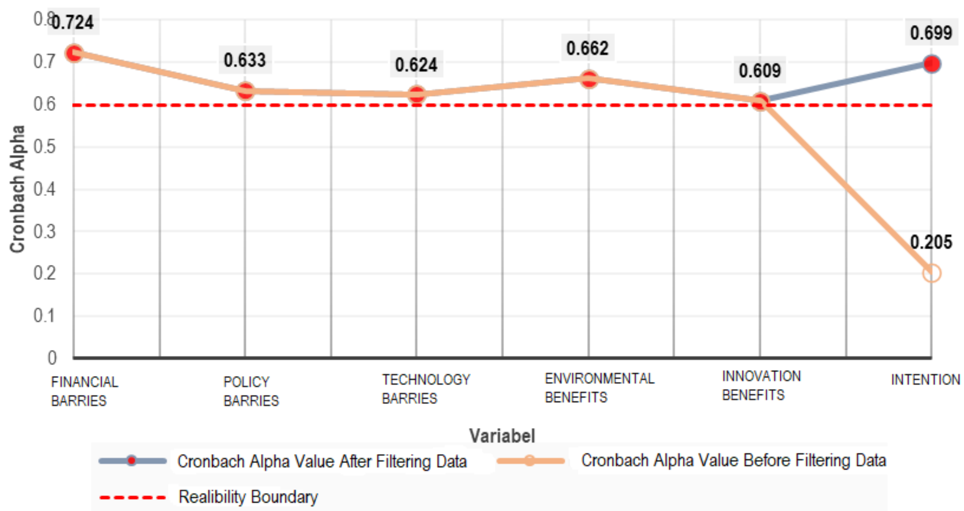

Figure 4. Graph of Reliability Test Results Before and After Filtering Data

3.2.2 Classical Assumption Test, T Test, F Test and R2 Test

The next test is the classical assumption test, in which the researcher performs a normality test, heteroscedasticity test, and multicollinearity test. The normality test results can be seen in figure 5.

One-Sample Kolmogorov-Smirnov Test

		Unstandardized Residual
N		100
Normal Parameters[a,b]	Mean	0E-7
	Std. Deviation	,28552942
Most Extreme Differences	Absolute	,077
	Positive	,077
	Negative	-,068
Kolmogorov-Smirnov Z		,766
Asymp. Sig. (2-tailed)		,600

a. Test distribution is Normal.
b. Calculated from data.

Figure 5. Normality Test from SPSS

Table 3 shows that the normality test results had been met because the significant value was greater than 0,05, indicating that the data distribution was normal. Meanwhile, Table 3 shows the results of the classical assumption test and hypothesis testing.

Table 3. Classical Assumption Test and Hypothesis T Test

Variables	Multicollinearity Test		Heteroscedasticity Test		T Test		
	Tolerance	VIF	t	Sig	Beta	t	Sig
Financial Barriers	0,611	1,638	-0,801	0,425	-0,370	-16,007	0,000
Policy Barriers	0,561	1,784	1,837	0,069	-0,460	-19,154	0,000
Technological Barriers	0,556	1,798	1,010	0,315	-0,350	-14,539	0,000
Environmental Barriers	0,716	1,396	-1,178	0,242	0,002	0,101	0,920
Innovation Benefits	0,776	1,289	1,262	0,210	-0,013	-0,647	0,519

According to the results of the multicollinearity test, the VIF value for all variables was less than 10 and the tolerance value was greater than 0.01, indicating that the model was free of multicollinearity issues. While looking at the heteroscedasticity test results, it can be seen that the sig value for ABRESID for each variable was greater than 0.05, it indicated that there was no heteroscedasticity in the model.

Following the testing of the classical assumptions, the hypothesis was tested. Table 3 presents the T test results, which show that the variables of financial constraints, policy barriers, and technological barriers all influenced the intention to use BIM. While environmental benefits and innovation benefits had no effect on the intention to use BIM.

In addition to testing the classical assumptions and hypotheses, a F test was performed, and the results revealed that all the variables of benefits and constraints influenced the intention variable in BIM implementation at the same time. Furthermore, model testing results showed that the R-square value was 0,970, indicating that the model was very strong at predicting the effect of the independent and dependent variables (Figure 6).

