PERFORMANCE EVALUATION FOR CONSTRUCTION VALUE ENGINEERING STUDY

Wei Tong Chen[1], Hong-Long Chen[2], Po-Yi Chang[3] and Tsang-Jung Wang[3]

[1] Associate Professor, Dept. of Constr. Engrg, Nat'l Yunlin University of Sci. and Tech., Yunlin, Taiwan
[2] Assistant Professor, Dept. of Industrial Engineering and Management, I-Shou University, Kaohsiung, Taiwan
[3] PhD Student, Graduate School of Engrg. Sci. & Tech., Nat'l Yunlin University of Sci. and Tech., Yunlin, Taiwan
Correspond to Chenwt@ce.yuntech.edu.tw

ABSTRACT: This paper presents an evaluation model for the performance of Value Engineering Study (VES) for construction projects. The proposed model consists of 6 PEGs and 32 PEIs. The expertise of the proposed model was collected from VE experts in Taiwan using two-phase questionnaire survey. One real-life VES of construction projects was used to demonstrate how the proposed model works. The proposed model not only can be used by project owners to appraise the performance of VES team but also be used by the VES teams to conduct self-diagnosis, improvement, and motivation for achieving better performance. Additionally, the proposed model is capable of: (1) clarifying the defects of VES and avoiding committing same mistakes, (2) assisting inexperience team members to implement VES and catch the critical issues of a VES.

Key words: Value Engineering Study, Construction Project, Performance Evaluation

1. INTRODUCTION

Value Engineering (VE) is an organized application of common sense and technical knowledge to locate and eliminate unnecessary project costs. Such an application can effectively reducing costs and enhance project value. According to a study by [1], the execution of VE job plan, the personality of the VE team leader, client input, the relationship of the VE plan and design teams, and the nature of the project itself all contributed significantly to the success of the VES.

Although success of a VES is heavily dependent upon numerous factors, the success of the VES is currently evaluated by the acceptance rate of its recommendations and total potential savings achieved during a VES. Consequently, it is common for value engineers to focus on the total potential savings to sell the VES to a project owner. Considerable focus on potential savings, however, may obscure some defects during a VES and, thereby, the opportunity to enhance the benefits of a VES is lost. Since adherence to a job plan assures maximum benefits while offering greater flexibility, the implementation of job plan can be used to evaluate VES performance [2].

This study surveyed the opinions of VE experts regarding job plans and their relationship to VES performance assessment. Factor analysis was then employed to analyze these opinions and group these opinions. The groups were weighted using the Paired Comparison Method (PCM), whereas the weights of the items were computed using the Simple Weight Average Method (SWAM). The proposed model was then used to analyze one real VES for a construction project to demonstrate the model's application.

2. VALUE ENGINEERING

2.1Value Engineering Study

For construction projects, a VES integrates money, manpower, materials, equipment and other resources to fulfill job plan by a VES team that seek alternatives equipped with same functions to the original design while reducing costs. A VES usually requires significant integration of special entities, perceptible goals, specific project duration, and technical management abilities. Technical management abilities include: professional, leadership, and relationships among team members. These factors have considerable influence on VES performance and the quality of any recommended alternatives.

2.2 VE Job Plan

A key component of the VE process is its use of a carefully crafted and thoroughly tested job plan. Adherence to the job plan focuses efforts on its specific decision process that provides focus, a schedule, and the key elements required to secure a high-quality product. The job plan and its sub-elements does this by highlighting and focusing each employee on the correct issues, essential needs, criteria, problems, objectives, and concerns.

The job plan can help teams avoid making incorrect decisions by providing a well-defined procedure designed to overcome human limitations, such as the need for repetition before a task becomes a habit, and natural human restrictions such as the ability concentrate on three to five items at a time. Owing to its worldwide popularity, the six-phased job plan procedure of SAVE International was utilized to serve as the basis for VES performance evaluation in this research. All phases (Information, Function Analysis, Creation, Judgment, Development and Presentation) in the VES are performed sequentially.

2.3 Value Study Team

The VES team assembles a heterogeneous group of experts to assess the value improvement options for a product, process or project. Team members have the option of participating full time and asserting their knowledge [3]. Selecting appropriate team members improves confidence in the process and promotes team building. Team members should represent diverse backgrounds and experiences and have the knowledge required to fully cover project issues and objectives. These areas of expertise typically include cost estimating, procurement/materials, and the technical disciplines unique to a construction project such as design, construction, environmental, and so on. In addition to being technically competent, team members should comprise those who are knowledgeable in the range of disciplines that are applicable to the concerns of end users and the impact of study. These individuals must generate positive attitudes and be willing to investigate new ideas and then rationally evaluate these ideas. Additionally, the team members should be experienced in applying VE methodology [4,5].

