FRAMEWORK OF DECISION MAKING FOR MANAGING VARIATIONS TO CONSTRUCTION DESIGN

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ABSTRACT

The aim of the study is to improve the decision making process for managing variations of the construction project. The research bjectives are to identify and establish the decision making process for variation works, to determine the factors that influences construction professionals in the decision made, to identify and select the best practice for developing a conceptual framework of decision making process, and to develop a framework of the decision making process for variation works that is able to analyze the impacts caused by these factors. Research methodology consist of identifying best practices for developing a conceptual framework with data collected using selective sampling method from six case study with 18 construction professionals interviewed using semi-structured questionnaire. Data analysis showed that the impact caused by each influencing factor of the decision making for variation works can be analysed to find out whether it give a positive, negative or neutral impacts. The framework of decision making process for variation has been developed based on best practices to improve decision making process by reducing the influence caused by these factors such as client, contractor, procurement system etc. Validation by industry experts on the developed framework was made to ensure that the framework will be capable to be applied to future variations decision making process in order to reduce disputes and litigation in the construction industry.

INTRODUCTION

It is imperative that decisions concerning variations (on whether it is a change to the design or not as in the agreement or contract) must be thoroughly examined and the decision making process map out to aid construction professionals in determining its legitimacy. Construction professionals as decision makers must be able to substantiate and provide compelling reasons for their decisions, without which further disputes and conflict may occur leading to post-contractual claims and even presumably litigation.

Making decisions is extremely important to construction professionals and the decision making process, although cumbersome and involving many steps, must be established and applied. Wysocki (2014) admitted that the essence of the decision analysis process for decision making is by using different decision criteria, different types of information, and information of varying quality. It describes the elements in the analysis of options, alternatives and choices, as well as the goals and objectives that guide decision-making. However, Dietrich (2014) cautioned that there are many factors that influence the decision making process that can cause a negative impact, presumably affecting project performance standards of cost, time and quality (Phua 2013). In a construction project the most critical and problematic stage of the decision making process is due to the high incidence and impact caused by factors that influence decisions concerning variations (Arain and Low, 2005). If these factors can be systematically identified, analysed and evaluated than a better decision can be made (Drucker 1955; CII 1994; Ibbs 2001; Motawa 2003).

Studies in variation works, such as Ibbs et al. (2001) and Sutrisna et al. (2003) shows that the decision making process for variation works in the most critical stage of a construction projects which contributed to the major increase in time and cost. The literature review suggested that there are many factors that influence the construction professionals in making decision that can give negative impact on the decision made. The studies also suggested that currently no available framework of decision making process for variation works that can be used to analyse the influence caused by these factors. Therefore, it is a pressing need to study and develop a framework of a decision making process for variation works, to analyse the impact caused by these factors and later manage the negative impact to produce a better decision. The evaluation of these factors will improve on the accuracy

of the decision making process and provide more refined options to the decision-makers (Stone et al. 2013) in regard to the quality of the decisions, either good or bad (Arvai and Froschauer, 2010)

The aim of this study is to improve the decision making process for managing variations of the construction project. The specific objectives of this study are to identify and establish the decision making process for variation works, determine the factors that influences the construction professionals in the decision making process for managing variations works, identify and establish the best practice for developing a conceptual framework of decision making process and develop a framework of decision making process for variation works that is able to analyse the impacts caused by the factors.

The significance of the study is that the process will highlight the various influencing factors that ultimately became the grounds for further disputes and conflict, escalating to claims and litigation. The framework will aid decision-makers, especially construction professionals as the decision making process in variations to the construction work is not only a process to determine the best options or alternatives but also a process to legitimise the decision based on the agreement or contract.

IDENTIFY AND ESTABLISH THE DECISION MAKING PROCESS FOR VARIATION WORKS

Studies such as Lee et al. (2011) and Ibbs et al. (2005) suggested that variations are inevitable in any construction project. Owner initiated variation can come in the course of design or construction phase, unforeseen ground conditions may impose variations and technological developments may vary design and the choice of the Engineer or Architect. However, the Engineer or Architect may review the design and in the course of doing so, variations that can bring improvements or optimisation to the design and operation of the entire project may arise.