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	257,969	5	51,594	600,881	,000[b]
	Residual	8,071	94	,086		
	Total	266,040	99			

a. Dependent Variable: INTENTION
b. Predictors: (Constant), INNOVATION BENEFITS, POLICY BARRIES, ENVIROEMENTAL BENEFITS, FINANCIAL BENEFITS, TECHOLOGICAL BENEFITS

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,985[a]	,970	,968	,29302

a. Predictors: (Constant), INNOVATION BENEFITS, POLICY BARRIES, ENVIROEMENTAL BENEFITS, FINANCIAL BENEFITS, TECHOLOGICAL BENEFITS
b. Dependent Variable: INTENTION

Figure 6. F and R Test Results from SPSS

3.3 Discussion

Financial Barriers (H1) in the form of high licensing fees and certified BIM training costs are still one of the main obstacles in implementing BIM in Indonesia, especially for those who work in small companies and AEC students who will enter the industry but do not yet have a fixed income. This problem is also found in several previous studies that stated that financial barriers are the main problem in the transition of technology from conventional methods to BIM (Durdyev et al., 2021; Gerges et al., 2017; Ismail et al., 2017; Telaga, 2018). Construction service actors, particularly experts or technical staff who will use BIM, have such a large influence on BIM implementation in the sustainable construction process. In general, primary data collection results showed that technical experts/staff in construction services were experts/employees in the productive age range and should have high technological resilience which means H2 was accepted and associated with several previous study (Gardezi et al., 2014; Khosrowshahi & Arayici, 2012; Timothy O. Olawumi, Daniel W.M. Chan, Johnny K.W. Wong, 2018). Government involvement in initiatives to hasten the adoption and implementation of BIM in the AEC industrial sector is also thought to be weak. These issues include a lack of support from the government in dealing with financial issues (high license fees), which should be pursued through subsidies, as well as technical issues (a lack of free or affordable licensed training), and regulations governing the implementation of BIM in Indonesia are still viewed as being insufficient. These policy obstacles resemble a few of the situations discovered in earlier investigations. (Bui et al., 2016; Ullah et al., 2019; Van Roy & Firdaus, 2020). Most respondents were still students, and they had high expectations for self-development, particularly in developing knowledge of construction technology. Because they were used to using similar software, this reinforced the research findings that they did not feel the benefits of innovation from implementing BIM, so the hypothesis that the benefits of innovation affect the intention to implement BIM (H5) was rejected and. This problem was also found in several previous studies that indicated the lack of innovation benefits obtained in implementing BIM (Li et al., 2020; Tai et al., 2021). Meanwhile, environmental benefits did not have a significant impact on BIM implementation intentions, so H4 was rejected, possibly due to a lack of awareness of environmental conservation efforts, particularly at the technical level, where they believed environmental benefits had no bearing on BIM implementation. This is certainly unfortunate, considering that some findings from previous studies state that the implementation of BIM has a positive impact on the environment (Beazley et al., 2017; Bonenberg & Wei, 2015; Kresnanto & Putri, 2017). Table 4 shows the results of the test conclusions.

Table 4. Hypothesis Test Results

Variable	Rerearch Hypothesis	Test Conclusion
Financial Barriers	H1: Financial barriers have a negative effect on the intention to implement BIM	H1 was accepted with Sig 0,00
Technological Barriers	H2: Technological barriers have a negative effect on the intention to implement BIM	H2 was accepted with Sig 0,00
Policy Barriers	H3: Policy barriers have a negative effect on the intention to implement BIM	H3 was accepted with Sig 0,00
Environmental Benefits	H4: Environmental benefits have a positive effect on the intention to implement BIM	H4 was rejected with Sig 0,920
Innovation Benefits	H5: The benefits of innovation have a positive effect on the intention to implement BIM	H5 was rejected with Sig 0,519

Meanwhile, all hypotheses related to barriers, namely finance, technology, and policies, had proven to be negative, so hypotheses one, two, and three (H1, H2, H3) were indeed accepted. This confirms that there are still barriers to BIM adoption and implementation, so if you want to implement BIM more broadly, these barriers must be overcome. The results of this study associate the findings of (Primasetra et al., 2022) which states that the problems in the implementation of BIM in Indonesia are in the form of technical problems. However, the problems found in the implementation of BIM in this study are in the form of lack of awareness in utilizing innovations in the BIM concept and lack of awareness in environmental issues that are not discussed in the study conducted by (Primasetra et al., 2022)

