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Challenges of Implementing Building Information Modeling in Indonesia Construction Projects

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ABSTRACT: The future of BIM is exciting and full of challenges, but there are several barriers to implementing BIM effectively in the construction sector in Indonesia. Thus, the aim of this research is to examine the challenges of implementing BIM on construction projects, especially in Indonesia. Data was obtained from 45 respondents who answered questionnaire questions, including owners, consultants, contractors/subcontractors, private companies and state-owned enterprises representing construction parties in Indonesia. Empirical analysis using the Correlation Coefficient-A Measure of Linier method states that there are seven variables which are challenging variables in implementing BIM in construction projects. The seven challenge variables are BIM technical readiness, organizational paradigm changes regarding BIM, work environment awareness of BIM, compliance on BIM rules, increased competency and skills, consistent application of effective leadership, maturity of BIM utilization. These seven challenge variables have a linear relationship with the application of BIM in Indonesian construction projects. In conclusion, construction project parties in Indonesia must responses positively to these seven challenges to ensure that the implementation of BIM in construction projects in Indonesia is in accordance with the regulations released by the government.

KEYWORDS: Building Information Modeling, implementing, challenges, construction projects in Indonesia, correlation coefficient-a measure of linier relation

I. INTRODUCTION

The technology of building information modelling (BIM) provides a framework for organizing collaborative work in the construction industry and therefore provides a way to improve the quality of the entire value chain [1]; [2]. The BIM method is faster and more efficient for construction management, improves the quality of design and construction and during the construction period can reduce rework [3]. Increased use of BIM is expected to increase collaboration and reduce fragmentation in the AEC industry and ultimately lead to improved performance and reduced project costs. BIM will accelerate collaboration within the project team for the successful management of construction projects in their life cycles [4].

Several researchers concluded that in the absence of BIM, not only the aerchitecture, engineering, construction (AEC) industry but also operations face challenges in connection with construction projects that are fragmented and, in many cases, poorly integrated [1]. The future of BIM is exciting and challenging, however, there are several challenges in implementing BIM effectively in the construction sector and other industries [4].

According to Bryde et al [5], there are several challenges of BIM to cost, time, scope management, communication and other potential causes, for example, additional time may be required for intermediate conversion of traditional CAD standards to a BIM platform as well as project teams sometimes do not know how to best organize teams to take full advantage of BIM.The research results of Azhar [6] found three risks in BIM implementation, are : 1) how to determine ownership of BIM data, 2) licensing issues related to design, and 3) who will be responsible for updating BIM data and inaccuracies in the model.

The implementation of BIM in construction projects in Indonesia experiences many barriers based on the results of research by several researchers, including: human resources that are not ready, lacking and not trained properly [7]; [8]; [9]; [10], Lack of understanding about BIM and its benefits [10], Resistance to change [10], Lack of work culture [7], and Lack of knowledge and understanding [7]. This barriers is a challenge for the construction industry in Indonesia.

Based on the background of the problem above, the aim of this research is to examine the Challenges of Implementing Building Information Modeling in Indonesia Construction Projects.

II. LITERATURE REVIEW

BIM is a 3D model simulation that connects planning, design, construction and operational information so that it can increase construction effectiveness and efficiency. BIM is a combination of two important ideas, are : 1) Maintaining design information in digital form, making it easy to update

and share data between parties involved in the project. Both architectural, mechanical, electrical, plumbing, landscape and contractor design consulting companies. 2) The real-time concept of continuous connection between digital design data and building modeling technology innovations, so that it can save time and money and increase project productivity and quality [11].

