Civil and Sustainable Urban Engineering

Research Article
Volume 2(1), 2022, 44-55
https://doi.org/10.53623/csue.v2i1.86

The Barrier Factors to the Implementation of Building Information Modelling for Construction Industry in Sarawak

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SUBMITTED: 19 April 2022; REVISED: 12 June 2022; ACCEPTED: 16 June 2022

ABSTRACT: Building Information Modelling (BIM) Construction Lifecycle Process offers digital construction solutions throughout the whole project lifecycle by providing sustainable productivity and quality and increasing the work collaboration and efficiency of the design teams. BIM represents the development and application of computer-generated n-dimensional (n-D) models to simulate building construction planning, design, construction, and operation. In Sarawak, the BIM technology does not meet the construction stakeholder's expectations during the project lifecycles in different stages, which resulted in low BIM implementation. Therefore, this research study aims to identify the salient barrier factors to the implementation of BIM in the Sarawak construction industry, specifically in the design stage. To achieve the research study, the methodology is applied through literature review, followed by an online interview with BIM experts in Sarawak Construction Industry. Lastly, the findings of this study indicate the most salient factors faced by the Sarawak construction industry until the present, in terms of Technology, Cost, Management, Personal and Policy, such as (1) Lack of active participation from consultants in the project team, (2) Low enforcement from client, (3) Lack of senior management support, (4) Lack of desire to change of the older generation to implement BIM and (5) Lack of the knowledge regarding the cost benefits for implementing BIM.

KEYWORDS: BIM; design stage; BIM barrier factors; Sarawak construction industry

1. Introduction

Building Information Modelling is an emerging digital information technology in a collaborative space to deliver cost-effective and interoperable efficient construction and management processes [1]. BIM tools empower the design professionals for virtual construction, time, and cost stimulation, and perform sustainable and energy analysis at the early stages along the project lifecycles. Besides, managing construction projects requires various skills and time investment, and techniques. Building Information Modelling is also empowering building construction in 3D modeling to make a difference. It allows the Architecture, Engineering, and Construction (AEC) firms to efficient and effective collaborative construction models information related to structural, technical, and management throughout the lifecycles. Hence, the project players involved can examine the design models'

productivity and efficiency as results for a cost-effective and clash-free design. The modern technology of BIM has expanded to nD modeling and expanded 4D modeling with the time sequencing and processing, 5D modeling with a cost estimation of projects, 6D modeling with sustainability and energy analysis, and 7D modeling with operations and facility management, such as maintenance and technical specifications for future reference [2]. Hence, BIM is the most suitable technology for sustainable design modeling and virtual construction stimulation by early clash detection by early design assessment and reduces possible collision in the design drawing and design error tracking through pre-virtual construction stimulations to testify the performance of the models and improve the performance through the whole project lifecycles. BIM is implied in the construction projects to perform visual construction modeling and clash detection in the early design phase, improving the precision of site positioning and 3D site progress monitoring compared with the conventional 2D shop drawing.

According to the 10th Annual BIM Report, indicated that the United States has the most mature technology in implementing BIM (82%), following up with Australia (18-75%), the United Kingdom (73%), Singapore (50%), and Malaysia (13%) [3,4]. Based on the statistics of BIM Report 2020, Malaysia has relatively low BIM adoption compared to other developed countries [4]. Undeniably, there is abundant publication and resources concerning the status of BIM in the AEC industry in Malaysia. Several researches have been conducted, and few parameters have been identified in the design stage of the construction project lifecycle [5,6]. However, the researchers still fail to come out with a comprehensive strategic plan to identify all barriers factors that restrict the BIM adoption in the Malaysia construction industry, mainly in the design stage. Moreover, the Sarawak construction industry is far backward in performing new technologies since the AEC profession does not fully utilize BIM's potential benefits. In Sarawak, the BIM technology improved the efficiency in construction management and visualization in the project lifecycles, especially in the design stages [7].