4. CONCLUSION

Barrier variables, specifically financial, policy, and technological barriers, had been shown to have a negative effect on the intention to implement BIM, implying that the lower the barriers, the higher the intention to implement BIM, particularly for financial, technological, and policy barriers. As a result, if you want to expand BIM implementation, these barriers must be diminished. The environmental benefits and innovation benefits variables in this study had been shown to have no effect on BIM implementation intentions. Because BIM users, the majority of whom were millennials, faced no barriers to using technology, the benefits of innovation were perceived as mediocre and insignificant when compared to similar software. Meanwhile, environmental benefits did not have a significant impact on BIM implementation intentions, possibly because they did not yet have a sufficient awareness of environmental preservation efforts, particularly because they were at the technical level, and thus they believed environmental benefits had nothing to do with BIM implementation. Subsequent research on Building Information Modelling (BIM) implementation intentions can provide valuable insights into the construction industry. To achieve this, it is important to increase the number of respondents from both technical and managerial levels in the construction industry. This will help to provide a comprehensive perspective on the implementation intentions of BIM in the construction industry. Additionally, including the users as beneficiaries of BIM-based construction services in future research will help to understand the impact of BIM on the end-users and the construction process as a whole. This will further contribute to the development and growth of the BIM implementation in the construction industry.

REFERENCES

Abanda, F. H., & Byers, L. (2016). An investigation of the impact of building orientation on energy consumption in a domestic building using emerging BIM (Building Information Modelling). *Energy*, *97*, 517–527. https://doi.org/10.1016/j.energy.2015.12.135

Abanda, F. H., Vidalakis, C., Oti, A. H., & Tah, J. H. M. (2015). A critical analysis of Building Information Modelling systems used in construction projects. *Advances in Engineering Software*, *90*, 183–201. https://doi.org/10.1016/j.advengsoft.2015.08.009

Ahankoob, A., Manley, K., & Abbasnejad, B. (2022). The role of contractors' building information modelling (BIM) experience in realising the potential values of BIM. *International Journal of Construction Management*, *22*(4), 588–599. https://doi.org/10.1080/15623599.2019.1639126

Ahmad Jamal, K. A., Mohammad, M. F., Hashim, N., Mohamed, M. R., & Ramli, M. A. (2019). Challenges of Building Information Modelling (BIM) from the Malaysian Architect's Perspective. *MATEC Web of Conferences*, *266*, 05003. https://doi.org/10.1051/matecconf/201926605003

Ahuja, R., Sawhney, A., Jain, M., Arif, M., & Rakshit, S. (2020). Factors influencing BIM adoption in emerging markets – the case of India. *International Journal of Construction Management*, *20*(1), 65–76. https://doi.org/10.1080/15623599.2018.1462445

Alaloul, W. S., Musarat, M. A., Rabbani, M. B. A., Iqbal, Q., Maqsoom, A., & Farooq, W. (2021). Construction sector contribution to economic stability: Malaysian gdp distribution. *Sustainability (Switzerland)*, *13*(9), 1–26. https://doi.org/10.3390/su13095012

Aryani, A. L., Brahim, J., & Fathi, M. S. (2014). The development of building information modeling (BIM) definition. *Applied Mechanics and Materials*, *567*(June), 625–630. https://doi.org/10.4028/www.scientific.net/AMM.567.625

Azhar, S. (2017). Role of visualization technologies in safety planning and management at construction jobsites. *Sustainable Civil Engineering Structures and Construction Materials*, *171*, 215–226. https://doi.org/10.1016/j.proeng.2017.01.329

Babatunde, S. O., Udeaja, C., & Adekunle, A. O. (2021). Barriers to BIM implementation and ways forward to improve its adoption in the Nigerian AEC firms. *International Journal of Building Pathology and Adaptation*, *39*(1), 48–71. https://doi.org/10.1108/IJBPA-05-2019-0047

Badan Pusat Statistik. (2022). *Konstruksi dalam Angka 2022*. https://www.bps.go.id/publication.html

Badi, S., & Diamantidou, D. (2017). A social network perspective of building information modelling in Greek construction projects. *Architectural Engineering and Design Management*, *13*(6), 406–422. https://doi.org/10.1080/17452007.2017.1307167

