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Identifying the Critical Barriers Factors to the Implementation of Building Information Modelling (BIM) in the Sarawak's Construction Industry

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ABSTRACT: Building Information Modelling (BIM) is one of the most advanced developments in the architecture, engineering, and construction (AEC) industry that can generate a 3D virtual information model which can be used for planning, design, construction, and operations. As Building Information Modelling (BIM) approaches the construction industry as a new technology and process, changes in the industry have created some barriers to BIM adoption in Malaysia. This research aims to enhance the implementation of BIM in the construction stage of Sarawak's construction industry by identifying and classifying the critical barriers. This study fills this current knowledge gap and enhances the understanding of BIM in the construction stage and the factors that hinder implementation in Sarawak. To develop the challenges being faced in this industry, a set of barrier clusters based on people, process, policy, technology, and cost were pre-identified through a literature review, and a structured interview involving three BIM experts was conducted on WebEx to refine these barriers with the current industry situation. As an outcome, this study identified 49 of the barriers from the literature and refined them into 26 of the barriers under their main clusters. Interestingly, they all validated the fact that lack of government involvement in BIM implementation is an undeniable barrier factor to growing BIM utilization and reaching its full potential. This study will form the basis of further research, and additional studies focusing on prioritizing these identified barriers for strategic planning would help the construction players in their swift transformation to BIM.

KEYWORDS: Building Information Modelling; barriers factors; implementation; Sarawak; construction phase; 3D modelling

1. Introduction

The economy is evolving into digital renovation around the world, which means the current era is shifting from paper to digital transformation. That is when BIM enters into the construction industry as a platform to set up a collaborative working environment [1]. For this reason, BIM is regarded as a paradigm shift in the architectural, engineering, and construction (AEC) industry, considering that the potential usage of BIM would benefit the industry in ways such as reducing project schedules and costs, better coordination among stakeholders,

improving productivity, and higher-quality results [2]. Presently, BIM adoption is now a global concern. BIM is starting to take off not only in developed countries but also in developing countries [1]. In Malaysia, BIM has also implemented a national agenda through the Construction Industry Transformation Plan (CITP) in 2016 to transform the Malaysian construction sector into BIM maturity level 2 by 2020 [3].

Although the idea of implementing BIM in Malaysia was introduced by the director of the Public Works Department (PWD) in 2007, BIM adoption in the Malaysian construction industry is still considered very low and stagnant when compared to other developing countries (Jabatan Kerja Raya (JKR) 2013). According to the CIDB report in 2016, the Malaysia BIM adoption stage is at Level 1, and the percentage of BIM implementation in the construction projects is 17%. That progress is far behind others, while developed countries, for instance, the US, UK, and Singapore, are accelerating their rates by 71%, 54%, and 65% [3]. This slow adaptation of BIM in Malaysia somehow affects its evolution toward its step as a developed nation. Although there are benefits of using BIM throughout the project life-cycle, such as increased productivity and efficient design, assessment time and cost associated with design change, and elimination of clashes in design, most construction players in Malaysia neglect BIM usage awareness in the construction phase [4]. Moreover, when it comes to BIM in the Malaysian construction phase, only 4.2% of players were applying, and that is ten times less than the number of BIM applications in the design phase [5]. Thus, most construction players still keep the tendency to focus on BIM usage in the design stage, and that makes Malaysia a holdback to achieving a complete BIM level 2.

When it comes to the BIM adoption rate within the states of Malaysia, 78% of the country's BIM users are mainly in the central region. In Sabah and Sarawak, there is only a 6% BIM adoption rate. Sarawak has the second lowest BIM adoption rate in Malaysia [3]. Moreover, there is limited data related to the BIM study engaged in Sarawak. Most of the studies were mainly focused on the design phase of BIM. That created a void in the currently available literature to provide the information as references for Sarawak construction organizations to enhance their learning process. To implement BIM successfully in Malaysia, the usage of BIM in the construction phase needs to be taken into consideration. The aim of this study is to enhance the implementation of BIM in the construction stage of Sarawak's construction industry. To achieve that, the actual progress and challenges of BIM implementation in the real construction industry need to be carefully looked upon. In this study, the main objective was focused on the identification of barriers enhancing BIM implementation through a literature review and refined through a series of interviews with industrial BIM experts.

