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Critical Success Factors (CFSs) Implementation Cost-Benefit Analysis (CBA) Into Building Information Modelling (BIM) Application Through Malaysian Government Healthcare Projects

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Abstract: The healthcare industry in Malaysia is proving to be one of the most competitive industries today. The sector is expected to grow to 127 billion ringgit (US$30 billion) by 2027, fuelled by increasing demand for healthcare services from an aging population, rising affluence, and increasing life expectancy. An advanced support system is required to ensure the deliverable and have a significant impact on national growth. One commonly used framework to support such crucial decisions in public projects and policies is Cost-Benefit Analysis (CBA). Integration of more support systems such as CBA and Building Information Modelling (BIM) will further enhance government construction project delivery. The objective of this research was to analyse critical success factors toward the integration of CBA and BIM implementation in Malaysian government healthcare facility projects. The outlined research objective aimed to enhance the integration of CBA within BIM implementation. A mixed-methods approach had been selected to collect the data and obtain the desired information. Via this mixed method, a questionnaire survey was conducted first, followed by the interview session. 90 numbers of respondents (populations) registered via the MYBIM Resources Network List (MyBIM CIDB), 74 numbers of respondents were set as a sampling set, and five (5) random respondents who participated in the early questionnaire survey were then selected to be further interviewed. The most CSFs quoted by the respondents are "peoples" via the interview and training and development via a questionnaire survey. This finding, comparatively, looks almost similar to what was found by previous research done in Hong Kong and in the Kingdom of Saudi Arabia's construction industry. Since CBA and BIM are the most important tools in construction and its deliverables, it is expected that the government, via their technical agencies, will properly and strictly enforce their current policies, which will be followed by all the players in the construction industry. In addition, more training should be provided to equip our construction industry professionals with the latest technology regarding CBA and BIM.

Keywords: Cost Benefit Analysis (CBA), Building Information Modelling (BIM), Critical Success Factors (CSFs), Malaysia healthcare facilities

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1. Introduction

The construction industry is a highly competitive industry, and all parties must be highly competitive and innovative to make substantial progress and be successful (Chan et al., 2019). Large public investments in construction require an advanced support system to ensure deliverables and provide a significant impact on national growth. One commonly used framework to support such crucial decisions in public projects and policies is Cost-Benefit Analysis (CBA) (Belay et al., 2016). Building Information Modelling (BIM) can be claimed as a procedural and technological shift in construction; it is able to improve project delivery (Mohd Fateh & Abdul Aziz, 2021).

In the recent research, most of the scholars agreed that it endeavours to embed some of the advanced modelling methods such as BIM and CBA to maximise benefits to the project delivery, particularly in cost-saving (Belay et al., 2016). This was subsequently due to several issues highlighted by several researchers in government project deliverables with non-BIM adoption (Nur Sholeh. et al., 2020). In their research, they discovered that a project adopting BIM could cut time by 50% and reduce costs by 52.36%. In addition, Zainon et al. (2016) stated that BIM gained popularity due to its efficiency benefits in terms of time and cost savings and increased coordination and information exchange. While Lu et al. (2014) found that, when compared with the non-BIM projects, BIM implementation increased the effort input at the design stage by 45.93%, at the building stage, it decreased the cost per square meter of GFA by 8.61%. Taking a holistic view of AEC processes, BIM implementation contributed about 6.92% of the cost savings to the sample BIM project.

However, the level of adaptation of BIM in the Construction sector really depends on several barriers. Among the top barriers encountered by either developed or developing countries in adopting BIM are: i) A high initial cost; ii) Data ownership issues; iii) Interoperability between software programmes; and iv) A lack of standardised tools and protocols (Ullah et al., 2019). From another perspective, the integration of BIM and CBA is no exception to confronting the barriers, as CBA is more cost-oriented, and most of the parties might consider cost information to be confidential.

2. Literature Review

The development of BIM technology applied in the Architecture, Engineering, Construction, and Operation (AECO) industry acts as a cornerstone in speeding up the completion of the project. BIM was explained as an "intelligent 3D model-based process" tool for professional practitioners to efficiently plan, design, construct, and manage buildings and infrastructures (Autodesk, 2021). While Liu & Cao (2021) referred to BIM as a technological process of using a digital information model in a virtual environment in order to achieve construction management throughout the life cycle of construction facilities efficiently in the era of Integrated Digital Delivery (IDD). Moreover, Brahim (2018) claimed in her research that BIM is a methodology that improves the performance of work by allowing construction professionals to manage the construction process throughout the project lifecycle with the use of BIM technology. To summarise, Gerges et al. (2017), as cited in Darwish et al. (2020), concluded that BIM can enhance the procedures and technologies in the Architecture, Engineering, and Construction (AEC) industry.

