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The Pathology of the Hindrance Factors Impeding the Application of Value Engineering in the Construction Industry in Iran and Ranking Them by Use of Analytical Hierarchy Process

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Abstract

Nowadays due to the importance of value engineering, many researches have been done about it and application of it in engineering subcategories especially civil engineering. Researches have either paid attention to the structure of value engineering or to the procedures of getting it done or to mixing it with other managerial tactics like risk management, cost management, quality management, or to the diagnosis of the problems in the procedure of value engineering. However, the present research is about the diagnosis of the barriers against application of value engineering in civil engineering projects in Iran with collecting data and experts' views and engineers and professors and also application of statistical and AHP approach. The findings of this research include: diagnosis and ranking of the barriers against development and application of value engineering in civil projects with help of AHP-categorizing applicants of value engineering in terms of their field of work in civil engineering, their level of education, their experience and visualizing the amount of application of value engineering in today`s civil projects. It can be reached from data that the most important barrier is lack of the culture and aspiration for thrift. It can be reached from the research that the most important barriers against application of value engineering are lacking the related culture and incentive for thrift and good use of resources. Of course the activities of groups like value engineers club, civil engineers club, office of planning and controlling of presidency are most important in making applicants keen on using the value engineering.

Keywords

Value Engineering, Civil Projects, Analytical Hierarchy Process

1. Introduction

Value engineering method can make both reduction of costs (plus adding value) and improving the quality of products and services happen at once. Value engineering approach is a systematic and committed approach to an improved and added value product for every single resource spent. In a competitive market the way to success is to provide the best value for the price spent by consumer and this would be reached by function and cost calculation [1] [2].

Although a great sum of budget has been appropriated to civil projects but the reports of public planning and management organization show the delay in being done. The average time spent on executing the projects between 1374 and 1381 was 7.7, which means almost two times more than what was expected, also the quality of the projects executed was not at all acceptable and in 1381, only 2.3 percent of the projects received excellent quality award [3] [4] [5].

The delay due to late exploitation and inflation made the costs increase, the resources idle and the return on investment late. This would make the whole project economically unjustifiable and as a result a failure [6] [7].

Value engineering, whose appropriate results have been proved by its use in other countries, was appeared first in the Second World War where acquiring rare materials was very difficult and even impossible. The nature of value engineering makes it usable for all civil projects. This technique would reduce the price suggestion of innovative ways, developing teamwork and diagnosis of problems [8] [9] [10]. This paper reports the result of a research in diagnosis of barriers against applying value engineering approach in Iran apartment building industry.

The first appearance of VE in Iran goes back to late 1370s and public planning and management organization in clause 61 of the 3rd development plan mentioned VE as a method to simplifying and cost reducing approach and made administrative organizations' duty to make use of it.

The rest of this paper is organized as follow: the impact of the subject and the applied research method have been introduced in Section 2 and 3 respectively. Section 4 introduces the generic model. The statistical population is explained in Section 5. Section 6 discusses the calculation of the consistency ratio. Finally, Section 7 provides some final conclusions and directions for future work.

2. The Importance of Subject

The value engineering (VE), is more a process rather than a specific program or plan and it can be used both in business and technical management applications. The VE roles can vary in a product lifecycle. However, the main structure re-

mains the same besides any inherent differences or plan/program variation.

The main building blocks of the typical VE are depicted in Figure 1. The 6 different phases shown in this diagram could be summarized as the 3 main phases of:

1) Value discovery,

2) Value implementation (Going on-line), and

3) Value optimization and future support.

The goal of the value discovery (VD) is to "discover" the values that are relevant to, inspire, or inform a given design project [1] and identifying the business process optimization and the business model innovation potentials/opportunities. This could be accomplished using workshops, assessment tools, community education efforts, frequently open discussions, and design thinking. The VD activities resulting in a list of values and bringing into focus what is often implicit in a design project [11] [12].

