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A Comprehensive Analysis of Building Information Modelling (BIM) Service Quality and its Impact on User Satisfaction in Indonesian Construction

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Abstract
Building Information Modelling (BIM) is a technology that has been widely adopted in the construction industry around the world. BIM offers a variety of benefits, including increased efficiency, effectiveness, and project quality. The measurement of success of BIM implementation does not only lie in the technical aspects and calculation of numbers. But also, from the user's perspective. Service user satisfaction is key to assessing the extent to which BIM provides added value in the context of construction projects. The trick is to meet the expectations and needs of service users with good quality BIM implementation services. This study aims to examine service quality and service user satisfaction with BIM implementation in building construction projects in Indonesia. The research employed a descriptive qualitative approach using SERVQUAL to gauge BIM service quality and user satisfaction among construction project owners. Data collected through questionnaires was analyzed using SEM-PLS via SmartPLS software, highlighting significant values in BIM Implementation Customer Satisfaction (BICS). The study used a formative model in SEM-PLS and applied Important Performance Analysis (IPA) to identify areas for improvement.The research culminates in several notable conclusions regarding BIM implementation in Indonesia. Firstly, the overall perception among construction service users regarding the quality of BIM implementation showcases a predominantly positive scenario, with most aspects rated favorably. However, certain areas, notably reduced design changes and overall user satisfaction, require attention for improvement, despite the generally high satisfaction levels. Secondly, the pivotal factors influencing service quality and user satisfaction are the tangible aspects and responsiveness, demonstrating significant correlations with user contentment. Lastly, the enhancement of BIM implementation service quality directly impacts user satisfaction, emphasizing the necessity for improvement across seven key indicators encompassing Physical facilities, Response to Change, Communication Process, BIM Data Security, BIM Equipment, Ability to provide solutions and visualization quality.

I. Introduction

The implementation of BIM has reflected a significant evolution in the way the building sector plans, manages, and realizes its projects.[1]. One such innovation is Building Information Modelling (BIM), which is not only software or technology, but also a methodology that allows the complete integration of construction project information, from planning to maintenance [2].

Global and national trends show consistent growth in the adoption of BIM as a technology that is changing the face of the construction industry. From the global market value in 2021 which reached $7.26 billion, the projected market value continues to increase in the 2022-2030 period to reach $25.61 billion[3]. In Indonesia, interest in BIM implementation continues to increase over time, as illustrated by the increase in interest recorded in digital search since 2013 until now [4].

The acceleration of BIM implementation in Indonesia is driven by government regulations governing the use of BIM in government projects. For example, PUPR Ministerial Regulation No. 22/2018 requires government projects with land areas above 2000 m2 to use BIM in the design and construction phases. Meanwhile, Government Regulation No. 16 of 2021 affirms the obligation to use BIM in certain technology and capital projects. Data recorded the adoption of BIM in projects owned by the Ministry of PUPR which reached 307 in 2023[5].

Although construction contractors have highlighted the achievements and benefits of BIM implementation, the evaluation of service user satisfaction with BIM services is still classified as an aspect that has not been clearly revealed. Global studies show mixed results, ranging from AEC companies' distrust of return on investment in China[6]to a high level of satisfaction in Russia in 2019 [7].

The successful implementation of BIM is not only related to technical efficiency, but also to its ability to meet the expectations and needs of users of construction project services. Therefore, BIM service quality analysis is a key aspect in understanding its impact on service user satisfaction. This research is expected to identify critical factors that affect service user satisfaction within the framework of BIM adoption in Indonesian construction projects.

This study aims to conduct an in-depth analysis of the quality of services resulting from BIM implementation in Indonesian construction projects, with a focus on understanding how BIM can improve customer satisfaction. By understanding these dynamics, the research is expected to provide valuable insights for practitioners, construction companies, governments, and other related parties in [8]optimizing the benefits of BIM.

Previous research has focused on factors that influence BIM user satisfaction but has not specifically explored BIM service quality assessments. This gap becomes relevant considering that BIM is not just a physical product, but a work system implementation service that demands good delivery from contractors to construction project owners. Therefore, the focus of research is focused on the dimensions of BIM service quality using the SEM-PLS method and Important Performance Analysis (IPMA) to conduct service user perception surveys, identify performance factors that affect user satisfaction, and formulate strategies to improve BIM implementation performance.

Thus, this research positions itself as a significant contribution to improving our understanding of BIM implementation in the context of construction projects in Indonesia, by placing BIM service quality and service user satisfaction as the main measure of its success.

II. LITERATURE REVIEW

A. BIM Implementation of Customer Satisfaction

Building Information Modelling (BIM) is a digital representation of physical and functional characteristics of a facility [2].It provides a collaborative environment for project participants to design, construct, and operate a facility. BIM has been shown to offer several benefits, including improved efficiency, effectiveness, and quality of projects.

Customer satisfaction is a key indicator for any business [9].In the construction industry, customer satisfaction is typically measured by factors such as meeting project deadlines and budgets, delivering high-quality construction, and providing good communication and customer service.

BIM can play a significant role in improving customer satisfaction in the construction industry [10].For example, BIM can be used to: (a) Improve the accuracy of cost estimates and project schedules. (b) Reduce the number of change orders during construction. (c) Improve communication and collaboration between project participants. (d) Deliver a higher quality product to the customer.

Several studies have shown that BIM can lead to improved customer satisfaction. For example, a study by[11] found that BIM can improve customer satisfaction by up to 15%. Another study by [7]found that 80% of customers were satisfied with the results of BIM implementation.

However, it is important to note that BIM is not a magic bullet for improving customer satisfaction. There are a few other factors that also contribute to customer satisfaction, such as the quality of the construction team and the customers' expectations [12].

Here are some specific examples of how BIM can be used to improve customer satisfaction: (a) Clash detection: BIM can be used to detect clashes between different building components early in the design process. This can help to avoid costly and time-consuming delays during construction. (b) 4D scheduling: BIM can be used to create 4D schedules, which show the sequence of construction activities over time. This can help to improve communication and coordination between project participants and can also help to identify potential scheduling conflicts. (c) Virtual walkthroughs: BIM can be used to create virtual walkthroughs of the building before it is constructed. This can help the customer to visualize the final product and to make any necessary changes to the design. And there are many other examples.

