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BIM Implementation for Storing, Sharing and Capturing Knowledge in Indonesian Project Construction

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ABSTRACT

BIM as a digital representation of assets has been used to facilitate design, construction, and operation process to form a reliable basis for decisions. While knowledge is part of the company's assets, knowledge will be maintained in the system so that it may be recalled if needed if BIM is used to document, store, and distribute knowledge more easily. This study will determine how BIM adoption supports knowledge storage, knowledge share, and knowledge capture in Indonesian construction projects. Data was obtained by interview and analysed using qualitative method. The results showed that large state-owned construction companies in Indonesia had implemented BIM-based knowledge management to assist organisational knowledge management process, especially in knowledge capture, storage and share on several projects, and reduce knowledge loss due to time lapse. Finding also shows that knowledge created in a project is centralised in one model, and lessons or knowledge can be grouped with BIM user preferences.

1. Introduction

BIM is an architecture, engineering, and construction technology that simplifies processes and creates computer-generated models to simulate all processes from any given facility, such as those in planning, designing, building, and operating [1]. The code of ethics also anticipates the contribution of future research. There is greater space for future research development in BIM-based Knowledge Management since it is more profitable than Knowledge Management built on TI.

According to Meadati and Irizarry, BIM can be described as a key understanding. Some researchers are considering developing a foundation for knowledge that is tied to the BIM model to expand knowledge to address this problem. A few researchers have identified representations of conceptual knowledge based on ontologies to facilitate conceptual knowledge processing in BIM environments [2], [3]. CBR and RBR can be used for BIM-related knowledge elicitation [4]–[7].

In the context of BIM, parametric modeling using 3D graphics provides the opportunity to capture domain knowledge and transfer it to geometric expression. BIM is not just limited to 3D; it also includes documentation, alphanumeric, and geometrical information. Wang and Leite developed the KM prototype system, which allows for the tag-

shaped imprinting of knowledge acquired during the rapid coordination of mechanical, electrical, and plumbing design. Some studies on KM that are embedded in BIM connect BIM to a web-based system or a lightning-fast network for knowledge sharing [8]–[10].

Because understanding is best expressed in the form of BIM parameters that are agreed upon [11], project holders can communicate understanding through parameters while working collaboratively on a fully developed and integrated BIM model. Due to this, this study aims to identify BIM users who can facilitate Knowledge Capture, Knowledge Storage, and Knowledge Sharing for Indonesian construction projects.

2. Literature Review

The most recent research on KM in the BIM environment has focused on one specific stage of the life cycle of a construction project. For the design phase, [12] integrated two KM applications, RECALL and TalkingPaper, Utilizing BIM software to support digital documents, paper documents, and speeches to facilitate the knowledge capture process. To capture verbal knowledge about the energy building from the energy manager, [13] integrated the dialog verbal system with the BIM model. In particular, [14] emphasized the need for a system that could be used to capture knowledge acquired

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during the rapid coordination of MEP design to integrate BIM with software KM seamlessly. In this system, tag equipment is primarily used to facilitate learning.

Case-based reasoning (CBR) and rule-based reasoning (RBR) can be used to evaluate the knowledge that is flawed by BIM [4]–[7]. Mikulakova et al. outline the KM system for creating and evaluating a plan while utilizing CBR in a BIM environment. IFC serves as an information dissemination and understanding platform between BIM models and the basis for law. Zhang et al. developed a system for managing resources based on natural resources in a BIM context. The two systems in use also employ BIM visualization to display checking results that help articulate a point. According to Meadati and Irizarry, BIM can be characterized as a key concept. A few academics have suggested developing a foundational understanding of knowledge that is related to the BIM model to expand knowledge to address this problem. BIM models' parametric components can be viewed as tools for capturing and preserving knowledge, and this sort of knowledge can subsequently be exported to an external database for sharing and communication [15], [16].

Understanding the information given without regard to its context, especially when it comes from different project organizations [17]. Ho et al. built a BIM-enabled KM system for 3D visualization of knowledge based on experience to address this issue. The system uses AutoDesk Inventor to create BIM-based animations that allow users to understand and apply knowledge visually. A few researchers have acknowledged using representations of knowledge based on ontologies to facilitate the return of knowledge-based processes to BIM environments [2], [3]. For instance, the system developed by Motawa and Almarshad uses BIM knowledge as its foundation. Basis knowledge can be gained using the BIM model with the IFC standard. For the construction phase, Park et al. integrated BIM, augmented reality (AR), and ontology to aid in information gathering, understanding, and application, as well as an AR-based inspection system to enable management of the active phase of the construction phase.

Most of previous studies on KM based BIM are focusing on using BIM to facilitate capture, storage, sharing, and reuse of knowledge. However, Indonesia has a lot of ongoing research about KM based on BIM. In addition to that, since the Indonesian government's adoption of Permen PUPR 22/2018, all government buildings in the country that are not exceptionally sturdy are required to use BIM. Permen PP No. 16 for 2021 contains the obligation to use BIM at least up to the fifth dimension for the method of implementing technology-intensive building construction. It is obliged to use BIM up to the eighth dimension for the method of implementing capital-intensive building construction. Companies should take action with change when such a situation exists. Indonesian builders must first put themselves to adopt the most recent technologies in digital building.

3. Methodology

The methodology used in this study is a bibliography review and structured interviews. To address the question of how to implement BIM to facilitate information capture, knowledge storage, and knowledge sharing to support the

findings of this investigation, a bibliography review has been contributed, which can be seen in [Table 1](#). A survey was conducted in Indonesia regarding another BUMN contractor certified in ISO 19650.

