



Analysis of the Use of BIM on Project Performance in Infrastructure Projects

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Abstract:

Infrastructure projects have a high level of complexity because they involve the integration of interconnected cross-disciplines. This complexity requires strong team collaboration so that the processes of planning, implementation, and supervision can run optimally and achieve project goals effectively and efficiently. One of the main challenges faced in infrastructure projects is team collaboration. Improving project performance is a strategic focus in national development because it concerns budget efficiency, stakeholder satisfaction, and infrastructure sustainability. The presence of digital transformation to ensure orderly, effective, and efficient construction projects—such as *Building Information Modeling (BIM)*—strengthened by government policy support, namely Law No. 2 of 2017 concerning Construction Services and Regulation of the Minister of PUPR Number 22 of 2018, provides a strong foundation for performance improvement. The purpose of this study is to analyze the relationship between the use of *BIM* and project performance through the mediation of team collaboration. The project team respondents consisted of 45 individuals, namely Project Managers, Site Engineering Managers, *BIM* Managers, *BIM* Coordinators, and *BIM* Engineers/*BIM* Modelers. Questionnaires were used for data collection. The data analysis technique applied was *Structural Equation Modeling Partial Least Square (SEM-PLS)*. The test results showed that the use of *BIM* had a positive and significant relationship with team collaboration, that team collaboration had a positive and significant relationship with project performance, and that the use of *BIM* had a positive and significant relationship with project performance. Furthermore, team collaboration significantly mediated the influence of *BIM* use on project performance, with partial mediation. This study provides recommendations to increase the effectiveness of *BIM* utilization in strengthening team collaboration, which ultimately has a direct impact on improving project performance.

Keywords: BIM, Team Collaboration, Project Performance, SEM-PLS

INTRODUCTION

Infrastructure projects have a high level of complexity because they involve the integration of interconnected cross-disciplines. This complexity requires strong team collaboration so that the processes of planning, implementation, and supervision can run optimally and achieve project objectives effectively and efficiently (Al-Aidrous et al., 2022; Floricel et al., 2023; Majeed & Erzaij, 2020; Talesh & Gonçalves Filho, 2023). One of the main challenges faced in infrastructure projects is team collaboration. Inefficient team collaboration can negatively impact project performance. Meanwhile, improving project performance is a strategic focus in national development because it concerns infrastructure efficiency and sustainability. Therefore, various modern approaches have

begun to be applied to overcome these challenges, one of which is the adoption of digital technology in construction management that can accommodate team collaboration, such as *Building Information Modeling (BIM)* (Cao et al., 2022; Lu et al., 2017; Pardosi & Khatimi, 2022). This effort is also strengthened by government policy support, as stated in Law No. 2 of 2017 concerning Construction Services, which emphasizes the importance of innovation and efficiency in the implementation of construction services (Manurung, 2022; PP RI Nomor 14, 2021). In addition, PUPR Minister Regulation Number 22 of 2018 requires the use of *BIM* for state buildings with an area of more than 2,000 m² and more than two floors. This regulation marks the government's commitment to encouraging digital transformation to realize orderly, effective, and efficient construction projects, which directly support the achievement of better project performance.

The use of *BIM* allows for digital integration of project data, including design, cost estimation, work schedules, and *as-built* documentation. This technology has the potential to increase transparency, reduce technical errors, and optimize the decision-making process. Studies such as those by Wijaya (2023) and Khasafaldo (2023) show that *BIM* can improve efficiency and accelerate project execution. However, other research also emphasizes the effectiveness of team collaboration as a result of *BIM* adoption (Mieslenna & Wibowo, 2019).

Some studies show inconsistent results regarding the direct relationship between the use of *BIM* and project performance. For example, a study by Rachman et al. (2024) found that the use of *BIM* does not always have a significant impact on project outcomes without adequate cross-team synergy. On the other hand, research by Abbasnejad et al. (2021) states that the optimal use of *BIM* can support the creation of strong team collaboration. This indicates the existence of a research gap, where there is still room to examine the role of team collaboration as a mediating variable in the relationship between *BIM* usage and project performance.