Baloi, D. (2003). Sustainable construction: challenges and opportunities. *Association of Researchers in Construction Management*, *1*(September), 289–297. www.csir.co.za/akani

Beazley, S., Heffernan, E., & McCarthy, T. J. (2017). Enhancing energy efficiency in residential buildings through the use of BIM: The case for embedding parameters during design. *Energy Procedia*, *121*, 57–64. https://doi.org/10.1016/j.egypro.2017.07.479

Belay, S., Goedert, J., Woldesenbet, A., & Rokooei, S. (2021). Enhancing BIM implementation in the Ethiopian public construction sector: An empirical study. *Cogent Engineering*, *8*(1). https://doi.org/10.1080/23311916.2021.1886476

Bello, S. A., Oyedele, L. O., Akinade, O. O., Bilal, M., Davila Delgado, J. M., Akanbi, L. A., Ajayi, A. O., & Owolabi, H. A. (2021). Cloud computing in construction industry: Use cases, benefits and challenges. *Automation in Construction*, *122*(xxxx), 103441. https://doi.org/10.1016/j.autcon.2020.103441

BIM PUPR. (2018). *Tim BIM PUPR dukung Pemanfaatan BIM pada Proyek Infrastruktur PUPR Yogyakarta*. http://bim.pu.go.id/berita/baca/18/tim-bim-pupr-dukung-pemanfaatan-bim-pada-proyek-infrastruktur-pupr-yogyakarta.html

Bonenberg, W., & Wei, X. (2015). Green BIM in sustainable infrastructure. *Procedia Manufacturing*, *3*(Ahfe), 1654–1659. https://doi.org/10.1016/j.promfg.2015.07.483

Bui, N., Merschbrock, C., & Munkvold, B. E. (2016). A Review of Building Information Modelling for Construction in Developing Countries. *Procedia Engineering*, *164*(1877), 487–494. https://doi.org/10.1016/j.proeng.2016.11.649

Chan, D. W. M., Olawumi, T. O., & Ho, A. M. L. (2019). Perceived benefits of and barriers to Building Information Modelling (BIM) implementatiofile:///C:/Users/WILDA/Desktop/NPC UNEJ/Jurnal BIM/464a35870b16a3ee0e2a79b299006669.pdfn in construction: The case of Hong Kong. *Journal of Building Engineering*, *25*(August 2018), 100764. https://doi.org/10.1016/j.jobe.2019.100764

Chen, K., & Lu, W. (2019). Bridging BIM and building (BBB) for information management in construction: The underlying mechanism and implementation. *Engineering, Construction and Architectural Management*, *26*(7), 1518–1532. https://doi.org/10.1108/ECAM-05-2018-0206

Cheng, B., Li, J., Tam, V. W. Y., Yang, M., & Chen, D. (2020). *A BIM-LCA Approach for Estimating the Greenhouse Gas Emissions of Large-Scale Public Buildings : A Case Study*.

Cheng, J. C. P., Tan, Y., Song, Y., Liu, X., & Wang, X. (2017). *A semi-automated approach to generate 4D / 5D BIM models for evaluating different offshore oil and gas platform decommissioning options*. https://doi.org/10.1186/s40327-017-0053-2

Dakhil, A., & Alshawi, M. (2014). Client's Role in Building Disaster Management through Building Information Modelling. *Procedia Economics and Finance*, *18*(September), 47–54. https://doi.org/10.1016/s2212-5671(14)00912-5

Dobson, D. W., Sourani, A., Sertyesilisik, B., & Tunstall, A. (2013). *Sustainable Construction : Analysis of Its Costs and Benefits*. https://doi.org/10.12691/ajcea-1-2-2

Durdyev, S., Mbachu, J., Thurnell, D., Zhao, L., & Reza Hosseini, M. (2021). BIM adoption in the cambodian construction industry: Key drivers and barriers. *ISPRS International Journal of Geo-Information*, *10*(4). https://doi.org/10.3390/ijgi10040215

Elshafey, A., Bahru, J., Saar, C. C., Technology, D., Centre, I., Bahru, J., Aminudin, E. B., Bahru, J., Gheisari, M., Usmani, A., & Bahru, J. (2020). *TECHNOLOGY ACCEPTANCE MODEL FOR AUGMENTED REALITY AND BUILDING INFORMATION MODELING INTEGRATION IN THE CONSTRUCTION INDUSTRY*. *25*(August 2018), 161–172. https://doi.org/10.36680/j.itcon.2020.010

Foufou, S., & Eds, K. T. (2016). *Product Lifecycle Management in the Era of Internet of Things*. *467*, 529–540. https://doi.org/10.1007/978-3-319-33111-9

Gan, V. J. L., Luo, H., Tan, Y., Deng, M., & Kwok, H. L. (2021). *BIM and Data-Driven Predictive Analysis of Optimum Thermal Comfort for Indoor Environment*.

