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COMBINATIVE FRAMEWORK FOR VALUE ENGINEERING AND BUILDING INFORMATION MODELLING IMPLEMENTATION AT LOD300 STAGE

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Abstract

Value Engineering (VE) involves a multidisciplinary team approach in a highly systematic workshop aimed at achieving Value for Money (VfM) focused on improving the function of a project, product, or service, not merely reducing costs. In the construction industry, VE is applied during the design or pre-construction phases of public, private, or Building Information Modelling (BIM)-based projects where benefits can be maximised. VE can be implemented more effectively with BIM, especially in providing accurate and adequate information. It is important to understand how these two concepts are related and how they benefit projects. Nevertheless, there is a dearth of research that combines VE practice with BIM to evaluate viable alternatives or improve design. This paper investigated the need for VE in the LOD300 phase for construction projects in Malaysia. In this work, a quantitative methodology was used to incorporate findings from the literature into a questionnaire survey that was purposefully distributed to industry practitioners with knowledge of VE, BIM, or both. A sample of 186 was drawn from a total population of 353 professionals: Members of the Institute of Value Management Malaysia (IVMM), Public Works Department of Malaysia (PWD) VM and BIM, and myBIM Centre Malaysia. 32% of responses were received, and the data collected were analysed using the Statistical Package for Social Sciences (SPSS). Based on the results, a framework was developed to include VE at the LOD300 phase in BIM. This paper provides empirical evidence of the benefits of this approach and offers construction practitioners with an overview of how VE can be systematically applied to BIM.

Keywords: Value Engineering; Building Information Modelling; detailed design stage; construction industry

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INTRODUCTION

Value Engineering (VE) is a creative, organised effort that assesses the requirements of a project with the goal of accomplishing the required functions at the lowest total cost (capital, staffing, energy, and maintenance) over the life of the project (Thomas, 2019). The success of the VE exercise is mainly influenced by the relationship of the multidisciplinary VE team, which is primarily determined by effective communication and strategic action of the team members. Male et al. (2007) found that the parts of the VE process, which include the study process, the commitment of team members involved in the project, the administration of the VE process, the commitment of executives, and efficient facilitation, influence the success of the VE exercise. Meanwhile, Building Information Modelling (BIM) is a recent innovation that is being considered to address issues such as low productivity in the architecture, engineering, and construction (AEC) industry (Abbasnejad et al., 2021). BIM offers significant advantages to the construction industry across the project's life cycle. Saraireh et al. (2020) pointed out that BIM technology generates a digitally created detailed virtual view of a building. This model can be used extensively in the planning, design, construction, and operation stages of facilities. Equally important, BIM has demonstrated its ability to boost efficiency and productivity throughout the design stage (Bentley, 2017; Haron et al., 2015; Migilinskas et al., 2013). VE implementation can be planned as part of the BIM preparation process to ensure smooth project execution. According to the previous research by Li et al. (2021), it is possible that approaches to integrate VE into BIM have the essential function of visualisation and clear information, and subsequently enhance both performances.

Background

SAVE International (2015) indicates that VE methodology is a systematic and structured method for enhancing projects, products, processes, services, and organisations. It helps to achieve the best possible balance between function, performance, quality, safety, and cost. The primary goal of the VE in construction is to eliminate superfluous expenses while enhancing the level of performance and quality in such a way that the owner's demands are met or satisfied. Although the VE method is gaining more and more attention from stakeholders (Baarimah, et al, 2021), the conventional VE method has several shortcomings or restrictions, such as an overemphasise on cost and not promoting nor improving creativity (Wao 2015). The application of VE alone is insufficient to prevent the desired goals from being realised (Li et al., 2021). Theoretically, there are a variety of software solutions available in the AEC industry to facilitate interdisciplinary collaboration work (Faraj et al., 2000; Rosenman et al., 2007), especially BIM, which has recently emerged and is being used in many countries, including

Malaysia (Latiffi et al., 2013). In a randomised controlled study of the behaviour of BIM, Li et al. (2014) reported that modern BIM tools have enabled a response system that tracks the impact of design changes associated with costs. Li et al. (2014) added that the visualisation of construction activity analysis aids cost planning operators in identifying conflicts and communicating design alternatives that may be more cost-effective and time-saving.