The researchers have determined a broad of BIM benefits in the past years [7,8]. However, despite the values and changes stimulated by BIM, the Sarawak construction sector still fails in implementing BIM in its construction projects. Some research study on the BIM barrier factors in the construction industry has been identified. However, there is still a lack of a study to identify the comprehensive barriers factors and findings for a strategic plan for enhancing the implementation of BIM adoption in the design stages for the construction industry in Sarawak. Once the strategic plan is documented, the strategy plan enables the owners and other project stakeholders to quickly assess barriers to BIM implementation to come out with suitable detailed solutions focusing on the design stage in the Sarawak construction industry [9,10]. Therefore, this study aims to identify the comprehensive barrier factors of low BIM adoption in the Sarawak construction industry. This research aimed to inspect and evaluate the overall views of the factor and barriers on BIM implementation in the design phase.

2. Methodology

The conducted methodology in this research was based on the critical review, through the literature review to identify the comprehensive barrier factors of BIM-based on various sources such as journals, articles, thesis, government reports, news, and official portal of Constructioopn Industry Development Board, Malaysia. The identified barrier factors were used to determine the current BIM implementation in the Sarawak construction industry. In

this research, the focus was to inspect and evaluate the overall views of the factor and barriers of low BIM implementation in the design phase. The factors and sub-factors affecting BIM adoption were summarized to identify the barrier gaps in BIM implementation by data collection from the literature review and online interviews with BIM experts. Research regarding the barrier to BIM adoption in the construction industry is done within and out of the Malaysian context (Fig. 1).

2.1. Research area identification

The preliminary study refers to finding the problem and forming the objectives of the research. This part is conducted based on the review of available literature in Malaysia and internationally. Literature related to BIM and current BIM implantation in the Malaysia construction industry was reviewed through journals, articles, thesis, government reports, news, and official portal of Construction Industry Development Board (CIDB), Malaysia. The literature review is identified and implemented to identify the comprehensive barriers of low BIM adoption in the Sarawak construction industry. Furthermore, the literature study lead to a better view of the current situationn regarding the Sarawak construction industry's low BIM adoption rate. Based on the objective listed, the data were analyzed from two sources. First, a literature review needs to be collected from reliable sources to identify the significant factor that affects the BIM implementation in the international and local context to get a deep insight into the BIM implementation and technology at the current phase. Second, the participants were selected from the local company registered under the BIM CIDB portal and JKR Miri to comprehend the research area and objective. Next, the interviews was conducted online to refine the barriers factors by adding and removing the barriers based on the clusters. The online interview was conducted using Curtin endorsed platforms such as Cisco WebEx with BIM experts from the construction industry and academic field in Sarawak Malaysia. A consent form and participant information statement for interviews would be sent to the participants to endorse the willingness.

2.2. Identify the barrier factors

The literature review was conducted to identify the comprehensive barriers affecting the BIM adoption rate in the design stages focusing on the Sarawak construction company. All the required data for this study were collected through reliable sources such as journals, papers, books, interviews, questionnaires, and Malaysia's government portals. The required data was gathered from literature and reviewing related studies. The primary and sub-factor were then categorized. The comprehensive barriers factor summary was then sent to the BIM experts in Sarawak Construction Company for justification and discussion about adding the additional barriers, relocating the barriers under the appropriate criterion, and removing the barriers that were not concerned with the current construction industry. The experts can also supplement extra information based on their field experience and professional advice working in the Sarawak construction industry. The data collected based on the critical review and online interview was applied to identify the critical review barriers gap.

2.3. Online Interview and Survey

The list of the BIM experts in Sarawak was collected from professional engineering organizations such as Public Work Department (JKR Miri), Construction Industry Development Board (CIDB) portal. Besides, requests for the list of professional holders were sent to the government authority such as the Board of Engineering Malaysia, Institution of Engineers Malaysia (IEM). Besides, online websites such as LinkedIn were used to obtain the list of BIM experts. The list of BIM experts was categorized based on their file of experts, years of experience, working position, and the district zone. The BIM users mainly focused on the company owner, Architects, Structural Engineers, Mechanical, Electrical, and Plumbing Engineers, Consultant, Contractors, and Clients for online interviews. Next, the list of BIM experts was filtered based on their expertise to validate as the participants. Next, an email was sent to the participants to indicate their interview willingness. A reminder was sent to the respondent who has not replied from time to time within three times, and the respondent was taken off from the list if they have not replied yet. The respondent was sent an interview consent form for time confirmation to conduct the interview. The comprehensive barriers factor list was sent to the BIM experts in Sarawak Construction Company. The interviews aimed to add and relocate the barriers under appropriate criteria and remove the barriers that not appropriate under the participant's overview. The interview was conducted through an online platform WebEx, and audio/video recorded (Fig. 1).