In general, BIM represents a potent instrument capable of enhancing customer satisfaction within the construction sector. By employing BIM to improve the accuracy of cost estimates and project schedules, reduce the number of change orders during construction, improve communication and collaboration between project participants, and deliver a higher quality product to the customer, contractors can significantly increase the chances of satisfying their customers.

B. Service Quality

Service quality is a method developed by [13]to measure the quality of a service. The most popular service quality method is the servqual method, which is divided into 10 main dimensions of service[14]. The 10 dimensions are then summarized by Parasuraman into 5 dimensions[14].The explanation is as follows:

1. Tangible

It entails the capability to deliver the finest service/product, directly perceptible to customers.Such as the physical quality of the product, the equipment used or the employees who operate the job. In the context of this study, tangible is the level of the contractor's ability to produce BIM services in construction projects.

2. Reliability

It involves the capacity to deliver the services consistently and precisely as promised.This dimension is abstract and directly intersects with consumer expectations. In the context of this study, reliability can be interpreted as the level of reliability of contractors in meeting the expectations of BIM implementation from service users in the project.

3. Responsiveness

It is an awareness and desire to be able to help consumers and provide services quickly based on the wishes and needs of the customer / owner. In the context of this study, responsiveness can be interpreted as the level of responsiveness of contractors in responding to owner requests related to BIM involvement in project problems.

4. Assurance

It is a knowledge, behavior (attitude), and ability of the company / employee that gives rise to confidence and trust. Assurance is related to certainty, precisely the certainty that customers get from the behavior of business actors. In the context of this study, assurance can be interpreted as the level of owner trust and confidence bestowed by the contractor in the effectiveness of integrating BIM into the project.In addition, the communication ability of contractor BIM personnel is also an assessment aspect in assurance.

5. Empathy

It is a concern and attention that is carried out personally to the owner as a consumer. In the context of this study, empathy can be interpreted as the level of empathy / concern of the Contractor's BIM Team to be able to contribute to the success of the project.

C. Related Research

This research intersects BIM objects and construction projects. In terms of customer satisfaction, related research is categorized into at least 3 clusters as follows:

Table 1 Related Research

No	I	II	III
Cluster	Construction Costumer Setisfaction (CCS)	BIM Implementation Costumer Setisfaction (BICS)	BIM Costumer Setisfaction (BCS)
Users	Project owners	Project owners	Software users / Operator
Output	Level of satisfaction with the performance of construction services	Level of satisfaction with the performance of BIM implementation	Level of satisfaction of software users
Beneficiary	Contractors	Contractors	Software makers
References	[15]–[18]	[7], [10], [19], [20]	[12], [21], [22]

Of the three clusters, this research is included in cluster 2, namely BIM Implementation Customer Setisfaction (BICS). The difference from previous research lies in the research problem, approach in identifying research variability and problem-solving methods. [19], [20], focused on the search for configurations to improve BICS performance. [7]is more about the BICS level survey, while [10]seeks input from experts and consumers whether BICS can improve CCS. While this study focuses on BICS level surveys and factor identification analysis to improve BICS performance.

In terms of variables,[19], [20], are of the view that to be able to produce BICS (in this study the term BIM user satisfaction / BUS is used) an appropriate configuration is needed, where it is all influenced by two main things, namely BIM performance and project complexity. The configuration for BIM performance consists of 4 aspects, namely BIM accuracy, information integration, functional advantages, and management support. Meanwhile, in this study, a service quality approach was carried out through 5 servqual dimensions to measure BICS.

In terms of problem-solving methods, [19], [20], used Entropy & Tringular Fuzzy Number (TFN) to look for relationships between Configuration 4 BIM performance criteria and project complexity to generate relationships to BICS. The 4 criteria are based on BIM dimensions (BIM 3D to BIM 7D). While in this study, the method used is SEM-PLS to see the value and relationship between 5 servqual dimensions based on BIM dimensions against BICS. Next, the figure is analyzed for factors that need to be improved using IPMA.

D. Structural Equation Modeling – Partial Least Square (SEM-PLS)

SEM is a type of multivariate analysis in the social sciences. Multivariate is one of the statistical application methods that can be used to analyze several research variables simultaneously[23]. Inresearch with CB-SEM and SEM-PLS approaches used in different contexts, it is necessary to understand the differences between the two to apply the right method in research.

The use of the SEM-PLS method has several advantages, including being considered efficient because it does not rely on various assumptions, can work effectively with small samples, and with complex models, the SEM-PLS model can be tested.The disadvantage of SmartPLS is that it can only read Excel data in CSV format [24].

III. METHODOLOGY

The research uses a descriptive qualitative approach with the SERVQUAL method to measure the quality of BIM implementation services and user satisfaction. The research focuses on project owners who necessitate incorporating BIM into their construction endeavors.

A. Data Collection and Analysis

The research data is collected through questionnaires and analyzed using SEM-PLS. The primary data collection process is as follows:

1. Formulate questionnaires based on literature reviews and previous research, including the formulation and verification of research variables.
2. Collect data through the distribution of questionnaires to project owners, including BIM Managers, BIM Officers/Engineers, BIM Modelers, or other parts responsible for monitoring BIM implementation in their companies.
3. Input data and perform SEM-PLS analysis using SmartPLS software to produce significant values from factors in BIM Implementation Customer Satisfaction (BICS) based on 5 SERVQUAL dimension variables.

The SEM-PLS measurement uses a formative mode, which means that the indicators are connected to the latent variable in a one-way direction. Changes in the indicators will be reflected in changes in the latent variable. In the formative model, two measurement evaluations are carried out namely measurement of Outer Model & Inner Model. Besides that, studies are also carried out to classify indicators and variables whose performance currently needs to be improved or maintained using Important Performance Map Analysis (IPMA).