Barriers to implementing BIM in construction projects include technological factors, are the lack of BIM software packages, lack of information sharing, and lack of ability for two or more systems or components to exchange information and interpret it and then use the information [12]. Another factor commonly identified in the literature regarding barriers to BIM adoption are socio-organizational barriers that include important aspects such as team resistance to change, which causes a generational gap in BIM skills and understanding between young and mature practitioners (13]. Meanwhile, [14] stated that, there is a generation gap in the construction industry between those who use BIM and are exposed to the risks associated with it and those who negotiate and sign contracts. Despite the rapid increase in the adoption of more collaborative tools such as BIM in design and construction, legal teams and corporate boards must invest time in understanding the nuances of the technology so that all parties can develop regulations, protocols, and contract documents that can meet. The needs of intelligent 3D modeling implementations, continues to develop in all phases of the project. Ineffective and lack of training in BIM was found to be one of the reasons for less than slower adoption of and apprehensions BIM in construction job sites. [15].

According to [1], the challenges faced by the construction industry in implementing BIM are 40 variables which are categorized into four large groups: Technical, Organizational, Environmental, Government/Legal. Meanwhile, [16] shows 36 challenges in implementing BIM, which are categorized into three large groups, are organization, project and project and organization.

As cited in [17], in Indonesia, the implementation of BIM at the PUPR Ministry is currently starting to be carried out in state buildings with an area of more than 2,000 m2 and more than two floors. BIM is used from the planning stage to construction, and can even be used at the operation and maintenance stages. BIM technology policies can minimize the impact of work delays, additional costs, and construction failures. This implementation has been carried out and initiated in the construction of state buildings within the Directorate General of Human Settlements in several projects including the renovation of the Gelora Bung Karno Main Stadium, the renovation and development of the Manahan Stadium in Solo, the construction of Pasar Atas Bukittinggi in West Sumatra, as well as the stadium and aquatic arena for PON Papua and other buildings [18]. Likewise, in development of the Ibu Kota Nusantara (IKN), the new capital city of Indonesia, BIM technology has been implemented as a result of collaboration between the PUPR Ministry and private parties from Singapore who are vendors providing BIM software services [19]. Although the use of BIM can facilitate coordination, integration, efficiency and control of construction implementation, however, the results of [20] show that, BIM adoption in Indonesia is relatively slow. Optimal BIM implementation is based on the implementation of two main factors, are maturity in the use of BIM functions and implementation of supporting facilities.

In order to answer these barriers, the solution proposed [10] is will/intention, technological factors, organizational culture (support, openness, adaptability. The research results of [4] answer the barriers experienced by construction projects in Indonesia in the context of implementing BIM in a sustainable manner so that construction project management in its life cycle is successful. In order, these five factors are 1) Understanding and awareness of the importance of BIM; 2) Establishment of BIM standards, codes, rules and regulations; 3) Competencies and Skills; 4) Commitment and Consistency; and 5) Monitoring and Evaluation. These are the challenges that must be faced by construction projects or the construction industry in Indonesia.

Based of the literature review show seven main variables that become barriers and at the same time challenges in implementing BIM in construction projects as shown in Table 1. and the framework for this research is shown in Figure 1.

Table 1. Barriers and Challenges to Implementing BIM in Construction Projects

Main Variables	Sub Variable	References
Technical	Difficulty in adapting BIM Technology and Process; Lack of domestic-oriented BIM Tools; Increased workload for model development; Cost of technology;BIM training and its cost; The complexity of BIM technologies (software);The requirement of high-specification computers	[1]
	Implementation of supporting facilities	[20]
	Most of the significant barriers dealt with the, management of data, and interoperability of the software.	[16]
Organization	Resistance to change; Negative attitude towards data sharing; Misunderstanding of BIM; Negative Attitude towards working collaboratively; Lack of a well- established BIM-based workflow; Immature dispute resolution mechanisms for BIM implementation; Lack of BIM knowledge; Lack of awareness of BIM benefits; Lack of BIM	[1]

