BIM implementation in Sarawak construction industry: Awareness, readiness and challenges

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Abstract. Lack of coordination and fragmentations have always existed among the stakeholders and parties involved in the implementation of planning, design and construction process of construction projects, especially in the aspects of information transfer. In the recent trends, Building Information Modelling, BIM has been introduced to address the fragmentation issues. The BIM framework is based on the notion of coordination between stakeholders in digital format for information exchange throughout the construction progress. Although BIM technology has been implemented in Malaysia for several years, low adoption is found within the Sarawak construction industry. This paper aims to assess the awareness and readiness for BIM implementation in the Sarawak construction industry. The study was carried out using questionnaire survey across the districts in the Southern Region, Central Region and Northern Region of Sarawak. There are in total 404 responses received, and it is revealed that only 14% of the participants have experience in BIM-related projects. This is still far from the goals set by the Construction Industry Development Board (CIDB) Malaysia. Meanwhile, 63% of respondents had heard of BIM and 46% of them had attended some seminar or program related on BIM. The investigation of awareness, readiness and challenges of BIM implementation has been further inferred and compiled as a foundation guideline for the proposed solution framework to increase BIM usage in the state. It is hopeful that proposed solution framework can help in overcoming BIM implementation barriers in the Sarawak Construction Industry.

1 Introduction

The construction industry has governed the modernization of countries around the world over centuries. The construction industry controls, in particular, the economic trend of a country, which means that any impact of this industry will have an impact on the entire economic condition of a country and vice versa. It is important to recognize that the

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construction industry is an enormous process involving many projects, myriads of people, different companies or businesses, different sizes, part of a country with different skills and capabilities and always subject to change in the environment [1]. However, there are many issues in construction industries that are thought to be grossly inefficient in comparison with other industries such as the automotive industry.

The heterogeneity of the construction industry has led to the inefficiency of the industry and Mohd Nawi, Baluch, & Bahauddin, [2] claimed that these fragmentations exist within the traditional construction process between the construction stakeholders and the parties in the construction process. Construction projects involved various players at different stages of the project, starting from initiation to closure of the project. If lack of coordination and fragmentation especially in information transfer persists, the construction industry will certainly be brought to a standstill and finds it difficult to forge ahead. In fact, this has caused the construction industry to slip back in terms of efficiency and economy [3].

Since the fragmentation of the construction project has caused inefficient collaboration and cooperation between different parties, stakeholders and organizations in the construction industry [4], Construction Industry Development Board, CIDB has introduce an improved system and management of project by Building Information Modelling (BIM) which align to the Industrialized Revolution 4.0. BIM is known as an Information and Communication Technology (ICT) with the ability to transform the construction industry by improving efficiency, productivity and reliability. It is a collaborative approach based on digital technologies that enable more efficient methods of architecture, engineering and construction (AEC) resource design, development and maintenance to more effectively implement cost effective and clash-free design and greater construction productivity and efficiency [5].

Wong, Wong, & Nadeem, [6] also concurred that the use of BIM affects all aspects of building construction from design, estimate, supply chain, implementation phase, construction process, resource allocation, necessity for efficiency, facility and asset management and finally demolition. The BIM technology allows for generating a three-dimensional (3D) model, scheduling whole project duration, estimating cost of the project, assessing sustainability and achieving facility management applications [7]. BIM implements a framework based on the notion of coordination between stakeholders for digital information exchange throughout the construction progress [8]. It also helps the various parties to work on the same basis and to foster shared responsibilities. When BIM fills the gap in the construction sector, it is proposed that this transformation of digitalization be implemented to fill the deficit [9] caused by lack of coordination in information exchange.

The government of many countries all around the world has realized the advantages that BIM has to offer to their construction industry and has since developed a plan and invested money to incorporate BIM into their construction industry. BIM has been more and more widely implemented in developed countries such as the United States, the United Kingdom, Hong Kong, Singapore, and South Korea [10, 11]. The increasing application of BIM in developed countries such as New Zealand and Australia has led to further research studies on BIM and other fields related to the construction project process, along with security management, project management, maintenance services, and so forth [12]. In European countries, the adoption of Building Information Modeling (BIM) standards have been expedited and one of the example of using BIM environment is under-construction project of the Departures Area Expansion of Naples Capodichino International Airport, IV Bridge, [13].