Meanwhile, scholars have discovered numerous definitions of CBA. Cost-benefit analysis is a formal analysis of the impacts of a measure or programme, designed to assess whether the advantages (benefits) of the measure or programme are greater than its disadvantages (costs) (European Road Safety Observatory, 2018). Nevertheless, David (1998) defined CBA as the process of using theory, data, and models to examine trade-offs, products, and activities for assessing relevant objectives and an alternative solution to assist decision-makers in choosing the most appropriate alternatives.

2.1 Benefits of Integration: CBA and BIM

Integration of CBA and BIM provides investors with both transparency of value and an understanding of the risks of a complex infrastructure project (Parker, 2014). Furthermore, these tools can define relationships between objects and keep changes consistent and coordinated. So, as the design changes, so can the economic costs, benefits, and risks. BIM can show the economic business case for design alternatives while maintaining constraints such as building codes, design or safety criteria, and local or community standards. The integration of CBA and BIM is expected to enhance government construction project delivery (Belay et al., 2016). It can be summarised that, in managing a megaproject that involves a longer span of several activities and challenges, one method cannot be used alone to make a sound critical decision. A combination of more than one method is necessary and thus requires a holistic, integrated, multi-criteria decision-making process.

2.2 The Significant Implementation of BIM and CBA Through a Government Hospital Project

The healthcare industry in Malaysia is proving to be one of the most competitive industries today. The sector is expected to grow to 127 billion ringgit (US$30 billion) by 2027, fuelled by increasing demand for healthcare services from an aging population, rising affluence, and increasing life expectancy (Medina, 2020). The construction process for healthcare is more complex with emerging healthcare disruption, ageing infrastructure, and increasing patient demands for better services and facilities. Hence, BIM, the process of creating and managing digital information about a built asset, needs to be the standard for building projects, especially in the construction of complex healthcare projects (News Hub Asia, 2019).

In addition, Malaysia's government's ongoing efforts to combat the outbreak of the COVID-19 pandemic, which spread in early 2020, reflect the importance of health care for the country. The 12th Malaysian Plan presented by the former Prime Minister on September 27, 2021, has 9 main focuses, among which the 5th focus is on government efforts to increase the well-being of Malaysian families (Prime Minister's Office of Malaysia, 2019). Through this focus, the government has identified proactive measures to increase the preparedness of hospitals and achieve a ratio of 2.06 hospital beds per 1,000 population by 2025. This concern will certainly cost billions of ringgits in development. Therefore, it is significant and relevant for BIM and CBA to integrate, especially for government hospital projects, to ensure the delivery of the project will be more efficient and can be completed with time, quality, and fixed costs. Zhen (2021), stated that the introduction of BIM technology into the health facility construction management stage is important because of its visualisation, so as to minimise the design defect and make the engineering drawings more intuitive and easier to understand. It can also contribute to great cost savings, improve engineering quality, and provide data support for later operation and maintenance activities.

2.3 Critical Success Factors Towards Implementation of CBA and BIM

There are several challenges in implementing BIM, which regard knowledge, cost, technology, policies, organisational structure, legal issues, and others. Tan & Taib (2018) splits the factors influencing the challenges of BIM implementation into two elements, specifically technical and non-technical factors whereas, technical factors comprise technology, expertise, standards, and legal, while non-technical factors involve cost, corporate structure, and people. In addition, there have been several studies conducted to determine the CSFs of BIM adoption in the construction industry within Malaysia and abroad. There are various variables of CSFs in BIM adoption discovered by scholars around the globe, the most recent one as conducted within Malaysia, Hong Kong, and the Kingdom Saudi Arabia being tabulated in the following table:

Table 1 - CSFs for BIM implementation

No.	CSFs For BIM Implementation		
	Malaysia (Sinoh et al., 2020)	Hong Kong [1] (Chan et al., 2019)	Kingdom of Saudi Arabia (Darwish et al., 2020)
1	Seeks for A Better Communication Process in Providing Design Ideas/ Solutions to Clients.	BIM Standardization Within the Industry	Coordination Among All Project Teams / Parties.
2	Encourages Initiatives in Developing New Solutions or Processes.	Training Program for BIM	Providing Training & Development
3	Explores A Better Process of Exchanging Design Ideas with Team Members.	Financial Support from the Government	BIM Awareness Within the Industry.
4	Senior Management to Exhibits Decisive Leadership.	The willingness of Staff to Learn New Technology	BIM Function & Features.
5	Priority in Professional Development with Regards Tools and Knowledge.	Client's Acceptance Toward BIM	Perceived Benefits from BIM to Client
6	The Use of Technology in the Coordination Process	Information Sharing Procedures	The Availability of Competencies & Experiences.
7	To Provide a Clear and Easy Understood Workflow	Organisation Support Structure for BIM With the	Establishment of a Suitable Model for BIM

	Process.	Organisation	Implementation.
8	Using The Latest & Update Technology Both Hardware & Software in the Design Process	Competent Technical Support Team Within the Organisation	Availability of Qualified Staff.
9	Looking for a Better Coordination Process.	Professional BIM Design Team Within the Organisation.	Setup BIM As an Open Sources Program For IFC.
10	Provided Extensive Software Training.	Continuity of BIM Investment & Upgrade Within the Organisation.	Client Requirement & Ownership.
11	Ensure the Extensive Us of Libraries, Standards & Web Resources.	Motivation & Encouragement from Top Management.	Availability of Appropriate Software & Hardware Tools
12	Initiate An Innovation Where All Employees Be Included in the Decision Process		Information & Knowledge Sharing Within the Industry
13	Initiate the Changes for All Members of The Organization		Government's Roles and Support.

Referring to the table above, several similar variables of CSFs have been highlighted among the researchers:

2.3.1 *Information and knowledge sharing procedures (Chan et al., 2019), (Darwish et al., 2020).* These CSFs elaborate more on how BIM information, such as drawings and cost data, is shared among all parties involved. This information normally comes with the company's copyright and creative idea content. In addition, cost data is usually sensitive and confidential.

2.3.2 *Government's roles and support (Chan et al., 2019), (Darwish et al., 2020).* Beyond the government's continuous efforts to promote the benefits of BIM in Construction, industry players also hope that the government can provide support and benefits in terms of finance because BIM involves a costly system. This may include subsidies on any purchase or system (both hardware and software) and any incentive, such as tax relief or recognition.

2.3.3 *Establishment of a suitable and standard BIM model within the industry (Chan et al., 2019), (Darwish et al., 2020).* Research also discovered and encouraged the establishment of suitable and standard BIM procedures to serve as a guide to better BIM implementation in projects. Subsequently, it also enables smoothness in the workflow process and provides better practicality and efficiency.

2.3.4 *Training and development of BIM (Chan et al., 2019), (Darwish et al., 2020), (Fetters, 2016).* Providing continuous training and development, particularly towards BIM technologies and procedures, seems to be among the CSFs, which is being highlighted by all three (3) researchers. They agreed that it is to ensure the employee is really competent and equipped with the latest technology to deal with their daily work related to the BIM system. However, this training and development require capital investment, which might be a constraint for several organisations in the industry. Moreover, it also required time and willingness among employees.

3. Methodology

A mixed-methods approach was selected to collect the data and obtain the desired information. Via this mixed method, a questionnaire survey was conducted first and followed by the interview session, where five (5) random respondents who participated in the early questionnaire survey were then selected to be further interviewed. This is to enable the data to be verified during the interviews. A mixed-methods design offers a number of benefits to approaching complex research issues as it integrates philosophical frameworks of both post-positivism and interpretivism, interweaving qualitative and quantitative data in such a way that research issues are meaningfully explained Fetters (2016). It also offers a logical grounding, methodological flexibility, and an in-depth understanding of smaller cases (Maxwell, 2016). Furthermore, a combination of these techniques also provides assistance to expand the finding derived from the first phase of the investigation and to validate the quality of the conclusion derived from one type of study by checking it against a mixed design (Tashakkori & Newman, 2010).

These questionnaires had been circulated among the BIM Consultant population, who register with the PWD BIM Unit and MyBIM CIDB, and also among construction professionals who have direct exposure to Construction Projects with BIM Execution. The amount of sampling for this survey is set at 74 respondents. This is based on the 90 respondents (populations) registered via the MYBIM Resources Network List (MyBIM CIDB). There are no proper bodies being established to provide appropriate registration and member monitoring, as is being provided by other professionals such as architects, engineers, and quantity surveyors.

