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Factors Affecting BIM (Building Information Modeling) Utilization Based on Stakeholder Perceptions in Indonesia

Anjar Primasetra [a,b,*], Dewi Larasati [a], Surjamanto Wonorahardjo [a]

[a] *Department of Architecture, School of Architecture Planning and Policy Development, Institut Teknologi Bandung, West Java, Indonesia*
[b] *Architecture Department, Faculty of Engineering, Universitas Langlangbuana, West Java, Indonesia*
*Corresponding author: *anjarprimasetra@gmail.com*

Abstract*— Implementing Building Information Modeling (BIM) in Indonesian construction can potentially optimize material resources, labor, and energy efficiency. However, several challenges hinder its effectiveness, including proficiency, standards, policies, infrastructure, and BIM access. This research aims to identify and address factors impeding BIM implementation, providing recommendations for stakeholders to impact the construction industry positively. Conducted through a quantitative approach, the study gathers data online via questionnaires distributed among BIM stakeholders, encompassing practitioners, academics, and government representatives. The data is meticulously analyzed using ANOVA, factor analysis, and factor rotation techniques. The research identifies five key factors contributing to BIM issues in Indonesia based on eigenvalues exceeding 1.0. These factors encompass limited BIM access, challenges in proficiency and mastery, incomplete data on components and materials, inaccessible BIM infrastructure, and restricted collaboration across domains. The users' expectations center around BIM dissemination and standardization, easy data accessibility, establishing a robust Indonesian BIM community, affordability and accessibility of BIM infrastructure, and user-friendly BIM platforms. The anticipated outcomes of this research offer practical implications for the construction industry. These include recommendations for enhanced BIM training, proposing government funding to facilitate companies in acquiring necessary BIM software and hardware, and promoting BIM knowledge through seminars. The overarching goal is to address the identified challenges, fostering efficient BIM utilization in the Indonesian construction industry.

***Keywords*— Building information modeling; factors; implementation; perception; stakeholders.**

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I. Introduction

The development of the construction industry in Indonesia is increasing, in line with the acceleration of development carried out by the government, especially in infrastructure. However, this construction has long been hierarchical and complex, leading to problems such as poor performance, slow progress, and delayed job delivery. Examples of low construction performance, such as poor productivity, low quality of work, and cost overruns, are caused by the lack of interoperability among information data and stakeholders engaged in construction [1]–[4]. Therefore, solving these problems requires strategies to improve the construction industry in Indonesia. One of the strategic solutions that can be taken is the utilization of Building Information Modeling (BIM), which can solve interoperability problems in construction (a collaboration between fields). BIM is widely known as a construction implementation method that can provide a lot of efficiency in terms of material and labor resources and serve as an overview of the energy consumption efficiency of buildings at the initial design stage [5], [6]. BIM has become dominant in the digital architecture trend and transformed into one of the main streams of the current 4.0 construction industry era. BIM can integrate almost all processes in the life cycle of buildings and reach aspects of the sustainability of the built environment [7]–[10].

BIM utilization for construction is growing worldwide nowadays. BIM implementation can be further developed in the future by considering the following factors: organizational culture in construction companies (technology, business processes, and people), education and training in mastering BIM technology (people, training, best practices), information management to facilitate collaboration among information and across fields in construction (people, information formats, quantity, and quality of information) [11], [12]. However, these factors also faced several challenges, so the implementation of BIM did not run smoothly and as expected. For example, the UK faced challenges, including construction industry companies' unfamiliarity with BIM utilization. to replace the old workflow with BIM, insufficient company capital to invest in hardware and software, and inadequate benefits of BIM compared to the costs invested. In the UK, BIM has challenges when it is used to fulfill the housing industry, especially prefabricated housing. The UK government supports prefabricated housing development there, so BIM will likely enter this field to get maximum results. Implementing BIM in prefabricated construction and off-site manufacturing, especially in building componentization, can speed up the production process [13]–[16].

In another country, for example, Ukraine, BIM can also be used for residential renovation projects. Its utilization in home renovation projects positively impacts work efficiency, costs, accurate building model information, schedules, and the detection and elimination of defects [17]. BIM can be used in the construction of mass housing building projects because it affects the processing time, cost, and quality of construction in every building life cycle [18], [19]. BIM can also be applied in logistics design for construction projects or the pre-construction phase with the scope of component dimensions, tools, materials, human resources, cost estimation, and time [20].