BIM processes are incorporated into both buildings and infrastructure and have added potential for complementary workflows such as laser scanning, drone survey technic and rapid energy analysis in the retrofit and refurbishment sector. Besides of architectural -

structural BIM cooperation, BIM have further expand for transportation infrastructure mainly focusing on roads, highways, and bridges [14]. BIM technologies is also a partnership between the construction industry and the software industry, creating an environment in which both companies have opportunities and synergies [15].

Malaysian Public Work Department (PWD) embraced BIM since then by targeting that BIM should be implemented on 10% of public projects under Rancangan Malaysia ke-11 (RMK11) above RM 50 million. [16] has reported on the number of BIM implementation in PWD'S BIM Projects. Although BIM technology has been implemented by the Malaysian Government, few stakeholders are using the BIM concept, some opting to outsource the BIM works to their project deliverables rather than just implementing the technology internally [17]. The annual BIM report showed that the implementation of BIM in Malaysia was still limited when compared to the standard practice of BIM implementation in several developing countries [18, 19]. Malaysia's construction culture and environment may be a factor that slows down the BIM implementation process. The construction stakeholders refused to implement BIM because they are comfortable with the traditional construction process [20]. The resistance to learning new technology and/or approach is also contributing to the limitation of BIM adoption.

In Sarawak, the Pan Borneo Highway Sarawak project began in January 2016 with the adoption of Malaysia's first-ever Highway Information Modelling (HIM), a combination of Geographical Information Systems (GIS) and Building Information Modelling (BIM) [21]. However, previous research study on the implementation of BIM in the Sarawak construction industry urges action to be taken. The awareness and knowledge on the implementation of BIM seems limited when compared to the standard practice of BIM implementation in several developing countries, even in some West Malaysia cities like Kuala Lumpur. Therefore, this study aims to study the issues that are perceived in BIM implementation in the Sarawak construction industry in more detail. Whether or not the industry is still struggling to understand the advantages of BIM implementation in practice and lacking of awareness to impact of modern technology will further be studied.

2 Research method

A questionnaire survey was conducted to assess the level of awareness and readiness of the Sarawak construction industry to implement BIM. Besides, the perception assessment, the survey also examines the challenges, benefits and solution framework for BIM for the Sarawak construction industry. A total of 500 questionnaires was distributed throughout Sarawak across the southern, central and northern regions of Sarawak. The surveys are distributed among major construction players, including architects, engineers, contractors, developers, surveyors, government officials, etc. 404 out of 500 respondents give feedbacks on the survey and Figure 1 showed the profile of respondents by professions. About 65% has at least 5 years of working experience in the construction sector. Refer to Figure 2.

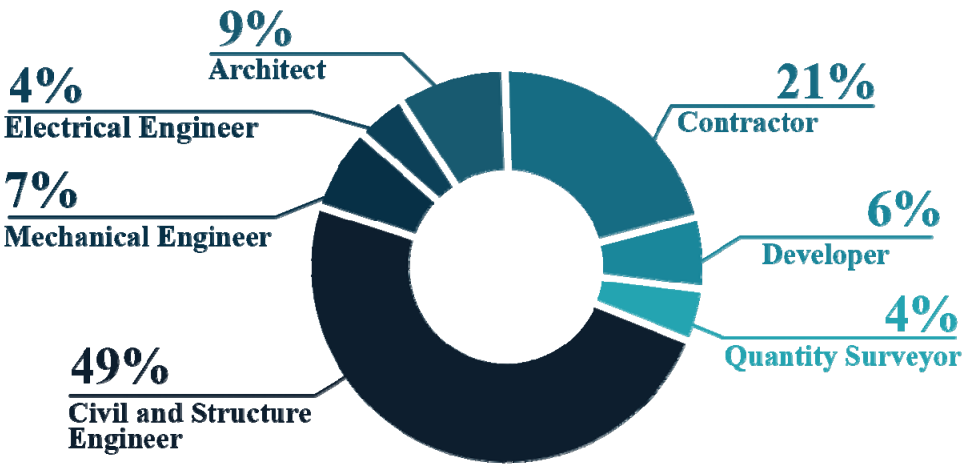

Fig. 1. Profile of respondents by profession.