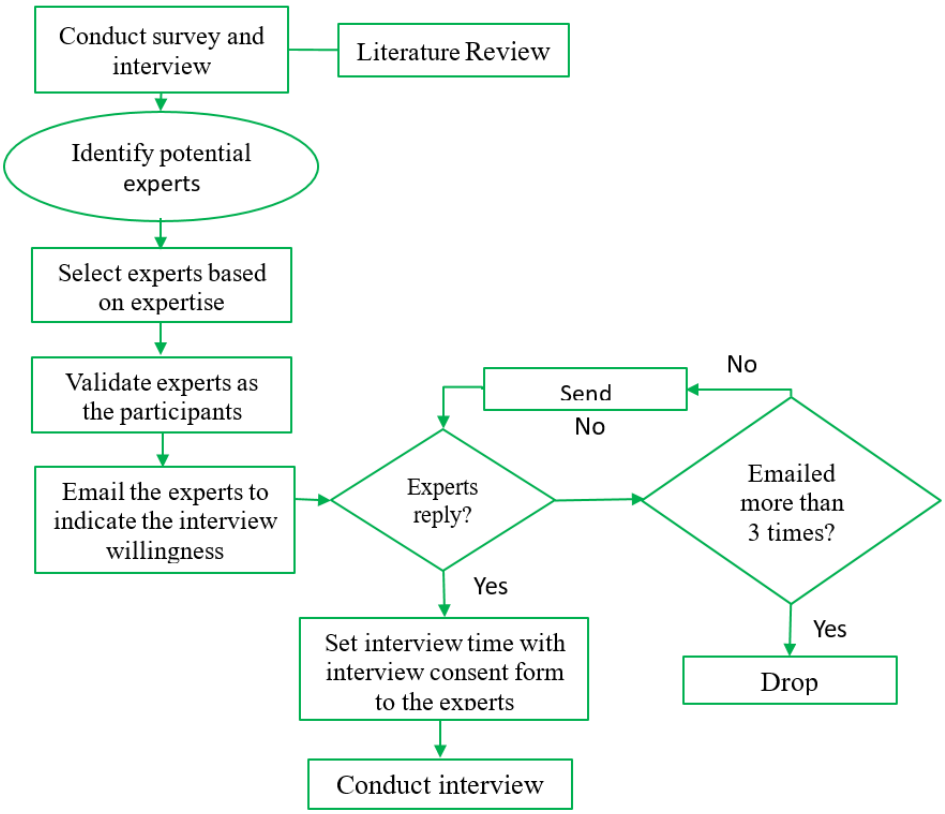

Figure 1. Flow chart of the online interview methodology.

3. Results and Discussion

This section outlines the findings of the main and sub barriers of the BIM implementation in the AEC industry. The factors consist of Technology, Cost, Management, Personal and Policy.

Next, online interviews have been conducted with the BIM profession in the Sarawak construction industry to discuss the current barriers faced and refine the identified barriers as well as to determine the current barriers faced by the Sarawak construction field to implement BIM technology.

3.1. Identify Main Barrier Parameters for implementing BIM

In the first stage, a significant of barriers factors were identified, and data were collected from literature reviews and interviews with the local BIM experts. As a result, several journals and reports have been referred to investigate the barrier factors of BIM implementation of the Sarawak Construction Industry's current design phase. Hence, the data research has been conducted from the literature review from 2010 to 2021 reports [10-13]. Correspondingly, an interview consent form was sent to the BIM experts for participating in the interview. A total of 3 interviews have been conducted, consisting of BIM experts from different fields such as lecturers, engineers, and consultants. Out of the three interviewers, only one interviewer was from West Malaysia. During the interviews, the discussion has been conducted to justify the reliability of the barriers factors based on their professional views and experience in the Sarawak construction fields. To ensure the consistency of the data, the discussion from the previous interviews was brought forward to the following interviews to avoid any clash. According to the the finding, five main clusters were identified, such as Technology, Cost, Management, Personal, and Policy. The sub-cluster was determined and refined based on the five main clusters based on the main cluster through literature review. This research has combined the existing literature review and the BIM expert's interviews to finalize the influencing factors in the Sarawak region. This research has classified Technology, Cost, Management, Personal, and Policy as the five main clusters, corresponding with the sub-clusters, focusing on the BIM barriers factors in the design phase in the Sarawak construction industry.