The goal of value implementation (VI) is creation/delivery, validation and execution of the values and the value translation towards going on-line. Value implementation requires a time course. It has a time course of value growth, which is a process of value discovery and realization. The value implementation becomes the main focus for different companies to provide business capability in order to increase business competency to reach their organizational performance. The IT Value Implementation (IVI) became the important concern for the microfinance sector to improve their organizational performance in order to gain competitive advantage [13]. Value translation/operationalization is the activity of embodying or expressing values in system design, which involves defining or articulating values in concrete terms, and implementation which involves specifying corresponding design features [11]. The translation of values into value profiles and the crafting of the resulting statement of values (SOV) is a bottom-up process involving all stakeholders [12].

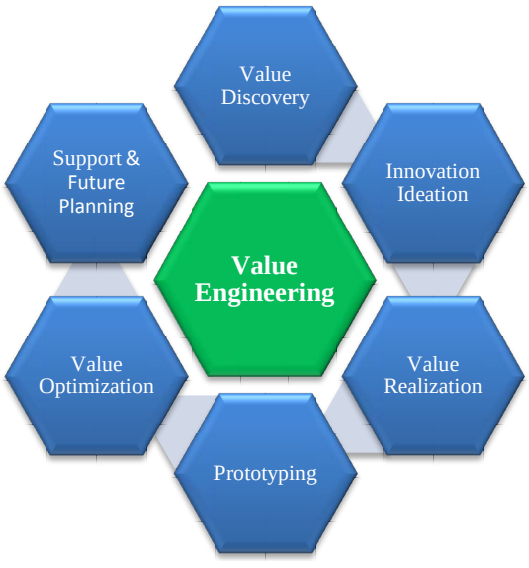

Figure 1. The importance of VE.

Value optimization (VO) and future support have to be conducted after VI. The VI needs to be continuously evaluated and improved to ensure the business application can result in the expected value, control, and aligned with the organization's strategy to get an edge competence that focuses on achieving the business objectives of the organization [13]. The goal of VO is to ensure that the delivery is on time, on budget, on value and it is the key element to deliver the results of the previous steps and to help assure the value outcome.

The VO is not only the final step but also one of the most critical elements as it focuses on the organizational realization and implementation and leverage of the whole organization. The VO is critical to future success and therefore needs to be a focus and a priority. A vision and strategy need to be defined that will allow this business to drive value optimization, contribute back to the organization, and support the overarching vision and strategy of the organization. The strategies/methods may include internal testing among the design team, user testing in controlled environments, formal/informal interviews and surveys, the use of prototypes, traditional quality assurance measures such as automated and regression-oriented testing, etc. [11] [12].

3. Research Method

The main research method strategy is depicted in **Figure 2**. The research started with the idea. Then a comprehensive literature review, to define the main research questions and state-of-the-art relevant works. The research plan is defined based on the research question towards finding the answer. Different experiments and/or analytical/statistical studies would be implemented and the relevant data will be collected for further processing and study. The research question should be answered based on the results and the processed data as outcome of the research.

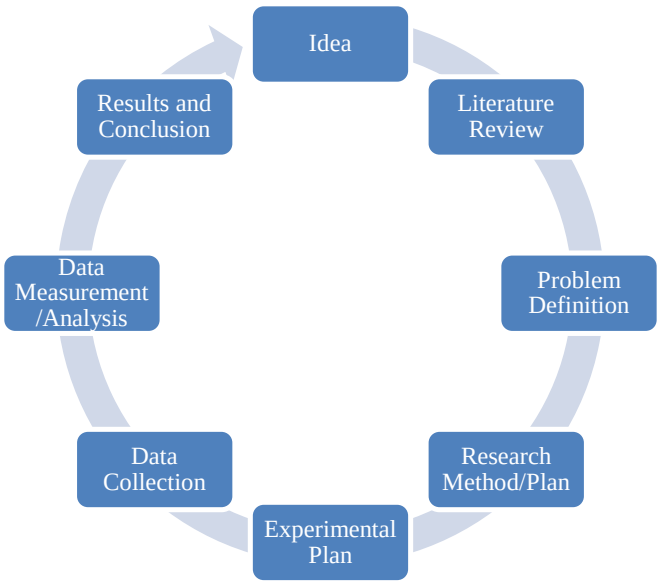

Figure 2. Research method.