Lee et al. (2011) argue that cost related to project variations is one of the most sensitive aspects of construction project management, but it is also one of the most difficult to control. Ibbs et al. (2005) reported that an aspect of variation not yet well researched is the variation's timing. However, little is known from previous studies about the impacts of variation orders issued late (post-contract stage) or at earlier (pre-contract) stage of a project. Issa et al. (2005), Ibbs et al. (2005), Meng et al. (2008) identified too many variation orders as responsible for cost and time overruns. Hence there is limited research geared at studying the impacts of the magnitude (sizes) of the variation orders on project price and schedule duration. Project management team need to envisage variations in a project in a timely manner. According to Kartan (1996), conflict will be minimised on a project when problems are found at the earliest possible stage of the project thereby enabling the implementation of counter measures.

According to Hao et al. (2008) the effort of managing variation orders has imposed a huge burden on project management and effectively managing these variation orders in construction processes is not trivial because variation orders are part of contract and they need to be strictly traced in terms of contract, documents, approval process, payment claims etc. Management of public sector projects is highly infested with large scale of unethical practices and there was lack of generally acceptable procedure for variation orders management in Malaysia construction industry. Hence very little is found in the literature with respect to the integration of a problem solving systematic variation order management process into construction projects in Malaysia context especially on management of variation orders.

Variation works management research have sought to develop a decision support system and framework for assisting construction professionals. Some of the recent efforts in developing a decision making framework for managing variation works are summarised. In Construction Industry Institute (1997) framework, the main process involves balancing variation culture, recognize variation, evaluate variation, implement variation and continuously improve from lessons learn projects. The formulation of this proactive framework is based on five main components of decision making process. However, the developed framework has insufficient detail and lack quantitative assessment. Ibbs et al. (2001), taking the cue, then developed a framework with the main process having 2 levels. Level 1(decision making process) involves balancing variation culture, recognize variation, evaluate variation, implement variation and continuously improve from lessons learn projects. Level 2 (project management process) involves analysis at the briefing, design, tender, construction and maintenance. However, this framework still does not have a methodological assessment to managing changes. It is important to embrace positive changes and mitigate negative changes effectively. Motawa (2003) developed a framework that models the cause-effect relationship and evaluate the factors before the variation occurs. The main process includes pre-variation, identify and evaluate, approve and propagate the concerned variations and post changes. The primary issue concerned is its appropriateness of the framework in complex project scenario which needs detailed assessment of environmental factors that caused changes. Arain & Phang (2006) developed a knowledge based system for managing variations, focussing on KBDSS (knowledge based decision support system) with the main process to include for identify variation, recognize, diagnosis, implement variation and controlling strategies and learning from past experiences. The developed toolkit has two rating techniques - analytical hierarchical process (AHP) and simple multiple attribute rating technique (SMART), however an aspect of the rating is the

importance to determine prominent factors influencing decision on variations. These factors need to be identified and assigned scores at the identification process. The nature of these factors must also be taken into consideration as it is highly prone to frequent changes occurring from different sources and caused by variety of reasons.

The analysis of the features of these frameworks has established the main steps of a decision making process.and provide an opportunity to utilise the existing frameworks in terms of effectiveness, level of detail and ease of use in the project change management context.

FACTORS INFLUENCING CONSTRUCTION PROFESSIONALS IN THE DECISION MAKING PROCESS

Many studies in variation works such as Ibbs et al., (2001) and Sutrisna et al., (2003) shows that decision making process for variation works in the most critical stage of a construction projects which contributed to the major increase in time and cost. These studies suggested that there are many factors that influence the construction professionals in making decision that can give negative impact on the decision made. The studies also suggested that currently no available framework of decision making process for variation works that can be used to analyse the influence caused by the factors. Therefore, it is a pressing need to study and develop a framework of a decision making process for variation works, to analyse the impact caused by the factors and later manage the negative impact to produce a better decision made.