Data was obtained by interviewing eight respondents and analysed using thematic analysis. Nvivo 12 Program 12 was used to analyse data since it is suitable to assist qualitative type analysis. By utilizing the Nvivo 12 Plus program, the interview quality assurance data was obtained. NVivo assists in organizing these data sources within the software, making it easy to access and manage, NVivo also supports thematic analysis, where researchers identify and analyze recurring themes and patterns in the data and provides various tools for coding and analyzing qualitative data. Data was coded based on themes, topics, or patterns, making it easier to identify trends and insights; NVivo simplifies the qualitative research process, saving researchers time by automating data coding, sorting, and retrieval tasks.

The respondents were chosen based on purposive sampling technique, since it is suitable specific considerations by the desired criteria to determine the number of samples to be studied [18]. The use of purposive sampling in this study aims to discover how BIM can facilitate knowledge capture, storage, and knowledge sharing in state-owned construction contractors with ISO 1960 BIM in Indonesia. The goal of qualitative research is to explain a phenomenon using multiple data points that are also multiple data points, emphasizing the significance of the underlying structure and specifics of the data that was collected. This study's kind of qualitative research methodology is called case study research. Case study research is done on any given piece of software, be it a program, a project, an experiment, a group of people, or any other set of circumstances or conditions

4. Result and Discussion

There is little information about ISO 19650-certified contractors has been published. Therefore, estimating the number of respondents and potential contractors for survey research is challenging. Because of this, researchers are considering using koranbumn.com and LinkedIn websites, which provide news and information about SOEs and business-oriented social media sites. To find contractors that comply with the ISO BIM standard, use the keyword 'ISO 19650.' Further results were obtained from ISO 19650 SOEs. Many experts are employed as BIM Engineers at PT. A, PT. F, PT. H, PT. I, Directors at PT. B, BIM Modelers at PT. C, PT. D at VP-EBIM, and BIM Junior Experts at PT. G ([Table 2](#)).

4.1. BIM – Based Knowledge Capture

The eight interviewees were interviewed in stages during December 2022, each lasting about 1-2 hours, this is because of limited time, budget, and the ability of researchers to affect the size of the research sample. Small sample due to limited resources, the number of BUMN contractor resource persons who have experience implementing BIM and KM in construction projects. Questions on knowledge capture, storage, and sharing, as well as previous literary research, were gleaned from previous researcher analysis results. Knowledge capture can be done in various ways, according to the interview results analyzed in [Figure 1](#) from the previous

Table 1. List of BIM implementation questions facilitating knowledge capture, knowledge storage, and knowledge sharing

No	Question	Literature Source
BIM-based Knowledge Capture		
1	BIM is a tool teams and enterprises can utilize to leverage their expertise by recording, sharing, and reusing knowledge in addition to data and information.	[12]
2	Construction companies use the BIM ecosystem to save information through a few plug-ins or a web-based solution.	[9]
3	Construction companies use BIM to apply parameters in BIM models using external apps or web-based systems by capturing knowledge through APIs.	[14]
4	The construction business sets appropriate criteria to enable the BIM model to capture knowledge about an object or a project.	[15]
BIM-based Knowledge Storage		
5	Construction companies have already embraced BIM as a fundamental understanding tool.	[15]
6	Building Information Modeling (BIM) is promoted by construction businesses as a knowledge source for learning about building projects.	[15]
7	To identify all the technical and maintenance information of the building, including the information on building elements connected to the components maintained, the construction business utilizes project information, and the elements already saved by the BIM module will be obtained.	[6]
8	The construction industry uses effective BIM technologies as a repository of information that may provide information in a consolidated, global context.	[11]
9	Construction companies use BIM to automatically enhance constructability, decrease construction duration, and lower construction costs.	[4]
BIM-based Knowledge Sharing		
10	Construction companies utilize BIM to represent knowledge and make it easier to retrieve knowledge.	[2]
11	IFC guidelines state that the aim for construction companies is to inform clients of the BIM model.	[6]
12	Building information modeling (BIM) is used by a construction organization to inform procedures, knowledge acquisition, processing, evaluation, and visualization.	[19]
13	Construction companies may readily access error management information using the building fault data in the BIM.	[3]
14	When a contractor evaluates a design feature in a 3D model that is compliant with BIM, the risk identification system that construction companies employ that is connected with BIM is helpful for automatically detecting risk.	[20]
15	Construction firms utilize BIM software to share design and engineering knowledge effectively.	[10]
16	Construction organizations utilize BIM in real-world projects that need expertise and cooperation to improve organizational participation in the purposeful pursuit of knowledge-sharing and provide knowledge-sharing work tools.	[21]
17	Building businesses combine BIM and CDE to make accessible repositories and data-sharing platforms available to support collaborative work on construction projects.	[22]
18	BIM is used to share knowledge among various project phases.	[22]