3.1.1. Technology Factor

Technology factors are referring to technology issues concerning BIM implementation in the construction project. The BIM software technology is usually considered the applicability, ease of use, compatibility, and interoperability of the software. At present, the lack of computable digital design data was a significant problem facing the Sarawak construction industry [16]. Moreover, software data interoperability was identified as the biggest problem in collaborating and data exchange in the 3D construction models [17]. The purpose of the BIM software interoperability was to facilitate the "information" exchange between different digital systems such as AutoCAD, Revit. In the actual scenario, the different designer teams are having difficulties applying the different software to generate the BIM model. As a result, software compatibility was determined in transferring data from existing software to new BIM software. Yet, the lack of data exchange standards and computable digital design data limits the BIM integration in the Sarawak construction industry [17]. For example, the local construction company could directly access the available information without spending time navigating the BIM model. Hence, future research should allow accessible BIM data exchange, reuse data without needing to re-input it, orientate the data in the platform, and combine them in the future [16].

3.1.2. Cost Factor

In the Sarawak construction industry, it is common to alleged BIM implementation to be costly. The BIM perceived a high initial cost for software licenses and hardware were identified, following with the professional training for the staff in the company. Contemporarily, the Small, Medium-Sized enterprises (SMEs) show resistance in implementing BIM if it does not perceive long-term benefits since the company would have to invest a significant amount of expenses in the initial stages [17]. Indeed, there are abundant open resources and journals related to BIM online. However, insufficient data and outcomes have proven the values of BIM in Sarawak due to the lack of comparison with the conventional methods. [18]

3.1.3. Management Factor

The BIM enforcement by the clients and senior managers is essential in spearheading the BIM technology into the company administration. One of the main factors was the reluctance of the consultant firm and construction company to learn and adopt a new technology from the traditional practices [9,10]. Past research shows that most organizations were complacent with the current business process because that they were afraid of the uncertainties since some people think that the technology take over their role and establishment in the company. Thus, the people refuse to apply the technology in the company since BIM experts was needed and the current roles of the old workers were taken over. Moreover, engagement from the clients plays a significant role in promoting BIM since the clients were responsible for supplying the information to the design team and consultants during the design phase. Hence, well-educated clients were essential to the architects and consultant engineers since BIM implementation involves a collaborative effort between the stakeholders throughout the project life cycle, especially in the design phase by formulate strategies to enforce strict plans to motivate the workers to support the BIM Execution Plan [15]. In addition, the lack of participants from the consultants in project teams also hinder the BIM implementations. Lastly, support from the top management is vital to contemplating BIM value in terms of cost, time, and process.

3.1.4. Personal Factor

In personal, the salient factor encountered was the lack of sufficient BIM specialists in the Sarawak construction industry [15]. The lack of awareness regarding the BIM software training and the lack of time from experimentation and implementation in fast-paced projects is the main reason for the resistance of the stakeholders to implement BIM since BIM technology is considered new within Sarawak until now [19]. Moreover, BIM development is based on knowledge and training. Hence, the company need to hire knowledgeable workers with related expertise and BIM usage or provide training to the current staff to adapt to the new process. Knowledge sharing is also one of the obstacles in the construction organization due to the reluctance of the designers and consultant firms to share what they know with other companies, such as load inputs, stimulation, and risk assessment between the project teams [7]. Besides, the study found that the lack of collaboration between the stakeholders in the design team also hinders the adoption of BIM. Those different designers have their way of methods and preferable software to be used for model designing. Nowadays, while carrying out a project, the stakeholders use different software and platform while carrying out the works. Hence, a

universal platform is crucial to enabling different stakeholders to communicate and collaborate to save time and ensure fast response to any project changes [20].