Table 2 Research Instrument

Variable	Dimension	Indicator
BIM Implementation Service Quality (BISQ)	Tangible (X1.1)	X1.1 .1 – X1.1.3
	Empathy (X1.2)	X1.2 .1 – X1.2.3
	Reliability (X1.3)	X1.3 .1 – X1.3.3
	Responsiveness (X1.4)	X1.4 .1 – X1.4.3

Variable	Dimension	Indicator
	Assurance (X1.5)	X1.5 .1 – X1.5.3
BIM Implementation Customer Satisfaction (BICS)	Perception of Project Efficiency	Y1.1
	Project Timeliness	Y1.2
	Project Cost Control	Y1.3
	Construction Quality	Y1.4
	Reduction of Design Changes	Y1.5
	BIM Data Quality	Y1.6
	Improved Collaboration	Y1.7
	BIM Technology Acceptance	Y1.8
	Intention to Use BIM	Y1.9
	Overall User Satisfaction	Y1.10

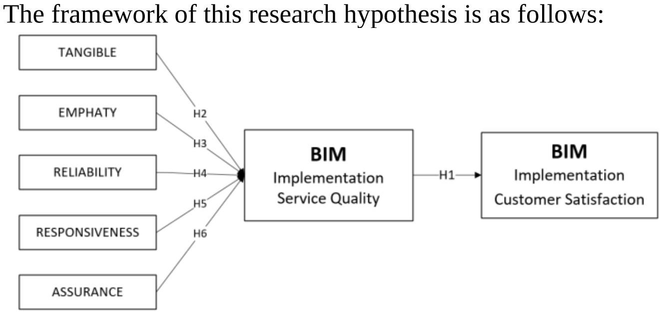
B. Expected Outcomes

The expected outcomes of the research are:

1. Find out the perceptions of construction service users regarding the quality of BIM implementation services in Indonesia.
2. The factors that most significantly affect the quality of BIM implementation services (BISQ) and BIM service user satisfaction (BICS).
3. The performance of BIM implementation service quality indicators and variables

C. Research Hypothesis

The framework of this research hypothesis is as follows:



IV. RESULT AND DISCUSSION

A. Respondent Characteristics

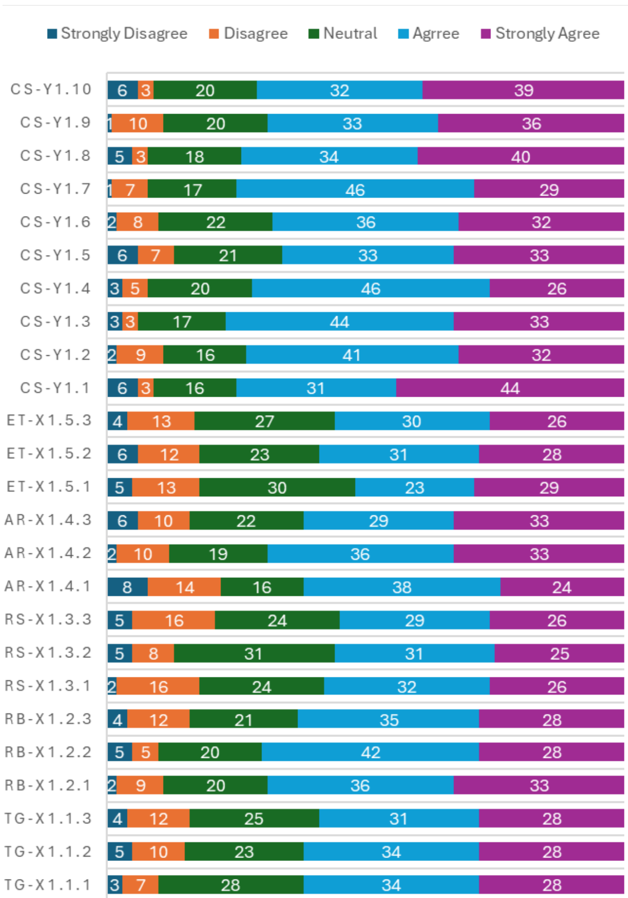
The importance of analyzing respondents' character descriptions is a crucial aspect in ensuring that questionnaires are distributed to the right target, so that the data collected becomes valid and reliable. The following is a recapitulation of the respondent's character:

No	Variables	Respondents (n=100) Percentage (%)
1	**Gender**	
	Male	73%
	Female	27%
2	**Age**	
	21-30 Years	37%
	31-40 Years	47%
	41-50 Years	13%
	Over 50 Years	3%
3	**Education**	
	Diploma / Vocation	2%
	Bachelor	70%
	Master / Doctor	28%
4	**Company Characteristics**	
	State-owned Company	27%
	Private Company	22%
	Government Institution	51%
5	Position Character	
	BIM Manager	10%
	BIM Coordinator	5%
	BIM Engineer / Officer/ Specialist	42%
	BIM Modeler	0%
	Others with BIM responsibilities	22%
	Other	18%
5	Experience in BIM	
	< 3 years	45%
	3 - 5 Years	24%
	5 - 10 Years	17%
	> 10 Years	14%
6	Project Character	
	Build	76%
	Design & Build	22%
7	Project Status	
	Under Construction	63%
	Handover	37%

The survey results depict a predominantly male respondent group (73%) compared to female participants (27%), with the majority falling within the 21 to 40 age range (84%). Educationally, the majority hold bachelor's degrees (70%), followed by master's or doctorate degrees (28%), while only a small minority have diplomas or vocational education backgrounds (2%). Professionally, a larger percentage work in government institutions (51%), followed by private companies (22%) and state-owned enterprises (27%). In BIM-related roles, most serve as BIM Engineers/Officers/Specialists (42%), while BIM Managers represent only 10% of respondents. Experience-wise, a significant number have less than 5 years in BIM (45%), with the majority holding less than 3 years of experience (31% have 3 to 10 years, and only 14% exceed 10 years). In terms of project types, the majority involve building construction projects (76%), followed by design and construction projects (22%), with a significant proportion currently in the construction phase (63%) and the remaining undergoing handover (37%). Overall, the survey reflects a dominant male presence in the 21 to 40 age range, predominantly holding bachelor's degrees and working in government institutions, with substantial involvement in building construction projects.

B. *Descriptive statistics*

Descriptive statistical analysis on service quality, BIM implementation and user satisfaction BIM implementation is an important step in understanding respondents' perceptions and views regarding the use of BIM technology. The collection of this information allows us to explore the extent of user satisfaction with various aspects of the services provided in the context of BIM implementation. Respondents searched for each dimension of this service represented in percentage and average assessment, providing comprehensive insight into the quality of BIM services implemented and their impact on user satisfaction.



The results of the Descriptive Statistics of BIM Implementation Service Quality in table 4.1 show thatthe reliability dimension received the highest assessment with an average of 3.81, indicating a strong level of confidence in the reliability of the system and the accuracy of the information provided. While the tangibles dimension shows a fairlyhigh rating, it is slightly lower than reliability, with an average of 3.71. Responsiveness, assurance, and empathy received relatively similar ratings, ranging from 3.61 to 3.72, indicating a good level of satisfaction, although it varied slightly in certain aspects. Overall, all dimensions showed positive ratings, but reliability and tangibles stood out as the aspects most highly rated by respondents.

