



## VALUE ENGINEERING ANALYSIS FOR THE EDUCATIONAL BUILDINGS IN EGYPT

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### ABSTRACT

General Authority for Educational Buildings (GAEB) in Egypt is responsible for new construction and maintenance of the educational building [1]. According to the Sixth Five-Years Plan in Egypt, the program of educational structures includes new construction of about 2915 schools, with 39.8 thousand classes. Also, maintenance works for buildings about 1250 schools. These works needs a high budget but the available budget is less than the required budget. Therefore, GAEB should apply optimization techniques to save cost and optimize the benefit from the available budget with the same quality level or more. This paper aims to apply value engineering technique on educational building to maximize the utilization of the available construction and maintenance budget. In this paper value engineering technique, is applied on a model of primary school. The paper suggested that GAEB should construct a value engineering department included in its organization structure. Finally it draws overall conclusions about the application of value engineering (VE) in the GAEB in Egypt. Also, to get the optimum set of activities, alternatives for cost saving and maximize the utilization of the available funds for new construction and maintenance works. The value engineering technique application is based on data collected from GAEB.

Received: 8 January 2012; Accepted: 20 April 2012

**KEY WORDS:** value engineering (VE); optimum value; building design; cost saving

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## **1. INTRODUCTION**

Most of the economical problems are resulted from the misuse of available resources. Having better control on resources would result in more efficient economy, and that will build a better living standard for people. Construction industry is one of the activities that has a lot of manpower invoked in, as an example in any construction project you would find so many types of materials, and specialized categories such as labours with there different categories. One can judge that a country is economically booming if it has a boom in the construction industry.

The construction industry always has one of the biggest shares in any country's budget and the construction of educational buildings represents a high percent of this industry. In this era of the rapid rise in the price of materials, escalating labour wages caught by inflation, and increasing energy costs, General Authority for Educational Buildings, as being responsible for educational construction projects in Egypt, is seeking every avenue to improve value and conserve resources. Also, due to constrained budget is seeking optimum value and makes money stretch to preform the required building and maintenance plan.

In Egypt, there are a big number of school buildings under construction and there are more will be constructed. So, if you could make a small percent of saving in one item, it means that you will make a large sum of money saved from the construction process of these current and future schools building. During the Sixth Five-Year Plan, the Ministry of Education assigned about 5800 million Egyptian pounds to fund the program of school buildings. This program which includes the construction of 2915 school buildings is a part of the electoral program of the President on the establishment of 3500 schools including 48 thousand classes over six years. This program aims to prepare schools and operating equipment classes with the start of each academic year, and provide workshops and technical education labs machinery and equipment required for operation and training [1].

This study aims to maximize the utilization of the available funds for GAEB. Also, reduce the total cost of school buildings construction by using VE methodology taking into account to required quality, time of construction, pupils comfort and maintenance cost. By Value Engineering technique application, we can achieve these aims. As it is the cost optimization technique that stresses on the client needs, and consider the function of the element as abase for alternative cost comparison in the analysis used – function oriented technique.

This study is concerned with the educational buildings in Egypt. These buildings are classified-according to General Authority for Educational Buildings–to many different models. In this study eight classes' model (six classes+two classes for kindergarten) are used for value engineering application to get the optimum value and cost savings of construction cost for the school building in the construction phase.

## **2. VALUE ENGINEERING HISTORY AND METHODOLOGY**

### *2.1. Origin of value engineering*

Value engineering (VE) developed during World War II in the United States. It began as a search for alternative product components, a shortage of which had developed as a result of

## VALUE ENGINEERING ANALYSIS FOR THE EDUCATIONAL...

the war. Due to the war, however, these alternative components were often equally unavailable. This led to a search not for alternative components, but to a means of fulfilling the function of the component by an alternative method [2-4]. It was later discovered that this process of "function analysis" produced low-cost products without reducing quality and, after the war, the system was maintained as a means of both removing unnecessary cost from products and improving design. The process of VE based on analysis of function was therefore born. Though value analysis has been applied in various fields with considerable success in recent years, everyday economic practice has created new problems and situations that require further development in the methodology of value analysis [4-6].

### *2.2. Value engineering approach*

#### *2.2.1. Definition and objective of value engineering*

There are many value specialists who introduce a definition for value engineering. Zimmerman and Hart definition is: "Value engineering is a proven management technique using a systematized approach to seek out the best functional balance between the cost, reliability, and performance of a product or project" [4,7]. From this definition of VE, one can say that the specific objective of the value engineering systematic approach is to provide a means of total cost control anywhere within a project's life cycle. This total cost control is accomplished, basically, by identifying and separating the necessary from the unnecessary costs. The second step is to remove the unnecessary costs and develop alternate means of accomplishing the required function at a lower total cost. This is done while maintaining the required quality and reliability of the project to which the systematic approach is applied.

#### *2.2.2. Value engineering job plan*

The job plan is the disciplined system which combines the special technology of value analysis with other procedures and techniques to result in the complete analysis. It is the systematic approach of VE and the road map for defining the required task and determining the most economical combination of functions to achieve the task. The job plan provides the value practitioner with the following [4,5]:

1. An organized and objective approach.
2. It forces a concise description of purpose.
3. It zeroes in on high cost areas. It allows the VE team to identify the concentration of cost, and to associate the cost required to achieve a purpose.
4. It forces people to think deeper than their normal habit solutions.
5. A universal approach which unifies the language and expressions to be used by VE professionals.