Figure 3 shows the flowchart of the applied VE. This has been introduced regarding to the model presented in [14]. As depicted in Figure 3, the process starts with problem definition. Then the ideas will be listed and roughly analyzed for potential cost/energy-saving, and based on formal and/or informal brainstorming.

The review of the design information has been followed by modelling of the items energy/cost. The items with the best cost-saving potential being selected and fed into the function analysis stage and the function-based energy model will be sketched. A basic function would be selected in a detailed study and the ideas fitting this basic function are generated. Then the best idea will be selected and prepared for the value proposal, followed by detailed study of the ideas with the best cost-saving potentials in order to prepare the value proposal.

4. Generic Model

The most important factors effecting VE and execution of the civil affair development projects in Iran are as follows [15] [16] [17]:

- Employer
- Engineering teams
- Project manager
- Planning and controlling team
- Exploiter
- Resources
- Consultant
- Media
- Cultural remains

5. Statistical Population

5.1. Statistical Population Process

The total number of 100 people (BA and higher) were chosen who were employed by the organizations who had applied VE. Then 100 questionnaires were distributed of which 80 were usable. In order to make sure that the samples were honest at the time of answering, two questions were put among the questions which would prove above matter. First the samples were asked if they are familiar with VE and if they would answer yes then the follow up questions were asked to assess their answer like how many workshops have you attended or if you are aware of the existence of VE. 20 questionnaires were rejected for they were not honest in their answers.

The samples field of study were divided into three groups: civil engineers (73%), industry engineers (13%), and other engineers (15%). The samples' activity background are: civil engineers in public organizations (48%), civil engineers in private organizations (35%), contractors (5%) and others (3%). The experience of sample population are: over 25 years (20%), between 20 and 25 years (15%), between 15 and 20 years (20%), between 10 and 15 years (8%), between 5