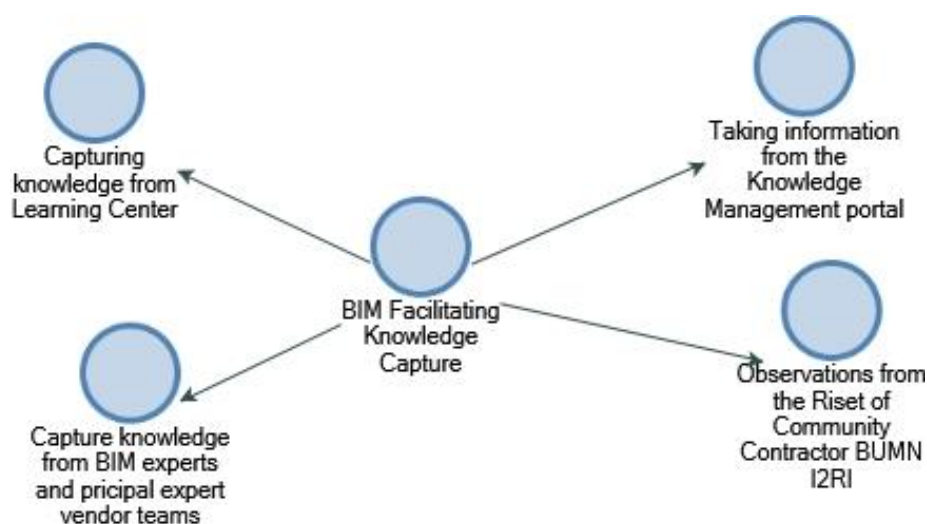


Figure 1. NVivo 12 Plus analysis results on the use of BIM facilitating knowledge capture

Table 2. Resource Person Profile

	Company	Position	Work Experience
Interviewee 1	PT. A	BIM Engineer	5 Year
Interviewee 2	PT. B	Directors	13 Year
Interviewee 3	PT. C	BIM Modeler	7 Year
Interviewee 4	PT. D	VP EBIM	15 Year
Interviewee 5	PT. F	BIM Engineer	5 Year
Interviewee 6	PT. G	BIM Junior Expert	5 Year
Interviewee 7	PT. H	BIM Engineer	8 Year
Interviewee 8	PT. I	BIM Engineer	4 Year

paragraph. The most prevalent knowledge transfer comes from the BIM Expert and Expert Team of Principal Vendor BIM, followed by the Riset Community of Contractor BUMN I2RI, with each individual using the company's knowledge management and learning center. This indicates that information capture can be carried out with the aid of a BIM specialist, a research and knowledge management portal, or a company learning center.

Anyhow, here are some quotes from BIM experts who support knowledge capture:

"We also attempt to start BIM at the contractor, and go to the expert, and typically it's from the primary vendor, to invite a team of specialists for the commencement of the dialogue."

(Interviewee 1).

"We have the name KM portal (<http://knowledge.brantas-abipraya.co.id/>), and this KM portal has a section dedicated to innovation, which we manage in BIM and in the innovation dashboard at CDE." (Interviewee 2)

"There is a term for administration, there is SAP, and that pack also uses Tilos for the timetable, but for me now again, the pack is also studying BIM with ISO 19650 standards."

(Interviewee 3)

"We have a sort of energy department or section here, called the Nindya Learning center, which you may access through its website." (Interviewee 4)

"Typically, it comes from the central team; in the heart of our corporate headquarters, there is a language that controls it. If so, we have a dashboard that is kind of like our own. It may be possible to describe it as a form of internal PP team knowledge management." (Interviewee 5)

"In our office in Waskita Karya, we have a department that focuses on this particular area of knowledge, and we've just started talking about it. It's also new in other karya karyas, too. And if there is a department riset in another BUMN karya, then we will be a part of the ministry of BUMN community. I2RI (Indonesia Infrastructure Research and Innovation Institute)."

(Interviewee 6)

"BIM is capable of capturing data on a global scale, but it is required that at least one person be willing to report it."

(Interviewee 7)

"BIM has undergone recent innovation, and Wika Tbk has a BIM research division that is more focused on knowledge management." (Interviewee 8)

In Figure 2, it can be seen that understanding is being conveyed slowly by using a few methods that are most commonly used with the help of the common data environment (CDE). This is because CDE data is used for

processes such as transmittal, approval, and uploading other data during construction, as well as for main maps of work processes that use BIM and for later processes such as clash detection and LoD BIM from the initial phase.

Any suggestions from experts on BIM that involve enabling knowledge capture indefinitely or in real time across work processes, such as the following:

"BIM is a new field of study due to the digitalization of construction projects, thus it is likely that people who are hilarious with technology and want a bright future with technology are required. Therefore, every type of building and every parameter that must be modelled cannot be the same. But perhaps you can build the Main map process from scratch."

(Interviewee 1)

"Therefore, if we utilize CDE. Data mining for a corporation will be created using the information gathered from various projects." (Interviewee 2)

"Therefore, using LoD and compiling it at the start first, I typically arrange it first in excel, for in shopdwing LoD is not very widely used, which uses LoD a lot in As Built Drawing for example concrete work is done by whom, by the main contractor or subcontractor, the source of the concrete is from which bathing plant." (Interviewee 3)

"There's something that you don't know in the detecting class, but in the field it turns out, oh there's something new so it has to be captured so that information has to put into the latest model." (Interviewee 4)

"The job scheduling team, perhaps, if the owner signifies that the owner occasionally prefers to not go right into the field. Normal modeling and mapping are done after previous work has been completed. Now that's delivery in real time."