Gang, B., Ming, H., Jun, S., & Lye, M. (2018). Adoption of sustainable construction for small contractors : major barriers and best solutions. *Clean Technologies and Environmental Policy*, *0123456789*. https://doi.org/10.1007/s10098-018-1598-z

Gardezi, S. S. S., Shafiq, N., Nurudinn, M. F., Farhan, S. A., & Umar, U. A. (2014). Challenges for implementation of building information modeling (BIM) in Malaysian construction industry. *Applied Mechanics and Materials*, *567*, 559–564. https://doi.org/10.4028/www.scientific.net/AMM.567.559

Georgiadou, M. C. (2019). An overview of benefits and challenges of building information modelling (BIM) adoption in UK residential projects. *Construction Innovation*, *19*(3), 298–320. https://doi.org/10.1108/CI-04-2017-0030

Gerges, M., Austin, S., Mayouf, M., Ahiakwo, O., & Jaeger, M. (2017). AN INVESTIGATION INTO THE IMPLEMENTATION OF BUILDING INFORMATION MODELING IN THE MIDDLE EAST Amr Saad BIM Implementation Consultant, BIM PROJECTS, Egypt; amrsaad@bimprojects.net Tamer-El Gohary Senior BIM and planning engineer. *Pg. 1 Middle East. Journal of Information Technology in Construction (ITcon)*, *22*(2), 1–15. http://www.itcon.org/2017/1

Ghaffarianhoseini, A., Tookey, J., Ghaffarianhoseini, A., Naismith, N., Azhar, S., Efimova, O., & Raahemifar, K. (2017). Building Information Modelling (BIM) uptake: Clear benefits, understanding its implementation, risks and challenges. *Renewable and Sustainable Energy Reviews*, *75*(September), 1046–1053. https://doi.org/10.1016/j.rser.2016.11.083

Ghozali, I. (2006). *Aplikasi Analisis Multivariate dengan Program SPSS*. Penerbit UNDIP.

Gledson, B. J., & Greenwood, D. (2017). The adoption of 4D BIM in the UK construction industry: An innovation diffusion approach. *Engineering, Construction and Architectural Management*, *24*(6), 950–967. https://doi.org/10.1108/ECAM-03-2016-0066

Guerra, B. C., & Leite, F. (2021). Resources , Conservation & Recycling Circular economy in the construction industry : An overview of United States stakeholders ' awareness , major challenges , and enablers. *Resources, Conservation & Recycling*, *170*(March), 105617. https://doi.org/10.1016/j.resconrec.2021.105617

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate Data Analysis (7th ed)*. McGraw-Hill Education.

Hill, R. C., & Bowen, P. A. (2010). *Sustainable construction : principles and a framework for attainment Sustainable construction : principles and a framework for attainment*. *September 2013*, 37–41. https://doi.org/10.1080/014461997372971

Hong, S. H., & J H Yu. (2018). *Identification of external variables for the Technology Acceptance Model (TAM) in the assessment of BIM application for mobile devices Identification of external variables for the Technology Acceptance Model (TAM) in the assessment of BIM application*. https://doi.org/10.1088/1757-899X/401/1/012027

Ismail, N. A. A., Chiozzi, M., & Drogemuller, R. (2017). An overview of BIM uptake in Asian developing countries. *AIP Conference Proceedings*, *1903*(November 2017). https://doi.org/10.1063/1.5011596

James P, & Matipa W M. (2004). *Sustainable Construction in a DevelopingCountry: an Assessment of How theProfessional'S Practice Impact theEnvironment. 2*(September), 1359–1366.

John, R., Heap-Yih, C., & Christopher, P. (2015). Adoption of Building Information Modelling technology (BIM). *Engineering, Construction and Architectural Management*, *22*(1), 91–107.