Apart from Ibbs et al., (2001) and Sutrisna et al., (2003), the following factors were derived from the literature based on the understanding that construction professionals have to make decisions quickly (Menches and Chen, 2013), within the constraints of the rules and standard operating procedures (Elms and Brown, 2012; Volker, 2012) and conforming to the project performance standards of cost, time and quality (Phua, 2013). The influencing factors include standard forms of contract; practice; professionals, professionalism, professional institutions; client; contractor; other construction professionals; experience and knowledge acquisition; procurement system; and non-specific influencing factor. The selected factors will be used in the conceptual framework of the decision making process. Data collection on samples chosen based on the selective sampling method were made with the purpose of determining the patterns of impact from the influencing factors. The samples used were based on the following criteria: respondents have agreed to discuss the process of making decisions for the variations; researcher has good relationship with the respondents to get their commitments to give honest responses to the questionnaire; respondents agreed to the time and predetermined date of the interview to avoid delay; and projects are still required for the study to reach the saturation point of the number of samples needed.

Six case study were selected, each case study with three units of analysis consisting of construction professionals, with the focus on a specific variation event that has occurred. The interview with the respondents were based on semi-structured questionnaire to determine whether decision process for variation were influenced by all or any of the nine factors i.e. standard form of contract, practice, professionals/professionalism, client, contractor, other construction professionals, knowledge/experience, procurement system and non-specific factors. The factors that has influenced their decisions will be indicated in the answers or responses to the questionnaire. The process of decision making for the variations of each case study was recorded and later converted into transcripts of the statements made. The whole transcripts then exported into computer software called nVIVO™. The transcripts of each case study will be transformed into qualitative data and then able to be managed and explored to find out the patterns of the data based on the frequency of existence of each factor during the decision making process of each case study. All factors were compared with the type of respondents, whether Architect, Engineer or QS. The score was based on the frequency of the influencing factor indicated by the respondents confirming (based on nVIVO™ analysis) that it has influenced the decision making process. The greater the number of frequency the higher will be the score. The cross-tabulation between the factors and the type of respondents was made for each case study and the results of the cross-tabulation were used to analyse the impact caused by each factor whether positive, neutral or negative. The score of each factor were shown by using bar charts or graph to find out the patterns of the response by the respondents.

The data are ordinal in nature as it involves factors involving decisions and non-parametric. All data statistically analysed using SPSS version 22. Data presented from the sample of 18 respondents are numeric discrete variables which means that the values are usually complete integers (0, 1, 2, 3, ...) and refers to the frequency for which the 9 (nine) influencing factors were detected in the responses. Frequency means the count of the number of times an event occurs or a count of the results and is not a measure of how often something occurs. Thus the statistical analysis is the result for the mean, median, mode, standard deviation, skewness, standard error of skewness, kurtosis and standard error of kurtosis for each influencing factor and its nature or degree of influence of positive, neutral and negative. It must be noted that the ‘neutral’ level being the middle response is actually ‘neither positive nor negative’.

Statistical test was done for the purpose of identifying the association between these influencing factors and the level or degree of influence. A standard chi-square test will not take into account of the nature or degree of

influence due to data being ordinal and non-parametric, thus an alternative and appropriate method is to apply the Kruskal-Wallis test, sometimes described as an analysis of variance of ranks as it does bear a resemblance to the one-way independent ANOVA. The test works on determining the measure of the aggregate degree to which the groups of the different level or degree of influence (positive influence, neutral influence, negative influence) differ. In the Kruskal-Wallis test, the means are based on ranks or by ranking the data rather than testing the actual scores by scoring each rank so that the lowest score or values would be ranked '1, the next lowest '2' and continue to ranking '27' denoting that there are 27 nature or degree of influence in the research. If the scores are tied, then the ranks will be the average of the ranks had not the tied scores. As the means are based on ranks, further procedures requires defining the ratio symbolized by the letter H which is the between-groups sum of squared deviates and by referring to the sampling distribution of chi-square df (degrees of freedom) of 2, and the results shows the scores with their respective ranking in bracket.