(Interviewee 5)

"This is still being looked into for both my research and the BIM research. For instance, I attempted to determine how much opnam costs utilizing the free use of excel on Google Apps yesterday. Then later what sort of information is now the opnam so next we capture we write the volume that comes how many are installed how much later it is integrated." (Interviewee 6)

"Go back if real time wants it to be real-time, it's BIM. If I'm not mistaken, there is also a CDE, and yes, we also have cloud data available that we're confident we can input some or a lot of, and everyone may use it by his access." (Interviewee 7)

"According to the requirements of the evaluation, "we employed the safety of using CDE (common data environment). For instance, if it is now widely recognized, Autodesk Construction Cloud and has incorporated with construction Build and construction documents." (Interviewee 8)

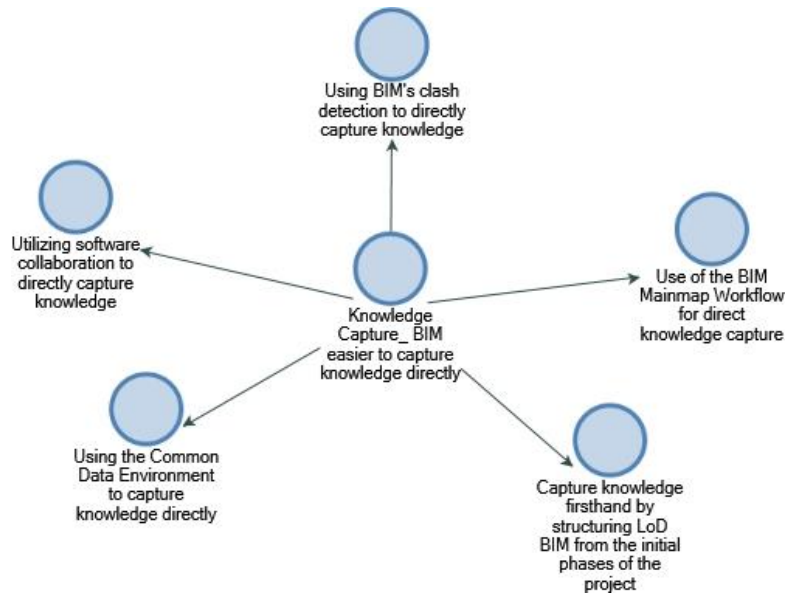


Figure 2. Nvivo 12 Plus analysis of how BIM is used during the project work process makes it easier to capture knowledge directly or in real time.

Figure 3 illustrates the response from the Interviewee, demonstrating how BIM may benefit from the outcomes of collecting the registered knowledge by including 3D data into the documentation snapshot, BIM uses the registered knowledge based on the unique characteristics of each project worker.

Any suggestion from a BIM-related expert can benefit from the following body of knowledge:

"It can be quite likely, in my opinion, but it depends on the data, like I said, it depends on the project's support, and it also depends on the capability of the person in charge of implementing BIM in the project." (Interviewee 1)

"Yes, we can since we can insert 3D data into the photo documentation so, if necessary, the documentation will emerge as proof that it has been done with the identity of the date and other information existing." (Interviewee 2)

"Yes, sir, but since VR hasn't been utilized much, it's difficult to know if it can be employed in current projects from previous ones." (Interviewee 3)

"It could, but only as a control, with project and procurement department changes. If the situation is the same, it can be added to the list even though some of the challenges are different in the actual project, as we are all aware. However, if the model is the same, we can typically use it." (Interviewee 4)

"However, we only change again when necessary, which is why everything related to work, including buildings, infrastructure, and EPC work, is included in our management papers. Our EPC work methods cannot be used in buildings, and vice versa." (Interviewee 5)

"Perhaps not all of them, given that BIM is mostly software-driven nowadays; hence, the driver's dependability depends on the program in use and the storage system in question. It is difficult to upload information or knowledge in the BIM model; whether it is worthwhile depends on the storage or device." (Interviewee 6)

"This is possible because we are able to evaluate our work results without the use of data or recent project information from 3D models or other inputs. As a result, we cannot advance our development as much as we would like, even if there were recent project problems." (Interviewee 7)

"So actually the knowledge is not obtained only from directly, meaning directly such as seminars, training, but also indirectly it is based on the problems we face, so that internal discussions arise, then ideas arise, then finally solutions emerge like that including problems in collecting tender documents, combining one document with another document quickly and neatly." (Interviewee 8)

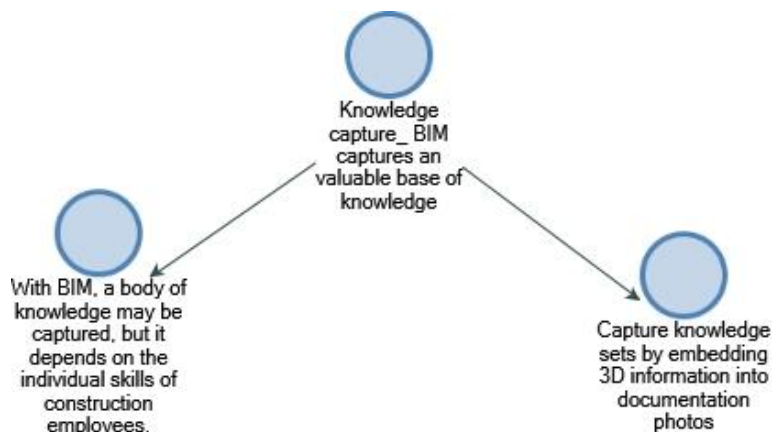


Figure 3. NVivo 12 analysis results and information on BIM capture a valuable knowledge base that can be transmitted