Kalantari, S., Shepley, M. M., Rybkowski, Z. K., & Bryant, J. (2017). Designing for operational efficiency: facility managers' perspectives on how their knowledge can be better incorporated during design. *Architectural Engineering and Design Management*, *13*(6), 457–478. https://doi.org/10.1080/17452007.2017.1348333

Khan, A. (n.d.). *Building Information Modelling (BIM) based Sustainability analysis for a construction project*.

Khosrowshahi, F., & Arayici, Y. (2012). Roadmap for implementation of BIM in the UK construction industry. *Engineering, Construction and Architectural Management*, *19*(6), 610–635. https://doi.org/10.1108/09699981211277531

Kim, K. P. (2019). BIM-Enabled Sustainable Housing Refurbishment — LCA Case Study. In *Sustainable Construction Technologies*. Elsevier Inc. https://doi.org/10.1016/B978-0-12-811749-1.00019-5

Kresnanto, N. C., & Putri, W. H. (2017). Lean and sustainable construction : link between the sustainability report disclosure and the impact on profitable opportunities for investors Lean and sustainable construction : link between the sustainability report disclosure and the impact on profitab. *IOP Conf. Series: Materials Science and Engineering 650 (2019) 012017*, 1–7. https://doi.org/10.1088/1757-899X/650/1/012017

Ku, K., & Taiebat, M. (2011). BIM experiences and expectations: The constructors' perspective. *International Journal of Construction Education and Research*, *7*(3), 175–197.

https://doi.org/10.1080/15578771.2010.544155

Lee, G., Park, H. K., & Won, J. (2012). D 3 City project - Economic impact of BIM-assisted design validation. *Automation in Construction*, *22*, 577–586. https://doi.org/10.1016/j.autcon.2011.12.003

Li, J., Afsari, K., Li, N., Peng, J., Wu, Z., & Cui, H. (2020). A review for presenting building information modeling education and research in China. *Journal of Cleaner Production*, *259*, 120885. https://doi.org/10.1016/j.jclepro.2020.120885

Lin, Y. C., Chen, Y. P., Yien, H. W., Huang, C. Y., & Su, Y. C. (2018). Integrated BIM, game engine and VR technologies for healthcare design: A case study in cancer hospital. *Advanced Engineering Informatics*, *36*(February), 130–145. https://doi.org/10.1016/j.aei.2018.03.005

Liu, S., Xie, B., Tivendal, L., & Liu, C. (2015). The Driving Force of Government in Promoting BIM Implementation. *Journal of Management and Sustainability*, *5*(4), 157. https://doi.org/10.5539/jms.v5n4p157

Mahiwal, S. G., Bhoi, M. K., & Bhatt, N. (2021). Evaluation of energy use intensity (EUI) and energy cost of commercial building in India using BIM technology. *Asian Journal of Civil Engineering*, *22*(5), 877–894. https://doi.org/10.1007/s42107-021-00352-5

Mcauley, B., Hore, A., & West, R. (2019). Building Information Modelling in Ireland 2019. *Construction IT Alliance Limited*, 33. https://doi.org/10.21427/wy14-n123

Mieslenna, C. F., & Wibowo, A. (2019). Mengeksplorasi Penerapan Building Information Modeling (Bim) Pada Industri Konstruksi Indonesia Dari Perspektif Pengguna Exploring the Implementation of Building Information Modeling (Bim) in the Indonesian Construction Industry From Users ' Perspecti. *Jurnal Sosial Ekonomi Pekerjaan Umum*, *11*(1), 44–58.

Migilinskas, D., Balionis, E., Dziugaite-Tumeniene, R., & Siupsinskas, G. (2016). An advanced multi-criteria evaluation model of the rational building energy performance. *Journal of Civil Engineering and Management*, *22*(6), 844–851. https://doi.org/10.3846/13923730.2016.1194316

Mohammed, M., Shafiq, N., Al-mekhlafi, A. A., Al-fakih, A., Zawawi, N. A., Mohamed, A. M., Khallaf, R., Abualrejal, H. M., Shehu, A. A., & Al-nini, A. (2022). *Beneficial Effects of 3D BIM for Pre-Empting Waste during the Planning and Design Stage of Building and Waste Reduction Strategies*.