2. Methodology

The research activities, including a comprehensive literature review and standardized interviews, were focused on the research methodology process to achieve the defined research objectives of this study. The purpose of doing an intensive literature review for the methodology part is to identify the barriers to BIM implementation in the construction stage. The relevant publications from books, journal articles, and conference papers between 2014 and 2021 were analyzed, synthesized, and critically reviewed in this study. Subsequently, a set of barriers that hinder BIM implementation was developed as a draft for the interview. The results were validated by conducting structured interviews with three BIM experts.

2.1. Literature review for barriers identification

A literature review was conducted to provide an overview of the current knowledge of BIM in the industry and to identify the barriers to BIM implementation in the construction phase. The relevant publications were reviewed, such as books, journal articles, and conference papers. Additionally, a detailed literature study focusing on the barriers to BIM implementation was also conducted to establish the various barriers to BIM within the construction industry in developing countries. As a result, a set of impediments to BIM implementation in Sarawak was created. These barriers were clustered as sub-factors under the main factors of people, process, technology policy, and cost. Later, during the interview sessions, they were required to refine and evaluate with the BIM experts.

2.2. A structured or standardized interview

The purpose of interviewing for this project is to clarify and refine the most significant barriers. A structured interview design is selected for the interview design. In that way, it can be designed for the respondents to respond to the same format of questions in that same way. It will help us compare their answers effectively and precisely. Although most questions in the structured interviews are based on closed-ended questions to get fixed responses, they will also contain a few open-ended questions that can help us gather more available information and assess the legitimacy of the answers [6]. The BIM experts for the interview are selected from academic or industry backgrounds and have experience of more than three years in the BIM field. A sheet list of barrier factors that have been identified through literature will be distributed before the interview session so that they can figure out possible answers on reflection. During the interview session, we will discuss adding or removing the factors according to the current construction industry situation and relocating the barriers under the appropriate criterion. The interview will be conducted in English through the online platform WebEx, and it will be audio/video recorded with their permission. It will take about 30 minutes to complete. The outcome of the interview will clarify the most significant barriers according to the requirements within the Sarawak construction industry. The research processes are described below in Figure 1.

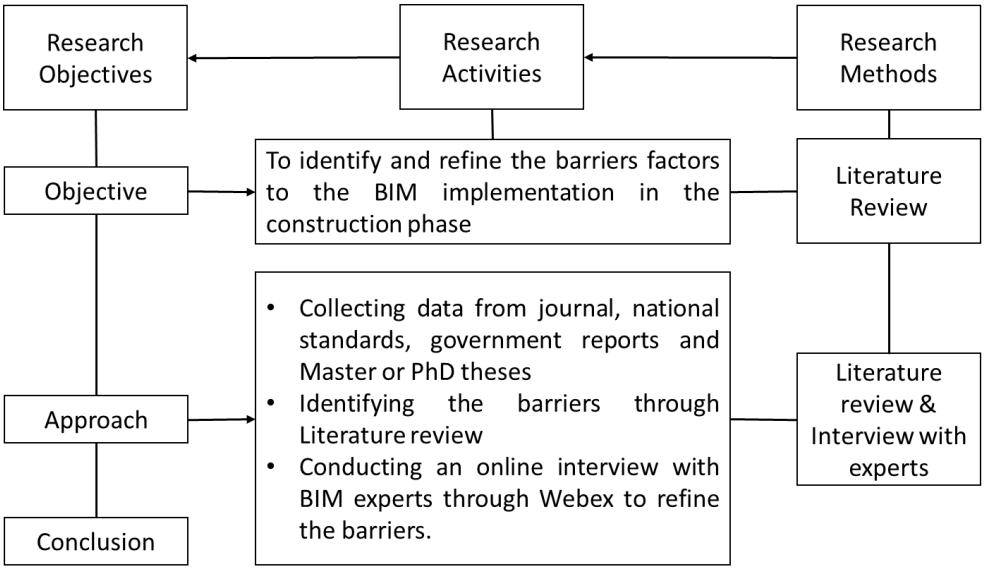

Figure 1. Research methodology process.