3. Model Building

The principal objective of this research is to develop a model that can evaluate VES performance for construction projects. The development of the VES performance evaluation model comprises three major steps: (1) development of a list of nominated performance evaluation items (NPEIs) in related to VES job plan phases that were defined by the performance evaluation groups (PEGs); (2) identify the primary PEIs under each PEG; and, (3) allocate the weights to PEGs and PEIs. The proposed model was then used to assess a real VES of a construction project. To realize these objectives, this study conducted a two-phase questionnaire-based survey to collect related data.

3.1 Questionnaire Survey

A phase-one questionnaire, which was conducted to identify the important PEIs, was based on the results of an extensive literature review and was consolidated through a series of pilot studies. A total number of 47 nominated PEIs in the questionnaire were divided into six PEGs and 47 NPEIs. The NPEI grouping was based on the phases of VES job plan, including information, function analysis, creation, judgment, development and recommendations. The questionnaire asked respondents to grade importance of each item in relation to VES performance evaluation based on a 5-point Likert scale in which 5 represented extremely important for a given item and 1 represented least important. To ensure consistency in responses, a brief definition of each item was also provided.

The sample population used for the phase-one questionnaire survey was limited to 212 VE researchers and practitioners in Taiwan. All members of the sample population had taken the Module I VE training course certified by SAVE International. Most respondents held AVS certification and a few were CVS both certified by SAVE International. Seventy-seven respondents returned their completed questionnaires, representing a response rate of 36.32%.

A phase-two questionnaire was designed to determine the relative weights for the six PEGs. A 5-point Likert scale was used to measure the importance of PEGs. Each of the six PEGs was compared with each of the other PEG based on the preference identified by the questionnaire respondents. The relative weight of one PEG over another can be extremely significant (5:1) to extreme unimportant (1:5). The phase-two questionnaire was sent to the 77 individuals who responded the phase-one questionnaire. Forty-two completed questionnaires were returned, comprising a 54.5% return rate.

3.2 Determining the Weights of PEGs and PEIs

In this research, the first stage of the factor analysis determined the strength of the relationships among the variables, i.e., the 47 NPEIs, measured by the correction coefficients for each pair of variables. The Bartlett's test of spericity was 2499.865 and the associated significance level was 0.000, indicating that the population correlation matrix was not an identity matrix. The value of the Kaiser-Meyer-Olkin (KMO) measure of sampling accuracy was 0.775, which is significantly higher than 0.5 and, hence, considered acceptable. The results of these tests showed that the sample data was suitable for factor analysis.

As shown in Table 1, all Cronbach’s α for the two groups were larger than the minimum acceptable standard (0.7) suggested by Hair [6]. Thus, it was concluded that the analysis had very good reliability. The six PEGs were able to explain 58.73 % of total variance and was considered acceptable. A total of 32 PEIs were selected.

A consistency test (homogeneity of fit) was used to validate 42 of phase-two questionnaires. The value of consistency ratio (CR) of each returned questionnaire was calculated: questionnaires with CR values ≤ 0.1 were treated as valid questionnaires.

A total of 24 returned questionnaires passed the consistency test and, thereby, were considered valid. Based on these 24 valid questionnaires, the weight of each PEG was further calculated. Weights of PEGs were obtained by averaging the item scores of the 24 valid questionnaires. Table 2 shows the complete scheme and weights of the PEGs and PEIs.

4. Application of the Proposed Model

The proposed model was applied to the VES performance of Tainan station of the Taiwan High Speed Rail (THSR) to demonstrate its use. The largest BOT (Build-Operate-Transfer) railway project in the world runs approximately 345 km from the north of Taiwan to the south, passing 14 major cities and counties, and 77 townships and regions. The total construction cost of this mega-project is approximately US$15 billion. The Tainan station, one of the eight passenger stations along the HSR line, is located at the southern end of HRS line. The VES of the Tainan station was conducted during station design phase. Two CVSs were hired by the design consultant. One CVS was the team leader and the other served as the VES coordinator. After nine days' working, the VES team generated 12 recommendations and achieved a total potential savings of US$2,663,970 and US$17,197,120 in maintenance costs.