VE and BIM share the same objectives in terms of effectiveness and cost reduction. Both include a life-cycle view of completed and operational assets. One way that BIM can help with VE is by allowing for faster analysis of alternative design options (RICS, 2017). As a result, it is incredibly beneficial for the integration of VE in BIM in the AEC industry to optimise and maximise its benefits. Although many researchers, such as Baarimah et al. (2021), Dcrnirdogen et al. (2021), and Wei and Chen (2020), had taken the initiative to understand and research the integration of VE in BIM, Li et al. (2021) discussed that there has been no study conducted on how VE is being applied in BIM to enhance the design or choose a suitable alternative. Despite several studies that have been carried out to state the usefulness and effectiveness of BIM and VE separately, the research on combining and integrating VE in BIM is lacking. In order to fill this gap, this paper investigated the potential integration of VE in BIM during the detailed design stage for the construction project in Malaysia.

LITERATURE REVIEW

Value Engineering

As part of the value management (VM) process for projects, VE interventions are implemented in the design development stage and are considered a disciplined method for delivering required functionality and quality while preventing unnecessary costs (Kelly et al., 2014). In the design stage of project implementation, VE is often used to align or re-align technical solutions to meet business requirements and scope (JKR Malaysia, 2013). According to the Economic Planning Unit (EPU) (2011), VE must be applied at all levels of design development to ensure that the project achieves the specified functions and objectives. This method must be performed to find alternatives and the optimal method to implement a project to optimise value for money and increase the effectiveness of the project.

VE in Malaysia

In Malaysia, VE was introduced in 1986 (Che Mat, 2010; Jaapar, 2008; Jaapar & Torrance, 2007). It is evident that its application is increasing in Malaysia. Therefore, in order to aggressively promote the use of VE in the industry, it is crucial to first analyse the current stage of its application before developing a system of VE concepts to suit the existing local environment. The Economic

Planning Unit (EPU) of the Prime Minister's Department established a dedicated VM division to manage VM for government projects and programmes. To enhance the value of future public projects and programmes, the EPU released the "Value Management Guidelines Circular 3/2009," which made VE/VM mandatory for public projects worth RM50 million and above (Jaapar et al., 2012). Subsequently, the EPU published its first implementation guideline for VM in government projects, which became the main reference for VM implementation in 2011. In addition, the Malaysian Public Works Department (PWD) published its own VE guidelines in 2013, which are consistent with the EPU implementation guide. Both EPU and PWD are working closely to strengthen the implementation of the value methodology for the government.

Prior to mandatory implementation for public projects and programmes, VE/VM was implemented in various private projects. According to Abd-Karim (2016), Malaysia Airport Holdings Berhad (MAHB) published the first guideline for VM implementation in 2008. This guideline is the result of successful VM studies conducted for works, supplies, systems, and facilities valued at over RM300,000. Meanwhile, the establishment of the Institute of Value Management Malaysia (IVMM) in 2000 shaped the landscape and served as the foundation for the institutionalisation of value methodology in the country. IVMM published the National VM Guide in 2018 and the VM Competency Standard in 2021, which have strengthened the VE/VM implementation structure in Malaysia.

VE implementation

The VE process is conducted through a structured set of steps or phases called ‘job plans’ that are followed systematically during the workshop. The VE job plan was initially developed by Miles in 1961 and continued to be investigated and developed as part of enhancing the implementation of VE (Abd-Karim et al., 2011). According to JKR Malaysia (2013), a job plan comprises three stages: Pre-Lab, Lab, and Post-Lab. The Pre-Lab Stage of any VE study is the planning phase in which the study context and objectives are set, project information is acquired and analysed, and the lab agenda and logistics are planned. At this stage, the project's readiness to undergo VE will be assessed, information will be collected and synthesised, and VE lab activities will be planned. The members will investigate value misalignments and devise methodologies, tools, and approaches for attaining VE study objectives. During the Lab Stage, the lab members will delve more into value discrepancies and possibilities for achieving or improving existing situations. The Lab members will jointly produce, assess, and develop options during the interaction before recommending the best solutions. The Lab stage typically lasts 3-5 days, depending on the design complexity and scope of the VE study. To enable efficient and robust decision-making, the following Lab phases are carried out in this order:

1) Information – To develop an understanding of the project and its details and verify the project's details.
2) Function – To understand the project's functions and to identify mismatches and potential value improvements.
3) Creative – To generate innovative and creative ideas as alternative ways to perform functions and enhance the project's value.
4) Evaluation – To identify and shortlist potential value-improvement ideas from the generated ideas.
5) Development – To develop ideas as workable options into the best or preferred solutions by further analysing their viability.
6) Presentation – To present and gain approval from stakeholders to proceed with the VE implementations.

Building Information Modelling (BIM)

Construction projects are becoming increasingly complex and challenging to govern. Information and communication technology (ICT) has been developing at a rapid pace in response to the rising complexity of projects (Bryde et al., 2013). One of the most promising recent innovations in the AEC industry is Building Information Modelling (BIM). BIM technology creates a digitalised exact virtual representation of a building. This model, referred to as a building information model, can be applied to facility planning, design, construction, and operation. It has evolved into a necessary technique, which includes the digitalisation of the built environment supply chain (Saraireh et al., 2020). According to what has been defined by Succar (2009), BIM is a digitised format for integrating building design and project data over the course of the life cycle of the building. It is possible to conclude that BIM is a technique for creating digital (3D) information models using the appropriate tools in order to facilitate communication and engagement among stakeholders.

BIM in Malaysia

Since 2009, the private sector has been primarily responsible for the advancement of BIM in Malaysia. In 2007, the Director of Malaysia's PWD proposed the idea of using BIM in Malaysia. As a result, the first government project to adopt the BIM methodology was unveiled in 2010 (Haron et al., 2017). The PWD has embraced BIM since then, with the target of implementing BIM on 50% of projects worth RM10 million and above, with an increase of 10% in the following year under the PWD Strategic Plan 2021-2025. Through BIM, stakeholders can utilise the developed data not only in the planning and design phase, but also in the implementation phase during construction.

BIM adoption necessitates the creation of dependable mechanisms for the transfer of information between different software tools. It also requires enabling efficient and direct coordination and monitoring procedures between project participants and team members. An acceptable level of interoperability and standardisation of work practices must be achieved for project participants and team members. The collective expertise of project participants enables us to define the decision-making process prior to the use of BIM in individual projects. It also allows us to make recommendations for the planning process in a small business environment with different software and work methods (Migilinskas et al., 2013).

Generally, there are conflicting views on the benefits of BIM, leading to widespread misunderstanding of the projected outcomes. Farouk et al. (2023) conducted a study on trust challenges and strategies in BIM-based projects in Malaysia and found that organisations must create more trust and faith in the transition to BIM. The number and range of definitions demonstrate the current ambiguity in describing and quantifying BIM, as well as in analysing its potential benefits (Haron et al., 2017). Any definition of BIM should not be one-sided but should include the essential features assigned to it. There is a risk in providing a restrictive definition of BIM as it makes establishing a baseline for comparison more difficult (Izadi Moud & Abbasnejad, 2012). A restricted definition also makes benchmarking difficult, if not impossible, for improving BIM utilisation.

BIM Level of Development (LOD)

BIM is a technical creation that is used in the geometric modelling of a facility's performance and the administration of construction projects (Farouk et al., 2023) BIM replaces 2-dimensional (2D) drawings with a 3-dimensional (3D) model as part of an architectural design. The 3D model for the construction project must be intertwined with contextually data-rich building subcomponents. Lévy (2011) stated that all data concerning contextual data-rich building elements were derived primarily from the level of development specification. The American Institute of Architects (AIA) established the Levels of Details (LoD) in 2008, when it initially introduced five 'levels of development' for defining the amount of detail about the BIM model. But later, to help the building trades adopt and implement them in a better way, the Levels of Development (LOD) were published in 2013 (United BIM, 2023). The LOD concept is established in BIM to allow construction stakeholders in the AEC industry to specify and express with a high level of content clarity while also ensuring the reliability of the 3D models at various stages.