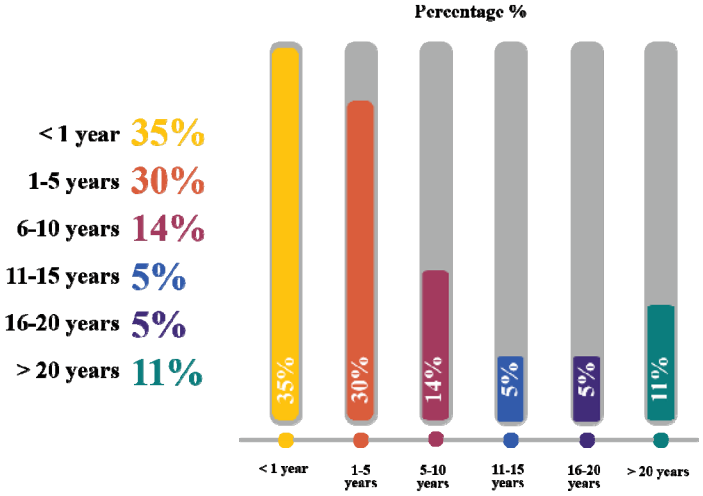

Fig. 2. Working experience.

The instrument used for data collection was a questionnaire comprising seven sections as follows:

Section A: Demographic information
Section B: Organisation background
Section C: BIM awareness and BIM readiness
Section D: BIM in organisation
Section E: BIM implementation
Section F: Challenges of BIM implementation
Section G: Direction of BIM in Sarawak construction industry

3 Results and discussions

This section focuses on the data analysis results obtained from the questionnaire survey, conducted among the construction industry professionals in Sarawak. This survey reflected the level of current practice of Building Information Modelling (BIM) implementation.

This will serve as an important baseline and a critical reference point when assessing the changes and effects of implementing of BIM in the Sarawak construction industry. The main focus is in the respondents' awareness and readiness for BIM implementation. However, another important point for discussion will be on the benefits and challenges of BIM implementation in the construction industry in Sarawak. A proposed framework will be introduced to overcome problems in the implementation of BIM in the state.

3.1 BIM Knowledge

BIM is an exceptional model that has recently transformed global construction and has gradually improved and transformed the construction industry in the world. The introduction of BIM in Sarawak Construction was considered positive, as evidenced by the survey. As shown in Figure 3, 63% of respondents know of BIM, while only 37% said they had not heard about it.

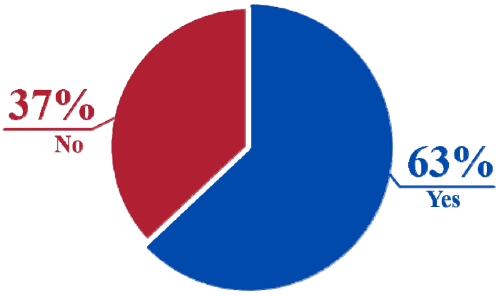

Fig. 3. Respondents that heard about BIM.

Undeniably, the government through its various agencies, such as the Public Works Department (JKR), CIDB, and other professional bodies, has been aggressively promoting BIM through the various events. A series of BIM awareness program was organized by CIDB since 2014. The awareness programs, such as BIM Day and Nationwide BIM Road Tour, are part of CIDB initiatives to enhance the awareness of the construction industry and understanding of BIM [22].

Despite this, there is only 38% of the respondents have attended related seminars or programs on BIM as seen in Figure 4. Among the respondents that have attended any seminar or program on BIM based on professionals, civil and structure engineers have attended BIM related program (46%) followed by architects (23%), contractor (21%), developer (4%), mechanical engineer (3%), quantity surveyor (2%), and electrical engineer (1%).

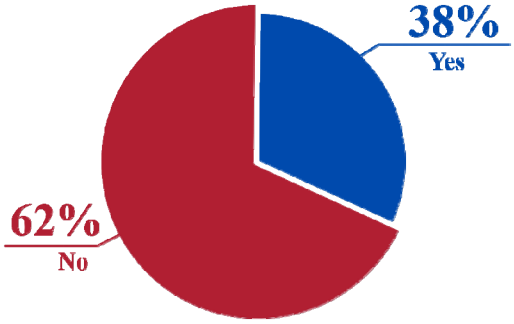

Fig. 4. Respondents that have attended any seminar or program on BIM.