Monteiro, A., & Poças Martins, J. (2013). A survey on modeling guidelines for quantity takeoff-oriented BIM-based design. *Automation in Construction*, *35*, 238–253. https://doi.org/10.1016/j.autcon.2013.05.005

Musarat, M. A., Alaloul, W. S., & Liew, M. S. (2021). Impact of inflation rate on construction projects budget: A review. *Ain Shams Engineering Journal*, *12*(1), 407–414. https://doi.org/10.1016/j.asej.2020.04.009

Mytafides, C. K., Dimoudi, A., & Zoras, S. (2017). Transformation of a university building into a zero energy building in Mediterranean climate. *Energy and Buildings*, *155*, 98–114. https://doi.org/10.1016/j.enbuild.2017.07.083

Natephra, W., Motamedi, A., Fukuda, T., & Yabuki, N. (2017). *Integrating building information modeling and virtual reality development engines for building indoor lighting design*. https://doi.org/10.1186/s40327-017-0058-x

Nguyen, V. C. (2020). Human capital, capital structure choice and firm profitability in developing countries: An empirical study in Vietnam. *Accounting*, *6*(2), 127–136. https://doi.org/10.5267/j.ac.2019.11.003

Noviani, S. A., Amin, M., & Hardjomuldjadi, S. (2022). *The impact of 3D , 4D , and 5D Building Information Modeling for reducing claims to service providers*. *26*(1), 47–56.

Plessis, C. Du. (2006). A strategic framework for sustainable construction in developing countries. *Construction Management and Economics*. https://doi.org/10.1080/01446190600601313

Primasetra, A., Larasati, D., & Wonorahardjo, S. (2022). BIM Utilization in Improving Energy Efficiency Performance on Architectural Design Process: Challenges and Opportunities. *IOP Conference Series: Earth and Environmental Science*, *1058*(1). https://doi.org/10.1088/1755-1315/1058/1/012018

Putri, W. H., & Kresnanto, N. C. (2021). Deteksi Resiko Finansial dan Kontrol Perilaku dalam Implementasi Building Information Modeling (BIM). *Universitas Janabadra Yogyakarta*.

Ramya, M., & Ramadasan, T. D. (2016). *Analysis on Causes for Accidents in Construction and Its Safety Measures*. 127–132.

Rodgers, C., Hosseini, M. R., Chileshe, N., & Rameezdeen, R. (2015). Building Information Modelling (Bim) within the Australian construction related small and medium sized enterprises: Awareness, practices and drivers. *Proceedings of the 31st Annual Association of Researchers in Construction Management*