2.3. BIM barriers refinement through expert interviews

Due to time constraints and a lack of available professionals, a total of three experts from academia or industry with more than three years of experience in the BIM field were invited to provide detailed feedback on the identified barriers in the literature. The interviews aimed to elicit detailed information about the various aspects of BIM in Sarawak and its implementation stage. Table 1 summarizes the interviewees' backgrounds.

Table 1. Interviewees' profiles and backgrounds

Interviewees	Education	Position	Responsibilities	Experience
(1)	Master of Science in Built Environment	Business Development Executive	conducting market research and evaluation in understanding the viability of the proposed technology (IBS and BIM)	around 3-5 years, as Manager and Planner positions
(2)	Bachelor of Science in Petroleum Engineering	Senior. Planner	developing maintenance schedules for site team campaigns in Sabah/Sarawak waters and giving planning and scheduling (P&S) training	around 7 years, as Planning Engineer and Application Engineer
(3)	Bachelor of Engineering in Civil Engineering.	Senior. Principal Solutions Architect	providing services to the client such as developing Work Programme and other project control tender documents, assisting P6 implementation, and giving planning and scheduling (P&S) training	around 11 years, as Planning Engineer and Project Engineer

3. Results and Discussion

3.1. BIM barriers identification through literature

To implement BIM successfully in the Malaysian construction industry, it needs to overcome several barrier factors. A detailed literature study focusing on the barriers to BIM adoption in developing countries was conducted to establish the various barriers to BIM within the Malaysian construction industry. The relevant developed countries and Malaysia publications, such as books, journal articles, and conference papers between 2014 and 2021, were analyzed, synthesized, and critically reviewed in this study. As a result, a set of barriers that hinder BIM implementation was developed.

3.2. BIM main-barriers to the BIM implementation

According to the UK BIM Report 2017, it was suggested that the adoption of BIM was comprised of four fundamental components: people, process, policy, and technology [7]. People have to adapt to new situations and conditions if BIM is to be executed successfully. The human factor has emerged as a resistance to BIM when the industry is not fully aware of BIM knowledge [3]. BIM is a process that assists in the transition from traditional 2D CAD to an integrated 3D model. Since the current engineering industry is experienced in working in procedurally driven environments, BIM adoption requires an enormous change in existing processes [8]. Moreover, government policy may differ in each country. But there is no doubt that shifting a construction industry into BIM affects its traditional scheme and forces the government to make changes. Following John Rogers (2015), when it comes to buying the major vendors' software, Malaysia is at a disadvantage over developed-nations because of its

unequal purchasing power parity [9]. Thus, cost was considered as an extra main barrier factor that made the core factor to the BIM implementation five components: People, Process, Policy, Technology, and Cost. The sub-factors are identified as an output of an intensive literature review. Later, these barriers are refined and evaluated by the BIM experts in the interview sessions.

3.3. BIM sub-barriers to the BIM implementation

In the following Table 2, a total of 49 sub-barriers in accordance with their five main barriers were identified through the literature along with their meanings.