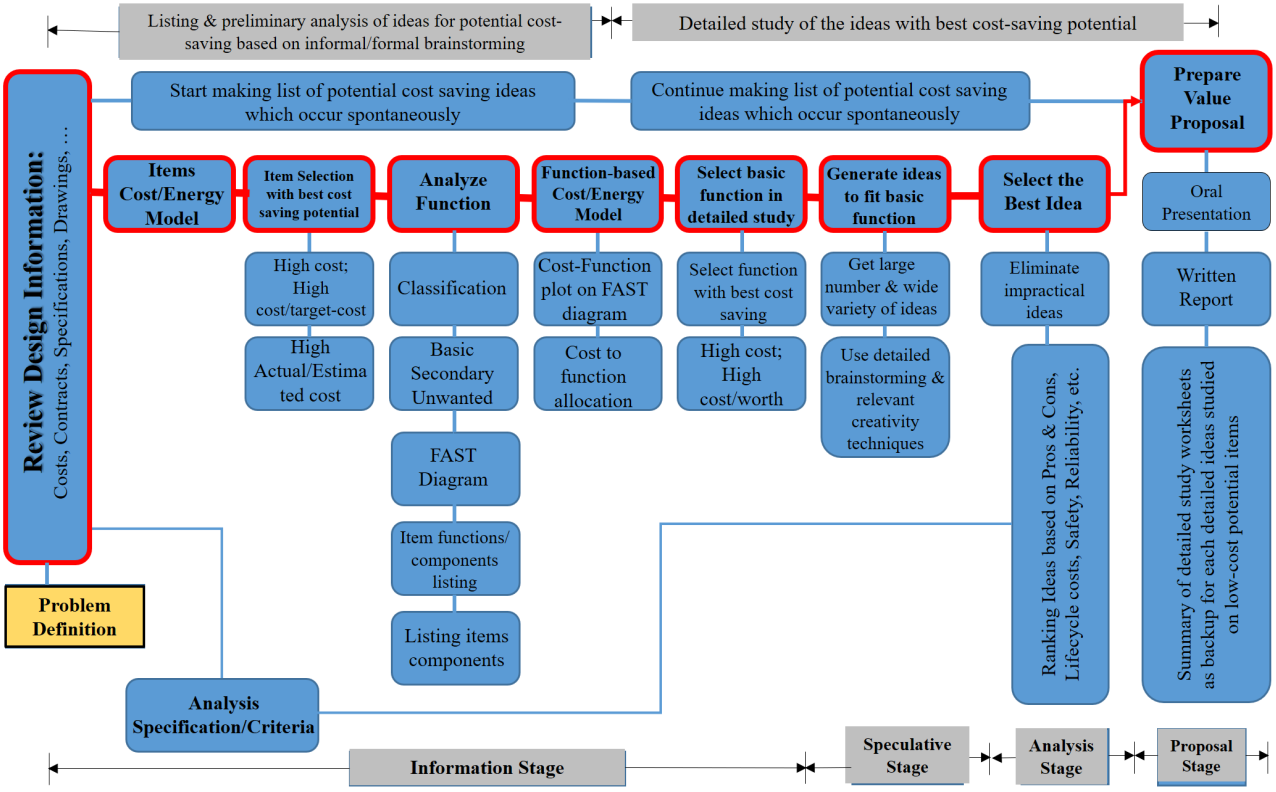

Figure 3. VE flow chart (source: www.12manage.com).

and 10 years (25%). The level of familiarity of sample population with VE is very much (10%), high (74%) and average (16%).

5.2. The Questionnaire

The questionnaire has been prepared based on AHP and it is in Persian due to the comfort of the participants who all spoken Persian as their first language.

The questionnaire includes two different kinds of questions:

1) First kind:

Five general questions. These questions include:

Question (1).The level of the education;

Question (2). The field of study;

Question (3). The field of activity;

Question (4). The duration of experience on civil affairs operation;

Question (5). The address and the name of the organization (optional).

2) Second kind:

45 questions on the basis of the binary comparative (barriers).

5.3. Diagnosis of Barriers against Application of VE in Civil Projects

After library readings and relative researches and also interview with the experts, the sum of 15 barriers were chosen of which with further analysis 10 were chosen. Table 1 shows the 10 hindrance factors impeding the application of VE in

the construction industry. Due to the high volume of data caused a long processing-time, after consulting with several experts in the field (from both academy and industry) and active pioneer companies in the value engineering, the list was shorted from 15 to 10. This shortened list covered the most recommended factor, used in this study.

5.4. The Research Conduction Levels

Levels of conducting the research include the following four steps:

First step: forming hierarchy tree;

Second step: allocation of benchmark index and weighing the alternatives;

Third step: adding up the benchmark's indexes and alternatives' weights;

Fourth step: compatibility test.

In AHP method benchmarks' weight will be appointed by comparing two by two based on the Table 2. Table 2 shows the Pairwise comparison as introduced by T. L. Saaty's AHP in [18] [19].

Table 3 shows the resulted answers of the questionnaires and Table 4 shows the criterion weight matrix.

Table 1. The hindrance factors impeding the application of VM in the construction industry.

Row	Hindrance Factors Impeding the Application of VM
1	Lack of culture and incentive for thrift and good use of resources
2	Conformity with contractor's opinion
3	Lack of knowledge about VE
4	Lack of cooperation and interaction with the internal VE team
5	Lack of legislation providing for application of VE in the construction industry
6	Lack of workshops
7	Lack of support and active participation from owners and stakeholders
8	Lack of VE experts
9	Lack of risk and innovation
10	Lack of time to conduct VE studies

Table 2. Pairwise comparison (T. L. Saaty's AHP, [18] [19]).