Team collaboration itself is a critical factor in modern construction projects, particularly in digital ecosystems such as *BIM*. Effective team collaboration can accelerate the flow of information, improve interdisciplinary coordination, and minimize conflict. In the context of *BIM* implementation, team collaboration is an essential prerequisite for ensuring that the available data can be optimally utilized by all project teams.

The objectives of this study are: (1) to analyze the relationship between the use of *BIM* and team collaboration; (2) to analyze the relationship between team collaboration and project performance; (3) to analyze the relationship between the use of *BIM* and project performance; and (4) to analyze the relationship between the use of *BIM* and project performance through the mediation of team collaboration.

This study is expected to make a scientific contribution to the literature on the relationship between *BIM* adoption, team collaboration, and project performance. It can also serve as a reference for project teams and other stakeholders in enhancing the effectiveness of *BIM* usage to strengthen team collaboration, which ultimately has a direct impact on improving project performance.

RESEARCH METHODS

This research is quantitative in nature and was carried out from March to June 2025. The independent variable of this study is the use of *BIM*, the mediating variable is team collaboration, and the dependent variable is project performance. The research population consisted of the infrastructure project team of PT Hutama Karya Persero. Respondents included Project Managers, Site Engineering Managers, *BIM* Managers, *BIM* Coordinators, and *BIM* Engineers/*BIM* Modellers, with a total of 45 participants. The sampling technique applied was non-probability sampling, specifically *purposive sampling*.

Data for this study were obtained through questionnaires adapted from previous research and adjusted to fit the research statements, using a *Likert* scale ranging from 1 to 5. The data analysis method employed was *Structural Equation Model-Partial Least Square (SEM-PLS)*. The *SEM-PLS* data processing utilized the SmartPLS 3 application, which was used to analyze the relationships among the variables.

RESULTS AND DISCUSSION

This study aims to analyze the relationship between the use of BIM and project performance through the mediation of team collaboration on infrastructure projects. The test was carried out using the SEM-PLS method through the SmartPLS 3.0 program to measure the correlation between variables.

Model the Relationship Between BIM Use, Team Collaboration, and Project Performance

In this study, the characteristics of the respondents can be seen based on age, education, work experience, experience using BIM, and position. The research data was obtained from a questionnaire that had been distributed to all 45 respondents. Based on the data obtained through the questionnaire, the characteristics of the respondents were obtained as in Table 1.

Table 1. Respondent Characteristics

No.	Respondent Characteristics	Frequency (f)	Percentage (%)
1.	Age		
	21-25 th	7	16%
	26-30 th	18	40%
	31-35 th	10	22%
	36-40 th	5	11%
	41-45 th	3	7%
	46-50 th	2	4%
2.	Education		
	D3	0	0%
	S1	34	76%
	S2	11	24%
3.	Work Experience		

No.	Respondent Characteristics	Frequency (f)	Percentage (%)
	<5 th	16	36%
	6-10 th	14	31%
	11-15 th	10	22%
	>15 th	5	11%
4.	Experience Using BIM		
	<2 th	11	24%
	3-5 th	27	60%
	6-10 th	7	16%
5.	Position		
	<i>Project Manager</i>	7	16%
	<i>Site Engineering Manager</i>	8	18%
	<i>BIM Manager</i>	8	18%
	<i>BIM Coordinator</i>	7	16%
	<i>Beam Engineer/Beam Modeler</i>	15	33%

Validity and Reliability Tests

Validity test results for BIM usage variables with 16 valid statements, team collaboration with 15 valid statements, and project performance with 15 valid statements. In the reliability test of the three variables, a consecutive Cronbach's Alpha value was obtained, which was 0.968; 0,949; and 0.943, the results showed that Cronbach's Alpha value > 0.70, so the questionnaire was declared reliable.

SEM-PLS (*Structural Equation Model-Partial Least Square*)

The SEM-PLS model is used to analyze the relationship between BIM use and project performance through team collaboration mediation.