Table 1
Scores and ranking (in brackets) of influencing factors across all case study

Influencing factor	TOTAL (FREQUENCY)					
	POSITIVE		NEUTRAL		NEGATIVE	
Standard forms of contract	10	(19.5)	8	(16.5)	7	(14)
Practice	10	(19.5)	15	(23.5)	11	(21)
Professional, professionalism,	2	(4)	6	(10.5)	8	(16.5)
Client	16	(25)	19	(27)	18	(26)
Contractor	7	(14)	15	(23.5)	6	(10.5)
Other professionals	6	(10.5)	13	(22)	6	(10.5)
Experience/Knowledge	5	(7.5)	9	(18)	0	(1.5)
Procurement system	5	(7.5)	7	(14)	1	(3)
Non-specific influence	0	(1.5)	3	(5.5)	3	(5.5)
Mean rank	12.11		17.83		12.06	
Standard deviation (SD)	7.92		6.96		8.21	
Sum of ranks (Tc)	108.9		160.5		108.5	
Sampling distribution of **H** is **3.15**						
Sampling distribution of chi-square with **df** (degrees of freedom) = k – 1, which is **2**						
P value is **0.207**						

The Kruskal-Wallis test revealed that based on critical values of chi-square and df (degrees of freedom) of 2, the **H** value of 3.15 does not fit into any of the corresponding level of significance of 5.99 at *p*(.05) and the next ascending order of significance of 7.38 at *p*(0.025). If the statistics are not significant, then there is no evidence of differences between at least two of the groups of degree of influence.

Nature or degree of influence of neutral (neither positive nor negative) are ranked higher compared to nature or degree of influence of positive and negative with a mean rank of 17.83, suggesting that construction professionals were aware that some of these factors were acknowledged to be able to influence their decisions, however it is not possible to be exact or precise as to the extent of the influence and how it plays a part in the final decision. These specific factors above the mean rank were client, practice, contractor, other construction professionals and experience/knowledge.

IDENTIFY AND SELECT BEST PRACTICE FOR DEVELOPING A CONCEPTUAL FRAMEWORK OF DECISION MAKING PROCESS

It is evident that research in framework of decision making process in construction has focused heavily on developing decision strategy, innovative techniques, and information technology tools for construction professionals to formulate and manage construction project successfully. The discussion about the framework for decision making process was presented earlier.

Table 2
The features of the framework of decision making process

	Decision Making Framework	Existing Framework	Required Capability
Process	Identify variation	Develop a new approach	Aim to manage variation
	Recognize variation	PCMS Framework	Identify the cause of variation Identify the risk of variation Identify the characteristics of knowledge
	Evaluate/Diagnosis of variation	Develop new approach	Identify the nature of variation Identify the impact of variation Select most appropriate criteria of influences (positive and negative influences)
	Implement variation	Develop a new approach	Aim to communicate and communicate the variation
	Implement controlling strategies	PCMS framework	Control the implementation tailored to revised duration
	Learning from past experience	Knowledge base system	Aim to share past experience for future project

Nevertheless, some of the decision making processes for variation management developed in the Project Change Management System (PCMS) by Ibbs (2001) framework can be fruitfully utilised for aiding construction professionals in managing the construction works. The PCMS framework is adopted because it enables the identification and recognition of the variation and the key dimensions and risk issues associated with it. The

distinction between sources of variation is made and each is managed differently. For example, for 'client-related' variation, which is generally held as beneficial variation must be managed differently with 'design-related' variations which is held as detrimental variations. Moreover, the adoption of the decision making framework will help construction professionals to explore the positive and negative influences (evaluation criteria) order to select the factors tailored to the needs of a fair and equitable variation orders management. Table 2 summarises the suggested features of the framework stages and key analytical questions in the systematic decision making process.