	expertise; Reluctance to hire BIM experts; Fear of the outcomes; Reluctance to change to BIM; Lack of collaboration among parties; Immigration of skilled experts; Lack of support from top management.	
Environment	Lack of professional Interactivity; Insufficient external motivation; Lack of research on BIM implementation GCC; Improper introduction of BIM concepts;Unwillingness to try BIM process; Lack of experience; Improper interoperability between traditional methods and BIM ;Lack of BIM demand; Lack of time to implement; Immigration of skilled experts	[1]
Government/Legal	Lack of protection for intellectual property rights; Lack of BIM standards; Lack of a standard form of contract for BIM implementation; Lack of insurance applicable to BIM implementation; No-governmental enforcements; Lack of national agenda; Lack of support and motivation	[1]
	Establishment of BIM standards, codes, rules and regulations	[4]
	Lack of national standards for BIM in the US,	[16]
Competencies and Skills	The project team must have the competencies and skills needed to deal with environmental changes.	[4]
	To improve competence and skills, team members need training	[21]
	Ineffective and lack of training in BIM	[15]
	Most of the significant barriers dealt with the training of employees,	[16]
	Human resources that are not ready, lacking and not trained properly	[7]
Effective Leadership	Leadership characteristics, are strong character; responsible for the successful implementation of the project; have clear communication, demonstrate honesty, integrity, trustworthiness and ethics; and act according to what is said to be relevant to the sustainable implementation of BIM in construction projects for life cycle success.	[22] [23] [4]
Maturity of BIM Utilization	Collaboration Team Building, Communication, and Clash Detection	[20]

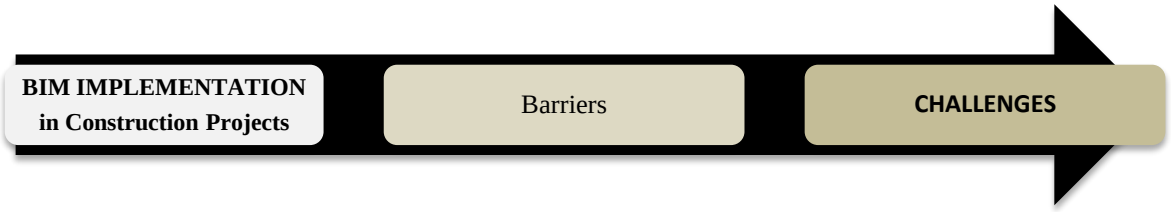


Figure 1. The Conceptual Framework of the Study

A barriers is something, material or nonmaterial, that stands in the way progress. Meanwhile, challenges are things or objects that inspire determination to improve ability to overcome problems or barriers which mean something that makes us more determined in doing something and getting results [24]. In this research, the barriers faced in implementing BIM on construction projects as shown in Table 1. are challenges for organizations and construction projects. Therefore, in this research, the seven main variables in Table 1. need to be narrated again as a challenges for implementing BIM in construction projects, especially in Indonesia, as shown in Table 2. The challenges variables contained in Table 2 are the instruments used in this research.

Table 2. Variables Challenges of Implementing BIM in Construction Projects

Code	Variables Challenges of Implementing BIM in Construction Projects Variables
X1	BIM technical readiness
X2	Organizational paradigm changes regarding BIM
X3	Work environment awareness of BIM
X4	Compliance on BIM rules
X5	Increased competency and skills
X6	Consistent application of effective leadership
X7	Maturity of BIM Utilization

III. RESEARCH METHOD

The main objective of this research is to analyze the challenges of implementing BIM in construction projects, especially in Indonesia. Therefore, data collection and data analysis are an important part of this research stream. Valid data from valid sources is needed to produce valid

conclusions, so that the results of data analysis will provide information or recommendations to decision makers for immediate action.

A. Data collection

The data collection process is important because it influences the achievement of the goals that have been set [25]. The online survey was conducted in the form of a questionnaire format developed systematically to investigate professionals' perceptions of AEC, which contains two main sections. The first part focuses on identifying the identities of the 45 selected respondents/institutions, are owners, consultants, contractors/subcontractors, private companies and state-owned enterprises, with the hope of representing the population of the construction industry in Indonesia. These experts or institutions have applied BIM or other digital technology in managing construction projects without being limited to certain types of construction. The second part of the survey concentrates on ascertaining experts' perceptions regarding the challenges of implementing BIM in construction projects with questions developed through a critical review of the literature and complemented by interviews regarding the challenges of implementing BIM covering seven main variables, are, technical, organizational, environmental, Government/ Legal, Competencies and Skills, Effective Leadership and Maturity of BIM Utilization. Thus, it is hoped that this process can provide valuable input for this research and have a positive impact on the construction industry in Indonesia.