Reflective Measurement Model Evaluation

Value *outer loading* is the result of the first convergent validity test. According to (Hair et al., 2021) value *outer loading* acceptable if > 0.70. Values below 0.70 will be removed from the model and retested. In this study, in the first stage, the *outer loading* found 6 indicators below 0.7, namely in KT2, KT3, KT10, KP8, KP9, KP12, KP13, and KP14 with values of 0.662, 0.669, 0.656, 0.691, 0.700, 0.680, 0.569, and 0.498. In the second stage, the *outer loading* overall > 0.70. Table 2, Table 3, and Table 4 show the results of the *outer loading* value of the two stages.

Table 2. Results of *Outer Loading* Value of BIM Use Variables

Code	Grade Level 1	Grade Level 2
BIM1	0,891	0,891
BIM2	0,818	0,819
BIM3	0,835	0,835
BIM4	0,895	0,896

Code	Grade Level 1	Grade Level 2
BIM5	0,880	0,880
BIM6	0,883	0,883
BIM7	0,745	0,745
BIM8	0,782	0,781
BIM9	0,856	0,856
BIM10	0,906	0,906
BIM11	0,804	0,804
BIM12	0,704	0,703
BIM13	0,851	0,851
BIM14	0,836	0,837
BIM15	0,721	0,722
BIM16	0,810	0,811

Table 3. Results of *Outer Loading Value* of Team Collaboration Variables

Code	Grade Level 1	Grade Level 2
KT1	0,775	0,788
KT2	0,662	
KT3	0,669	
KT4	0,743	0,745
KT5	0,742	0,742
KT6	0,807	0,819
KT7	0,832	0,833
KT8	0,784	0,790
KT9	0,870	0,877
KT10	0,656	
KT11	0,820	0,807
KT12	0,866	0,867
KT13	0,743	0,746
KT14	0,815	0,817
KT15	0,823	0,817

Table 4. Results of *Outer Loading Value* of Project Performance Variables

Code	Grade Level 1	Grade Level 2
KP1	0,818	0,840
KP2	0,748	0,737
KP3	0,827	0,854
KP4	0,794	0,772
KP5	0,759	0,776
KP6	0,782	0,776
KP7	0,820	0,838
KP8	0,691	
KP9	0,700	
KP10	0,708	0,730
KP11	0,906	0,912
KP12	0,680	
KP13	0,569	

Code	Grade Level 1	Grade Level 2
KP14	0,498	
KP15	0,822	0,840

Value *Average Variance Extracted* (AVE), which describes how much an overall variable can explain the variation of the measurement item, can be used to determine the convergent validity of a test. AVE value > 0.50 according to (Hair et al., 2021) indicates that the average variance of the measurement item contained by the variable is above 50%. The results of the AVE value of this study can be seen in Table 5. These results show the AVE values of all three variables above 0.50, which means that the convergent validity is well met for all measurement variables.

Table 5. AVE Value Test Results

	Average variance extracted (AVE)
Use of BIM	0,686
Team Collaboration	0,648
Project Performance	0,655

Recommended value for HTMT, a discriminant validity test proposed by (Hair et al., 2021) is below 0.90. HTMT is the ratio of Heterotrait (the average correlation between items that measure different variables) to the geometric multiplication root of Monotrait (the correlation between items that measure the same variable). The findings of HTMT values can be seen in Table 6. The association of each variable with other variables is less significant than the root value of the overall AVE of the variable. Therefore, it can be said that the validity test can be met.

Tabel 6. Nilai Heterotrait Monotrait ratio (HTMT)

	Use of BIM	Team Collaboration
Team Collaboration	0,769	
Project Performance	0,771	0,877

Cronbach's Alpha and Composite Reliability are used in the PLS reliability test, and the required values are greater than 0.70. The table shows the results of Cronbach's Alpha and Composite Reliability. All measurement items that measure each variable are declared consistent and reliable, based on Composite Reliability and Cronbach's Alpha total value.