According to Latiffi et al. (2015), there are five (5) levels of LOD, where each level represents a distinct set of content criteria, approved model use, and model purpose: LOD100 (Concept Design), LOD200 (Schematic Design), LOD300 (Detailed Design), LOD400 (Fabrication & Assembly), and LOD500 (As-built). LOD300 is similar to construction documentation, where the model will contain accurate quantity, size, location, orientation, and detailing, fabrication, assembly, and installation information. Information contained in LOD300 models can be used during the construction phase of the project (United BIM, 2023). Moreover, there is also a specification for LOD350 that develops coordination between any disciplines, such as clash detection. LOD is used to address a variety of issues that arise during the design stage. BIM users can specify the use of the building models, and stakeholders can understand the usability and limitations of the models they receive (Latiffi et al., 2015).

Design Changes in Construction Project

In many construction projects, frequent design changes may negatively affect project performance, cost overruns, delays, and function failures. Mohamad et al. (2012) classified the key sources of design changes as clients, consultants, and contractors, who are the primary parties in building construction projects. However, despite the negative impact of design changes, little attention is given to proactively managing these effects, such as through VE and BIM implementation (Kelly & Male, 2003; Moayeri et al., 2017). Table 1 illustrates the typical causes of design changes in the construction industry.

Table 1. The causes of design changes

Factor	Causes
Client's related	• Change of requirement/specification • Addition/omission of scopes • Slow decision making • Unclear initial design brief
Design consultants related	• Erroneous/discrepancies in design • Have difficulties in capturing client's needs • Unstructured design process • Lack of design checking system • Outdated design due to new technology
Contractor's related	• Request to use available materials • Alternative construction methods (improving the buildability) • Lack of experience about new construction technologies • Use of alternative materials
External related	• Changes in government regulations • Poor economic conditions • Differing site conditions • Unexpected changes in material availability

(Mohamad et al., 2012; Yana et al., 2015; Yap & Skitmore, 2017)

The Integration of VE and BIM

There are many negative effects associated with frequent design changes in construction projects, including poor performance, cost overruns, delays, and the inability to fully function. According to Love et al. (2002), project changes may occur as a result of both internal and external factors. On the other hand, Mohamad et al. (2012) classified the key sources of design changes as clients, consultants, and contractors, who are the primary parties in building construction projects. However, despite the negative impact of design changes, hardly any attention is given to proactively manage these effects, such as through VE and BIM implementation (Kelly & Male, 2003; Moayeri et al., 2017).

VE implementation can be planned during the preparation of the BIM Project Execution Plan (BPEP) to enable seamless project execution. To execute the project, it can be used as a resource. According to JKR Malaysia (2021), BPEP embodies the process and methodology for delivering collaborative working practices for BIM projects. It comes in two forms: pre-contract and post-contract. In pre-contract, information is provided for BIM modelling activities during the design phase, while in post-contract, it is coordinated and managed during construction and operation (JKR Malaysia, 2021). JKR Malaysia (2013) pointed out that two intervention points can be implemented throughout the design phase: VE on concept design and VE on detail design. The use of the BIM model, on the other hand, needs to be adapted to VE intervention in each selected phase, depending on the LOD of the model that has been developed by the designer. Combining VE into the BIM preparation process can be strategically scheduled to promote seamless project execution. As indicated in prior research conducted by Li et al. in 2021, it is conceivable that methods that integrate VE into BIM, focusing on providing clear visualisations and information, can lead to improved overall performance.

Conceptual framework

VE and BIM are combined during design changes at the detailed design stage at LOD300, where design changes frequently occur by using VE, according to the conceptual framework that was developed based on the literature reviews that were conducted. As such, this conceptual framework corresponds to JKR Malaysia (2021), indicating that interactions between the two methods can be more effectively implemented once VE and BIM are integrated during the detailed design phase (LOD300). The integrated approach helps stakeholders understand designs more clearly through 3D visualisation, increases the effectiveness of VE implementation, and provides more transparent and informative design input. Based on the above literature and case studies, there is a need to integrate VE into BIM implementation during the detailed design stage of construction projects.