Meanwhile, service user satisfaction with BIM implementation in Indonesia shows that there are ten variables that describe customer satisfaction with various aspects of BIM implementation. The perception of project efficiency (Y1.1) showed that 44% of respondents gave a very positive assessment, stating that BIM implementation provides significant benefits to project efficiency. On the other hand, the variables of project timeliness (Y1.2) and project cost control (Y1.3) also received high ratings with an average of 3.92 and 4.01, indicating that respondents benefited from better project timing and budget through BIM implementation. However, construction quality (Y1.4) showed a somewhat lower valuation with an average of 3.87, hinting at potential improvements in this aspect.

In addition, the reduction in design changes (Y1.5) and BIM data quality (Y1.6) also received good ratings, however, there is room to increase satisfaction in this aspect with ratings of 3.80 and 3.88 respectively. Furthermore, increased collaboration (Y1.7) and acceptance of BIM technology (Y1.8) received positive ratings, indicating acceptance and benefits in terms of collaboration and adoption of this technology. The intention to reuse BIM (Y1.9) has an average rating of 3.93, indicating a willingness to continue using this technology. Finally, overall user satisfaction (Y1.10) reached an average of 3.95, illustrating general satisfaction with BIM usage. Although overall user satisfaction with BIM is high, some aspects such as construction quality and BIM data quality as well as reducing design changes still require attention to improve overall satisfaction.

C. *Outer Model Analyis*

Analyzing the measurement model (outer model) is a crucial step in Structural Equation Modeling (SEM) aimed at assessing the correlation between latent variables and their indicators.The goal is to ensure that the indicators used to measure hidden variables reflect the constructions represented by those variables. At this stage, a series of important tests are carried out, including Multicollinearity Outer VIF, Multicollinearity Inner VIF, convergent validity, discriminant validity, and reliability tests. All these tests will not be discussed one by one but in general show good results so that the processed data is declared valid and reliable. Some of the tests that will be discussed here are testing convergent validity and testing the Significance of the Relationship between Dimensions (LOC) and Variables (HOC).

1. Convergent Validity Testing

After assessing multicollinearity, the subsequent step involves conducting convergent validity testing by examining the importance of outer weights and outer loadings.The purpose of this test is to ascertain the extent to which the indicator represents a hidden variable by having a significant loading factor value. If the outer loadings value exceeds 0.50 with a p-value below 0.05 [25], the indicator can be considered for use. However, if the value exceeds that threshold, it is important to evaluate the significance of outer loadings. Indicators with significant values may be preserved, while insignificant ones may need to be removed. Details of the results of the outer weights and outer loadings significance testing can be found in Table 4.11 below.

The results of convergent validity testing from SEM-PLS analysis show that most indicators of independent variables (BIM Implementation Service Quality) and dependent variables (BIM Implementation Customer Satisfaction) have good convergent validity. Convergent validity indicates the extent to which indicators that are part of the same construction correlate with each other and map to the sameconcept.

A high Outer Loading valueusually above 0.7) indicates that the indicator in the variableis well able to reflect the measured construct. While considerable Outer Weights (generally more than 0.5 or 0.6) indicate the significance of the indicator's contribution to a variable that is greater than its contribution to other variables, thus strengthening the validity of the discriminant. That is, the result confirms the match between the indicator and the measured variable, indicating that the indicator really represents the construct in question.

Table IV.1 Outer Weights and Loadings Significance Test

Item	Outer Weights	P Values - Outer Weights	Outer Loading	P Values – Outer Loading
X1.1.1 -> X1.1 (TANGIBLE)	0,298	**0,091**	0,829	**0,000**
X1.1.1 -> X1 (BISQ)	0,118	**0,168**	0,658	**0,000**
X1.1.2 -> X1.1 (TANGIBLE)	0,245	**0,186**	0,727	**0,000**
X1.1.2 -> X1 (BISQ)	-0,057	**0,541**	0,577	**0,000**
X1.1.3 -> X1.1 (TANGIBLE)	0,609	**0,001**	0,943	**0,000**
X1.1.3 -> X1 (BISQ)	0,349	**0,008**	0,748	**0,000**
X1.2.1 -> X1.2 (RELIABILITY)	0,279	**0,195**	0,770	**0,000**
X1.2.1 -> X1 (BISQ)	-0,061	**0,384**	0,513	**0,000**
X1.2.2 -> X1.2 (RELIABILITY)	0,578	**0,004**	0,899	**0,000**
X1.2.2 -> X1 (BISQ)	0,117	**0,192**	0,599	**0,000**
X1.2.3 -> X1.2 (RELIABILITY)	0,332	**0,144**	0,799	**0,000**
X1.2.3 -> X1 (BISQ)	0,139	**0,177**	0,532	**0,000**
X1.3.1 -> X1.3 (RESPONSIVENESS)	0,261	**0,168**	0,802	**0,000**
X1.3.1 -> X1 (BISQ)	0,036	**0,674**	0,606	**0,000**
X1.3.2 -> X1.3 (RESPONSIVENESS)	0,133	**0,576**	0,734	**0,000**
X1.3.2 -> X1 (BISQ)	-0,022	**0,822**	0,554	**0,000**
X1.3.3 -> X1.3 (RESPONSIVENESS)	0,714	**0,003**	0,972	**0,000**
X1.3.3 -> X1 (BISQ)	0,336	**0,004**	0,734	**0,000**
X1.4.1 -> X1.4 (ASSURANCE)	0,305	**0,083**	0,843	**0,000**
X1.4.1 -> X1 (BISQ)	-0,043	**0,625**	0,643	**0,000**
X1.4.2 -> X1.4 (ASSURANCE)	0,576	**0,001**	0,935	**0,000**
X1.4.2 -> X1 (BISQ)	0,138	**0,312**	0,713	**0,000**
X1.4.3 -> X1.4 (ASSURANCE)	0,250	**0,168**	0,820	**0,000**
X1.4.3 -> X1 (BISQ)	0,133	**0,179**	0,625	**0,000**
X1.5.1 -> X1.5 (EMPHATY)	0,136	**0,348**	0,738	**0,000**
X1.5.1 -> X1 (BISQ)	0,043	**0,501**	0,576	**0,000**
X1.5.2 -> X1.5 (EMPHATY)	0,440	**0,014**	0,866	**0,000**
X1.5.2 -> X1 (BISQ)	0,034	**0,737**	0,676	**0,000**
X1.5.3 -> X1.5 (EMPHATY)	0,567	**0,001**	0,915	**0,000**
X1.5.3 -> X1 (BISQ)	0,174	**0,051**	0,714	**0,000**
Y1.1 <- Y1 (BICS)	0,122	**0,000**	0,791	**0,000**
Y1.10 <- Y1 (BICS)	0,137	**0,000**	0,818	**0,000**
Y1.2 <- Y1 (BICS)	0,136	**0,000**	0,782	**0,000**
Y1.3 <- Y1 (BICS)	0,125	**0,000**	0,762	**0,000**
Y1.4 <- Y1 (BICS)	0,135	**0,000**	0,716	**0,000**
Y1.5 <- Y1 (BICS)	0,112	**0,000**	0,773	**0,000**
Y1.6 <- Y1 (BICS)	0,146	**0,000**	0,775	**0,000**
Y1.7 <- Y1 (BICS)	0,106	**0,000**	0,703	**0,000**
Y1.8 <- Y1 (BICS)	0,140	**0,000**	0,788	**0,000**
Y1.9 <- Y1 (BICS)	0,143	**0,000**	0,756	**0,000**