Table 3
Stages and key diagnostic questions in the decision making framework for variation works

Stage	Diagnostic Question	Solutions
Stage 1	**Identify source of variation**	
	What is the source of variation?	(a) Client; (b) Design (c) Regulation (d) Site Conditions
	Is it a variation or not?	(a) Yes (proceed to next stage) (b) No (Register in risk management system)
Stage 2	**Define/Recognize the variation**	
	Identification of the factors	(a) Standard form (b) Practice (c) Professional/Professionalism (d) Client (e) Contractors (f) Other construction professionals (g) Experience, Knowledge (h) Procurement system (i) Non specific influence
	Do the factors influence decision making?	(a) Positive impact (proceed to next question) (b) Neutral (proceed to next question) (c) Negative impact (proceed to next stage)
	Is it fair and equitable to both parties?	(a) Yes (Lesson learned) (b) No (back to negative)
Stage 3	**Evaluate cost and time impact**	
	What is the impact to the cost?	
	What is the impact to the time?	
Stage 4	**Provide alternative/selection of variation options**	
	What are the clauses in contractual document	(a) Relevant Clauses (b) Fair and Balance Solution
Stage 5	**Approve variation**	
	What are the type of contractual document	(a) Architect's Decision (b) Engineer's Decision
Stage 6	**Implement variation order**	
	What is the action plan?	(a) Action plan communication (b) Action plan for documentation
Stage 7	**Lesson learned**	
	Why is the existing decision making ineffective?	
	What additional issues need to be addressed?	

The proposed framework involves the following seven stages as shown in Table 3

DEVELOP A FRAMEWORK OF THE DECISION MAKING PROCESS FOR VARIATION WORKS THAT IS ABLE TO ANALYZE THE IMPACTS CAUSED BY THESE FACTORS

The analysis shows that the factors influencing the decision can be analysed based on the impact caused by the factors whether positive, neutral or negative. The framework of decision making process for variation now can be finalised based on the results of the analysis. The final framework can be illustrated with the following flow chart in Figure 1.

The framework consists of seven stages and the explanation is as follows:

Stage 1: Identify source of variation and allocate the risk of influence

The first stage of the framework is to clarify whether or not a request for variation by contractors considered as variation works in the terms of contract. It involves two main tasks: a clear category of source of variation and subjective analysis by the construction professionals of which aimed to clearly identify positive impact variations and negative impact variations at the early stage variation occurrence. If there is no variation dimension for the construction project problems, the construction professionals need to coordinate and register the problem in the risk management system. The decision makers should made a clarification of the variation orders based on construction professionals' experience and tacit judgement in each specific variation order request by the contractors.

Since the impact of each factor has been quantified based on the results of the data analysis, at this stage the decision makers can better manage the influence by assigning which factors have greater negative impact. Therefore, the focus will be on those factors that has greater negative impact for decision makers to evaluate for further analysis in Stage 2.