4.2. BIM – Based Knowledge Storage

According to the eight speakers' interviews, BIM may be utilized as a learning tool for building projects or for other employees to acquire lessons. It can also work in conjunction with other knowledge management technologies to be used as a medium for storing knowledge (Figure 4). There are some suggestions from BIM experts that support knowledge storage, such these:

“There is usually a portal for employees, so later on the portal there is for learning the term is that there is Sharing knowledge from all projects, not just BIM, but also for example in some project projects there are lessons learned that can be taken or can be learned by other projects that may be applicable in the project, that is the portal.” (Interviewee 1)

“Yes, because the information is integrated into the system and is accessible, the process is complete, and learning from this activity is possible. Yes, if we utilize CDE. Data mining for a corporation will be created using the data gathered from various projects.” (Interviewee 2)

“Yes, sir, it is data storage, and by database it can utilize BIM since Autodesk delivers BIM 360 as a project database from construction planning even up to maintenance may be maintained there,” (Interviewee 3)

“For storage tools, we don’t utilize BIM. BIM is merely a concept; we only save data on the cloud, so it isn’t just for BIM. Nindya Synology is the loader. If the owner and other stakeholders are interested in using CDE, they should get involved; otherwise, the purpose of CDE is deficient.” (Interviewee 4)

“Yes, undoubtedly, it has been utilized to fulfill its commitments, particularly when utilizing ACC (Autodesk Construction Collection, formerly known as BIM 360). However, if you could say one general thing, it would be to start storing data using Google Drive. ACC there is WIP (work in

progress), possibly still being processed by the contractor, yes if it’s to share, share it the language from us is mature, we just need to sign later after the share is published, publish it if, for example, the design we had in opinion has been approved it goes to publish, and finally archive well that’s everything in the folder.” (Interviewee 5)

“Yes, like I stated before since it is heavy and we are integrated. Yes, some of us save owner-related information in BIM, while others only keep other information for knowledge we keep online. The key issue is that because of the size and weight of storage, not everything is kept in BIM.” (Interviewee 6)

“Therefore, if a storage container is stored in a common data environment, it will be more effective and valuable since everyone will have access to it according to their needs and may utilize it in real time if necessary.” (Interviewee 7)

“Owners and vendors who can access data during a project’s progress are only likely to be able to do so now thanks to the common data environment (CDE), which is available. Alternatively, the company may offer cloud services tailored specifically for projects, in which case all data from the Cloud has already been stored and is ready to be accessed.” (Interviewee 8)

The knowledge storage is obtained utilizing the BIM process database from the project's inception to the end phase from the outcomes of BIM-related analysis as reporting component connected to knowledge capture (Figure 5). The following quotes from BIM-related sources provide the basis for reporting on knowledge storage:

“It depends on the owner’s preference as to whether it is to be reporting content for invoices. There will be data that we obtain from BIM whether we utilize the database from the BIM process or whether we must still use a manual method in the future.” (Interviewee 1)

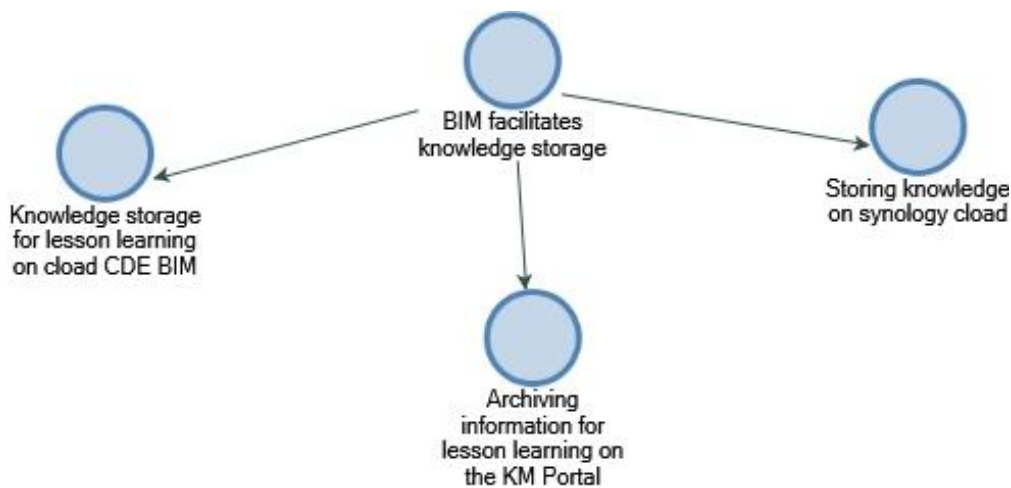


Figure 4. Nvivo 12 Plus analysis findings on how BIM facilitates knowledge storage



Figure 5. Nvivo 12 Plus examination of how BIM may be used as reporting material for knowledge storage

“Therefore, in the future, we’ll enhance the CDE’s capabilities up to operations and start entering system procedures that need data uploads from each user into the CDE once again. The data will not be provided if it is not uploaded, which means management judgments may be incorrect as a result of previously unupdated data. As a result, everyone will be required to constantly share and update their data, or else it won’t be possible to make management decisions. in order to enable timely and accurate decision - making.” (Interviewee 2)

“Yes, sir, since we report to the owner on a schedule every month, which at first reports on the implementation of BIM to what stage or progress updates can also include reporting from the owner to BPJT.” (Interviewee 3)

“Stakeholders can be integrated with it, particularly for owners and consultants. But at this moment, the volume is still not acknowledged if the report’s findings are to be used by an outside team (BPK), such as an audit. But if the owner has merely accepted it through the BPK and has not yet reported through the BIM.” (Interviewee 4)