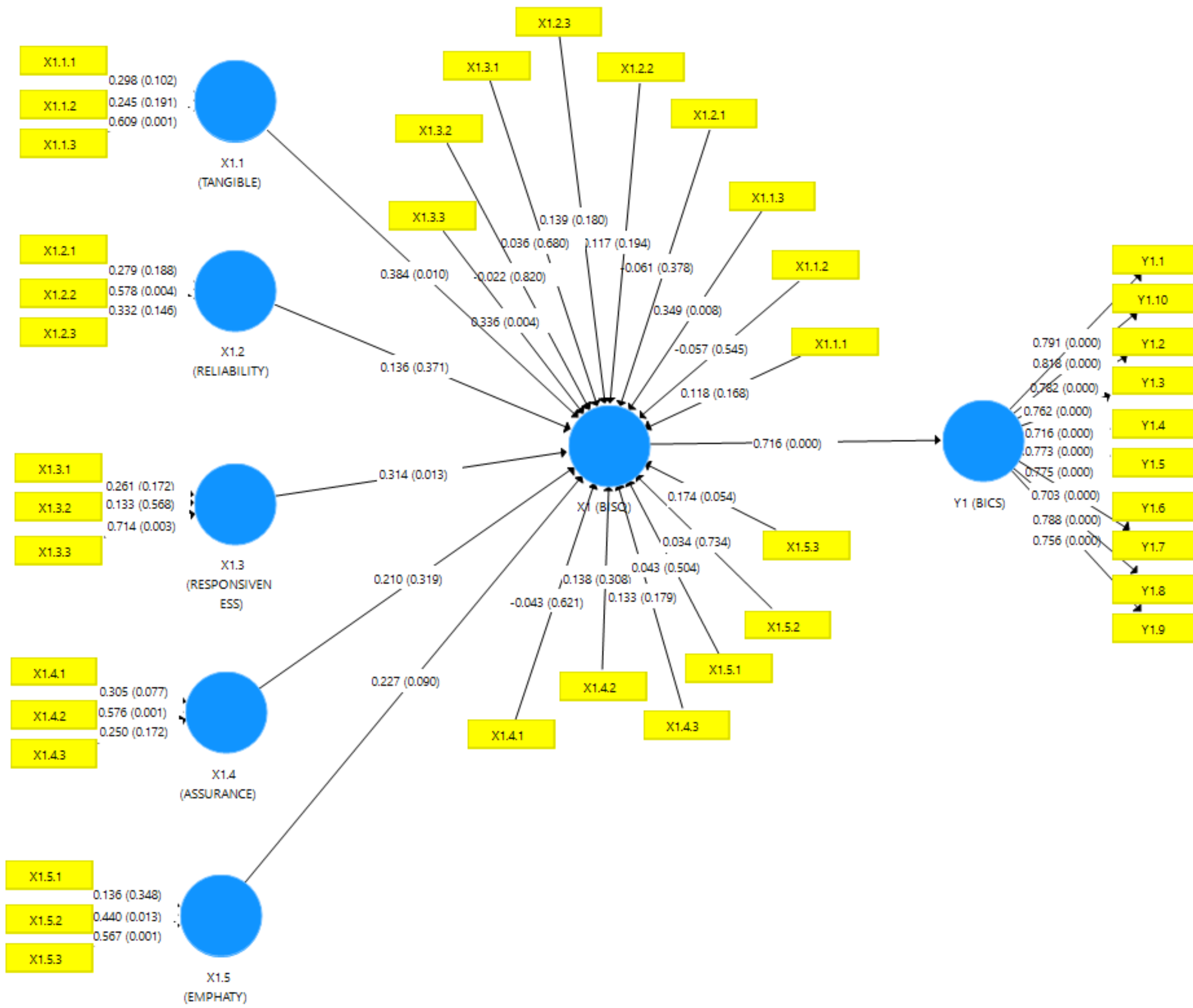


Figure IV.1 Outer Loading Signifikansi

2. Testing the Significance of the Relationship between Dimensions (LOC) and Variables (HOC)

Significance Testing of the Relationship between Dimensions (LOC) and Variables (HOC) is used to evaluate the extent to which the relationship between a latent variable and a particular dimension can be explained significantly. The standard by which significance is assessed can be seen from the T Statistics value, which ideally is at least more than 1.96 (in the case of two sides) to assert a strong enough significance at a given confidence level. A p-value lower than 0.05 is generally considered a significance limit at a 95% confidence level.

The findings from the SEM-PLS analysis demonstrate the importance of the connection between dimensions (LOC) and variables (HOC) within the model.In this examination, it is important to understand the significance of the relationship between the latent variable (X1) that reflects the quality of BIM services and the manifest variable (Y1) that describes service user satisfaction. The relationship between the BIM service quality construct (X1) and service user satisfaction (Y1) shows very strong significance, with a high T Statistics value of 15.102 and a p value close to or equal to zero. That is, the variable of BIM service quality significantly affects service user satisfaction on construction projects.