The previous research concluded that BIM implementation is influenced by (1) technical factors that are directly related and (2) non-technical factors that are indirectly related to BIM utilization, such as the availability and capability of worker skills, affordability of BIM infrastructure (hardware and software), BIM standards, BIM training to increase resources, and whether there is a client demand for BIM that affects regulations in their implementation. Thus, in this study, there are three types of identification discussed, including:

- Identification of technical implementation conditions, including BIM Maturity Level, LOD implementation, and BIM collaboration interoperability
- Problem identification is used to discover the big picture of implementation problems faced by BIM stakeholders in Indonesia related to non-technical matters such as collaboration issues, management, BIM infrastructure affordability, number of teams, and policies about BIM standards.
- Identification of expectations, including the expectations of BIM users regarding BIM implementation standards, level of BIM mastery, as well as the ease and affordability of BIM access so that BIM development and implementation can be further developed

It is hoped that the findings of the formulation related to the identification of the three things above can be a recommendation for policymakers regarding BIM implementation for construction so that construction in Indonesia can develop better in the future.

II. Materials and Method

BIM implementation in developing countries, for example, in China, is starting lately compared to European countries and the United States. However, stakeholders of the Chinese government, BIM consultants, and the training center are very concerned about BIM development. A series of activities were carried out to develop BIM widely in China, from seminars on BIM, design competitions using BIM, training, and so on. This makes BIM utilization well-development in China [21]–[23]. They also used BIM for prefabricated buildings, which facilitates the process of materialization and componentization [24]–[26].

Not only have developed countries also begun to utilize BIM for the construction industry, but developing countries are also the same. Previous research [27] explained that the use of BIM in several countries with high-income differences (Afghanistan, India, Malaysia, and Saudi Arabia) has five critical overlapping factors, including the availability of standards for implementing BIM, cost-benefit of implementing BIM, stakeholder's willingness to learn BIM methods, consistent views on BIM among stakeholders, and the existence of a standard contract on obligations and risk allocation. In addition, critical factors also often look different at income levels, especially between low and high-income countries, with a significant gap between them. In developing countries, one of which is Indonesia [28], there are five primary challenges in BIM implementation: lack of BIM training, lack of experience, absence of client demand for BIM, high costs, and insufficient information technology facilities. The results showed that 60% of the respondents were unfamiliar with BIM utilization in construction. As many as 70% of respondents only reached BIM level 1, predominantly carried out by the infrastructure sector.

From the results above, many factors are needed, not only through technical aspects related to information technology but also non-technical factors such as human resource factors and the company's affordability in providing infrastructure for BIM implementation. As part of developing countries, Indonesia must consider many important things to implement BIM to develop the construction industry. The BIM utilization trend in developing countries has not been as advanced as in developed countries. The problem encountered was using outsourced IT personnel, and practices such as using 'fake' IT licenses were found to save costs and activate BIM [29]. The level of awareness of BIM utilization in Indonesia is relatively high, but the level of its use is still low. For practitioners, BIM has benefits for performance efficiency in construction, namely time, effort, and cost. Meanwhile, for academics in Indonesia, BIM is practical for modeling, which is also often seen in construction practice in Indonesia [30].

Several factors must be considered in BIM utilization: People, Processes, and Policy [31]–[33]. At least three elements affect the performance of the BIM implementation process in construction activities: BIM maturity level, level of detail (LOD), and BIM interoperability. BIM Maturity refers to the amount of building information provided in a building's life cycle for any purpose of the construction (transporting materials, construction, operation, and demolition). BIM maturity is described in dimensions ranging from 3D to 7D [34]. Level of Detail (LOD) is a code that refers to the extent of the building model and the level of the building design detail. This LOD is distinguished by the numeric code LOD 100 to LOD 500. Meanwhile, BIM interoperability adapts and collaborates between platforms to achieve reliable and efficient construction goals. It can be said that the primary key of BIM is in the interoperability aspect that supports the collaboration process between the stakeholders involved in construction, including collaboration for all construction stakeholders: architects, structural engineers, MEP engineers, building owners or managers, and other stakeholders, such as government and green buildings evaluator [35]. These three elements are essential technical elements to consider in the BIM implementation: BIM Dimension, interoperability, and LOD, which are described in the figure below:

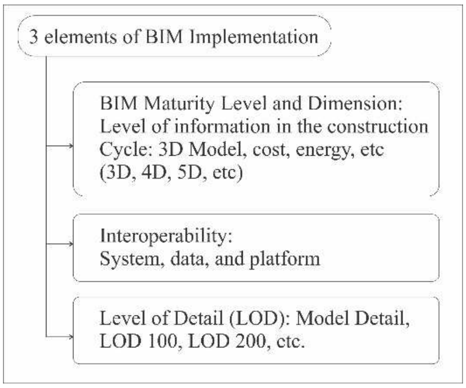


Fig. 1 BIM elements

The BIM implementation impacts the quantity surveyor (QS) profession in many countries, including Malaysia, which will implement it. With BIM level 4D, QS has similarities in communication platforms. This will facilitate the construction process, especially those related to scheduling and calculating future construction costs [36]. The maturity level of BIM does not stop at the 4D level; it can also be upgraded to advanced levels such as 6D and 7D. Level 6D is used to achieve information related to building energy assessments so that architects and planners can identify energy use at the initial design level. The use of BIM for building energy simulation can cut hours of work for workers who operate it. However, the challenge is the limitations and difficulties in skill issues, especially the mastery of the software technology used. In this case, interoperability is essential to integrate BIM with building energy in its life cycle, which is part of the 6D dimensional information [37], [38].

The methods used in this research are as follows:

- Quantitative research, conducted through questionnaires, is based on the content found in the literature study on BIM elements: BIM maturity level, interoperability, and LOD. These BIM elements are translated into questions, including the level of BIM use by respondents, collaboration experiences in BIM, projects frequently undertaken with BIM, and so forth. Additionally, respondents were asked about the problems encountered in using BIM so far and their expectations for BIM development in Indonesia's construction sector.
- Conducting an online survey involves distributing questionnaires through the Google Form platform.
- Data collection that was then analyzed using several analyses distribution, ANOVA, and factor analysis
- Distribution analysis was conducted to map respondents, domicile, income level of respondents, and respondents' backgrounds.
- Data analysis using ANOVA analysis to determine the tendency of respondents' level of BIM maturity related to the dimensions of BIM, the projects they are working on, and the tendency of respondents to the benefits of using BIM.
- Conducting factor analysis to conclude causes and factors of problems using BIM and respondents' expectations of BIM implementation in Indonesia.

III. Result and Discussion

This research is quantitative. The data collected was obtained from a survey through an online questionnaire. The sampling used was purposive/targeted sampling. The targeted respondents were BIM users from various professional circles ranging from Senior Architects, Junior Architects, Drafters, etc. Using a Likert scale of 1-5, the contents of the questionnaire that were asked to respondents consisted of several parts, namely:

- Questions about respondent's attributes related to professional background, income, age, number of work team members, length of work, and home-based residence/domicile.
- The question of how often respondents used BIM for their construction projects. This would later be related to the BIM utilization level or dimensions.
- Questions about the frequency with which respondents used specific BIM software.
- Questions about building components that are often made using BIM
- Questions about respondents' perceptions of the benefits of BIM utilization
- Questions about respondents' perceptions of the problems faced by BIM utilization
- Questions about respondents' perceptions of future BIM development expectations

Respondents who filled out the online questionnaire reached 121 respondents, with the most significant percentage being from a senior architect background. Namely, 26% and 17% of the total respondents were contractors. In terms of domicile of respondents, most of the respondents lived in Java (82%), while the fewest were from Bali or Nusa Tenggara, which was 2% of the total respondents.

In addition, they were also asked about the number of people in the work team and the respondents' income to observe the background trend of respondents who are accustomed to using BIM. Hence, it can illustrate the relationship between the number of work teams and BIM utilization and the relationship between respondents' income and the tendency to use BIM. Most respondents were from a group of five people, as much as 45%, and from a work team group, with a total of 5-15 people in a work team, as much as 36%. Meanwhile, based on the respondents' income attributes, the highest number who filled out online questionnaires were from the income group of 6-12 million Rupiah, as much as 35%. Regarding using BIM for specific purposes, residential projects were the most frequently undertaken projects, with the highest average score of 3.21. Infrastructure projects had the lowest value, with a score of 2.34. The following is a graph showing the use of BIM for a particular project based on respondents' choices:

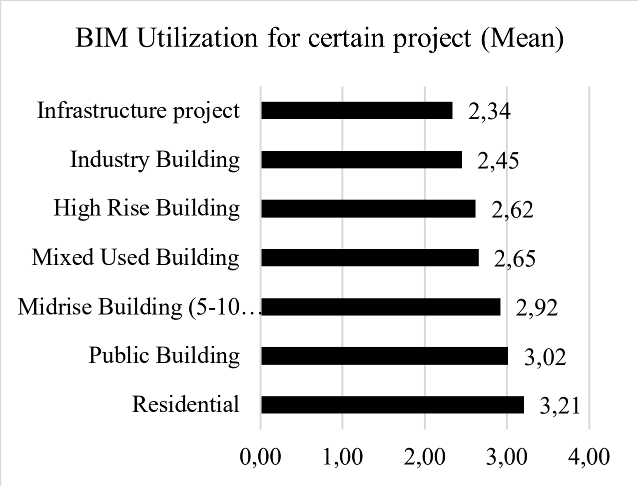


Fig. 2 Distribution Graphic of BIM utilization for a specific project

The aspect of BIM maturity level is also a question in the questionnaire. The questions related to the BIM maturity level were intended to determine the respondents' perception and the depth of their experience using BIM for construction. The highest average score for respondents' choice was at BIM maturity level 3D for conceptual design and DED, with an average value of 3.63 and 3.77. At the same time, the lowest value was at BIM level 7D for facility management, which was 1.92. Meanwhile, the 6D BIM used to convey building energy information had a low average value of 2.17. This may indicate that respondents' perceptions related to the experience of using BIM were still limited to the 3D level BIM. In contrast, the use of BIM for building energy at the 6D level has not been widely used. The following is a table that explains the average value of respondents' choices related to the BIM maturity level based on the respondent's primary background:

TABLE I
MEAN ANOVA OF RESPONDENTS' CHOICE RELATED TO BIM MATURITY LEVEL

No	Respondent's Background	BIM 3D-Conceptual Design	BIM 3D-Detail Engineering Design	BIM 4D	BIM 5D	BIM 6D	BIM 7D
1	Junior Architect	3.6	3.9	2.5	2	1.6	1.8
2	Senior Architect	3.1	3.2	2.2	1.8	1.9	1.6
3	Other central (civil engineer and mechanical engineer)	4	3.5	2.4	2.4	1.8	1.3
4	Lecturer or researcher	3.5	4	2.8	1.8	2.3	1.7
5	Draftsman	4.1	4.2	3.2	2.2	1.8	1.7
6	Contractor	3.7	4	3.5	3.3	2.1	2.2
7	Architecture Student	3.7	4.1	2.6	2.5	3.2	2.7
8	Government	3	3.1	2.6	2.7	2.3	2.1
	Mean	3.6	3.7	2.7	2.3	2.1	1.9

Based on the previous study, BIM's maturity level can be increased by maximizing BIM interoperability since it makes a straightforward calculation of a material's carbon emission value and makes it possible to create effective design alternatives. The BIM software materials database helps architects assess carbon emissions quickly and efficiently [39]–[41]. BIM 6D can also integrate the green building assessment process into the design process. The method was used to apply BIM appropriately, good collaboration between stakeholders, change the green building rating tool to match BIM, provide material data that can support the assessment of green buildings, provide good project examples that can be followed, and provide a full mandate in the use of BIM for all construction stakeholders [42]. 6D BIM information can also be integrated into the development of interoperability using a plugin to calculate the carbon emission value of building design materials and combined with the green building rating tool [43]–[45]. The BIM dimensions associated with the building design phase mostly relate to Cost (5D dimension), sustainability and building energy (6D dimension), and traditional 3D modeling. The factors that influence the BIM maturity level in Indonesia are policymakers' commitment, systems and infrastructure development, and the quality and capability of experts [46], [47]. These aspects can be said to be non-technical aspects not directly related to the BIM implementation in construction. BIM frameworks for running performance construction protocols consist of BIM fields, maturity stages, and lenses. Field: players (including policy, technology, and process). Maturity stages: BIM level. Lenses: relating to data information and analysis that can present a specific view of knowledge [48], [49].

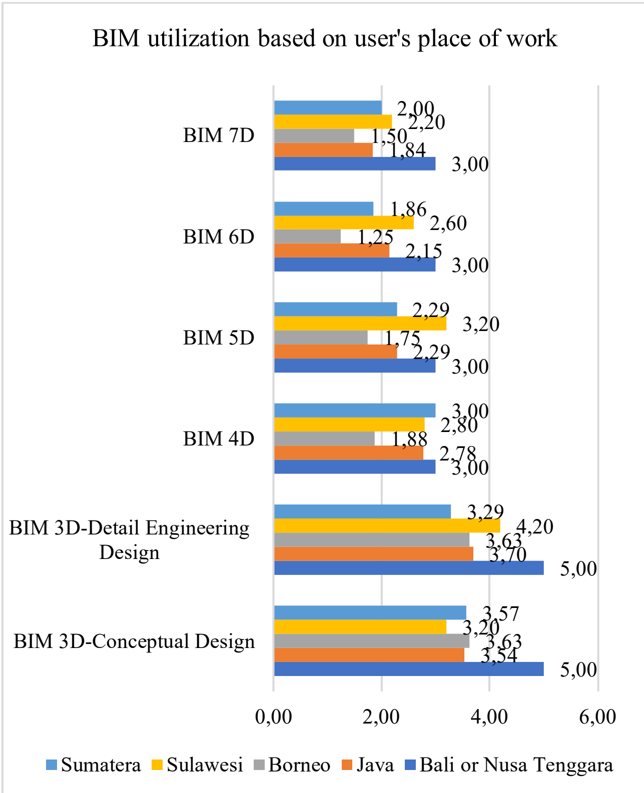


Fig. 3 BIM utilization based on the user's domicile.