Table 7. Cronbach's Alpha and Composite Reliability Values

	Cronbach's alpha	Composite reliability
Use of BIM	0,969	0,972
Team Collaboration	0,950	0,957
Project Performance	0,941	0,950

Structural Model Evaluation

The degree of variation in changes of independent variables to dependent variables was assessed using the R Square value test. The value of R Square is included in one of three categories according to (Hair et al., 2021), i.e. R Square 0.75 substantial, 0.50 moderate, and 0.25 weak. The value of R Square can be seen in Table 8.

Table 8. R Square Value

	R Square
Team Collaboration	0,583
Project Performance	0,752

The results of Table 8 show that the team collaboration variable shows the model at the moderate criterion with a value of 0.583 ranging from a value of 0.50 and the project performance variable shows a model at the substantial criterion with a value of 0.752 ranging from a value of 0.75. Furthermore, the Q Square test illustrates how well the model has predictive relevance. According to (Hair et al., 2021), Q Square has a value of 0.25, 0.50, 0.75 then the meaning of Q Square is low, moderate and high. Table 9 shows the results of the Q Square Predict score. According to Table 9, the team collaboration variable has a Q Square value of 0.356, around a value of 0.50 indicating moderate prediction accuracy, and the project performance variable has a Q Square value of 0.461, ranging from a value of 0.50 indicating moderate prediction accuracy. The value of the Q Square can be seen in Table 9.

Table 9. Q Square Value Results

	SSO	SSE	Q2 (=1-SSE/SSO)
Team Collaboration	540	347,971	0,356
Project Performance	450	242,416	0,461

Hypothesis testing is carried out through bootstrapping by taking into account the significance value between the construct (t-statistic) and p-value. Hyposthesis is accepted if the p-value < 0.05 and the t-statistic > 1.96. Table 10 shows the results of the direct effect bootstrapping test. The direct influence test values can be seen in Table 10.

Table 10. Direct Impact Testing

	Original Sample (O)	T Statistics (O/STDEV)	P Values
The Use of BIM → Team Collaboration	0,763	22,090	0,000
The Use of BIM → Project Performance	0,311	2,675	0,008
Team Collaboration → Project Performance	0,606	5,445	0,000

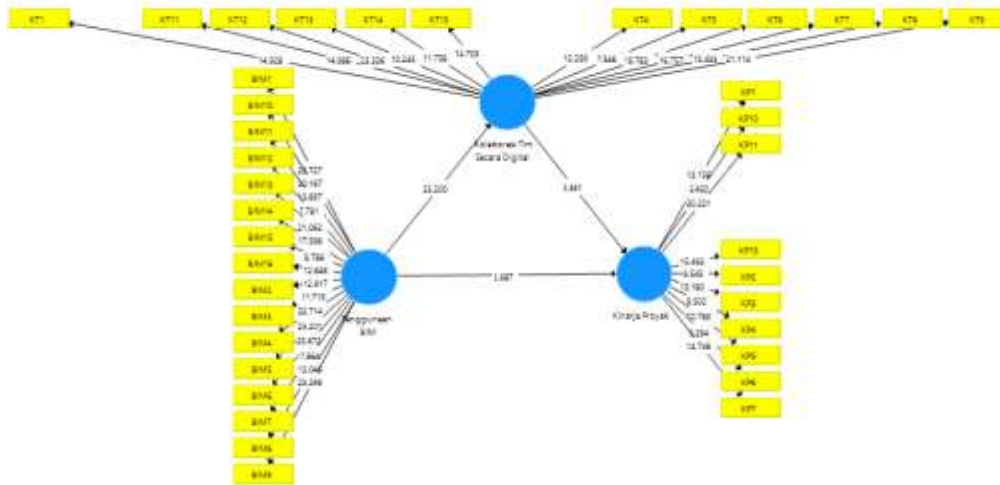


Figure 1. Bootstrapping Results

Based on the results of the direct effect test, it can be concluded as follows:

1. The value of the path coefficient (*original sample*) the use of BIM for team collaboration is 0.763, which is a positive value, which means that the use of BIM has a positive effect on team collaboration. The result of the t-statistical value was obtained 22.090 and the p value was 0.000 which means that the result is significant, because the t-statistical value is greater than the t-table value ($22.090 > 1.96$) and the p value is smaller than 0.5 ($0.000 < 0.5$) so it can be concluded that the use of BIM has an effect on team collaboration (accepted hypothesis). The results of this study are consistent with the research conducted by (Migilinskas et al., 2013) which states that the use of BIM as a collaborative technology encourages the adaptation of project teams in adopting an integrated collaborative work pattern. Through a digital model that can be accessed together, BIM creates a work environment that is more open, responsive, and adaptive to project dynamics. According to research (Sampaio et al., 2023) through the use of BIM, all team members have access to project information in a timely manner *real-time*, coordination becomes more efficient and minimizes miscommunication.
2. The value of the path coefficient (*original sample*) team collaboration on project performance is 0.606, which is a positive value, which means that team collaboration has a positive effect on project performance. The results of the t-statistical value were obtained $5.445 > 1.96$ and the p value was 0.000 which means that the results are significant, so it can be concluded that team collaboration has an effect on project performance (hypothesis accepted). The results of this study are consistent with the research conducted by (Wang et al., 2021) which states that the effectiveness of BIM-based team collaboration directly increases the efficiency of project performance, because the more optimal the use of BIM used for team collaboration, it can minimize miscommunication that risks causing rework and accelerate decision-making so that

it has a direct impact on project performance. According to research (Shang & Shen, 2014) team collaboration using BIM creates an integrated and data-driven work ecosystem. This is an important element in ensuring that all parties move based on the same information, thus encouraging the achievement of project targets consistently.

3. The value of the path coefficient (*original sample*) the use of BIM on project performance is 0.311, which is a positive value, which means that the use of BIM has a positive effect on project performance. The results of the t-statistical value were obtained $2.675 > 1.96$ and the p value was 0.008 which means that the results are significant, so it can be concluded that the use of BIM has an effect on project performance (hypothesis accepted). The results of this study are in line with the research conducted by (Azhar, 2011) which states that the use of BIM significantly improves the performance of construction projects. BIM is not just a visualization tool, but also an integrated project management tool that has great potential to improve project results and performance efficiency. According to research (Bryde et al., 2013) BIM is an effective project management tool in increasing the success of construction projects, especially for complex and large-scale projects.

Mediation/Indirect Influence Test

The mediation variable explains that there is a variable that intervenes the influence of an independent variable on the dependent variable. The results of the indirect influence test are shown in Table 11.

Table 11. Indirect Influence Testing

	Original Sample (O)	T Statistics (O/STDEV)	P Values
The Use of BIM → Team Collaboration → Project Performance	0,463	5,169	0,000

Based on the results of the indirect influence test, it can be concluded that the effect of the use of BIM on project performance through team collaboration is 0.463 and the p value is significant ($0.000 < 0.05$). This shows that team collaboration plays a significant role as a variable that mediates the influence of BIM use on project performance. (Hypothesis accepted). The mediation is included in the *complementary (partial mediation)* category. In conclusion, the relationship between the use of BIM and project performance can be influenced by team collaboration as mediation. The good use of BIM will affect effective team collaboration so it will help improve project performance. Therefore, it is important for the project team to be able to use BIM effectively, so that with the support of good team collaboration so that all information and teams are integrated with each other and will improve project performance.

CONCLUSION

Based on the analysis of the use of *BIM* on project performance in infrastructure projects and the discussions that have been carried out, the following conclusions are obtained: The use of *BIM* has a positive and significant relationship with team collaboration, indicating that the greater the use of *BIM*, the higher the effectiveness of team collaboration. Team collaboration has a positive and significant relationship with project performance, showing that the more effective the team collaboration, the higher the project performance. The use of *BIM* also has a positive and significant relationship with project performance, which means that the greater the use of *BIM*, the better the project performance. Furthermore, team collaboration significantly mediates the influence of *BIM* usage on project performance, with partial mediation.

The suggestions that can be made based on these conclusions are as follows: for readers, it is hoped that this study can broaden knowledge and understanding related to the use of *BIM* and project performance, as well as the indicators that influence it. For contractors, it is recommended to increase the adoption of *BIM* in order to improve project performance.

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