BIM-based seminars or projects initiated by the government have been put forward to increase BIM knowledge and awareness among players in the Malaysian construction industry. Unfortunately, these initiatives are less within the Sarawak construction industry. Table 1 also shows that although most of the respondents heard about BIM (Figure 3), they still claimed of low confidence level in using knowledge and skills in BIM. Among the respondents that are aware of BIM, 25% of the total respondents not very confident at all in their knowledge and skills in BIM and follow by 26% of the respondents of not very confident, and 38% claimed that they are in between the confident and not confident. For those who have high confidence level in BIM knowledge and skills, they claimed to have attended BIM-related programs, refer to Table 5. On the contrary, the respondents who did not attend any BIM related program are the ones in the not very confident range.

Therefore, the respondents' insufficient understanding of BIM is related to not having attended any seminars or programs related to BIM. However, those who attend but still lack confidence argue that they have not fully utilize the knowledge, awareness, and ways to implement BIM provided by the workshop or training program. On the other hand, the participants need to build up their confidence level by involving themselves in BIM related projects to increase their experience in implementing BIM. It is undeniable that participants cannot fully implement skills and knowledge from BIM seminar or program unless they use the knowledge in BIM related project. The chances or the opportunities to be involved in BIM related project is needed.

Table 1. Respondents that heard about BIM based on confidence level regarding to average knowledges and skills in BIM.

Respondent that heard about BIM	**Confidence level on knowledge and skills in BIM**					
	Very confident	Quite confident	In between	Not very confident	Not very confident at all	Total
Yes	6	23	97	66	63	255
	2%	9%	38%	26%	25%	100%
NO	1	4	42	47	55	149
	1%	3%	28%	32%	37%	100%

Table 2. Respondents that have attended any seminar or program on BIM based on confidence level regarding to average knowledges and skills in BIM.

Respondent that have attended any seminar or program on BIM	**Confidence level on knowledge and skills in BIM**					
	Very confident	Quite confident	In between	Not very confident	Not very confident at all	Total
Yes	7	17	61	27	19	131
	5%	13%	47%	21%	15%	100%
NO	0	10	78	86	99	273
	0%	4%	29%	32%	36%	100%

3.2 BIM awareness in Sarawak

The effective platform of resources should be made available to enhance the awareness of BIM in the Sarawak construction industry. Dissemination of information, programs, and activities through shared resources should be reliable, user friendly, accessible, and up-to-date. When these resources are functioning effectively, they can become powerful tools to increase the awareness level of BIM among the industry players. Based on the findings, the main source of information come from CIDB Malaysia (22%) followed by Publication (13%), BIM consultant (13%), online resources (13%), professional bodies or institute (12%), colleagues (8%), and E-construct Service Sdn Bhd (9%).

Therefore, the survey provided a concrete suggestion that CIDB Malaysia can supply any seminar or program on BIM to the Sarawak construction industry as it is a reliable a source for the respondents. To enhance the determination of CIDB to ensure easier and more affordable access to BIM for the industry players [15], the collaboration with the BIM consultant in Sarawak construction industry is essential in Sarawak to move the overall BIM awareness to the next level.

The rapid adoption of BIM in Sarawak requires an awareness of BIM at an early stage of the projects within the players' organisations. Due to big process and technology changes within the organization, organizations need to provide training to employees to help develop a set of knowledge and skills that are critical to BIM implementation. However, the survey shows that 79% of respondents' organisations did not provide training in using BIM tools and work processes for their technical staffs. This finding indicates that the required knowledge of BIM is still minimal despite the awareness of BIM of the respondents.

3.3 BIM readiness in Sarawak

Organization readiness will determine the possibilities of an organization to adopt BIM. The readiness can be expressed as the level of preparation, potential to participate, or capability to innovate [23]. Figure 5 shows that the despite willingness to change, the organisations are not ready. The finding shows the unwillingness of organizations to invest in and develop capability in BIM, where over half of the responses failed to allocated any financial incentives or support to use BIM, adopt clear policies to support BIM implementation, and invest in BIM hardware and software.