Definition	Weight Index
Equally important	1
Equally or slightly more important	2
Slightly more important	3
Slightly to much more important	4
Much more important	5
Much to far more important	6
Far more important	7
Far more important to extremely more important	8
Extremely more important	9

Table 3. Answers of questionnaires. The rows are the questions' number and the columns show the score in the questionnair.

	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Q01	6	2	8	2	6	8	2	4	6	1
Q02	2	4	6	4	6	2	4	2	1	1
Q03	1	1	2	2	1	1	1	2	1	6
Q04	1	2	1	1	1	1	6	4	4	1
Q05	6	1	1	1	6	8	1	2	8	1
Q06	8	2	2	6	8	8	2	4	8	8
Q07	4	6	4	6	4	6	6	2	4	4
Q08	4	2	4	4	2	1	2	2	2	1
Q09	2	6	6	8	2	2	2	2	6	8
Q10	−4	2	−2	2	1	−6	−2	−6	−6	1
Q11	−6	−2	−6	1	−6	−8	−2	−2	−6	6
Q12	−6	1	−8	−2	−6	−8	4	−8	−2	1
Q13	1	−2	−8	−2	1	1	−2	−2	−2	1
Q14	2	1	−6	4	2	1	1	1	2	8
Q15	−2	4	−4	4	−2	−2	4	−2	−2	4
Q16	−2	1	−4	2	−4	−8	1	−2	−4	1
Q17	−4	4	−2	6	−4	−6	1	−6	1	8
Q18	−2	−4	−4	−2	−6	−2	−4	4	1	6
Q19	−2	−2	−6	−4	−6	−2	2	−2	4	1
Q20	4	−4	−6	−4	1	6	−4	4	8	1
Q21	6	−2	−4	2	2	6	−2	6	8	8
Q22	2	2	−2	2	−2	4	2	4	4	4
Q23	2	−2	−2	1	−4	−2	−2	4	2	1
Q24	1	2	1	4	−4	1	−2	1	6	8
Q25	1	2	−2	−2	1	1	7	−6	4	−6
Q26	6	1	−2	−2	6	8	1	−1	8	−6
Q27	8	2	1	4	8	8	2	2	8	2
Q28	4	6	2	4	4	6	6	1	4	−2
Q29	4	2	2	2	2	1	2	−1	2	−6
Q30	2	6	4	6	2	2	2	−4	6	2
Q31	6	−2	4	1	6	8	−6	6	4	1
Q32	8	1	2	6	8	8	−4	7	4	8
Q33	4	4	4	6	4	6	1	6	1	4
Q34	4	1	4	4	2	1	−4	6	−2	1
Q35	2	4	6	8	2	2	−4	2	2	8
Q36	2	2	2	6	2	1	2	2	1	8
Q37	−2	6	4	6	−2	−2	6	1	−4	4
Q38	−2	2	4	4	−4	−8	2	1	−6	1
Q39	−4	6	6	8	−4	−6	2	−4	−2	8
Q40	−4	4	2	1	−4	−2	4	−2	−4	−4
Q41	−4	1	2	−2	−6	−8	1	−2	−6	−8
Q42	−6	4	4	2	−6	−6	1	−1	−2	1
Q43	1	−4	1	−2	−2	−6	−4	1	−2	−4
Q44	−2	1	2	2	−2	−4	−4	−4	2	4
Q45	−2	4	2	4	1	2	1	−4	4	8

Table 4. Criterion weightmatrix.