Table 2. BIM barriers and their meanings

Barrier Factors		Statement of meaning	References
Main	**Sub**		
People	Lack of BIM professionals on the project	When the industry is not thrilled with BIM, the demand for BIM experts becomes undersupply.	[1,2]
	Lack of BIM knowledge	Without the arrangement of seminars, conferences, and workshops on BIM, the industry is unaware of BIM knowledge.	[2-5]
	Insufficient availability of BIM training	Quality training from experienced BIM trainers is rare to access for learners.	[2,4,5]
	Lack of awareness of BIM benefits	Without the arrangement of seminars, conferences, and workshops on BIM, the industry is unaware of BIM knowledge.	[1,3,6]
	Lack of competency among team members in using BIM	Without proper training on BIM, the effectiveness and productivity of team individuals will be low when using non-traditional methods.	[6-8]
	Reluctance from Client or Consultant to implement BIM	Without consequential understanding and awareness of BIM, each party in the industry is hesitant to adopt BIM.	[2,4,8-10]
	Resistance to change by staff	Some employees believe that BIM is too complicated, and thus it is faster to complete project projects with non-BIM tools.	[4,7,11]
	Resistance to change new technology	Some suspect that BIM is just an unassembled technology with limited features.	[2,7,12,13]
	Clients do not request/enforce BIM	Without significant knowledge and awareness about BIM, Clients may not wish to implement BIM in their projects.	[2,4,5,8,9]
	Other team members do not require BIM	In a traditional project team, not all team members will be able to follow the BIM guidelines.	[2,5]
	Difficult to learn	Some users may see BIM software are difficult to learn as they are attached with information.	[8,14]
	Limited or no previous experience working with other companies on BIM projects	Without the industrial training/experience or BIM education from universities, the industry will still be operating with inexperienced users.	[15,16]
	Lack of interoperability between BIM software used by team members	The current standards and methods were not focusing on integrated practice. That impedes the effective data exchange between different BIM tools.	[2,12,16,17]
	Negative Attitude towards Working Collaboratively	Some may have different ideas about working collaboratively. They believe these tensions from working collaboratively may delay the project, overrun the budget, and damage the employee relationship.	[11,18]
	The steep learning curve for BIM trainees	For some people, innovation does not always come easy. For them, it is impractical to implement BIM because of its steep learning curve: complex software and high initial cost.	[1,16,19]

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Barrier Factors		Statement of meaning	References
Main	**Sub**		
Process	Lack of time for experimentation and implementation in fast-paced projects	It is challenging to implement and experiment with BIM in fast-paced projects as it needs to finish quickly.	[6]
	Lack of references to assist in implementing BIM	The lack of BIM projects in the past makes it difficult for the organization to refer to the data and report of the project.	[4–6,11]
	Lack of time to implement	Implementation of BIM needs learning time, and most of them would be lost productivity which makes companies reluctant to give time for implementation.	[6]
	Lack of supply chain buy-in	Although BIM can enhance supply chain management, the current industry is not ready to provide fabrication from shop drawings.	[2,4,20]
	Lack of direction of BIM in the industry	The industry is not having enough government involvement in setting the direction of BIM at the national level	[6]
	Inadequate familiarity with the use of BIM	Companies are not practising BIM projects, or students were not influenced by the use of BIM on their projects.	[6,20]
	No BIM requirement/mandate exists in the industry	The industry is not getting enough government involvement in setting the policy of BIM mandating.	[6,12]
	The assumption that conventional methods are better than new processes	The current experts in the industry are comfortable and confident with the traditional method. Adversely, BIM is a new user interface for them.	[2,9,10,12]
	Application of BIM will affect the current process practice	Shifting the industry into collaborative BIM will affect the current esoteric style of the industry.	[5,21]
	Application of BIM will affect the current productivity	Some are afraid that working collaboratively may affect their current productivity.	[4,5,22]
	Not ready to distort normal operational structure	Along with the changes from the current top-down operational structure to a collaborative approach. The industry is not ready to change the roles and responsibilities of each party.	[8,10]
	Extra efforts for BIM model development	All stakeholders have to be collaboratively involved in the BIM model development. Developing a 3D information model may have to put more effort than that of 2D models.	[11,13]
	ROI (Return on Investment) of using BIM not clearly defined	ROI report based on the initial investment to the long-term profit is not identified for the current area.	[2,7]
Policy	Lack of working procedures and BIM standards	Since the BIM system is diverse from the normal process, it changes the working procedures, and an official national BIM standard is required.	[2,4,5,10,23]
	Lack of government involvement	Although government need to take the primary role in BIM implementation, there is still a lack of government support: PWD.	[1,13,24])
	Lack of Protection for Intellectual Property Rights	In many computer-based e-procurement systems in construction, there were still several security issues and law enforcement.	[2,11,12,25]
	Unsupportive contract form for BIM-based collaboration	Government still need to improve BIM-supported contract for ownership and intellectual property.	[2,5,11,25]
	Incompatibility with Standard Methods of Measurement	The traditional standard methods of measurement were not incompatible with the software to calculate bills of quantities.	[12,13,26]
	Lack of Insurance Applicable to BIM Implementation	As construction projects are unpredictable and BIM is an unfamiliar process to the industry. Insurers are likely to pass over the projects.	[11,27]