The number of samplings is determined by using the sample size calculator provided by Raosoft. All research statements will be set according to the Likert Scale, from 1 to 5; whereas 1 (Strongly Disagree), 2 (Slightly Disagree), 3 (Slightly Agree), 4 (Somewhat Agree), and 5 (Strongly Agree). Findings were then transferred into Microsoft Excel software for further analysis. The mean value was computed to establish the rank of each of the research statements. Mainly, mean implies average, and it is the sum of a set of data divided by the amount of data. Where the mean value was derived from: *the value of frequency (Σ vf) obtained from the survey divided by the maximum value of frequency (Σ max of vf). Σ vf = (1*n) + (2*n) + (3*n) + (4*n) + (4*n) ÷ Σ max of vf = (5*N), where N is the total number of respondents, and n is the sub value of respondents for each of the selected Likert scales.*

4. Finding and Discussion

4.1 Demography Background for the Questionnaire Survey

Data on the demographic profile were acquired to gather personal information from the samples, as stated in Table 2. The greatest number of respondents responding to the questionnaire experienced varied between 0–5 years and 11–15 years in the construction industry. However, the number of respondents who have more than 10 years of experience is the largest sampling population within this analysis, which represented 66%; this conceivably will translate to a more sensible analysis.

Table 2 - Respondents' profile for the questionnaire survey

Profession	Number of Projects Handled Using BIM	Year of Experience In Construction Industry					Frequency (By Profession)
		0-5	6-10	11-15	16-20	>20	
Architect	0-4	-	1	-	-	-	4
	5-8	-	-	-	1	-	
	>9	-	-	-	1	1	
Engineer	0-4	2	1	2	1	-	10
	5-8	-	1	-	-	-	
	>9	-	-	1	1	1	
BIM Manager/ Modular	0-4	1	-	1	-	-	8
	5-8	1	-	2	-	-	
	>9	-	-	-	1	2	
Quantity Surveyor	0-4	5	2	5	3	4	23
	5-8	-	-	1	1	-	
	>9	-	-	-	2	-	
Project Manager	0-4	-	-	-	-	-	2
	5-8	-	-	-	-	1	
	>9	-	-	-	-	1	
Others	0-4	4	-	-	-	1	6
	5-8	-	-	1	-	-	
	>9	-	-	-	-	-	
Frequency (Experience)		**13**	**5**	**13**	**11**	**11**	**53**

4.2 Demographic Profile for a Semi-Structured Interview

All five (5) respondents have worked in the construction industry for various years and have been involved in BIM projects. Apart from that, the respondents approached came from different sectors of the construction industry: three (3) respondents were from government agencies, the Public Work Department (PWD), and two (2) respondents were from the private sector with a minimum academic qualification of a bachelor's degree. Representatives with different backgrounds were chosen to gain a variety of perspectives and understanding on the topic. A summary of the respondents' demographic profile is tabulated in Table 3.

Table 3 - Respondents' profile for the interview session

Respondent	Academic Qualification	Designation	Experience in Construction (Years)	Number of BIM's Project Involvement
R1	Bachelor (Hons) of Quantity Surveying, UTM Skudai	Quantity Surveying, Grade J41 at Public Work Department (PWD)	21	20 ~ 30
R2	Master of Construction Law, (LLM), University of Strathclyde, Scotland	Quantity Surveying, Grade J48 At Public Work Department (PWD)	18	5 ~ 10
R3	Bachelor (Hons) of Civil Engineering	Project Director Padang Rengas Construction (PRC) Sdn Bhd.	37	Only 1
R4	Master of Construction Management, UTM Skudai.	Civil Engineer, Grade J44 at Public Work Department (PWD) BIM Unit	14	> 20
R5	Bachelor of Architecture, International Islamic University Malaysia (IIUM).	BIM Modular, at EV Dynamic Berhad	3.5	Only 1 Project

4.3 Critical Success Factors (CSFs) Towards Implementation of Cost-Benefit Analysis (CBA) and Building Information Modelling (BIM) In Malaysia's Government Healthcare Facilities Project