Conference, ARCOM 2015, 691–700.
Santos, R., Costa, A. A., Silvestre, J. D., & Pyl, L. (2019). Informetric analysis and review of literature on the role of BIM in sustainable construction. *Automation in Construction*, *103*(February), 221–234. https://doi.org/10.1016/j.autcon.2019.02.022
Shin, M. H., Lee, H. K., & Kim, H. Y. (2018). Benefit-Cost analysis of Building Information Modeling (BIM) in a Railway Site. *Sustainability (Switzerland)*, *10*(11), 1–10. https://doi.org/10.3390/su10114303
Sirimal, E., Hassani, H., Heravi, S., & Huang, X. (2019). Annals of Tourism Research Forecasting tourism demand with denoised neural networks. *Annals of Tourism Research*, *74*, 134–154. https://doi.org/10.1016/j.annals.2018.11.006
Sopaheluwakan, M. P., & Adi, T. J. W. (2020). Adoption and implementation of building information modeling (BIM) by the government in the Indonesian construction industry. *IOP Conference Series: Materials Science and Engineering*, *930*(1). https://doi.org/10.1088/1757-899X/930/1/012020
Sriyolja, Z., Harwin, N., & Yahya, K. (2021). Barriers to Implement Building Information Modeling (BIM) in Construction Industry: A Critical Review. *IOP Conference Series: Earth and Environmental Science*, *738*(1). https://doi.org/10.1088/1755-1315/738/1/012021
Sugiyono. (2016). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D.* PT Alfabet.
Sugiyono. (2017). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D.* CV Alfabeta.
Sui Pheng, L., & Shing Hou, L. (n.d.). *The Economy and the Construction Industry 2.1 Some Basic Concepts of the Construction Industry 2.1.1 Construction as an Economic Activity*. https://doi.org/10.1007/978-981-13-5847-0_2
Sun, C., Jiang, S., Skibniewski, M. J., Man, Q., & Shen, L. (2017). A literature review of the factors limiting the application of BIM in the construction industry. *Technological and Economic Development of Economy*, *23*(5), 764–779. https://doi.org/10.3846/20294913.2015.1087071
Tai, S., Zhang, Y., & Li, T. (2021). Factors affecting BIM application in China: a social network model. *Journal of Engineering, Design and Technology*, *19*(2), 373–384. https://doi.org/10.1108/JEDT-12-2019-0330
Telaga, A. S. (2018). A review of BIM (Building Information Modeling) implementation in Indonesia construction industry. *IOP Conference Series: Materials Science and Engineering*, *352*(1). https://doi.org/10.1088/1757-899X/352/1/012030
Thomas E. Glavinich, D.E., P. E. (2008). *Contractor ' s Guide to Green Building Contractor ' s Guide to Green Building Construction*. John Wiley & Sons, Inc.
Timothy O. Olawumi, Daniel W.M. Chan, Johnny K.W. Wong, A. P. C. C. (2018). Barriers to the Integration of BIM and Sustainability Practices in Construction Projects : A Delphi Survey of International Experts. *Journal of Building Engineering*, 1–34. https://doi.org/doi.org/10.1016/j.jobe.2018.06.017
Torkhani, R., Laval, J., Malek, H., & Moalla, N. (2019). Toward Information System Architecture to Support Predictive Maintenance Approach. In *Proceedings of the I-ESA Conferences* (Vol. 9, Issue April). Springer International Publishing. https://doi.org/10.1007/978-3-030-13693-2
Tulke, J. (2018). BIM-based design coordination. *Building Information Modeling: Technology Foundations and Industry Practice*, 317–327. https://doi.org/10.1007/978-3-319-92862-3_18
Ullah, K., Lill, I., & Witt, E. (2019). An overview of BIM adoption in the construction industry: Benefits and barriers. *Emerald Reach Proceedings Series*, *2*, 297–303. https://doi.org/10.1108/S2516-285320190000002052
UN Conference on Environment and Development: AGENDA 21. (1992).
Van Roy, A. F., & Firdaus, A. (2020). Building Information Modelling in Indonesia: Knowledge, Implementation and Barriers. *Journal of Construction in Developing Countries*, *25*(2), 199–217. https://doi.org/10.21315/jcdc2020.25.2.8
Volk, R., Stengel, J., & Schultmann, F. (2014). Building Information Modeling (BIM) for existing buildings - Literature review and future needs. *Automation in Construction*, *38*, 109–127. https://doi.org/10.1016/j.autcon.2013.10.023
Wang, B., Wang, Q., Cheng, J. C. P., Song, C., & Yin, C. (2021). Vision-assisted BIM reconstruction from 3D LiDAR point clouds for MEP. *Automation in Construction*, *xxxx*. https://doi.org/https://doi.org/10.1016/j.autcon.2021.103997
Wang, G., & Song, J. (2017). The relation of perceived benefits and organizational supports to user satisfaction

with building information model (BIM). *Computers in Human Behavior*, *68*, 493–500. https://doi.org/10.1016/j.chb.2016.12.002

Wei, M. N. U. H. H., Meng, H. L. C., & Elumalai, N. P. (2021). Building information modeling (BIM) incorporated green building analysis : an application of local construction materials and sustainable practice in the built environment. *Journal of Building Pathology and Rehabilitation*, *5*. https://doi.org/10.1007/s41024-021-00106-5

Wibowo, M. A. (2003). *The Contribution of The Construction Industry to The Economy of Indonesia: A Systematic Approach*. 255.

Zhang, L., Chu, Z., & Song, H. (2020). Understanding the relation between bim application behavior and sustainable construction: A case study in china. *Sustainability (Switzerland)*, *12*(1), 1–17. https://doi.org/10.3390/su12010306

Zhou, Y., Yang, Y., & Yang, J. Bin. (2019). Barriers to BIM implementation strategies in China. *Engineering, Construction and Architectural Management*, *26*(3), 554–574. https://doi.org/10.1108/ECAM-04-2018-0158

Zoghi, M., & Kim, S. (2020). Dynamic modeling for life cycle cost analysis of BIM-based construction waste management. *Sustainability (Switzerland)*, *12*(6). https://doi.org/10.3390/su12062483