From Table 1 above, the tendency of BIM level 3D (conceptual and DED) based on respondents' perception has a high level of tendency (value >4) in the options chosen by almost some respondents with various backgrounds. However, senior architects have a low preference for 3D-level BIM. This shows that using 3D BIM was not an option for respondents with an old architectural background. For BIM level 6D, related to building energy efficiency, students, lecturers, and researchers chose the trend the most. This may be linked to lecturers' assignments or research development related to BIM. Respondents other than students and lecturers/researchers had low scores and preferences for BIM level 6D, with an average score below 2. This would undoubtedly be a good development for the use of BIM level 6D for simulating buildings' energy efficiency.

Aspects of BIM maturity level was also analyzed based on the domicile of the respondents where they work, as in Figure 3. Most of them, especially those from Java (82%), had the highest average BIM level 3D used for DED purposes, while at the advanced BIM level 6D-7D, the lowest average scores were 2.15 and 1.84. Meanwhile, the intermediate BIM maturity level based on domicile with the highest score was BIM 3D-DED with a value of 3.96, and the lowest was BIM 7D with a score of 2.11. Interestingly, BIM users in Java, whose construction projects were more developed than those on other islands in Indonesia, still have an underdeveloped (3D) level of BIM usage. In fact, on the one hand, BIM users on the island of Java should be able to encourage the development of BIM usage for construction so that it is more widespread in Indonesia. In addition, BIM can be promoted to be utilized further with a higher dimension level so that the implementation of construction industry activities, especially in building energy efficiency and conservation, can develop properly. The following is a graph that shows the average value of BIM users based on their domicile as seen from their BIM maturity level:

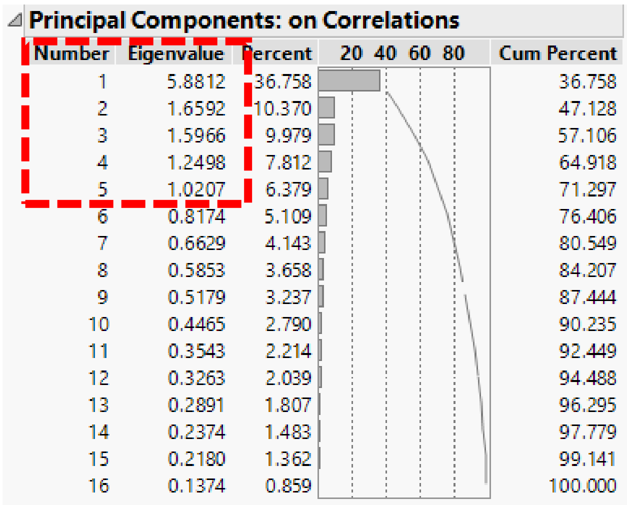
The correlational value of the BIM maturity level on the project being worked on is also seen from the data obtained. The table below describes the correlation value between the BIM maturity level and the projects the respondent has worked on:

TABLE II
THE CORRELATION VALUE OF BIM MATURITY LEVEL AND PROJECT

Correlation (Project-BIM Level)	BIM 3D-conceptual design	BIM 3D-DED	BIM 4D	BIM 5D	BIM 6D	BIM 7D
Mid-Rise Building (5-10 Stories)	0.47	0.43	0.40	0.35	0.36	0.28
High-Rise Building	0.33	0.33	0.34	0.36	0.34	0.24
Residential Building	0.47	0.45	0.38	0.18	0.21	0.09
Mixed Used Building	0.39	0.41	0.38	0.32	0.22	0.22
Infrastructure Project	0.29	0.38	0.49	0.56	0.39	0.44
Industry Building	0.37	0.36	0.33	0.49	0.29	0.35
Public Building	0.38	0.47	0.48	0.34	0.37	0.35

From Table 2, the most significant correlation value in the 3D-conceptual BIM implementation is in mid-rise and residential building projects, with a value of 0.47. The most considerable correlation value in BIM-3D DED is in public building projects, with a value of 0.47. In BIM 4D, the most significant correlation value is in infrastructure projects, 0.49. BIM 5D is an infrastructure project. Meanwhile, the correlation value in BIM 6D and 7D has the smallest correlation value below 0.45. There are indications that 6D and 7D BIM dimensions have not yet been developed for use in the implementation of construction projects.