B. Data Analysis

The process of examining, cleaning, transforming, and modeling data aimed at finding useful information, providing conclusions, and supporting decision making is called data analysis [26]. In this research, data analysis uses the Guttman scale and Likert scale to measure the research instruments, is questionnaires and the Correlation Coefficient a Measure of Linier Relation between variables and challenges in implementing BIM in construction projects.

B.1. Questionnaire measurement. The Guttman scale is a scale that requires firm answers, such as true - false, yes - no, never - no never, positive - negative, high - low, good - bad, and so on. There are only two intervals, in the form of multiple choice or checklist. Positive answers are given a score of 1, while negative answers are given a score of 0 [27]. In this research, positive and negative answers are used to measure the independent variable (X) which answers whether the variables in Table 2 are challenge variables for implementing BIM in construction projects. The results of respondents' answers are calculated using the following formula [28]:

$$RF = \frac{f}{n} X100\% \quad (1)$$

where :

RF= Relative Frequency of respondents' answers

f = Number of respondents' answers

n = Number of respondents

The Likert scale is a rating scale used to measure individual (respondent) assessments of feelings, attitudes, or perceptions related to a series of statements or individual items as declarative statements [29]. In this study, the level of suitability referred to in the Likert scale consists of five scale options that have a gradation from very weak relationship (VWR) to very strong relationship (VSR) for measuring dependent variable (Y), which answers the question of how the independent variables (Table 2) are related with Challenges of implementing BIM in construction projects. The five options are shown in Table 3.

Table 3. Assessment Gradation for Questionnaire Measurement

Likert Scale	Gradition
5	Very strong relation
4	Strong relation
3	Medium relation
2	Weak relation
1	Very weak relation

B.2. Correlation Coefficient-A Measure of Linier Relation

The correlation coefficient, denoted by *r*, is a measure of strength of the linear relation between the x and y variables. The strength of the relationship between chalenges variable with implementing BIM in the construction projects used the correlation coefficient between −1 and +1 calculated to represent the linear relation of the variable. The value of *r* is calculated from n pairs of observation (x, y) according to the following formula [28]:

$$r = \frac{Sxy}{\sqrt{Sxx}\sqrt{Syy}} \quad (2)$$

where :

r = correlation coefficient

Sxy = $\sum(x - \bar{x})(y - \bar{y})$

Sxx = $\sum(x - \bar{x})^2$

Syy = $\sum(y - \bar{y})^2$

Interpretation of the magnitude of significant correlations by Guilford [30] shown in Tabel 4.

Table 4. Guilford Interpretation of Magnitude Significant Correlation

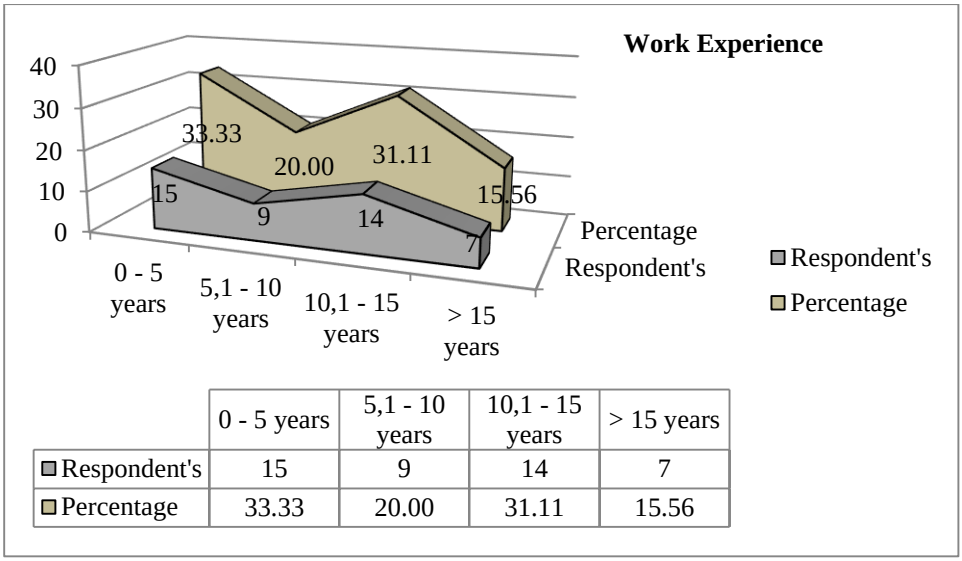
Absolute value of "*r*"	Interpretation
< 0.19	Slight; almost no relationship
0.20–0.39	Low correlation; definite but small relationship
0.40–0.69	Moderate correlation; substantial relationship
0.70–0.89	High correlation; strong relationship