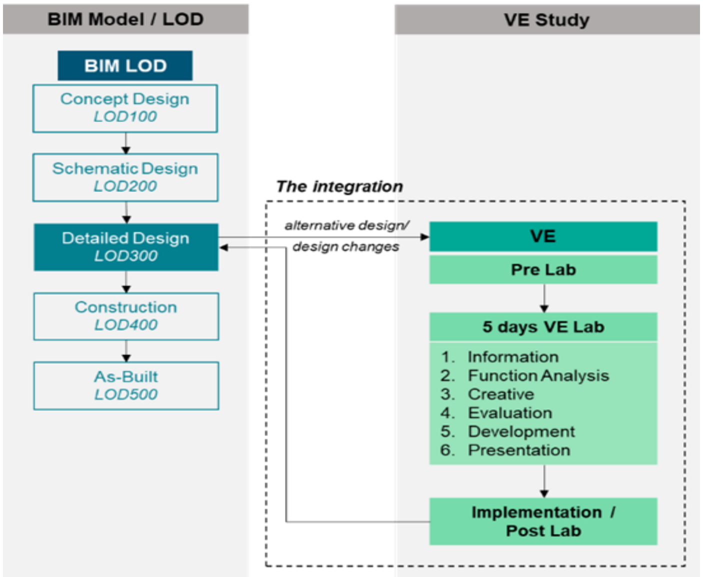


Figure 1. Conceptual framework for VE in BIM combination

METHODOLOGY

Quantitative methodology was adopted to achieve the research's aim and objectives, with a review of the literature incorporated into a questionnaire survey that were distributed to targeted respondents. Online questionnaires are a reasonably rapid and effective method of gathering a large amount of information from a broad sample of practitioners, especially during this COVID-19 pandemic situation. The Statistical Package for Social Sciences (SPSS) was used to analyse the data. The scope of this paper was the integration of VE in BIM. Thus, the respondents contacted were industry experts in VE, BIM, or both. The overall population size for each criterion was based on the organisation's official website, which provides this information. The largest numbers came from members of the Institute of Value Management Malaysia or IVMM, with 248, followed by myBIM Resource Network of CIDB Malaysia (75), BIM Unit, PWD (18), and VM Unit, PWD (12). This gave a total population size of 353 industry experts. To accommodate the large number of respondents, the sampling size for this research was defined using a table developed by Krejcie and Morgan (1970). Therefore, based on the above total population size of 353 (N=353), the required sample size was determined to be 186 (S=186). This paper also sought reassurance and consent from the expert to corroborate the findings at the end of the research.

ANALYSIS AND FINDINGS

From the survey, a total of 32% of responses were received. This rate of responses was higher than the average response rate of 5% to 15% of the questionnaire survey performed in the Malaysian construction industry, according to previous research by Idrus et al. (2018). Figure 2 shows that most respondents were members of IVMM (53.4%), followed by respondents in the myBIM Resource Network List (29.3%). Meanwhile, respondents from the BIM Unit and VM Unit of PWD Malaysia had a proportion of 12.1% and 5.2%, respectively.