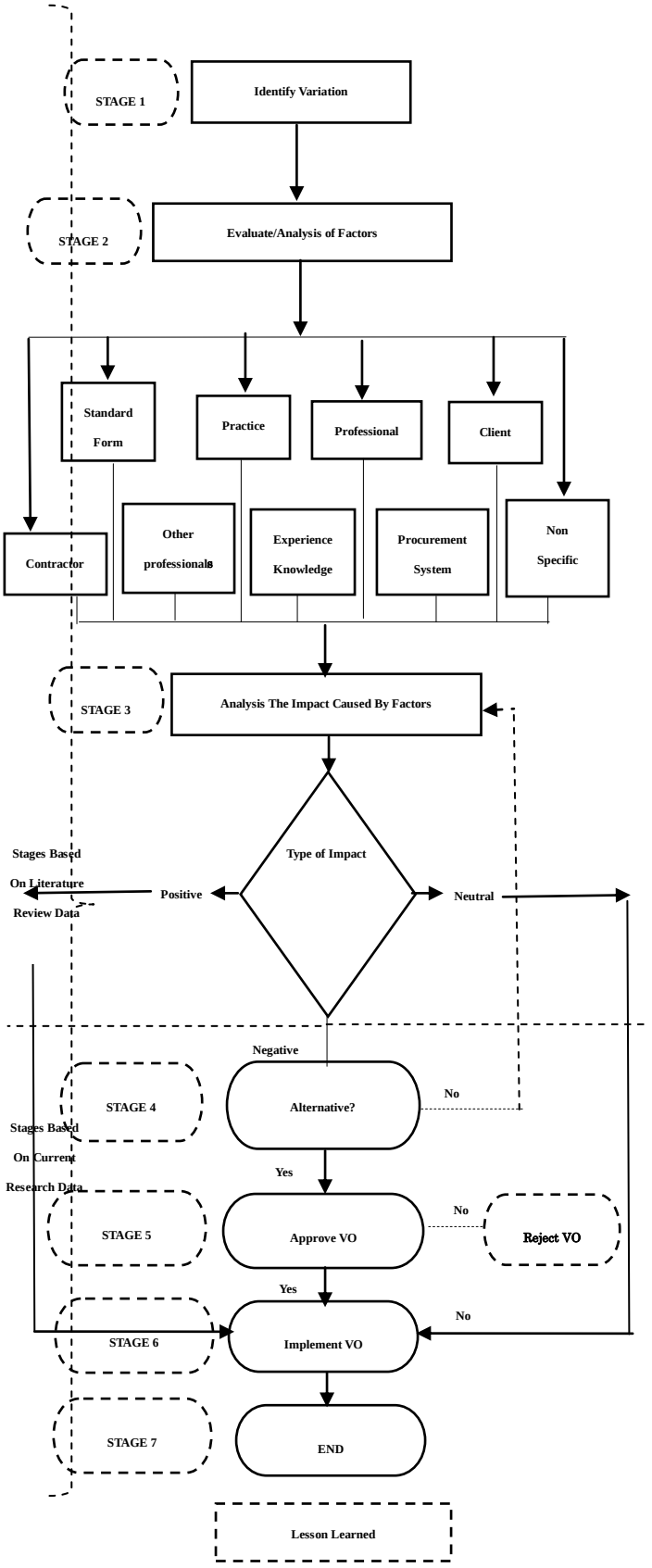

Figure 1
Framework of decision making process for variation works

Stage 2: Evaluate the impact caused by the factors

Stage 2 is aimed at determining if the construction professionals has been influenced by nine important factors to make decision for variation works. Variation works are inevitable in any construction project. Client initiated variation works can come in the course of design or construction phase, unforeseen ground conditions may impose variations and technological developments may vary design and the choice of the Engineer or Architect. However, the Engineer or Architect may review the design and in the course of doing so, variations that can bring improvements or optimisation to the design and operation of the entire project may arise. All these factors necessitate variations that bring enormous cost and schedule overruns. The impact of the various factors causing cost and time overruns of construction projects needs to be evaluated in depth and case by case in order to assist with decision making process. However, identifying the factors that influence construction professionals to do decision making on variation orders in the first place is very important in order to avoid potential changes in future projects or minimise their negative impacts on projects.

The main question (Do these factors influence decision making?) refers to the process of analysing the degree of influence of the factors to construction professional in making decision on variation works. It seeks to discover the level of influence to the construction professionals and will help them to manage variations better and earlier in the project life cycle. If these factors have any influence to the construction professional, he/she needs to proceed to the need steps of systematic analytical tools developed in the proposed framework.

The proposed analytical tools are categorisation of the variation works into three main parts: positive impact (+); neutral impact (0); and negative impacts (-). If these factors do not influence the construction professionals, he/she needs to solve the problem. The main outcome of this stage is a determination of whether the factors that influence construction professional to make decision and proceed to further stage of the framework.