Meanwhile, when looking at the relationship between specific indicators of BIM service quality (X1.1 to X1.5) and BIM service quality variables (X1), there are mixed results. Some indicators show a strong level of significance, such as the X1.1 indicator (TANGIBLE) and X1.3 indicator (RESPONSIVENESS) which have a low p value and a high

T Statistics, showing a significant impact on the overall BIM service quality variable. However, other indicators such as X1.2 (RELIABILITY), X1.4 (ASSURANCE), and X1.5 (EMPHATY) have higher p-values, indicating a weaker relationship with BIM service quality variables. Nonetheless, the analysis provides important insights into the contribution of each indicator to key constructs, highlighting which elements may be more significant in influencing the overall quality of BIM services.

Therefore, it can be asserted that the excellence of BIM Implementation Service Quality (BISQ) significantly influences service user satisfaction or BIM Implementation Customer Satisfaction (BICS).The dimensions of service quality that most influence BICS are the Tangible factor (Reliability) and the Responsiveness factor.

Table IV.2 Interconstruct Signification Test

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
X1 (BISQ) -> Y1 (BICS)	0,716	0,761	0,047	15,102	**0,000**
X1.1 (TANGIBLE) -> X1 (BISQ)	0,384	0,356	0,155	2,481	**0,013**
X1.2 (RELIABILITY) -> X1 (BISQ)	0,136	0,160	0,152	0,897	**0,370**
X1.3 (RESPONSIVENESS) -> X1 (BISQ)	0,314	0,299	0,130	2,409	**0,016**
X1.4 (ASSURANCE) -> X1 (BISQ)	0,210	0,199	0,214	0,979	**0,328**
X1.5 (EMPHATY) -> X1 (BISQ)	0,227	0,215	0,137	1,655	**0,099**

D.Inner Model Analyis

Following the assessment of the suitable outer model, the subsequent stage involves examining the structural model (inner model).To comprehend the connection among latent variables, the assessment of the structural model seeks to anticipate patterns of linkage among these unobserved variables. This assessment includes the coefficient of determination (R2), effect size (f2), model fit, and relevance of predictions to assess the quality of the inner model.

1. Coefficient of Determination Testing

The coefficient of determination (R-squared) test is used to assess the extent to which an endogenous variable (in this context, service user satisfaction) can be explained by its exogenous variable (BIM service quality). In SEM-PLS, the assessment begins by looking at the R-Square (R2) for endogenous latent variables that indicate how much exogenous variables affect endogenous variables. Although the R-Square (R2) provides information regarding the extent to which the independent variable explains the endogenous variable, its value can rise even though the exogenous variable is not significant to the endogenous variable.

This value represents how well the exogenous variable describes the endogenous variable. The guidelines provided by Hair et al. (2011) state that R-Squared values around 0.25, 0.50, and 0.75 indicate the level of strength of the relationship which can be classified as weak, moderate, and substantial. However, R-Squared adjusted values need to be considered, especially in complex models, to understand the extent to which they account for variability across multiple disciplines. An R-Squared value of 0.2 is considered high in some contexts, but in complex models, it is necessary to evaluate using an adjusted R-Squared value.

TableIV.3Coefficient of Determination Test

	R Square	R Square Adjusted
X1 (BISQ)	0,969	0,967
Y1 (BICS)	0,512	0,507

The results of the Coefficient of Determination Test (R-squared) obtained show how well the variability of endogenous variables (Y1 - Service User Satisfaction) can be explained by exogenous variables (X1 - BIM Service Quality) in this SEM-PLS model. Significant R-squared values, such as the 0.512 and 0.507 values recorded for Y1, suggest that approximately 51.2% to 50.7% of the variation in service user satisfaction on construction projects can be explained by the BIM service quality variables studied. These values are in a decent range, indicating a substantial influence of the factors observed in the model on service user satisfaction. Although not achieving a perfect score, these values can be considered significant because they are able to explain most of the variation in service user satisfaction based on the quality of BIM services analyzed.

2. **Predictive Relevance Testing**

The predictive relevance test helps in understanding how well the model can forecast endogenous variables from exogenous variables by showing the extent to which the model is able to predict variability in the data. The test was conducted with SEM-PLS Blinkfolding with the following results:

TableIV.4Predictive Relevance Testing

	SSO	SSE	Q^2 (=1 SSE/SSO)
X1	1500,000	894,000	0,404
X1.1	300,000	300,000	
X1.2	300,000	300,000	
X1.3	300,000	300,000	
X1.4	300,000	300,000	
X1.5	300,000	300,000	
Y1	1000,000	720,577	**0,279**

Table 4.13 shows the resulting Q² value, specifically for the endogenous variable Y1 (BICS) of 0.279. This value indicates that the model can explain about 27.9% variability in construction project user satisfaction based on the variability of measurement variables. For variable X1 (BISQ), approximately 40.4% of the variability can be accounted for by the measurement of BIM service quality.However, the value for X1 was not used as a basis in this study because predictive relevance through blinfolding was only applied to endogenous constructions with reflective indicators.

1. Model Fit Testing

Model fit tests help ascertain the extent to which the model-built matches existing data and whether the model can be widely applied to situations outside the sample data used. Below are the outcomes of the fit test conducted:

TableIV.5Model Fit Testing

	Saturated Model	Estimated Model
SRMR	0,055	0,055
d_ULS	0,357	0,357
d_G	0,186	0,186
Chi-Square	99,206	99,206
NFI	0,884	0,884

The Model Fit Test results show SRMR parameters close to 0.055, indicating the level of conformity of the model with the data. This value indicates that the model has a relatively low rate of prediction error. In addition, d_ULS and d_G values of 0.357 and 0.186 indicate a good model fit. Although Chi-Square is the statistical measurement used, the value of about 99.206 indicates that there is a difference between the observed model and the fully matched model, but the Chi-Square value cannot be applied to SEM-PLS due to its nonparametric nature. Meanwhile, an NFI of 0.884 indicates that the estimated model matches well with the data. In this context, these values indicate that the model under test has a good fit with the existing data, although each statistic has different standards of interpretation.

E. Analysis of Hypothesis Testing between Variables

At the research stage, the data analysis process has been carried out from the initial stage of formulating the model to the hypothesis testing stage. Testing this hypothesis is important to get answers to research questions and ensure the model designed can answer the problems faced. In addition, the purpose of testing this hypothesis is to affirm the effect of each lower-order construct on the higher-order that is the focus of the study.