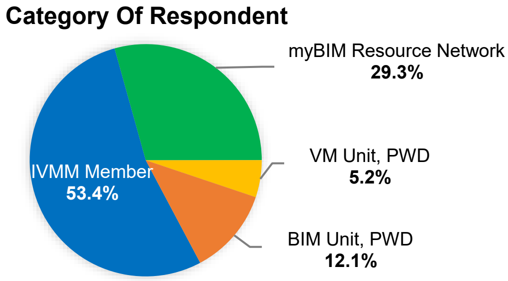
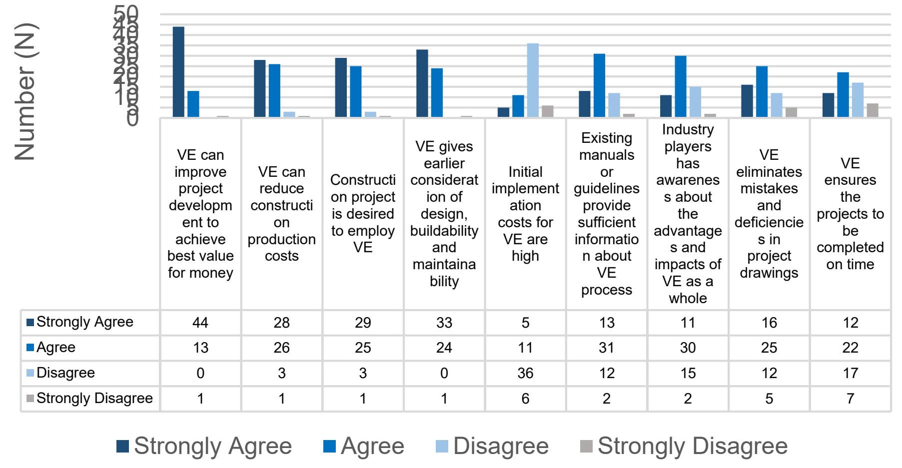


Figure 2. Distribution of respondents' categories

Meanwhile, Figure 3 indicates that industry practitioners agreed that VE can improve project development to achieve the best value for money, giving earlier consideration to design, buildability, and maintainability. Additionally, they disagreed that the implementation costs for VE are very high. It was also found that VE application maturity in Malaysia is at the Managed Level, which signifies that the organisation has implemented effective strategies and processes in accordance with its medium- and long-term goals. The findings of the research also highlighted that the application of BIM improves visualisation for construction projects, increases coordination of construction documents, and enhances productivity due to easy retrieval of information. Moreover, the BIM application maturity level in Malaysia was found to be at Level 2 (Collaboration), which indicates that the industry is currently developing building information in a collaborative 3D environment with data attached but in separate discipline models. Such findings are updated information, of which Sinoh et al. (2020) indicated that there was a transition from Level 1 to Level 2.



	VE can improve project development to achieve best value for money	VE can reduce construction production costs	Construction project is desired to employ VE	VE gives earlier consideration of design, buildability and maintainability	Initial implementation costs for VE are high	Existing manuals or guidelines provide sufficient information about VE process	Industry players has awareness about the advantages and impacts of VE as a whole	VE eliminates mistakes and deficiencies in project drawings	VE ensures the projects to be completed on time
Strongly Agree	44	28	29	33	5	13	11	16	12
Agree	13	26	25	24	11	31	30	25	22
Disagree	0	3	3	0	36	12	15	12	17
Strongly Disagree	1	1	1	1	6	2	2	5	7

Figure 3. VE/VM application in Malaysia

Many organisations do not have a systematic or structured process for accommodating design changes and only conduct review exercises. Based on the analysis, most industry practitioners agreed that the Malaysian construction industry is ready to adopt the approach of incorporating VE into BIM. The industry practitioners also highlighted the justification and reasons for its readiness to integrate, stating that the construction industry has embraced both methods and integration can give value for money while also complying with government policies. Additionally, they believed that the results from the integration of VE in BIM have the potential to provide positive outcomes and impacts to stakeholders. Furthermore, according to industry practitioners, integrated approaches can benefit and complement each other, while creating opportunities for everyone to improve the standard of work in the construction industry.