3.1.5. Policy Factor

The commitment and efforts of the government bodies in encouraging BIM adoption were crucial to formulating a national policy to motivate the construction players to implement BIM. In the context of policy, it was discovered that there were still unclear BIM execution procedures, a lack of standardizing documents and guidelines, and a policy mandating the use of BIM for design submission [17]. As the national policy and strategy plan were still ambiguous, it was hard for the local authorities to execute a new policy without enforcement from the government and relative departments such as PAM, LAM. Another barrier to BIM implementation is the uncertain policy of the BIM design model among the design team due to the lack of standardized policy and guidelines for the risk assessments for the data of the BIM model from loss or misuse [15]. In addition, there is no standard contract that specified the contract obligation and the dispute settlement for the organization [1]. For example, some of the designers claim that the BIM model is their intellectual property, not the company owners, even the owner paid for the design of the construction projects. In addition,, the construction players were not aware of the market support trend and government initiatives. The government has recently provided subsidies for purchasing BIM computer system and promoting "myBIMcentre" among the construction industry during the initial stages since the construction players were not aware of the market support trend and government initiatives [21].

3.2. Identify Sub Barrier Parameters for implementing of BIM

In Table 1 below, the parameter of the main barrier factors is shown along with the description for each sub-factors from the literature reviews of the past journals focusing on the design phase of the Sarawak construction industry.

Table 1. Identification and description of the barriers factors

No	Parameters and Description	Reference
1	Technology	
	a) Lack of interoperability, Software compatibility :BIM data exchange: re-use data without having to manually re-input it, link data, and combine data between several platforms.	[14,16]
	b) Poor holistic readiness: Organization framework readiness does not pay adequate attention towards externalities (people, technology, and engineer process in Malaysia design consultant)	[21,22] [17,23]
	c) Lack of data exchange in the Malaysia context: There are some limitations such as data losses like the geometry of the model when sharing data with others	[24,25]
	d) Resistance to adopt new technology from traditional method: The Small Medium Enterprise feel that their project are not complex enough to use BIM	[11,26]
	e) Lack of comparative analysis between the existing methods: There are a need for the comparative data analysis of the benefits of BIM and obstacles than hinders the BIM at the Sarawak construction industry.	[7,9]
	f) BIM software is too complicated to use in the local industry: The complexity of the BIM construction has lead to project failure and has been difficult to manage the design team.	[15,17,27]
	g) Lack of computable digital design data: Currently, the computer aided design creates only pictorial data.	

(continued on next page)

2	**Cost**	
	a) High cost to implement hardware: High cost are needed for the hardware and required hardware upgrades to compatible with high rendering software.	[[8,27]
	b) Additional cost for staff training to get use of the software: The staff must be trained to deploy the new technologies and to adapt BIM in the organization.	[28,29]
	c) High cost for purchasing the software license: The software license are ranges between twelve thousand Ringgit Malaysia to twenty thousand Ringgit Malaysia.	[30,31]
	d) Lack of the knowledge regarding the cost benefits for implementing BIM: Uncertain on how the BIM investment is returned and benefited to the company since significant cost needed to implement BIM.	[26,27]
3	**Management**	
	a) Low enforcement from clients: Lack of reference and direction for BIM in the construction industry.	[17,29]
	b) Reluctance for the consultant firm to shift from traditional practice: The consultant are afraid that jeopardize their establishment and the uncertainties.	[3,10]
	c) Lack of active participation from consultant in project team: There are obstacles in merging the model from different consultant firms.	[17,20]
	d) Lack of senior manager support: The manager are dissenting to imply new technology, since there are insufficient data and feedback from previous construction projects in Sarawak.	[15,28]
	e) Lack of guidelines for collaborations in the design team: Lack of clear guidelines and procedure to notify the collaborations process in BIM.	[13,30]
	f) Lack of the desire to change of the older generation to implement BIM: Fear of unknown and resistance to change from their comfort routine.	[29,31]
4	**Personal**	
	a) Lack of sufficient BIM trained specialist: The organizations resists because high initial cost has to be invested to retraining the workers.	[4,8]
	b) Lack of awareness of BIM training: The personal are not aware of the BIM training and awareness program.	[2,17]
	c) Lack of BIM skills among the stakeholders in the design stage: Lack of the strong mindset and proper methodology for BIM conceptual design.	[24,26]
	d) Lack of awareness of BIM benefits: There is lack of case study and relative construction projects that proved the benefit of BIM modelling in design phase of construction projects.	[3,15]
	e) Reluctance to share knowledge among companies: There are various reason for the company's reluctance to share knowledge such as job security, commercial value and company incentives.	[7,27] [20,24]
	f) Lack of team and work collaboration between the stakeholders in the design team: The lack of team collaborations in the design team results in misunderstanding, data misinterpretations, consequently, increased rework, which is not preferable to the consultants and architect.	[19,28]
	g) Lack of time for BIM experimentation and implementation in fast paced project: The BIM technology are considered new and fewer data of construction projects done in Sarawak construction industry.	
5	**Policy**	
	a) Unclear of the BIM execution procedure: a lack of standardizing documents and guidelines, and policy mandating the use of BIM for design submission in both private and public sector.	[3,17]
	b) Lack of standard documents and guidelines: There is no clear standard and policy on BIM process and procedure, no legal provision for intellectual property, cyber security, and ownership of the data model.	[1,3]
	c) Lack of policy mandating the use of BIM for design submission: The lack of the government active role of the BIM submission for the construction bid as well as the design modelling.	[21,30]
	d) Lack of support from government and professional bodies: As the national policy and strategy plan were still ambiguous, it is hard for the local authorities to adopt BIM without enforcement from the government and relative departments such as PAM, LAM.	[9,17]
	e) Lack of enforcement by the local authorities: The government does not supply enough standardized BIM related information to the construction industry.	[9,17]
	f) Unclear methodology and policy for distribution of cost for the development and operations of the BIM technology: There are lack of a standard of payment fees for the BIM design modelling and consultant fees.	[9,25]
	g) Unclear policy that support the current process practice in design construction model: Lack of government intervention for the standard policy that encourage construction players to adopt BIM in design modelling	[7,26]
	h) Non availability of BIM policy that relate to the market support: The construction players are not aware of the market support trend and government initiatives	[17]
	i) Uncertain policy regarding the ownership of the BIM design model: The designer are afraid to bear the risk of the design errors.	[7,17]