Derived from the outcomes of the direct relationship analysis presented in Table 4.10, one can infer that:

- A notable association exists between service quality (X1) and service user satisfaction (Y1) with an extremely low p-value (0.000), signifying a robust correlation between the two.
- Service Quality The implementation of BIM on the TANGIBLE dimension related to the quality of technology and equipment has a significant relationship with service user satisfaction, with a p-value of 0.013.
- Service Quality BIM implementation on the RESPONSIVENESS dimension related to the project team's response to service user requests or problems, has a significant relationship with service user satisfaction, with a p-value of 0.016.
- Service Quality BIM implementation on the dimensions of RELIABILITY, ASSURANCE, and EMPATHY has a p-value above 0.05, indicating no significant relationship with service user satisfaction.

Thus, from the results of the direct relationship test between variables, the Alternative Hypothesis (H1, H2 and H4) related to BISQ (X1) to BICS (Y1) and TANGIBLE (X1.1) and RESPONSIVENESS (X1.3) to BISQ (X1) is declared ACCEPTED. While hypotheses on other dimensions (H3, H5, and H6) relating to RELIABILITY (X1.2), ASSURANCE (X1.4), and EMPATHY (X1.5) against BISQ (X1) were declared REJECTED due to lack of evidence supporting a significant relationship.

Table IV.6 Test the Direct Relationship Hypothesis

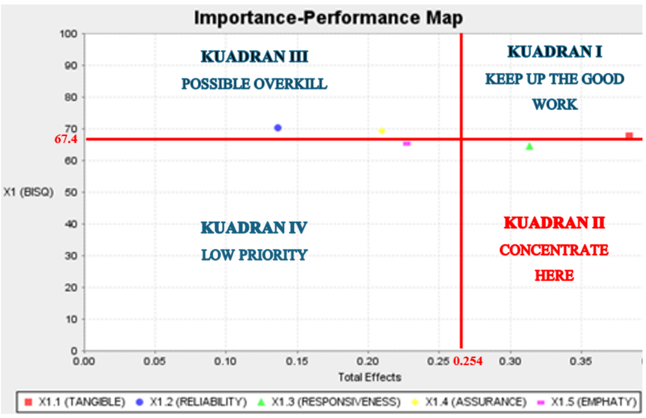
	Original Sample (O)	T Statistics (|O/STDEV|)	P Values
X1 (BISQ) -> Y1 (BICS)	0,716	15,102	**0,000**
X1.1 (TANGIBLE) -> X1 (BISQ)	0,384	2,481	**0,013**
X1.2 (RELIABILITY) -> X1 (BISQ)	0,136	0,897	**0,370**
X1.3 (RESPONSIVENESS) -> X1 (BISQ)	0,314	2,409	**0,016**
X1.4 (ASSURANCE) -> X1 (BISQ)	0,210	0,979	**0,328**
X1.5 (EMPHATY) -> X1 (BISQ)	0,227	1,655	**0,099**

F. Important Perfomance Map Analysis

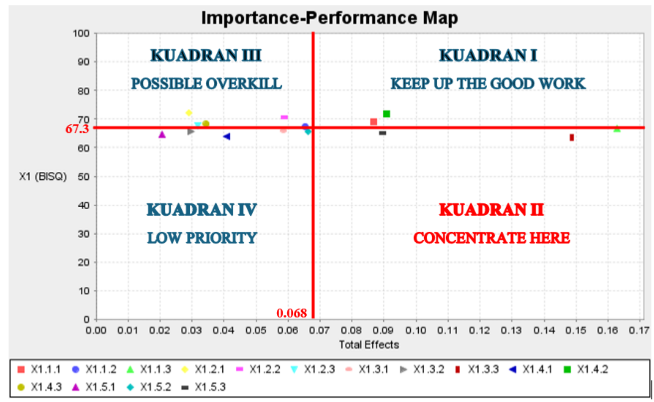
The subsequent stage involves generating latent variable scores through the utilization of the IPMA method, a technique beneficial for extending the insights gained from PLS-SEM baseline results using latent variable scores, as elucidated by referencescores [24]. [24]clarifies that the IPMA analysis relies on a structural model, where the importance value is derived from the total effect received by the construct, and the performance value is obtained from the latent variable score. Here are the results of IPMA testing on the ServQual construct:

Dimensi Service Quality	X1 BIM Implementation Service Quality (BISQ)	
	Total Effect	**Perfomance**
X1.1 (TANGIBLE)	0,384	67,595
X1.2 (RELIABILITY)	0,136	70,316
X1.3 (RESPONSIVENESS)	0,314	64,558
X1.4 (ASSURANCE)	0,210	69,248
X1.5 (EMPHATY)	0,227	65,350
Aveage	**0,254**	**67,413**

The results in table 4.17 show that dimensions X1.1 (TANGIBLE) and X1.3 (RESPONSIVENESS) have the highest total effect value. That is, these two dimensions according to respondents (service users) are the most needed or important dimensions. These results are in line with testing the significance of the relationship between dimensions (discussed in subchapter 4.5.2-point f) which also states that dimensions X1.1 (TANGIBLE) and X1.3 (RESPONSIVENESS) have the most significant relationship to BISQ. But in terms of performance, both dimensions have lower performance than other dimensions, namely 67.6 & 64.6. Where it can be said that the dimensions that are



FigureIV.3 Hasil Uji IPMA Komponen ServQual



FigureIV.2IPMA Test Results ServQual Indicator

TableIV.7Recapitulation of Test Path Coefficients IPMA ServQual Indicator

Dimensi	Code	Indikator	Total Effect	Performances	Kuadran	Rank
Tangible	X1.1.1	BIM Equipment	0,087	69,250	I	5
Tangible	X1.1.2	Visualization quality	0,065	67,500	III	7
Tangible	X1.1.3	Physical facilities	0,163	66,750	II	1
Reliability	X1.2.1	BIM Data Accuracy	0,029	72,250	III	14
Reliability	X1.2.2	Information Time Accuracy	0,059	70,750	III	9
Reliability	X1.2.3	BIM system reliability	0,032	67,750	III	12
Responsiveness	X1.3.1	Response Time	0,059	66,000	IV	8
Responsiveness	X1.3.2	Support Team Availability	0,030	65,750	IV	13
Responsiveness	X1.3.3	Response to Change	0,149	63,750	II	2
Assurance	X1.4.1	BIM team certification	0,041	64,000	IV	10
Assurance	X1.4.2	BIM Data Security	0,091	72,000	II	4
Assurance	X1.4.3	Documentation Quality	0,034	68,250	III	11
Empathy	X1.5.1	Needs Harvesting	0,021	64,500	IV	15
Empathy	X1.5.2	Ability to provide solutions	0,066	65,750	IV	6
Empathy	X1.5.3	Communication Process	0,090	65,250	II	3
Average			**0,068**	**67,300**		

considered important by service users have a bad rapid rapidity. In more detail, figure 4.4 divides the average BISQ performance value and the average service user interest value (total effect) into 4 quadrants.