Table 2. The Malaysian construction industry's readiness to integrate VE in BIM

			Respondents' knowledge and understanding			Total
			VE/VM	BIM	Both	
Readiness for integrating VE into BIM	Yes	Count	13	2	25	40
		%	68.4%	66.7%	69.4%	69.0%
	No	Count	6	1	11	18
		%	31.6%	33.3%	30.6%	31.0%

As the majority of industry practitioners, with almost 70% of respondents (Table 2), believe that the Malaysian construction industry is ready to integrate VE into BIM, the essential elements in developing the integration framework are found to be as follows:

Table 3. Essential elements to develop VE in BIM integration framework

Essential Elements	Industry's Input
Value approach that best apply	Reducing the cost and at the same time increasing the function and quality (known as 'Compound Approach')
Most efficient parties to be involved	Client, Design Consultant, Quantity Surveyor, Civil Engineer, Structural Engineer, Mechanical Engineer & Electrical Engineer
Key project documents	Cost estimation, design drawing and specifications
Optimal duration	More than 5 days (> 5 days)
VE method to be adopted	5 days VE Lab/Workshop
Issues arise in BIM implementation that VE can manage	High project cost and deficiency in construction quality
Potential outcome from the integration	Cost optimisation, achieve value for money and improve the performance in BIM process

CONCLUSION

Using the suggested approach, this paper provides benefits and guidance for construction practitioners interested in making design changes. This approach may improve efficiency, cost optimisation, or the performance of the BIM process. This paper also provides an overall perspective on how VE can be implemented with BIM during the detailed design stage of a construction project, as depicted in Figure 4. Through the output of the discussion, practitioners can assess the level of application and maturity of VE and BIM in Malaysia. Furthermore, practitioners may define the critical factors driving design changes, as well as approaches to overcome them through the application of a structured process, which is the best option. It is possible to increase industry awareness of the practicability of the integration approach by evaluating the integration of VE into BIM during the detailed stages of a construction project. Furthermore, the VE framework in BIM during the detailed design stage is developed based on the opinions and perceptions of industry practitioners. As a result, practitioners can proactively implement this systematic process to accommodate design changes.

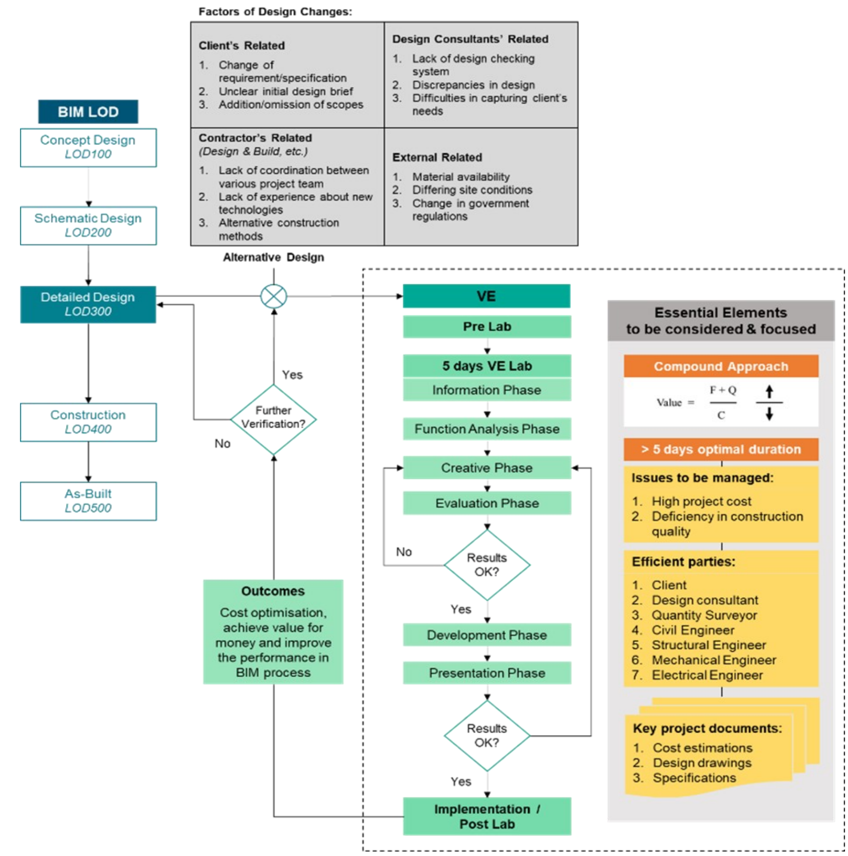


Figure 4. The integration of VE in BIM framework

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