The online questionnaire also asked about the problems respondents faced in utilizing BIM for their construction projects. The questions were submitted using a Likert scale with a score of 1-5. Those questions included issues related to the use of BIM, which were linked to user skills, hardware and software problems, collaboration between fields and BIM components, BIM management, and issues of affordability to access BIM data information. The results were then analyzed using multi-variate correlation analysis assisted by JMP statistical software. The next phase was to perform a principal component analysis. From the results obtained from the study, it was found that five points had an Eigenvalue of more than 1. This indicated that there may be five factors causing problems in using BIM in Indonesia. The following is graphic data from the principal component analysis, which is the basis for compiling a factor analysis to determine the causes of problems in the use of BIM in Indonesia:


Principal Components: on Correlations

Number	Eigenvalue	Percent	Cum Percent
1	5.8812	36.758	36.758
2	1.6592	10.370	47.128
3	1.5966	9.979	57.106
4	1.2498	7.812	64.918
5	1.0207	6.379	71.297
6	0.8174	5.109	76.406
7	0.6629	4.143	80.549
8	0.5853	3.658	84.207
9	0.5179	3.237	87.444
10	0.4465	2.790	90.235
11	0.3543	2.214	92.449
12	0.3263	2.039	94.488
13	0.2891	1.807	96.295
14	0.2374	1.483	97.779
15	0.2180	1.362	99.141
16	0.1374	0.859	100.000

Fig. 4 Principal Components: Correlation Analysis of BIM Utilization Problem

The Principal Component analysis graph data becomes the basis for the next step: factor analysis. From the existing unit of study, it was reduced to five major factors. These five prominent factors were grouped by looking at the results of the factor correlation value above 0.5 because the closer to the value 1, the correlation value of these factors has a significant correlation between units of analysis. The results of the factor analysis carried out based on five eigenvalues, which show a number more than 1, are described in the table below:

TABLE III
RESULTS OF FACTOR ANALYSIS OF BIM UTILIZATION PROBLEMS IN INDONESIA (FACTOR ROTATION BY CORRELATION VALUE)

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Limited access to software	0.8	0.05	0.02	0.18	-0.08
Software training is limited	0.7	0.1	0.21	0.07	0.13
High difficulty of Software used	0.7	0.18	0.18	0.09	0.21
The flexibility of the software is limited	0.04	0.8	0.14	0.15	0.04
BIM Model data is complex to export to other model formats	0.07	0.84	0.20	0.16	0.09
Lack of skill	0.3	0.65	0.08	0.17	0.15
Lack of manufacturing data	0.07	0.09	0.87	0.08	0.08
Lack of material data	0.03	0.04	0.84	0.24	0.14
Slight component variation	0.3	0.42	0.61	-0.04	0.04
Lack of components between software	0.3	0.34	0.60	0.04	0.25
Hardware is not affordable	0.09	0.22	0.05	0.79	0.21
Software is not affordable	0.2	-0.03	0.31	0.66	-0.001
Hardware less reliable	0.05	0.45	0.04	0.65	0.02
Not ready for collaboration	-0.01	0.04	0.29	0.13	0.84
Difficult collaboration between fields	0.5	0.34	0.07	-0.05	0.60
Difficult mastery by other fields	0.45	0.09	0.01	0.33	0.50

From the factor analysis table above, five factors are formulated that cause problems with the use of BIM in Indonesia:

TABLE IV
SUMMARY OF FACTOR ANALYSIS OF BIM UTILIZATION PROBLEMS

5 Factors of problems of BIM utilization in Indonesia	Keywords
Limited Access	Access
Lack of BIM skill	Skill
Limited completeness of BIM component and material data	BIM Data
Inaccessibility of BIM infrastructure	BIM Infrastructure
Collaboration is limited	Collaboration