Stage 3: Evaluate all factors contribution to the influence to decide whether or not to approve the variation

At this stage, the decision makers have to decide whether to approve or not to approve a variation work. The decision can be made by giving weightage to each factor based on the findings of this study. For example, if the influence is so great, the weightage should be lower.

This weightage helps in determining the influencing factors that give impacts to the decision making process. In addition, the decision maker definitely has a structured methodology in assessing the value of factors that impinges the decision process in managing variations.

Stage 4: Provide alternative/selection of variation options

The aim of Stage 4 is to select the variation options and categorised under an appropriate contractual arrangement. Variation orders must be resolved through a formalised variation management process in order to avoid delays and disruptions in the work program. It is also must be fair and equitable to the both parties involve in the building contract. By having a systematic way to deal with variation orders, the efficiency of project work and the likelihood of project success would increase. Systematic variation orders management are procedures for parties involved in construction project to implement for effective and efficient management of variation order. The main output of this stage is a set of variation procedures to be implemented in construction project.

Stage 5: Approve variation order

The aim of this stage is to approve the variation to help Architect/Engineer to prepare formal Architect/Engineers Instruction. This would entail determining the type of contractual document required. The issuance of written instruction comprehensively addresses the issues of scope, specification, cost and duration of the work. This stage involves approving the selected variation which consider the relevant clauses and fair and balance solution. The Architect/Engineer should use this stage to clearly outline the scope, specification and details of variation in written format. The main outcome of this stage is an Architect's Instruction or Engineer's Instruction.

Stage 6: Implement variation order

The aim of this stage is to implement variation order option to assist the construction professional in resolving variation works problems. The first question at this stage – "What is the action plan for communication?" - asks the construction professionals to develop a clear action plan for communication between project team before implementing variation order. It is important to develop an action plan of what is to be carried out before a variation order is implemented. The second question at this stage – "What is the action plan for documentation?" – refers to situation whereby if the construction professionals have decided to select certain variation options, he/she need to suggest established methods such as 'Quality Procedures' to document and disseminate the variation order options to the project teams. The main output of this stage is an implemented variation order options with consideration of systematic decision making process and factors that influence decision making.

Stage 7: Lesson learned and review procedures

The aim of Stage 7 is to provide a structured approach for evaluating the effectiveness of the variation options taken by construction professionals. The construction professionals have to examine whether chosen options have been able to minimise the impact of variation to the construction project. If the construction professionals are not fully satisfied with the efficiency of the chosen options, he/she is asked to specify what additional factors need to be considered. The lesson learned document for managing variation works should be shared between team members so that everyone can have a chance to understand the root causes of the problems, factors considered in decision making and to control variation options in a proactive ways. The main outcome from this stage is the lesson learned strategy to be used for future projects.

CONCLUSION

The findings of study have proven that the aim and objectives of the research has been successfully achieved. The framework of decision making process for variation works developed in this study, is the most significant contribution of the research which enable the decision makers to make a better decision before approving any variation works. The level of influence that can give a negative impact to the parties of the contract and if this can be reduced will ensure decisions on the variation works will be more fair and equitable.

In the past many decisions made regarding variations ends with unsatisfactory outcomes to either the Contractor or the Client, leading to disputes and litigations. A fair and equitable decision can be made if the decision makers use the framework of decision making process proposed in this study.

The findings of the study has significant contribution to a new knowledge in solving the problems of managing the impacts caused by these factors influencing the decision making process. The decision makers will benefit from the development of the framework of decision making process and a better decision can be made.

Managing variation works is the most critical stage of a construction projects, therefore, the developed framework of decision making process for variation works is a major step to reduce the problems of negative impacts caused by these influencing factors to the decisions made. The framework will become a significant guide to decision makers to make decision for variation works, which will contributes to a better, fair and equitable decisions.

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