The interview was conducted with the BIM profession in the Sarawak construction industry. The interview aims to revise the identified BIM barriers factors and recognize the current barrier factors of BIM implementation in the Sarawak construction industry. There were three respondents involved in the online interviews. The respondents consist of university lecturers, consultants, and managing directors for construction projects. Table 2 shows the background of the respondents.

Table 2. Background of the respondents

Respondent	Current Position in project	Experience in project using BIM (years)
R1	Institute advisor	5
R2	Consultant	5
R3	Managing Director	9

Based on Table 2 shows that the indicators of R1 to R3 represent the respondents that have conducted the interviews. All the respondents have more than 5 to 9 years of working experience conducting BIM projects. In addition, the respondents were all responsible for managing the project design modeling in construction projects and conducting research related to BIM. Based on the current position and experience in the project using BIM, it can be concluded that the respondents have equivalent experiences and knowledge on the BIM implementation in the Sarawak construction industry. Due to the pandemic, the interview was conducted online and recorded. The online interview was conducted using Skype and Cisco WebEx with the BIM Experts after they agreed to participate. The results are organized by categorizing barriers for main and sub-cluster was summarized as shown in Figure 2.

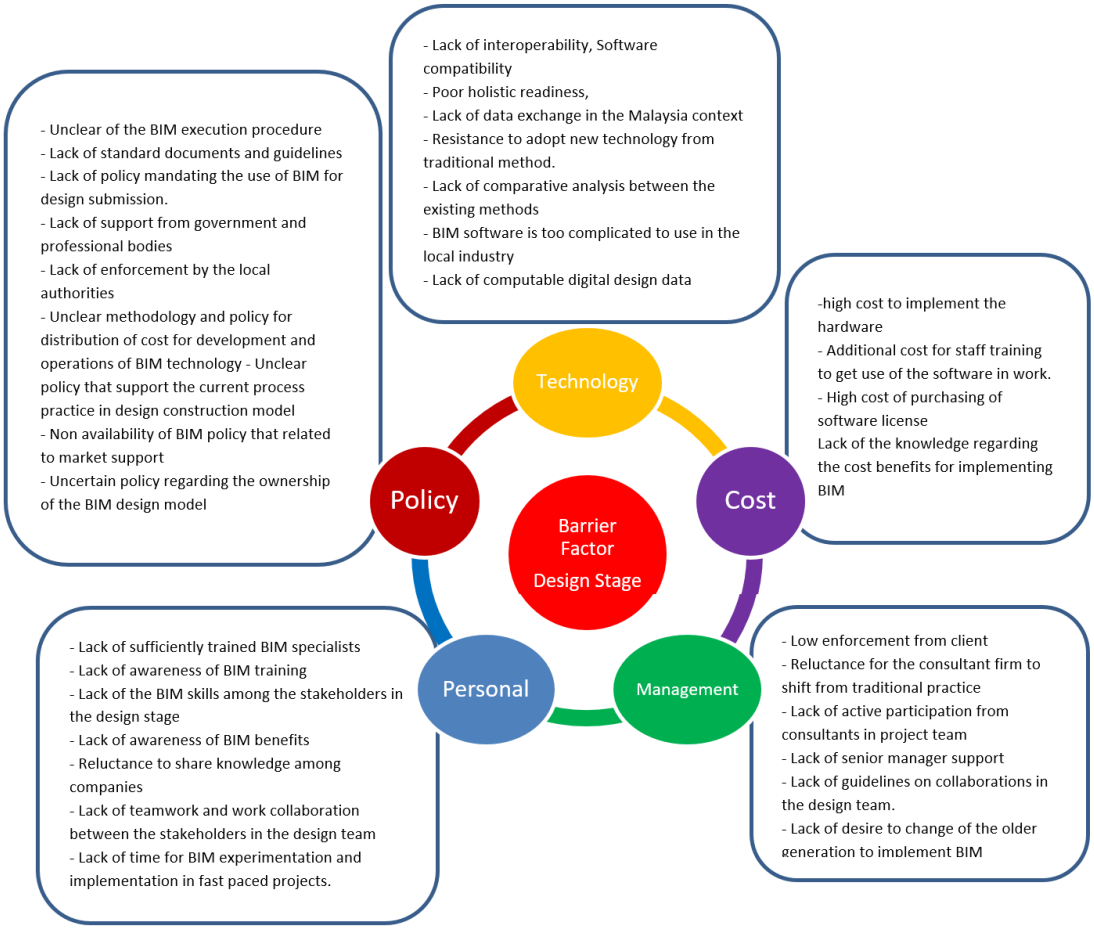

Figure 2. Revised BIM barrier factors in design phase from literature review and interview.

Three interviews have been conducted. According to interview 1, he determined that the barriers factor "Afraid of basic change of operation" moves from Personal to the main Legal cluster. It was mainly because most of the construction firms resist adopting new technology since there were not any clear national guidelines and policies to be mandated by the governments. Moreover, he also mentioned that the lack of information sharing occurs in the project team since the researchers were focusing on the