0.90–1.00	Very high correlation; very dependable relationship
≥ 0.30	Practically significant relationship

IV. RESULT AND DISCUSSION

A. Summary of Survey Respondent Characteristics

This survey is completely anonymous and voluntary and is completed by construction professionals working on civil projects in most parts of Indonesia. Participants were selected based on the criteria that they worked on one or more construction sites and had a supervisor. Using these criteria, 45 questionnaires were distributed online in 2023 and all were returned. In general, most respondents are familiar with the construction industry based on their long tenure, so that increasing the quality of the survey data and the persuasiveness of the results. Analysis of work experience is shown in Figure 2.



	0 - 5 years	5,1 - 10 years	10,1 - 15 years	> 15 years
Respondent's	15	9	14	7
Percentage	33.33	20.00	31.11	15.56

Figure 2. Work Experience of Respondent

B. Variables Challenges of Implementing BIM in Construction Projects

Using the Guttman scale and equation one, the results of the analysis of variables challenging the implementation of BIM in construction projects are shown in Table 5.

Table 5. Variables of Challenges of Implementing BIM in Construction Projects

Code	Variables of Challenges	Respondent's Answer				Total Respondent
		Yes	%	No	%	
X1.	BIM technical readiness	40	88.89	5	11.11	45
X2.	Organizational paradigm changes regarding BIM	41	91.11	4	8.89	45
X3.	Work environment awareness of BIM	42	93.33	3	6.67	45
X4.	Compliance on BIM rules	43	95.56	2	4.44	45
X5.	Increased competency and skills	43	95.56	2	4.44	45
X6.	Consistent application of effective leadership	44	97.78	1	2.22	45
X7.	Maturity of BIM Utilization	45	100.00	0	0.00	45

The analysis results in Table 5 show that respondents generally agree with the seven (X1, X2, X3, X4, X5, X6, and X7) variables which are challenges of BIM implementation.To examine the linear relationship between these variables and BIM implementation, it is explained in the following section.

C. Validity and Reliability Test

The validity used in this research (content validity) describes the suitability of a data measure to the questions in the questionnaire. A questionnaire is said to be valid if the questions in the questionnaire can reveal something that is measured by the questionnaire. The significance level used is 0.05. Testing the validity and reliability of questionnaire data

uses the correlation formula with the SPSS version 26 application. This is then verified using the "r" table, which is a table containing numbers which are usually used to test the results of the validity test of a research instrument.

- if *r* stat > *r* table, then the question or statement is declared valid
- if *r* stat ≤ *r* table, then the question or statement is declared invalid.

With a significance level = 5%, df = (n-2) = 43, obtained *r* table = 0.2940, then the results of the analysis are shown in Table 6. and Table 7.