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Barrier Factors		Statement of meaning	References
Main	**Sub**		
Technology	Existing hardware incapable of running basic BIM software	To design, test, and make changes to products in real-time, hardware with high specifications was in demand for BIM.	[6]
	BIM software is complicated to use	Since separated software from other areas was attached to BIM, the future ahead of BIM software is full of challenges.	[6,9,11,28]
	Unawareness of the technology	According to the CIDB 2016 BIM report, 55% of construction industry players in Malaysia were not aware of BIM technology.	[6,8]
	Non-availability of parametric BIM library/dataset	A proper BIM regional parametric library needs to be developed, and standardized components need to be uploaded	[8,13]
	Selection of Software and Hardware	Deciding which software & hardware to implement in the organization is always significant as they affect the project's productivity.	[8,11,29]
	Inadequate skills and competency, need for technical support	Since BIM is a new technology in the industry, it requires efficient technical support at all times.	[1,10]
	Data security	Data security becomes a problem since a BIM model have to be developed in a common data environment.	[10,11]
	The complexity of the BIM Model and building design	With the development of a competitive design market, building designs become more challenging.	[2]
Cost	High cost of technology	The cost is an issue for developing countries as the technology has to be paid for the same as developed nations.	[1,2,5,6,22]
	High training cost	Training cost for BIM is expensive. A BIM full course offered by Autodesk may cost upwards of $4,650.	[6,8,9]
	High cost of software and hardware to implement	The costs for software and hardware were the same as in developed nations.	[8,9,22]
	High cost in changing workflow and work process	Since BIM is an integrated approach, these changes in workflow and process may become costly.	[5,9,10]
	High cost for BIM experts	The average salary for a BIM manager in Malaysia may cost up to RM 6,294 per month.	[11,30]
	Increase in design cost	BIM is more cost-effective in the use of high-end projects. For a simple, low-rise building, the design cost may seem higher than the traditional one.	[11]
	Ambiguous economic benefits	The industry was lack of a proper report on the economic benefits of BIM projects.	[11]

3.4. Interview outcome

It generally takes about 30 minutes to complete. As an outcome of these interviews, (49) sub-barriers were refined into (26) sub-barriers respective to their main barriers. These barriers to BIM implementation in Sarawak are presented below in Figure 2. One of the close neighbors of Malaysia, Singapore, is the top BIM service provider in Asia. With the continuous development of economic relations between Malaysia and Singapore, the interviewees see that the market for BIM professionals is easy to access. For that reason, the "lack of BIM professionals on the project" factor was dropped from the people criterion. They do not think BIM is challenging to learn, and the learning curve of BIM is as usual compared to modern engineering software. They set "Other team members do not require BIM" as the norm, which means not all team members will not require BIM. Some will only use AutoCAD or their specialized software. Thus, they do not see it as a barrier. Furthermore, the interviewee agreed that BIM improved construction productivity by working collaboratively. So, "Negative Attitude towards Working Collaboratively" was also removed from the list. In the process

criterion, they agreed to remove "lack of direction of BIM in the industry" as the BIM roadmap in the Malaysian industry was already set by the authorities. In addition, beginning in 2018, any public project budgeted at RM100 million or above is mandated to use BIM. "No BIM requirement/mandate exists in the industry" was also removed from the list. The barrier "Inadequate familiarity with the use of BIM" was also deleted as there was a similar barrier to that in the People criterion. The barrier "Application of BIM will affect current productivity" was rejected from the list since the interviewee agreed that BIM will enhance construction productivity. According to the policy criterion, government-related working procedures, BIM standards, and intellectual property rights were compacted into a single barrier: "Lack of government involvement." As the interviewees do not think BIM is incompatible with the current standard methods of measurement, the barrier was left out of the list. The interviewee agreed that hardware is not a barrier in the technology criterion as the current hardware can still operate BIM software. They do not think BIM software is complicated to use. Since there were frequent BIM seminars in the industry and a demand, they doubted "unawareness of the technology" as a barrier. In the cost criterion, the cost of software and hardware was neglected as a barrier. They believed changing workflow and processes would not cost us anything apart from training. As a result of these discussions, the previously identified barriers in the literature were refined into 26 sub-barriers, as shown in Table 3.