design phase. In addition, he verified that the construction players lack the knowledge for information sharing in the Sarawak construction industry since the BIM was considered new to the Sarawak construction industry. To ensure the consistency of the data, the discussion from respondent one was pointed out in the following interview. For interview 2, the Legal cluster is changed to Policy. Besides, the barrier factor of lack of awareness of BIM training is added in the Personal cluster. He verified that most of the construction players are not aware of the BIM training organized by the official government such as CIDB. For interview 3, some considerations were taken since the respondent were not from the Sarawak construction industry. Lastly, the respondents were asked to comment on the barriers factor, whether it is inappropriate or any missing parameter to be added on.

4. Conclusions

The study concluded that the BIM technology in the design phase is still at a low pace in Sarawak. Several barrier factors that hinder the BIM implementation had been identified, such as “Lack of active participation from consultants in project team”, “Low enforcement from client”, “Lack of senior manager support”, “Lack of desire to change of the older generation to implement BIM”, which is mainly in the management cluster. Hence, the enforcement from the clients and senior management is crucial to ensure the BIM implementation in the Sarawak construction industry. At present, the CIDB is developing a framework of Construction Strategy Plan 4.0 (2021-2025) to assist the construction industry through the change. Therefore, government support is essential to increase the pace of BIM implementation in the Malaysian construction industry. Furthermore, the government initiatives govern the BIM implementation in the Sarawak construction industry. This research could be useful to improve BIM awareness by verifying the BIM barrier factors and to promoting BIM adoption among the local construction players of the design phase in the Sarawak construction industry.

Conflict of interest

The authors declare no conflict of interest.

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