“Therefore, if there is a particular cost for this, we have utilized ACC (Autodesk construction cloud). It is possible for reporting, often for transmission or delivery, approval or approval, since there is also an option, right? Who do we want to designate to MK or the owner? As long as they have access, that can be all.” (Interviewee 5)

“It may in one scenario. But it turns out that not all driver software can be digitally documented or stored in BIM.” (Interviewee 6)

“Most definitely. If we take Barthel as an example, the paper work is a lot to be utilized as reporting component, just as the data above, which is this data, I mean scientific knowledge, how much advancement is there in what position.” (Interviewee 7)

“We maintain everything in KM, that’s for sure. Everything is linked to innovation in the team. If it’s related to BIM expertise in implementing BIM in projects or related to innovations utilizing BIM, we retain it in KM. However, not all of them, there are numerous, different portions of the procedure, particularly KM, which is more about procedures, and afterwards.” (Interviewee 8)

According to the findings of additional analyses on BIM as a tool for systematic knowledge capture, the CDE BIM function is excellent and beneficial as a storage for project data and knowledge (Figure 6). The following are statements from sources that discuss systematic knowledge storage using BIM:

“Therefore, we typically employ a common data environment for self-storage in terms of BIM; however, a common data environment is not only for file repository or file storage.” (Interviewee 1)

“Yes, because BIM allows for quantity takeoff and picture documentation to be integrated in the model, and because we can use other apps to filter the information before it is released, we don’t have to insert it directly into the 3D characteristics.” (Interviewee 2)

“Yes, sir, as in, “There is a deadline for us to submit it for internal acceptance, how many days to the consultant supervision, and for example, like us, we can also see based on authority, who opened it, who deleted it.” (Interviewee 3)

“Administrative and technical documentation may be found in our properly categorized files. Technically, however, sections have also been divided. For instance, in the drawing or BIM folder, the model has been divided from the ability to become a draft, submit, and publish, but it has been nicely organized for us there.” (Interviewee 4)

“In other words, if we start with the file, it’s already there, perhaps with some work in progress or perhaps still being processed by the contractor, yeah, it’s been shared, and our language is ready; all we need to do is assign it afterwards since there is a publish after the sharing. If, for instance, what we are looking at with the design is already the acc, then it goes to publish later in the archive, so everything has been modified as needed in that folder, maybe with material approval, submission of progress, and submission of meetings inside it.” (Interviewee 5)

“As of right now, we are still operating according to procedure and as desired. We continue to process and conduct research at this time. The name hasn’t been preserved yet since this is also the BIM rule that the Ministry issued yesterday, particularly for the one-year staff building. It’s still running and being processed, so we’re working on it. While accepted for implementation, ISO standards and other European standards are still in the experimental and acclimatization stages. Due to the fact that our BIM is suitable for ISO and that it is still fresh for clan development, the data will enter there since we are currently processing it.” (Interviewee 6)

“We must also input it methodically for the previous one, correct? Right, so here is where we’ll enter the data? For instance, whether we build a structure on the roof or not, we will undoubtedly begin at the bottom and work our way up. On the other hand, internal input indicates that the input data we enter into the program is systematic, which implies that the output is also systematic. Along with the BIM organizational structure of the project, we have also put the BEP (BIM Execution Plan) to implementation.” (Interviewee 7)

“Yes, we are able to work together in a structured manner on all of that; BIM is the language used, and digitalization includes it. The major purpose of digitization is to make it easier for friends to collaborate on the main project.” (Interviewee 8)



Figure 6. Nvivo 12 Plus as a method for storing knowledge that is systematically organized

4.3. BIM – Based Knowledge Sharing

It was discovered through the analysis of interviews that there are several methods to share knowledge using BIM, starting with workflows, cooperation with web KM, creating QR Codes, post projects, and CDE BIM (Figure 7). The following are quotes from sources discussing the use of BIM as a tool for knowledge sharing:

“Officially, training is provided by the head office, and the operational department also hosts a sharing session. In light of this, I believe they have fresh perspectives on this BIM later on from each project, or perhaps it’s just the outcomes of their labor. You may use it on other pals; it is really helpful.”
(Interviewee 1)

“We do operate under the principle that the information generated must be easily accessible. Quickly accessible, thus we offer a QR code because we did not before display one. In the workplace, we also offer a QR code to access the dashboard and other resources, ensuring that information is sent swiftly. BIM in ISO complies with the older definition of ISO BIM.”
(Interviewee 2)

“To share knowledge, we can work together as a team with the scheduler or through BIM 4D, with the quantity surveyor as a team through BIM 5D quantity takeoff for billing and material needs with the logistics section, and with the HR department for HR needs, all of which can be integrated into the BIM workflow to work together on document management.” (Interviewee 3)
“You can accomplish that, but just as before, BIM is only used to visualize a number of alternative ways that are not compatible with BIM. We had a post-project review as one of the prerequisites for finishing the project, and typically, once the project was over, before he departed, the project head discussed his experience with the project with other

acquaintances.” (Interviewee 4)

“Naturally, undoubtedly, and certainly. Well, if you tell the narrative of CDE, it’s as if it was formerly likely that we would lose it or fail to remember whether the file files occasionally. Information can now be secured if this CDE is capable of more than just sharing it.” (Interviewee 5)