The VES team leader was invited by this research to evaluate the performance of this particular VES. This team leader has conducted more than 30 VE studies of construction projects in Taiwan. The utilization of the evaluation model was explained in detail to the team leader before he performed his evaluation. Table 3 presents the summary of these assessment results by the VES team leader.

Table 1. Rotated factor-loading matrix for 6 groups

# of PEIs	PEG1 Information	PEG3 Creation	PEG4 Judgment	PEG2 Function Analysis	PEG6 Recommendation	PEG5 Development
PEI01	.652					
PEI02	.609					
PEI05	.572					
PEI04	.435					
PEI17		.840				
PEI18		.823				
PEI22		.761				
PEI19		.553				
PEI24			-.823			
PEI26			-.730			
PEI29			-.712			
PEI30			-.703			
PEI31			-.643			
PEI32			-.617			
PEI10				-.831		
PEI11				-.785		
PEI15				-.707		
PEI08				-.706		
PEI09				-.668		
PEI12				-.621		
PEI14				-.588		
PEI16				-.549		
PEI41					-.751	
PEI45					-.680	
PEI42					-.617	
PEI47					-.616	
PEI44					-.595	
PEI43					-.577	
PEI35						.797
PEI38						.668
PEI39						.663
PEI37						.589
Cumulative %	36.659	43.042	47.854	51.755	55.462	58.729
Cronbach's α	0.8185	0.8811	0.8893	0.8761	0.9055	0.8842

Table 2. Scheme and weights of PEGs and PEIs of the proposed model

PEGs (Weight)	PEIs	PEI Average Score	PEI Weight
Information (0.1976)	Collected data completeness	3.98	0.0521
	Reliability of data sources	3.74	0.0489
	Review of cost data	3.83	0.0501
	Understanding owner's needs in terms of function and cost	3.55	0.0465
Function Analysis (0.2376)	Select targets and scoops for study	4.12	0.0315
	Define functions and contents of the study	3.94	0.0300
	Build cost models	3.93	0.0300
	Developing function-cost matrix	3.71	0.0283
	Establishing value indices	3.87	0.0295
	Identifying primary/secondary functions	4.21	0.0321
	Establish function logics and cause-result relationships	3.84	0.0293
	Build FAST diagrams	3.51	0.0268
Creation (0.1751)	Function-based creation	3.95	0.0454
	Open-minded thinking and unlimited speculation	3.80	0.0437
	Employing group thinking	3.85	0.0443
	Not criticizing others' ideas	3.63	0.0417
Judgment (0.1217)	Function-based evaluation	4.01	0.0208
	Application of evaluation techniques	3.90	0.0202
	Objectivity and appropriateness of evaluation factors	3.84	0.0200
	Determining the weights of evaluation factors	4.09	0.0212
	Evaluating and ranking feasible ideas	3.95	0.0205
	Selecting ideas for further development	3.66	0.0190
Development (0.1291)	Identifying the scoops of further development for potential alternatives	3.57	0.0324
	Performing benefit analysis for potential alternatives	3.51	0.0319
	Comparing the constructability of potential alternatives	3.73	0.0339
	Evaluating change order impact resulting from proposed alternatives	3.41	0.0310
Recommend. (0.1389)	Design and use of presentation facility	4.17	0.0227
	Certainty and accuracy of presentation content	4.24	0.0231
	Presenter's comprehension of the presentation content	4.29	0.0234
	Communication and persuasive abilities of the presenter	4.33	0.0236
	Functions and cost comparisons for proposed alternatives	4.35	0.0237
	Managing owner's preferences and needs	4.10	0.0224

Notes: PEI weight = (PEG weight) * (PEI average score under PEG) / (Sum. of PEI average score under PEG)

Table 3. Assessment results of VES by the VES team leader for the Tainan station

PEGs	PEIs	VP	P	F	G	VG
Information	Collected data completeness				●	
	Reliability of data sources					●
	Review of cost data				●	
	Understanding owner's needs in terms of function and cost				●	
Function Analysis	Select targets and scoops for study				●	
	Define functions and contents of the study				●	
	Build cost models					●
	Developing function-cost matrix		●			
	Establishing value indices		●			
	Identifying primary/secondary functions				●	
	Establish function logics and cause-result relationships			●		
	Build FAST diagrams			●		
Creation	Function-based creation				●	
	Open-minded thinking and unlimited speculation					●
	Employing group thinking				●	
	Not criticizing others' ideas				●	
Judgment	Function-based evaluation				●	
	Application of evaluation techniques			●		
	Objectivity and appropriateness of evaluation factors		●			
	Determining the weights of evaluation factors		●			
	Evaluating and ranking feasible ideas				●	
	Selecting ideas for further development				●	
Development	Identifying the scoops of further development for potential alternatives					●
	Performing benefit analysis for potential alternatives				●	
	Comparing the constructability of potential alternatives					●
	Evaluating change order impact resulting from proposed alternatives				●	
Recommendatio n	Design and use of presentation facility					●
	Certainty and accuracy of presentation content				●	
	Presenter's comprehension of the presentation content				●	
	Communication and persuasive abilities of the presenter				●	
	Functions and cost comparisons for proposed alternatives			●		
	Managing owner's preferences and needs				●	