The trend in low readiness is due to the lack of understanding the benefits of implementing BIM. Over the course of the research, it was found that there are no tangible and quantifiable case study reports are available in Sarawak, even in Malaysia to prove the

benefits of BIM implementation [22]. The Malaysia Productivity Corporation (MPC) reported that many construction organizations were unprepared to invest in new technologies and human resource training on a larger-scale basis because they were uncertain of the immediate future growth [24].

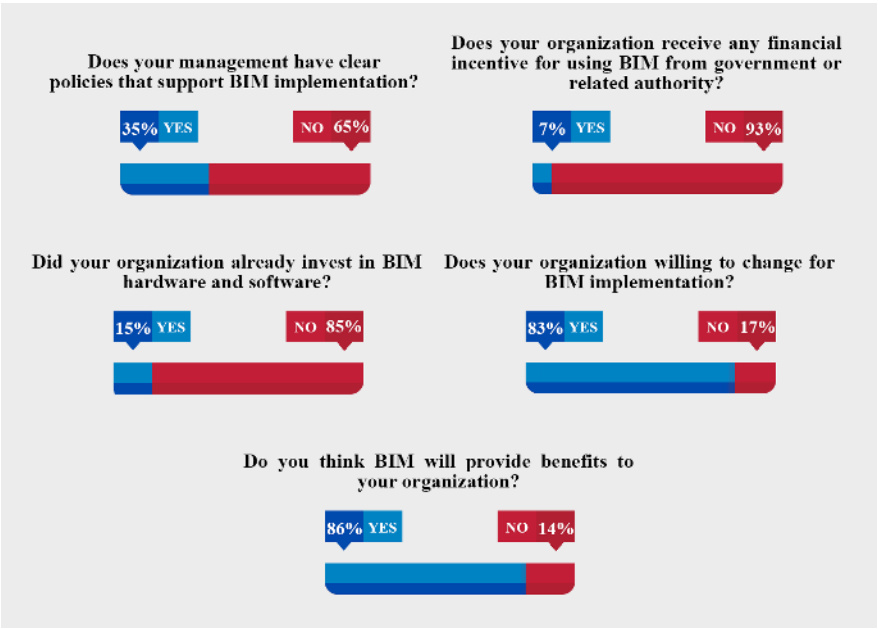

Fig. 5. BIM readiness in the construction industry.

3.4 BIM implementation in Sarawak

Based on the survey results, there is only 14% of the total respondents that experience in using BIM, whereas 86% claimed that they did not handle any BIM project at all. Further analysis with 13% of respondents with BIM experience, it found that 64% were from Kuching. This result can illustrate the rapid development of the city and the large infrastructure projects currently under construction, such as the Pan Borneo Highway Sarawak project. The result followed by 11% of the respondents from the district of Limbang and 9% of the respondents from the district of Sibu that were also involved in this project. Another 5% of the respondents from Miri participated in the offshore structure project.

Based on the respondents' professions, civil and structure engineers are leading adopters of BIM in Sarawak as 56% and followed by contractor at 15%. This result highlights that BIM is mainly used among professionals at the design stage, implementation of documents stage, and construction stages. For instance, there are high number of civil and structure engineers implementing BIM in the Sarawak construction industry from the Pan Borneo Highway Sarawak project, which currently in construction stage. Therefore, the survey has shown that the interest of civil and structural engineers, and contractors in BIM in Sarawak are predominantly because of the Pan Borneo Highway Sarawak project. This survey also determined that 9% of architect, 7% of mechanical engineer, 5% of developer, and 4% for both quantity surveyor and electrical engineer from entire pool of respondents have with experience in BIM.

3.5 Challenges of BIM implementation in Sarawak

Understanding the challenges of BIM implementation is the foundation for recognizing the barriers to BIM implementation in Sarawak. Table 3 presents several challenges that surround the implementation of BIM in Sarawak. To articulate the strategic BIM implementation, the challenges are divided into six categories – 1. people, 2. cost, 3. technology, 4. policy, 5. standard and 6. others. Table 3 shows that lack of BIM knowledge, lack of awareness of BIM benefits, high cost of software and hardware installation, lack of BIM training programmes, and high training cost are the critical challenges that hinder the implementation of BIM in Sarawak.