It can be seen in figure 4.4 that dimension X1.1 (TANGIBLE) falls into quadrant I, dimension X1.3.(RESPONSIVENESS) enters quadrant II, dimensions X1.2 (RELIABILITY) and X1.4 (ASSURANCE) enter quadrant III, and dimension X1.5 (EMPATHY) enters quadrant IV.From these findings, one can deduce that, overall, enhancing BIM implementation quality to elevate service user satisfaction necessitates boosting RESPONSIVENESS and sustaining TANGIBLE above the minimum performance threshold of 67.41.It would be better if TANGIBLE also improved considering its performance value, which is close to the minimum line of 67.59.

For more specific steps. Furthermore, further review was carried out by looking at the results of the IPMA test on each indiactor with the following results in Figure 4.4 and Table 4.16 show the indicators of BIM equipment and BIM data securityinto quadrant I, where the management of the contractor can be said to be good because of good performance and important values so that this achievement needs to be defended. Then, indicators of response to change, physical facilities, and communication processes, enter quadrant II, where management needs to develop due to poor performance while the importance of service users is high, so there needs to be more concentration. Next are indicators of visualization quality, BIM data accuracy, timeliness of information, and reliability of information systems, in quadrant III, where it can be said that these indicators have excessive performance due to high performance values while service users consider it unimportant. Finally, there are indicators included in quadrant IV, namely response time, availability of support teams, BIM team certification, understanding needs, and ability to provide solutions, which are categorized as low priority.

By considering the total value of effect and performance on each indicator, followed by the division of quadrants, a ranking is then made. The top 7 rankings will be improved with the following considerations:

1. Low performance factors and high interest of service users in physical facilities, Response to Change, and Communication Process underlie there is no reason not to improve the performance of these three indicators.
2. Although the BIM Data Security factor and BIM Equipment are included in the safe category (only need to maintain their performance) but it is very risky to go down, this is because the performance value is close to the average line, which is around 0.7 and 1.95. Plus, these two indicators have a high importance value (total effect) of 0.091 and 0.087. So, with the high risk. Then it is necessary to improve performance.
3. The ability to provide solutions and visualization quality factors fall into quadrants IV and III, but both are very close to the average line of service user interest scores, with a difference between 0.002 and 0.003. Thus, both have a real influence on service user satisfaction, especially when the performance value decreases. Therefore, both indicators need to be improved in performance.

It can be inferred that enhancing the performance of BIM implementation service quality is essential for augmenting service user satisfaction, encompassing 7 indicators, such as tangible aspects, which include physical facilities, BIM equipment, and visualization quality.Then the aspect of responsiveness is the response to change. As well as aspects of empathy include the communication process and the ability to provide solutions.

G. Discussion

In exploring the landscape of BIM implementation research, various studies have delved into the intricate dynamics of user satisfaction, revealing both similarities and distinctive viewpoints. Across these studies, a common thread emerges unanimous agreement on the positive correlation between BIM integration and user contentment. Universally, users perceive tangible benefits throughout the project phases, emphasizing the importance of elements like equipment, facility adequacy, and visualization quality, all intertwined with responsive communication and effective change management, as fundamental drivers of satisfaction. Amidst these shared conclusions, each study brings its unique approach to the forefront. Notably, this research takes a comprehensive stance by employing a broader framework to assess service quality dimensions like reliability, assurance, and empathy, providing a more holistic comprehension.

On the other hand, [19]utilized a QCA approach, unearthing distinctive configurations of factors influencing satisfaction, offering a deeper understanding of their interplay. [20]focused on developing a practical tool for measuring user satisfaction, while [7]centered on the dynamics of BIM application in Russia, shedding light on region-specific challenges and opportunities. [10], ventured into exploring the house builder perspective and its impact on client satisfaction within residential construction. This research's significant contribution lies in its in-depth analysis of service quality dimensions and their impact on user satisfaction, offering tailored recommendations pertinent to the Indonesian context. This enriches the existing knowledge base and sets a pathway for more effective and user-centric BIM implementation practices.

However, the authors acknowledge limitations regarding its generalization across different cultural contexts, reliance on potentially limited sample sizes, susceptibility to self-reported data bias, reliance on single-method approaches, and focus on specific aspects, emphasizing the need for diverse research methods and broader exploration of influential factors to develop a more comprehensive understanding of BIM adoption's impact on the construction industry.

Despite these limitations, the research offers a valuable starting point for understanding BIM implementation and user satisfaction in the Indonesian context. By acknowledging and addressing these limitations in future studies, researchers can build upon these findings and contribute to a more comprehensive and nuanced understanding of BIM adoption and its impact on the construction industry.

V. CONCLUSION

Considering the study's results, the perception of construction service users regarding the quality of BIM implementation services in Indonesia generally presents a positive depiction. Aspects such as tangibles, reliability, responsiveness, assurance, and empathy are considered good, indicating overall good implementation. However, there are areas that still need improvement, such as reduced design changes and overall user satisfaction. Despite this, the overall level of user satisfaction is still quite high with an average score of 3.94.

The most significant factors affecting service quality and service user satisfaction in BIM implementation in Indonesia are TANGIBLE with a p-value of 0.013 and RESPONSIVENESS with a p-value of 0.016. This shows a strong relationship between technology and equipment quality (TANGIBLE) and the project team's responsiveness to service user requests (RESPONSIVENESS) and user satisfaction.

The performance of BIM implementation service quality in Indonesia needs to be improved on 7 indicators, namely Physical facilities, Response to Change, and Communication Process because it is in quadrant II with low performance but important. BIM Data Security and BIM Equipment, although safe in quadrant I, has the potential to go down because it is only 4.7 and 1.95 away from the average value with high importance value. While the ability to provide solutions and visualization quality is very close to the average line of service user interest scores, with a difference between 0.002 and 0.003. Thus, both have a real influence on service user satisfaction, especially when the performance value decreases.

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