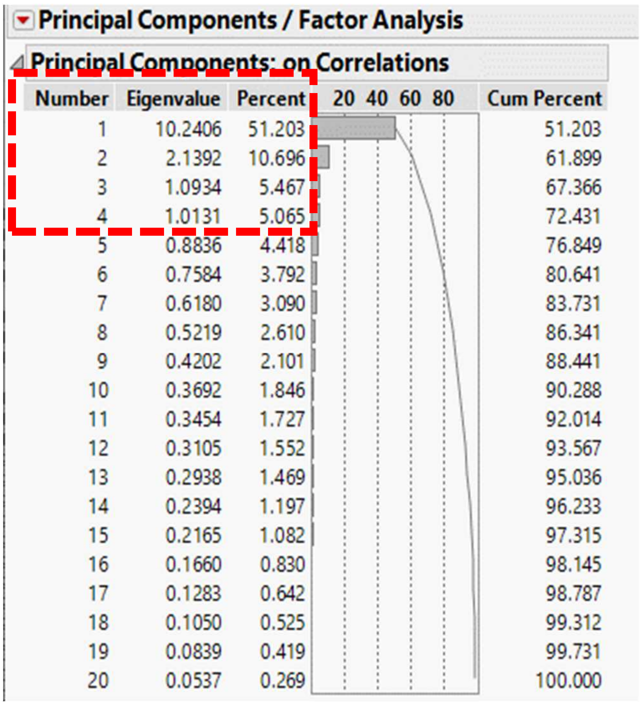
The five factors mentioned above can be the basis for construction industry stakeholders in formulating problems and solutions that have practical implications for the development of the construction industry ecosystem in Indonesia, for example, by creating BIM communities and forums between the government and the private sector to solve problems of access to the use of BIM, improving worker skills, centralized BIM data sharing, and also trying to solve BIM infrastructure problems such as limited access to software licensing and hardware upgrades. Thus, the implementation of BIM in the Indonesian construction industry will be better.

The problem factors of BIM implementation were in line with previous research stating that the problem of implementation of BIM in addition to the previously mentioned technical factors including (1) “perceived usability,” (2) “speed of BIM tools,” (3) “perceived benefits of BIM for the organization”, (4) “technology quality,” and (5) “experience and skills” [50], [51]. In addition, the most crucial Critical Success Factors (CSF) in BIM utilization are phasing and construction simulation at the 4D level, collision detection, support from top management, accurate design visualization, and improving construction project performance [52]. BIM is a new concept in construction that requires development in technical and non-technical issues; therefore, many parties still doubt the ability of the BIM concept to match the description given in addition to investment issues in hardware, software, and worker skill [53]. BIM can cause problems in construction activities. As mentioned by the researchers, the 7 Deadly Sins in BIM utilization are techno centricity, Ambiguity, Elision, Hypocrisy – the IPD (Integrated Project Delivery) excuse, Delusion, Diffidence – denying the need for process change, Monodisciplinary [54].

Based on previous research, other challenges in BIM utilization were conservative attitude, hardware software cost investment, and limited knowledge and experience, causing a low level of BIM maturity [55], [56]. Previous research concerning BIM implementation focused more on non-technical matters such as culture in working within the company, knowledge, experience, and so on. The barriers found in the BIM implementation by researchers, namely cost, legal, expertise, interoperability, awareness, culture, process, management, demand, project scale, technology, skills, training, contracts, and standards [57]–[59]. BIM utilization requires the development of reliable tools for exchanging information between multi-platform and majors but must still collaborate. Interoperability and collaboration have become very important [60].

In addition to the problem of using BIM, the respondents were asked questions on a Likert scale by choosing a score of 1-5 about their expectations for the development and utilization of BIM in Indonesia. The questions were related to respondents' expectations of BIM implementation standards, expectations related to ease of access, ease of collaboration, the BIM community, and BIM certification in Indonesia. Four Eigenvalue points had a value greater than one from the analysis process. This then became the basis for making the factors evolving respondents' expectations for the development of BIM implementation in Indonesia. The following graph shows the list of principal components with an Eigenvalue of more than 1.

Similar to the problematic factors of BIM implementation, the expected BIM factors were determined through principal component analysis by examining correlation values exceeding 0.5 and organizing them based on the proximity of the keywords identified from the questionnaire results. Four expected BIM development factors were identified: BIM standards, access and community, infrastructure, and skills. These four keywords form the foundation for developing the expectations of BIM users in Indonesia, ensuring proper development of BIM. The following presents the results of the analysis of BIM users' expectation factors based on the collected questionnaires:



Principal Components / Factor Analysis

Principal Components: on Correlations

Number	Eigenvalue	Percent	Cum Percent
1	10.2406	51.203	51.203
2	2.1392	10.696	61.899
3	1.0934	5.467	67.366
4	1.0131	5.065	72.431
5	0.8836	4.418	76.849
6	0.7584	3.792	80.641
7	0.6180	3.090	83.731
8	0.5219	2.610	86.341
9	0.4202	2.101	88.441
10	0.3692	1.846	90.288
11	0.3454	1.727	92.014
12	0.3105	1.552	93.567
13	0.2938	1.469	95.036
14	0.2394	1.197	96.233
15	0.2165	1.082	97.315
16	0.1660	0.830	98.145
17	0.1283	0.642	98.787
18	0.1050	0.525	99.312
19	0.0839	0.419	99.731
20	0.0537	0.269	100.000