Table 3. Challenges of BIM Implementation.

Challenges	Min score	Rank	Catergory
Lack of BIM Knowledge	3.91	1	People
Lack of awareness of BIM benefits	3.90	2	People
Lack of BIM training programs	3.86	3	People
High cost of software and hardware installation	3.83	4	Cost
High training cost	3.82	5	Cost
Lack of clear policies that support BIM implementation	3.75	6	Policy
Lack of standard BIM guideline, regulation, contract standardization, information ownership, and insurance risk management	3.75	7	Standard
Lack of BIM requirement/mandate in the industry	3.74	8	Policy
Lack of skilled and experienced organization to implement BIM	3.72	9	Other
No established contractual framework for working with BIM	3.71	10	Policy
Existing hardware not capable to run basic BIM software	3.71	11	Technology
Lack of BIM direction in industry	3.71	12	Policy
Difficulty to choose the most suitable software	3.70	13	Technology
Lack of references/sources to assist in implementing BIM	3.68	14	Standard
Lack of time to implement	3.67	15	Policy
Hard to implement BIM coordinate	3.62	16	Standard
Difficulty to share all the information between different stakeholders	3.62	17	Other
The assumption that conventional methods are better than BIM.	3.55	18	People

3.5.1 Challenges in people

The survey results shows that many organizations in Sarawak are increasingly aware of and are interested in implementing BIM. However, the lack of BIM knowledge is rated as the first as seen in Table 3. Indeed, it is safe to say that even though respondents have high

interest and willingness to establish or use BIM, they simply do not know how to implement BIM correctly and effectively.

The lack of awareness of BIM benefits persist as one of the hindrance in the comprehensive implementation of BIM concepts. Besides, BIM implementation requires the cooperation from all stakeholders from the conceptual to operational stage, there is always the possibility that some profession implement it and some refuses to use BIM and may not be able to engage with the BIM models. For example, if contracting parties to execute the BIM project cannot understand the ongoing advantages of using the model to its full extent, the overall project process will not achieve the maximum BIM effects.

The lack of BIM training programs has also influenced the rate of BIM implementation as few respondents had attended related BIM programs in full. The challenges lies in the belief that conventional methods are better than new processes (BIM) because conventional information exchange has delivered numerous projects despite its inherent problem such as delay, cost overrun, low productivity, and so on [25]. Respondents are comfortable in using conventional method. But it can be seen the respondents do have high readiness to accept and change for BIM as a new trend if it means there is an increase the overall project productivity.

3.5.2 Challenge in cost

The costs factor of BIM technology implementation is another big challenge when implementing BIM. Cost can be categorized into education training, administration, start-up cost in term of software and hardware installation which of high concern to the respondents based on the survey result. There is an absence of observable statistics to show the organization's investment return after BIM implementation showing the expected outcome necessary for a 3-to-5-years investment in the procurement of software and hardware [26]. High cost will affect the benefits of implementation and investment return.

Other than the high cost of software and hardware, the percepted high-cost in technology, training, and staff development needed are factors that hinder the implementation of BIM within the construction organization. To overcome such wariness tag to the implementing BIM, the respondents should be educated that the initial costs of investing BIM software and hardware are not costly when compared to the overall benefits of using BIM technology [27]. A study of the benefit-cost analysis of BIM has been set up based on a railway construction site in South Korea. The total up-front cost required to provide BIM for this particular project site was RM471,918.89. On the other hand, if BIM was implemented before construction, 12 errors would have been detected, and these errors could have been avoided. If not, the total cost to fix the error is RM675,319.83 [28]. In addition, high costs can also be related to external factors, such as specific use of a particular softwares, regulations imposed by the government or clients.

3.5.3 Challenges in standard

From the survey results, it shown that the challenges of BIM implementation also lie in the lack of BIM guideline, regulation, contract standardization, information ownership and insurance risk management. Respondents maintain their opinions on the lack of references or knowledge sources to assist in implementing BIM. They claimed that is not difficult to implement BIM coordination if assistance is available.