Table 6. Validity Test Results

Variable of Challenges	"*r*' stat	'*r*' tabel	Description
BIM technical readiness (X1)	0.8140	0.2940	Valid
Organizational paradigm changes regarding BIM (X2)	0.5260	0.2940	Valid
Work environment awareness of BIM(X3)	0.4730	0.2940	Valid
Compliance on BIM rules (X4)	0.5190	0.2940	Valid
Increased competency and skills (X5)	0.7420	0.2940	Valid
Consistent application of effective leadership (X6)	0.8550	0.2940	Valid
Maturity of BIM Utilization (X7)	0.7630	0.2940	Valid

Table 7. Reliability Test Results

Cronbach's Alpha	Cronbach's Alpha based on standardized items	N of items
0.863	0.864	7

The results of the reliability test based on the main variables above have a Crobach's Alpha value of 0.864, which is greater than 0.6, so the variables in this study are said to be reliable. So it can be concluded that the seven main variables are reliable so they are suitable to be used as measuring instruments for questionnaires in this research.

D. Correlation Coefficient-A Measure of Linier Relation

The linearity relationship between challenges (X) and the application of BIM in construction projects (Y) using the Correlation Coefficient-A Measure of Linear Relations is shown in Figure 3.

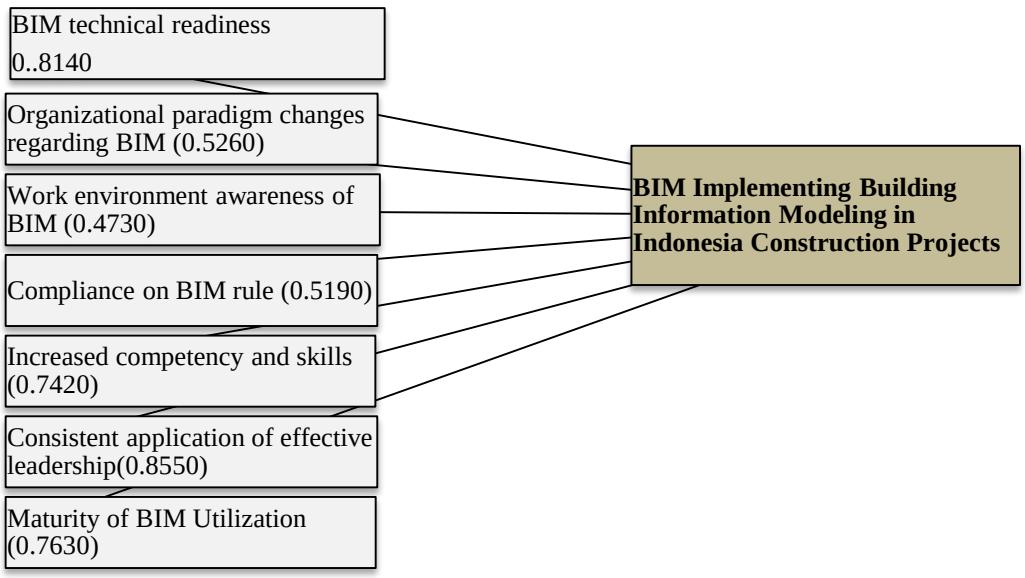


Figure 3. Relationship of Challenges with Implementing Building Information Modeling in Construction Projects

Table 4 shows the magnitude of the significant relationship according to Guilford's interpretation. Based on these values, the challenge variables for implementing BIM in construction projects are explained as follows:

***BIM technical readiness* (X1) :** The research results show that the existing relationship is high correlation with a strong relationship based on the value *r* = 0.8140, which means that BIM technical readiness is very important for maximum

implementation of BIM in construction projects. All facilities related to optimal BIM implementation must be available. This is in line with research by [15) that if construction projects as a community do not want to be left behind and considered an outdated field, then they must seriously provide the resources needed for the implementation of BIM. The same thing was conveyed by Pratama and Marzuki [20].

Organizational paradigm changes regarding BIM **(X2**): Most of the challenges, including the ones most commonly established in the literature, were determined at the organizational level. The research results show that the existing relationship is a moderate correlation with a substantial relationship based on the value r = 0.5260, which means that organizational paradigm changes regarding BIM are very important for maximum implementation of BIM in construction projects. The same thing was conveyed by [31] that BIM adoption and implementation at an organizational level can result in enhanced efficiency and reduction of errors and de-duplication of tasks because of the ability to foster greater collaboration between project stakeholders and departments, to integrate building systemsresolve conflicts and software interoperability. Further, BIM adoption at the organizational level can result in a positive return on the investment mostly generated through savings reduced project costs [6].