The most CSFs quoted by the respondents are "peoples" (10 density) via the interview and training and development (4.642 means) via a questionnaire survey. This finding, comparatively, looks almost similar to what was found by previous research (Chan et al., 2019) in the Hong Kong construction industry and (Darwish et al., 2020) in the Kingdom of Saudi Arabia. This may be due to all those countries still in the initial stages of BIM adoption. Even though people and training were quoted as the most important CSFs among the respondent, the respondent also comes to the conclusion that other CSFs such as technology, policies, training knowledge, and data sharing also have a significant impact on CBA and BIM adoption within Malaysia's construction industry. Out of this, previous research (Nur Sholeh. et al., 2020), (Ullah et al., 2019), (Liu & Cao, 2021), (Othman et al, 2021), (Einur Azrin Baharuddin et al., 2019) in recent years has discovered similar key CSFs: people, technology, and policy. Overall findings discovered via the questionnaire survey regarding the CSFs towards integration of CBA and BIM implementation in Malaysian government healthcare facilities projects tabulated as per Table 4.

Table 4 - The CSFs towards implementation of CBA and BIM in Malaysian government healthcare facilities project

No.	Research Statements	Median	Rank
D13	Training and development program for BIM.	4.642	1
D15	Priority in professional training and development with regard to tools and knowledge.	4.528	2
D03	Coordination among all project teams.	4.491	3
D02	Encourage initiatives in developing new solutions of processes.	4.396	4
D09	Information and knowledge sharing within the industry.	4.377	5
D17	Establish of a suitable (clear and easily understood) model for BIM.	4.377	5
D01	Seeks for a better communication process in providing design ideas/solutions to clients.	4.377	5
D05	BIM awareness within the industry.	4.358	8
D06	The willingness of staff to learn new technology.	4.358	8
D04	Financial/incentives from the government.	4.340	10
D14	Standardization of BIM functions and features within the industry.	4.340	10
D07	Continuity of BIM investment and upgrade within the organization.	4.321	12

D08	Motivation, support, and encouragement from top management within the organization.	4.283	13
D10	Initiate the changes for all members of the organization.	4.208	14
D16	Perceived the benefit from BIM to the client.	4.208	14
D11	Initiate an innovation where all employees are included in the decision-making process.	4.189	16
D20	Availability and the usage of the latest technology (software and hardware tools) in the design, coordination, and construction process.	4.189	16
D12	Client's requirements, acceptance, and ownership.	4.075	18
D19	Setup BIM as an open-source program for Industry Foundation Classes (IFC).	4.075	18
D18	Availability of qualified/competent/experienced staff.	4.057	20

In the qualitative approach, all the respondents agreed that standard government policy is the key element for the success of CBA and BIM integration, followed by technology via the latest hardware and software installations. In addition, the R4 insisted that the policies should not be standalone; proper comprehensive programmes should be developed so that integration of CBA in BIM becomes an obligation and not an option for the industry players. For others, key elements towards the successful integration of CBA and BIM have been simplified and tabulated in the following Table 5.

Table 5 - The simplified table of key elements of CBA and BIM implementation successes

No.	Key Elements of CBA and BIM Implementation Successes	R1	R2	R3	R4	R5
	People					
1.	People Acceptance	✓				
	Training					
2.	Number of Experts					✓
	Technology					
3.	Proper and the Latest, Hardware and Software	✓	✓			✓
	Policies					
4.	Should not be a Standalone Policy	✓	✓	✓	✓	
5.	Requiring BIM Design Standard		✓			
6.	Budget Allocation		✓			
	Promotion & Education					
7.	Comprehensive Programmes				✓	

Moreover, the analysis using ATLAS.ti 9.0 found that the "people" related factor was among the highest CSF quotes by the interviewer respondent with a density of 10, followed by the "technology factor" with a density of 9, and subsequently "policies", "training", and “finance", with densities of 5, 5, and 4 respectively. The detailed ATLAS.ti 9.0 networks for CSFs towards implementation of CBA and BIM in Malaysian government healthcare facilities are shown in Figure 1. Basically, all of these CSFs are interrelated to each other. For instance, to have people who are really equipped with BIM technology, those people should equip themselves with the necessary knowledge and skills, by attending the training and related programme organised by the industry. This required continuous internal self-encouragement and financial support from the organisation to provide the necessary hardware and software. This was agreed by Mohd Fateh & Mohammad (2021) highlighted by producing the network diagram, policy and decision-makers would be able to gain a better understanding of the CSFs towards implementation of CBA and BIM in Malaysian government healthcare facilities that need to be taken into account.