Fig. 5 Principal Components: Correlation Analysis of BIM Utilization Expectation

TABLE V
RESULTS OF FACTOR ANALYSIS OF BIM UTILIZATION EXPECTATIONS IN INDONESIA (FACTOR ROTATION BY CORRELATION VALUE)

Variables	Factor 1	Factor 2	Factor 3	Factor 4
Use of standard BIM output	0.87	0.14	0.13	0.17
Use of BIM standard	0.85	0.15	0.22	0.16
Application of BIM in all fields of construction (Architecture-Civil-MEP)	0.70	0.26	0.22	0.22
Equitable use of BIM	0.64	0.20	0.55	0.14
Legal and recognized BIM expertise certification	0.63	0.26	0.60	-0.003
Easy access to local BIM data	0.24	0.76	0.19	0.09
Easy collaboration in BIM components	0.01	0.74	0.25	0.35
Accessible and affordable BIM collaboration platform	0.05	0.73	0.29	0.29
Easy access for all people	0.27	0.70	0.08	0.19
Solid BIM community	0.30	0.70	0.14	0.34
Legal Aspects of BIM	0.41	0.69	0.11	0.03
BIM training affordability	0.29	0.17	0.79	0.16
Easy access to BIM training	0.43	0.20	0.75	0.18
Cheap hardware and software	-0.005	0.41	0.60	0.40
Ease and affordability of BIM certification	0.55	0.26	0.60	0.15
Easy to get software	0.27	0.12	0.08	0.76
Ease of use of BIM software	0.16	0.32	0.13	0.75
Reliable hardware in operating software	0.04	0.45	0.33	0.55
BIM component variations	0.48	0.32	0.24	0.44
Easy access to various BIM components	0.45	0.37	0.24	0.44

From the analysis of the factors above, the factors and keywords that represent expectations for BIM users in Indonesia are compiled and described in the table below:

TABLE VI
SUMMARY OF FACTOR ANALYSIS OF BIM UTILIZATION EXPECTATIONS

5 Factors of Expectation of BIM Users in Indonesia	Keywords
Equitable standards on BIM utilization in Indonesia	BIM Standards
Easy access to BIM data and a solid BIM Community for easy collaboration	Access Community
Affordability and ease of access to BIM infrastructure	BIM Infrastructure
Ease of operation of BIM (Software and components)	Skillfulness

IV. CONCLUSION

The study's results found five keywords related to the factors that pose challenges in BIM implementation in Indonesia. Meanwhile, four keywords are linked to the expectations of BIM users or stakeholders in Indonesia. This finding is crucial as a recommendation for policymakers to promote the use of BIM in Indonesia's construction sector.

The following contribute to the practical implication for the construction industry based on the policies: Establishing a standard for BIM utilization in the construction industry in Indonesia is essential. Although BIM has been regulated in the ministerial regulation of the Public Works and Housing Ministry of Indonesia (PUPR), the implementation procedures have not been detailed. Steps related to this standard include setting clear guidelines, specifying the required outputs, defining stages, outlining project criteria, and so on.

Provide ideas for the government to support the establishment of BIM funding, offering loan support for companies developing BIM for construction activities. Developed countries, such as Singapore, have implemented BIM funding support to boost the construction industry's development in construction projects, paving the way for a better future. Indonesia should consider adopting a similar approach to develop BIM funding.

Ensure easy and affordable BIM training and certification. The government and the local BIM community should initiate widespread promotion of BIM training and accreditation to cultivate a larger pool of BIM modelers and BIM engineer experts. This approach will result in a broader impact on the application and utilization of BIM in construction projects across Indonesia. Training and certification play a crucial role in fostering the adoption of BIM in Indonesia, particularly among users residing outside Java, where the percentage is currently low.

Ensure easy access to BIM material and component data. In this regard, it is also necessary to establish an open-source platform that all groups can utilize. The open-source BIM platform can serve as an alternative solution to the problem of inaccessibility related to BIM infrastructure, such as software and hardware.

A robust BIM community will serve as a forum for developing BIM implementation in the future. This community will contribute to fostering a healthy BIM ecosystem, enhancing collaboration in BIM usage in the years to come. Creating a BIM community is one way to address collaboration challenges, and in Indonesia, such a community has been established under the name IBIMI (Indonesian BIM Institute). However, the community's effectiveness can be further strengthened by reaching a broader audience and collaborating with the government to expand its network. Additionally, the BIM community can engage with academia to advance knowledge about BIM and develop programs for BIM education, ensuring more practical use in the future.

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