Work environment awareness of BIM **(X3)***:* The research results show that the existing relationship is a moderate correlation with a substantial relationship based on the value r = 0.4730. That mean environmental awareness in the workplace about BIM isn't simply about ticking boxes to look like a conscious employer, it is about understanding the why and the how BIM implementation in construction projects. Thus, work environment awareness of BIM is very important for maximum implementation of BIM in construction projects.

Compliance on BIM rules **(X4) *:*** Organization requires to comply with all laws, regulations and provisions set by the Indonesian government regarding the implementation of BIM. The government expects all construction parties to understand these regulations to get the benefits of BIM. This current study show that the existing relationship is a moderate correlation with a substantial relationship based on the value r = 0.5190 which means that Compliance on BIM rules is very important for maximum implementation of BIM in construction projects. The research results of [14) have stated the same thing, where legal teams and corporate boards must invest time in understanding the nuances of technologies such as BIM so that all parties can develop regulations, protocols, and contract documents that can meet the growing needs of implementing intelligent 3D Modeling in all phases of a project.

Increased competency and skills **(X5):** Competency refers to a combination of knowledge, skills and attitudes, where: a) knowledge consists of facts and figures, concepts, ideas and theories that are well established and support understanding of a particular field or subject; b) skills are defined as the ability and capacity to carry out processes and use existing knowledge to achieve results; c) attitudes describe dispositions and thought patterns to act or react to ideas, people or situations and are carried out throughout life [32]. The results of the current research show that this relationship is high correlation is strong relationship where r = 0.7420, meaning that increasing competency and skills in implementing BIM in the construction project process is important to address existing barriers. According to [4], the project team must have the necessary competencies and skills to face environmental changes by implementing BIM in the project life cycle.

Consistent application of effective leadership **(X6):** Successfully influencing and supporting a team or group of people is a person's ability that can condition their leadership to be effective. The results of the current research show that this relationship is high correlation with strong relationship where r = 0.8550, these mean there's much more to effective leadership than just delegating from the top but it must be accompanied by the attitude of the leader. Thus, consistent of effective leadership in order to implementasi BIM in construction projects is important.

Maturity of BIM Utilization **(X7):** BIM Maturity' refers to the quality, repeatability and level of excellence in BIM capabilities. Maturity' shows the extent of the capability in carrying out tasks or providing BIM services/products [33]. The current research results show that the existing relationship is high correlation with a strong relationship based on the value r = 0.7630, that mean maturity is the result of the project team growth and development process that takes place gradually until the personality within the team itself emerges to be more productive, trying to minimize deviations in the context of implementing BIM in construction projects.

CONCLUSIONS AND RECOMMENDATIONS

The future of BIM is exciting and full of challenges, but there are several barriers to implementing BIM effectively in the construction sector in Indonesia. To face these challenges, a solution has been produced through this research. The challenges that must be faced and followed up by construction organizations in Indonesia i.e., BIM technical readiness, organizational paradigm changes regarding BIM, work environment awareness of BIM, compliance on BIM rules, increased competency and skills, consistent application of effective leadership, and maturity of BIM utilization. Utilization of BIM can facilitate coordination, integration, efficiency and control of construction implementation. Construction project parties in Indonesia must responses positively to these seven challenges to ensure that the implementation of BIM in construction projects in Indonesia is in accordance with the regulations released by the government.

Future research also needs to be conducted to ascertain the severity of the identified challenges from the perspective of stakeholders such as design firms, construction firms, owners, and others. This analysis is important because each identified challenge can be perceived differently by each stakeholder, regarding its level of severity. Therefore, it is recommended to carry out an analysis of the severity of the identified challenges from a stakeholder perspective in the future. Knowing these challenges is important for the effective implementation of BIM in construction so that strategies can be developed to overcome the challenges.

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