“For sharing knowledge via the BIM tool, research is currently ongoing. However, we make it available online and it provides BIM data for minimal integration. Because CDE is linked to the owner and that owner has not yet been completely employed, we are in the habituation and experimenting stages of using CDE.”
(Interviewee 6)

“I’m with teammates. We transmit information based on how the schedule seems and how much it costs, for instance, whether I concentrate on 5D or my friend’s pricing on 4D scheduling. Finally, it might develop into a system.” (Interviewee 7)

“Yes, we do share knowledge. Additionally, we used to have Zoom events twice a month in addition to KM.” (Interviewee 8)

According to the findings of interview analysis relating to BIM as a method for information sharing that has a standard or format so that it becomes systematic, the results suggest that BIM exists and is covered by ISO standard BIM 19650, vendor training, and the company’s own knowledge management format (Figure 8). The following structure is used for quotes from sources about BIM as a common platform for knowledge sharing:

“Yes, if it is systematic, it could approach training more. If the training is effective, there will be training resources and modules that are supplied directly from the committee that supervises the training.” (Interviewee 1)

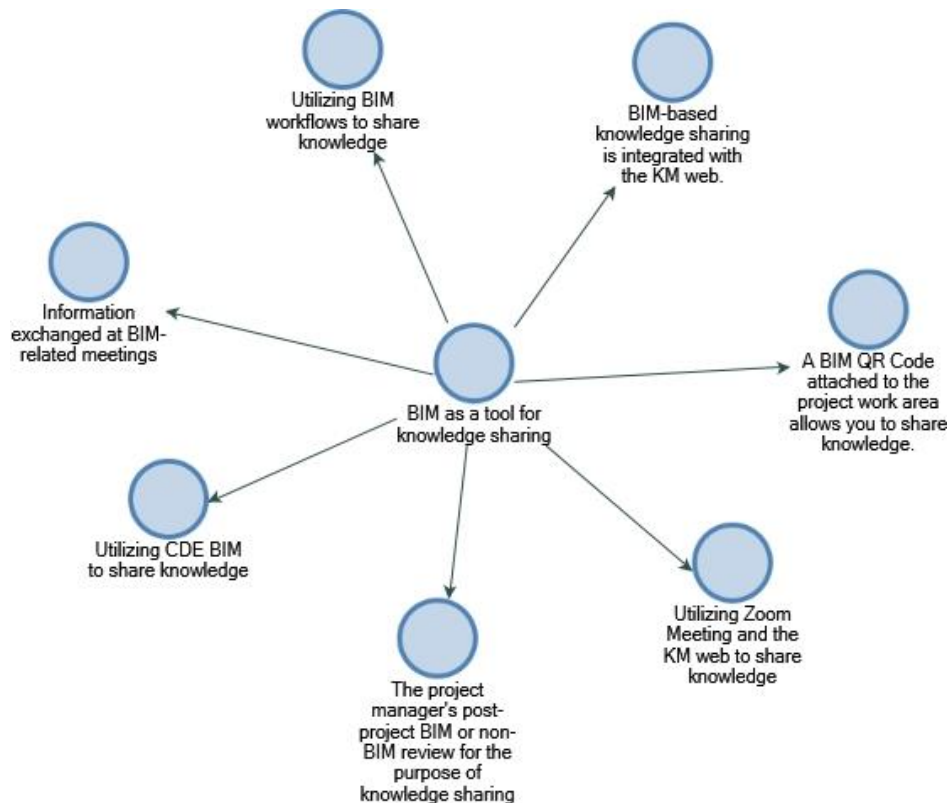


Figure 7. Nvivo 12 Plus analysis of BIM as a tool for knowledge sharing.

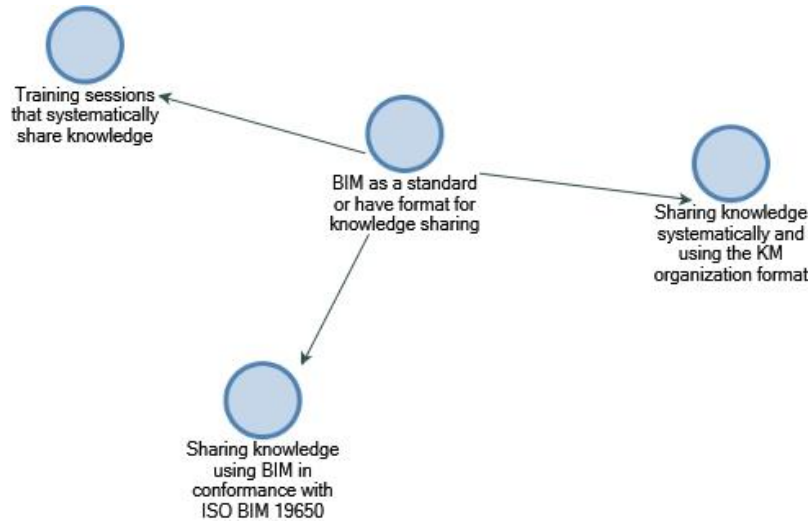


Figure 8. Nvivo 12 Plus analysis considering BIM as a standard or have format for knowledge sharing.