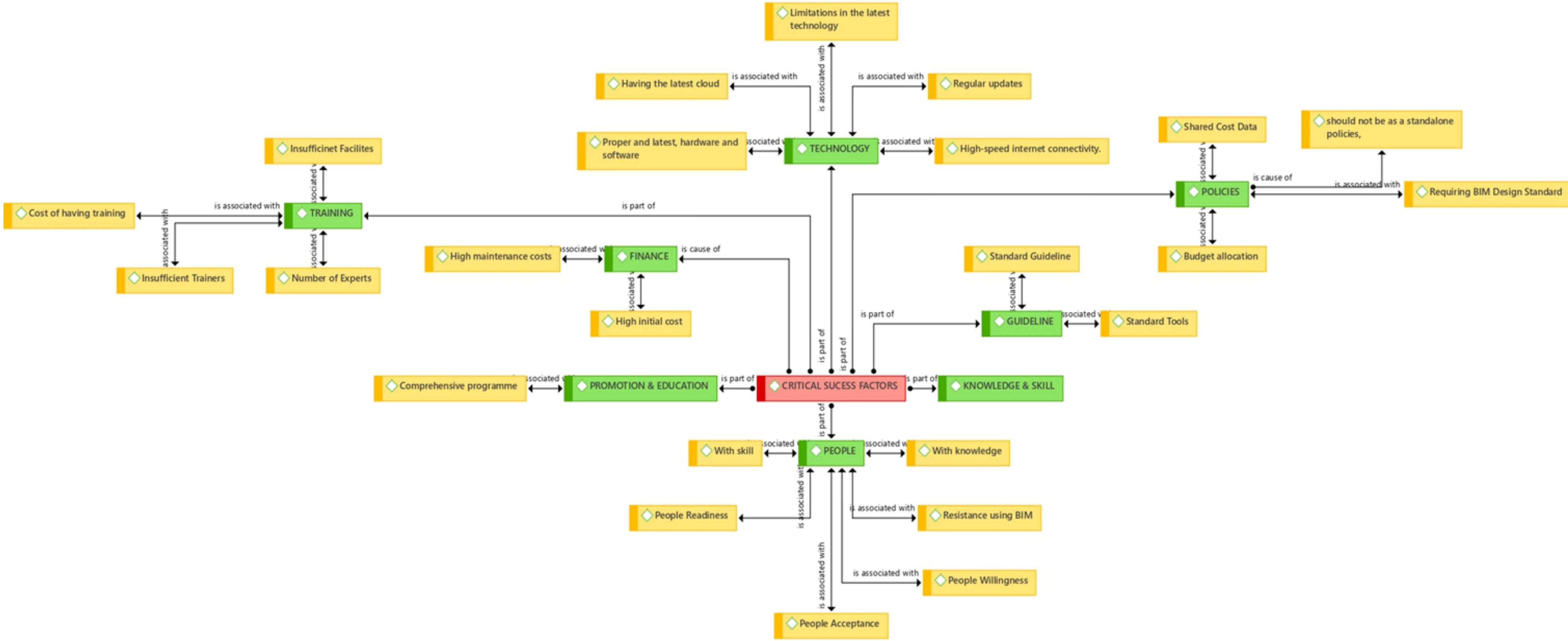

Fig. 1 - Atlas.ti 9.0 Network for CSFs towards implementation of CBA and BIM in Malaysian government healthcare facilities projects

5. Conclusion

As a conclusion, people, technology, policies, coordination, initiative, and knowledge sharing and training were among the most CSFs, discovered both via interview and questionnaire sessions, towards the integration of CBA and BIM implementation in Malaysian government healthcare facility projects. Basically, CSFs from non-technical categories (policies, people, and training) were more dominant compared to Technical Factors (Technology). Most of the respondents also agreed and confirmed via interview session that, considering these CFSs by all construction stakeholders, they will enhance the deliverable of a government building or facility project, both during construction and also during the asset life cycle span. Since CBA and BIM are the most important tools in construction and its deliverables, the government, via their technical agencies, will properly and strictly enforce their current policies to be followed by all the players in the construction industry. In addition, more training should be provided to equip our construction industry professionals with the latest technology regarding CBA and BIM. Industry players, especially the private sector, contractors, consultants, and developers, should have a high awareness of implementing CBA and BIM in Construction. They should not see the initial cost (direct cost) as a burden but instead see the savings in indirect costs on the cost of operation and maintenance of a building and facilities as an opportunity.

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