criterion	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10
m1	1.00	5.00	3.00	1.00	2.00	4.00	5.00	5.00	3.00	4.00
m2	0.20	1.00	0.50	0.25	0.25	0.50	1.00	1.00	0.50	1.00
m3	0.33	2.00	1.00	0.50	0.50	1.00	2.00	2.00	1.00	1.00
m4	1.00	4.00	2.00	1.00	1.00	3.00	5.00	4.00	2.00	3.00
m5	0.50	4.00	2.00	1.00	1.00	3.00	4.00	4.00	2.00	3.00
m6	0.25	2.00	1.00	0.33	0.33	1.00	2.00	1.00	1.00	1.00
m7	0.20	1.00	0.50	0.20	0.25	0.50	1.00	1.00	0.33	1.00
m8	0.20	1.00	0.50	0.25	0.25	1.00	1.00	1.00	0.50	1.00
m9	0.33	2.00	1.00	0.50	0.50	1.00	3.00	2.00	1.00	1.00
m10	0.25	1.00	1.00	0.33	0.33	1.00	1.00	1.00	1.00	1.00

Table 5. The normalized matrix.

criterion	m1	m2	m3	m4	m5	m6	m7	m8	m9	m10
m1	0.23	0.22	0.24	0.19	0.31	0.25	0.20	0.23	0.24	0.24
m2	0.05	0.04	0.04	0.05	0.04	0.03	0.04	0.05	0.04	0.06
m3	0.08	0.09	0.08	0.09	0.08	0.06	0.08	0.09	0.08	0.06
m4	0.23	0.17	0.16	0.19	0.16	0.19	0.20	0.18	0.16	0.18
m5	0.12	0.17	0.16	0.19	0.16	0.19	0.16	0.18	0.16	0.18
m6	0.06	0.09	0.08	0.06	0.05	0.06	0.08	0.05	0.08	0.06
m7	0.05	0.04	0.04	0.04	0.04	0.03	0.04	0.05	0.03	0.06
m8	0.05	0.04	0.04	0.05	0.04	0.06	0.04	0.05	0.04	0.06
m9	0.08	0.09	0.08	0.09	0.08	0.06	0.12	0.09	0.08	0.06
m10	0.06	0.04	0.08	0.06	0.05	0.06	0.04	0.05	0.08	0.06

Table 6. Final ranking of criterion: hindrance factors impeding the application of VM.

Row	Hindrance Factors Impeding the Application of VM	Relative weight
1	Lack of culture and incentive for thrift and good use of resources	23%
2	Lack of support and active participation from owners and stakeholders	18%
3	Lack of legislation providing for application of VE in the construction industry	16%
4	Lack of knowledge about VE	8%
5	Lack of risk and innovation	8%
6	Lack of workshops	7%
7	Lack of time to conduct VE studies	6%
8	Lack of VE experts	5%
9	Conformity with contractor's opinion	4%
10	Lack of cooperation and interaction with the internal VE team	4%

Table 7. Random consistency index.

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R.I	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.53	1.56	1.57	1.59

The next step is to calculate the relative weight of each criterion with help of geometric mean. In geometric mean, first the values of each column in Table 3 are added and then the value of each pairwise comparison matrix is divided by total of its column in order to calculate the normalized matrix of pairwise comparison, in the end geometric mean of each line in the normalized pairwise comparison matrix is calculated. Table 5 shows the resulted normalized matrix.

The final ranking of criterion (Hindrance Factors Impeding the Application of VM) is depicted in Table 6.

6. Calculating Consistency Ratio

Now raises the question of how trusted this hierarchy is. To answer this question, consistency ratio is used. When ratio is $1 \geq C \cdot R$, the ranking can be trusted.

Consistency ratio is calculated by the following formula.

$$\lambda_{\max} = \frac{1}{n}\left[\sum_i^n \left(Aw_1\right) / w_1\right] \tag{1}$$

$$\lambda_{\max} = \frac{1}{N} \tag{2}$$

$$C \cdot I = \left(\lambda_{\max} - n\right) \cdot \left(n - 1\right) \tag{3}$$

Random index: if the values in a matrix are acquired by random, then (n) is chosen from the random consistency index as shown in Table 7.

7. Conclusion

In conclusion, it can be said that the results in this paper can be trusted because 1 ≥ CR. With regard to the existent statistics, this research and other researches, the application of VE in Iran is not in a good condition. In this paper, lack of culture and incentive for thrift is the most important hindrance in application of VE.

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