Notes: VP- Very Poor, P- Poor, F- Fair, G- Good, VG- Very Good

Shown in Figure 1, the overall performance of the VES was unevenness. There was a substantial gap (27.21 points = 90.32 - 63.11) between the best performance (the development phase) and worse performance (the judgment phase). Performance during the development phase was scored at 90.32 (out of 100). This score shows that the team members had an excellent ability and suitable experience to further develop alternatives and, thereby, increase the efficiency of the VES development phase. The judgment phase received the lowest score (63.11), mainly a result of the fact that only a discussion and consensus method were applied during this phase. Evaluation tools, such as advantage/disadvantage analysis, feasibility analysis and weight paired comparison, were not used to appraise and combine the ideas. Additionally, some team efforts in development and recommendation phases were less effective due toe of the limited application of judgment tools.

Performance during the creation (84.98) and information (84.97) phases placed second and third, respectively. During the information phase, all collected data, the reliability of data sources, review of cost data, and understanding owner's needs in terms of function and cost were well performed, a result of the comprehensive project presentation question period conducted by the project manager of design team for the following areas: project background; design concept; owner requirements; projuct constraints; and, considered alternative concepts. The owner representatives also clarified the owner's needs and project constraints. During the creation phasethe following practices performed well: function based creation; open-minded thinking; unlimited speculation; group thinking; and, not criticizing others' ideas The poor performance of the function analysis phase (the second lowest score) was primarily a result of VES team members not completing the function-cost matrix or constructing FAST diagram, which is a key technique of VE. In order to improve the performance of the function analysis phase, team members may perform a function analysis in accordance with the features of the construction work. Various FAST diagrams can be developed based on a function analysis. By doing this, the primary/secondary functions of different works can be further clarified. An in-depth project understanding and more substantial idea generation can also be stimulated through FAST diagrams.

	Weight of the phase	Total points gained	Performance score
Information	0.1976	0.1679	84.97
Function Analysis	0.2376	0.1617	68.06
Creation	0.1751	0.1488	84.98
Judgment	0.1217	0.0768	63.11
Developmen t	0.1291	0.1166	90.32
Recommend ation	0.1389	0.1109	

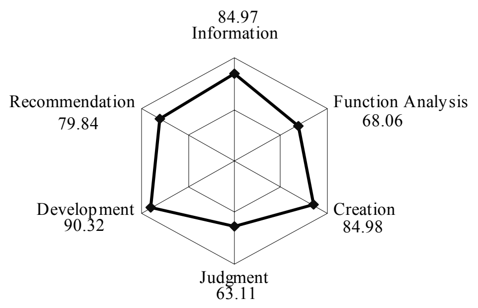

Figure 1. Results of performance assessment of VES

5. CONCLUSIONS

This study presented a novel proposed model for evaluation of VES performance for construction projects. The expertise evident in the proposed model was a product of the opinions collected from VE experts in Taiwan using two-phase questionnaire. Analytical techniques, such as factor analysis and paired comparison method, were used to group and weigh the PEIs and PEGs in the proposed model. This model consists of 6 PEGs and 32 PEIs. One real VES for a construction project was used to demonstrate how the proposed model works.

The proposed model can be used by VES teams to conduct self-diagnosis, improvement and motivation to achieve enhanced performance. The proposed model is also capable of the following functions: (1) correct misjudgment resulting from potential cost reduction; (2) clarify defects in a VES and, thereby, avoid repeating mistakes; (3) assist inexperienced team members in implementing a VES and identify the crucial issues in a VES; and, (4) provide an model approach that can be used by other industries to build similar models for assessment of VES in their fields.

ACKNOWLEDGMENT

The authors would like to thank Taiwan National Science Council for financially supporting this research under Contract No. NSC92-2622-E-224-022-CC3.

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