“Yes, in line with ISO BIM Utilize of share a digital representation of a constructed asset Construction and operation process to build a solid framework for choices thus use digital features to aid in the process of planning the construction process and the maintenance operation process.” (Interviewee 2)

“Yes, sir. The numbering format and name standards are contained in the BEP in accordance with ISO 19650, and it is the responsibility of the BIM modeller and BIM officer to produce the BEP format.” (Interviewee 3)

“For our format, there is a format at the conclusion of the project; the contents are virtually the same, just the presentation will be different.” (Interviewee 4)

“The norm is typically maybe certain firms if they already have standards, like in PUPR, obviously they have standards, there are already SOPs so we simply have to follow them.” (Interviewee 5)

“Yes, we have modeling-specific standard parameters and formatting.” (Interviewee 6)

“Due to the fact that it is ISO, we included it into our company’s procedures, thus we must also put it into practice. It will also be in the company’s future RKP (project work plan) as one of the points.” (Interviewee 7)

“There is knowledge sharing for KM format according to the general format at Wika, there is no typical format for training, the most important thing is there is a syllabus and then there are modules however for KM format for innovation there is already a template.” (Interviewee 8)

Because the BIM function allows coordination through a CAD data interchange system targeted at representing architectural, structural, and MEP industry data, the analysis of interviews linked to sharing information using BIM bridges

the culture of sharing knowledge between divisions in the firm (Figure 9). The following are quotations from sources that discuss how BIM might help firms foster a culture of knowledge sharing:

“The system is like sharing a session or a podcast; maybe it’s simply showcasing the outcomes and some of the procedures that are being used, but there’s no guideline; if it’s standard, maybe it’s more coaching, in my opinion, it can really bridge the culture of sharing throughout divisions.” (Interviewee 1)

“Yes, since the BIM QR code makes information simpler to obtain, demonstrates innovative technology, and enables the analysis of CDE data from other divisions, such as the tender division.” (Interviewee 2)

“Yes sir, bridging amongst stakeholders from consultants to quantity surveyors, quality control in one BIM platform.” (Interviewee 3)

“Yes sir, bridging amongst stakeholders from consultants to quantity surveyors, quality control in one BIM platform.” (Interviewee 4)

“Additionally, the tender was direct right from the start of the process. And lastly, yes, we utilize BIM in every tender. It is referred to as a beauty contest tender and has a price because it is intended to help. The team may then use that information to determine how much of the price will be allocated to the desired volume as well as how much AHSP is possible.” (Interviewee 5)

“You can do it, but there will be cultural adjustments. There is a culture that develops, and this culture may change. We will examine the model for the habituation and research responsibility to perform after attempting to employ VR to accommodate meetings using Google Glass in a metaverse.” (Interviewee 6)



Figure 9. Nvivo 12 Plus analysis on BIM as a conduit for knowledge-sharing with the organization.

“Yes, as I previously stated, everything will be systemized once we reach the BIM phase. For instance, the position is still personified from BIM, but it must be because we are dealing with the Division of Quantity Surveyors or integrating with the Procurement Division. It is still in the process right now, though, should be digitalized by you so that 4D BIM synchronized data is all that remains of it as well.”

(Interviewee 7)

“Because there are so many new things with BIM that are also helpful for projects, we frequently share expertise about it. In particular, the process of accelerating using BIM is quicker now that it can identify classes more accurately. So, that’s one of the novel ideas that we frequently discuss with our colleagues.”

(Interviewee 8)

The implementation of BIM itself in Indonesia is still in the adaption stage and level 2, so it still requires time for study linked to enabling knowledge management, especially in knowledge capture, storage, and sharing, according to the findings of the eight informants' interviews. Researchers claim that the main issue is the need for management and head office support to promote better BIM use in order to make knowledge capture, storage, and sharing easier and prevent the loss of the company's knowledge assets, which can be used to make decisions about new projects and the construction industry.

5. Conclusion

This study has found that the application of BIM to facilitate the capture, storage, and sharing of knowledge has not been widely implemented by state-owned construction companies in various types of construction projects. However, some large state-owned construction companies in Indonesia who had implemented of BIM-based knowledge management acknowledged that using BIM-based KM assist organizational knowledge management process especially in knowledge capture, storage and share on several projects, and to reduce knowledge loss due to time lapse. Finding also show that knowledge created in a project is centralized in one model, and lessons or knowledge can be grouped with BIM user preferences.

Finding suggest that the usage of BIM can continue to support a significant amount of knowledge management process, especially in knowledge capture and knowledge sharing. It is evident from the businesses that continue to conduct basic BIM knowledge training and collect expertise from the few BIM specialists who still exist in Indonesia. Therefore, corporates management should encourage their employees to keep updating data and saving their expertise using CDE.

As a result, several sources provided recommendations regarding BIM collaboration with digitalization, creating a culture of data openness for all stakeholders, and it is expected that BIM in Indonesia can conform to ISO 19650 so that BIM management can run smoothly, encouraging owners or employers to have standards related to modeling so that it is fully integrated, The project party is more proactive in asking for training or passing on knowledge to the central party regarding BIM and knowledge management training, using

the common data environment (CDE) more for analysis of decision-making related to the tenders that are participated in, maximizing lean construction by BIM integrates with the last planner system for monitoring, and e-learning platforms can collaborate with campuses to share knowledge related to the BIM syllabus, prepare, and execute.

Due to limited access to the sample and population of Indonesian construction businesses, the results cannot be generalized. Despite these shortcomings, the findings improve understanding on how BIM is utilized to facilitate knowledge capture, storage, and share in projects. As this research sample is primarily restricted to BUMN contractors with that certification, it is recommended that future research can be conducted on private contractors companies or project owners with ISO 19650 in Indonesia.

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Author Declaration

Authors' contributions and responsibilities

The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation and discussion of results. The authors read and approved the final manuscript.

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