Table 3. Refined barriers to the BIM implementation in Sarawak.

People	Insufficient availability of BIM training
	Lack of awareness of BIM benefits
	Lack of BIM knowledge
	Lack of competency among team members in using BIM
	Limited or no previous experience working with other companies on BIM projects
	Reluctance from Client, Contractors or Consultant to implement BIM
	Resistance to change by staff
	Resistance to change new technology
Process	Application of BIM will affect the current process practice
	Extra efforts for BIM model development
	Lack of project references to assist in implementing BIM as they are confidential
	Lack of time to implement
	Not ready to distort normal operational structure
	ROI (Return on Investment) of using BIM not clearly defined
	The assumption that conventional methods are better than new processes
Technology	Inadequate skills and competency, need for technical support
	Lack of interoperability between BIM software used by team members
	Non-availability of parametric BIM library/dataset
	The complexity of the BIM Model and building design
Policy	Lack of government involvement
	Lack of Insurance Applicable to BIM Implementation
	Unsupportive contract form for BIM-based collaboration
Cost	High cost for BIM experts
	High cost of technology
	High training cost
	Increase in design cost

Barriers to BIM implementation in the Sarawak construction industry were identified through literature and refined by a series of interviews with BIM experts. They all agreed that it is important to take into consideration the combined effort between clients and construction

professionals to advance BIM proficiency in the industry. Through the interviews, no experts pointed out a common challenge, "incompatibility with standard methods of measurement," which most countries face in their quantity surveying stage. Since most of the interviewees are experts in BIM and are trainers in BIM software, they have positive attitudes toward the transition between 2D and 3D systems. Undoubtedly, they all shared an interest in common that government involvement or policy-based push is similar to other countries' efforts to expand BIM usage and reach its full capabilities. The previous BIM studies in Sarawak stated the same thing about the significance of the government's role in BIM implementation and demanded the provision of national BIM standards and guidelines [1,31-33].

4. Conclusion

BIM is a new paradigm within AEC that encourages all stakeholders to be integrated and coordinated on a project. It created more cost and resource savings, greater efficiency, faster communication, more improvement in the prefabrication section, and higher quality. Apart from these undeniable advantages, the resistance from the industry to change in these new processes and technology has created some regional barriers. Several factors that hinder the adoption of BIM have been identified through literature and verified with interviews. As the government is encouraging the implementation of BIM level 2, the salient barriers among them need to be listed and addressed accordingly for the improvement of the construction industry. BIM has already proven to be an effective technology supported by numerous studies and reports. The best way to succeed in BIM implementation is for the private and public sectors to work together under the BIM implementation strategy and guidance. Based on the findings from interviews, it can be admitted that there are a lot of matters to be considered because of the barriers caused by people and process toward BIM. And they also have in mind that barriers caused by policy need to be considered. This study revealed that the current slow BIM adoption in Sarawak is caused by a series of combined reasons rather than a single cause. They need to be properly investigated, starting with the current priority issues and resolving them to advance to the digital construction era. This study inevitably has a few limitations. In this study, the construction phase of the Sarawak construction industry was mainly targeted, while states with a high level of BIM implementation were not included. The researchers could continue with this study's future work by prioritizing these identified barriers for strategic planning. Since there were different requirements for different states, research based on other regions was also required. Last but not least, phase-focus research such as design or facility management phases can still be considered for further research. The application of BIM is still dispersed in Malaysia, and the BIM model has not been utilized throughout the life cycle. An integrated implementation of the BIM information model throughout the project life cycle is the only way to get the full benefit of BIM.

Conflict of interest

The authors declare no conflict of interest.

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