The use of standard and guidelines are common throughout the conventional AEC industry but BIM intelligence which allow huge amount data sharing and exchanging may be unsuitable for conventional standard and guidelines [29]. Instead of bringing benefits but it may bring discord and disorder if there are no proper standard guidelines for BIM. A new

BIM standard guideline is required. Even though, CIDB has introduced a BIM Guide which is formulated as a fundamental approach to educate construction players for the BIM implementation in Malaysia, the BIM Guide will require more study to ensure that it can provide directives, references, and process guidelines to the construction players at both organizational and project levels.

3.5.4 Challenges in policy

It is undoubtedly that policy in the aspect of legal and intellectual property is an important factor in the successful execution of BIM related construction projects and improving the overall development of the BIM implementation. The policies that support or mandate the implementation of BIM in construction projects should resolve any legal risk related to the ownership of BIM data. The issue of licensing may bring contractual risks if lack of clear policy. Therefore, it is essential to have a concise and one of all policy in order to provide stakeholders a security in confidential data within the BIM model especially during the administration of construction projects within the environment of an electronic platform. It is shown in the survey that respondents are not as concern regarding policy at this point of the study as compared with other challenges. This is most likely due to their overall understanding on BIM in general as most respondents' knowledge are at the early stage of BIM implementation.

3.5.5 Challenges in technologies and others

For most of the respondents, the challenges in technology factor when implementing BIM are not the main concern. As a result, based on the perspective of the respondents, there is no difficulty in choosing the most suitable software. They also opined that the existing hardware are not capable to run basic BIM software. There are also issues with the large of area in Sarawak classified as rural without basic utilities and internet access, making the implementation of BIM difficult as BIM requires the transfer of digital BIM models using cloud based tools to engage with clients and partners. In that situation, BIM may not be able to be implement in rural projects.

3.6 Future direction of BIM implementation

This survey revealed that 96% of all respondents agree if the government mandate regarding the usage of BIM in the future in the Sarawak construction industry, they will have no choice. This finding highlights the critical role of having structured strategies in ensuring that all related organizations are well prepared to implement BIM at a higher level.

Besides that, adopting new standards and guides is not only a challenge both professionals and their organizations, but it may also even affect the organization's management structure. However, the results showed that 96% of the respondents and 83% of the organizations willing to change for the implementation of BIM. This means that the construction practitioners and their organizations in Sarawak do have high interest in BIM implementation.

Greater support might be needed from policy maker, government and authorities to promote the operational willingness of the construction players to implement BIM in Sarawak. Specialization of design services toward BIM, including project management, quality control, cost planning, time scheduling, structural design, etc to make BIM implementation more effective, rather than a must for a company that can fully implement BIM throughout the whole project progress

4 Conclusion

This study reflected the current practice level of BIM implementation in Sarawak construction industry. The result serves as a baseline for the transition from traditional coordination and information transfer into the BIM mode within the Sarawak construction industry. The findings from this survey indicate the awareness and knowledge of BIM among the Sarawak construction practiser is still on the low-average level after this initial introduction phase. However, 95% of the responses and 75% of the organizations are willing to implement BIM even if it means a change their organization structure.

Although the construction players have the awareness of BIM and the willingness to make change and way for BIM, the percentage of BIM implementation (13%) is extremely low. The considerably low rate of BIM implement in Sarawak underscores the significance of the diffusion of BIM within the construction organization and to understand the challenges in order to formulate strategies to implement BIM. In this study, several domain challenges that hinder the implementation of BIM in Sarawak are mainly as follows:

- Lack of BIM knowledge.
- Lack of awareness of BIM benefits.
- Lack of BIM Training programs.
- High training cost.

The level of readiness is determined by the tendency of an organization to implement BIM. Generally, the BIM readiness of the construction industry in Sarawak is still low where the organization lacks clear policies that support BIM implementation, lack of allocations for any financial incentive for using BIM, lack of BIM training provided to staff and lack of investment in BIM hardware and software. Therefore, strategies to successfully implement BIM should include methods and ways to overcome these challenges. The solution framework must include such strategies and guideline for governments, policymakers and relevant authorities to make an inroad to BIM implementation and increase the implementation rate in Sarawak construction industry.

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