The job plan is a systematic approach that follows the five basic phases. There are several versions of the job plan. The procedures are all similar in their approach. The following Five-Phase Job Plan is used to describe the procedure [4,8]:

1. Information Phase.
2. Creative Phase.
3. Judgment Phase.
4. Development Phase.

5. Recommendation Phase.

### 3. VALUE ENGINEERING METHODOLOGY APPLICATION

#### 3.1. Study job plan

In This study the building design model 8 are used in methodology application. This model is called as the eight classes model (six classes+two classes for kindergarten) as an application area of how value engineering makes more savings of new construction cost of school buildings. To achieve this, the study procedure will use the following job plan. The job plan is the systematic approach of VE and the road map for defining the required task and determining the most economical combination of functions to achieve the task. The following Five-Phase job plan was used to describe the procedures of study [4,6,9,10]:

1. Information phase
2. Creative phase
3. Judgment phase
4. Development phase
5. Recommendation phase

##### 3.1.1. Information phase

The purpose of this phase is to gain as much information and knowledge as possible, such as:

1. Information gathering; problem description, and objectives identification.
2. Analyzing cost information.
3. Function analysis.

##### 3.1.1.1. Information gathering

In order to assess the basic and secondary functions considered by each of the school building parties when selecting a project to undertake, a questionnaire was designed and sent to those parties. Questionnaires are extremely critical components of the research process because they provide an insight to which information is important and the opinion of the participants about the problems discussed. The design of the questionnaire requires very careful considerations. One should aim at formulating the questions such that no misinterpretation is possible. To do this, the following points should be taken into consideration in designing the questionnaire:

- 1) Proper introduction to the questionnaire explaining the purpose of the study and emphasizing the confidentiality of responses.
- 2) Questions must give the information required.
- 3) Questions must be concise and clear.
- 4) Questions must be presented in the best sequence possible preferably from simplest to most complex.

The questionnaire was designed in order to determine three basics:

- 1) To determine the items to be under study.

VALUE ENGINEERING ANALYSIS FOR THE EDUCATIONAL...

- 2) To determine criteria to be taken in consideration during study and the degree of importance for each criterion against each item. Figure 1 shows the second part of the questionnaire.
- 3) To determine to what degree each item achieves each criterion.

<b>Second:</b>							
Considere each of the factors listed below, identify the degree to which this factor should be considered in selecting alternatives of construction for listed items. Put the coresponding number of your selection (between 1 to 10) in the cells to the right where: (1) not important, (2) fairly important ..... (5) very important							
Factors (criterion)	Degree of importance						
	Play ground flooring	Bathroom flooring	Wash basins	Lavatory	Pissoirs	Input pipes	
1. Initial cost							
2. Construction duration							
3. Maintenance cost							
4. Constructability							
5. Efficiency							
6. Comfort pupils							
7. Aesthetics							

Figure 1. The second par of the questionnaire

Then, a group of high-maintenance-cost items was selected to be under study as an example of school items. The participants were classified as either:

- |                     |                  |
|---------------------|------------------|
| Owners              | Operators        |
| Designers           | Project managers |
| General contractors | Sub contractors  |
| Suppliers           |                  |

They were asked to give a certain weight to each factor according to its relative importance. This weight could range from 10 or 5 in some questions (considered as very favourable) and 1 (considered as non important or irrelevant). An empty space under each category was left to be filled in by the participant if, he wanted to add any additional factors or any additional alternatives that were not already mentioned.

Thirty questionnaires were delivered by hand to different prospective participants. However, only 60% of the participants responded to the survey. The remaining percentage did not answer, perhaps due to lack of time or due to secrecy of information.

The questionnaire was divided, as mentioned before, in to three main categories, namely:

- A) Items to be under study:
  - 1) Play ground flooring

- 2) Bathroom flooring
- 3) Wash basins
- 4) Lavatory
- 5) Pissiors
- 6) Input pipes

B) Criteria to be taken in consideration during study and the degree of importance for each criterion against each item:

- 1) Initial cost
- 2) Construction duration
- 3) Maintenance cost
- 4) Constructability
- 5) Efficiency
- 6) Comfort pupils
- 7) Aesthetics

C) The percentage each alternative achieves each criterion where alternatives of each item were mentioned against each criterion.

#### **Questionnaire evaluation and analysis**

As has been mentioned earlier, a small portion of the questionnaire were returned, among which some were misconceived by the participants, who, when asked about what they meant by their answers, gave unexpected understanding of the points under investigation, thus the questionnaires were excluded from further consideration. The number of finally considered questionnaires was 12, divided as follows:

- One technical office engineers.
- Three owners/operators.
- One structural designer.
- Two Project managers.
- One quality control engineer.
- Two contractors.
- Two consultant engineers.

The questionnaire was basically completed through personal interviews with the participants. The researcher was interested to interview the specialists concerned with research area because of:

- 1) Two-way discussion is possible, resulting in fewer misunderstanding.
- 2) The composition of questions, most of them require deterministic answers, which are more simple and easy for interviews.
- 3) Filling the questionnaire by personal interviews.

It was taken into account that the participant should represent his organization, thus all of the selected participants were either first-in-charge of their business, or department heads in multidisciplinary organizations. Some of the participants, however, answered the questionnaire in private, and then the answers were revised with the researcher in order to make sure that the correct meaning of each questionnaire item was conceived.

The analysis of the questionnaire aimed at finding the best suitable ranking in each

## VALUE ENGINEERING ANALYSIS FOR THE EDUCATIONAL...

category. The method used was calculating the means of the provided answers to find the most selected items or alternatives, thus representing the first priority for the participant. The analysis yielded the results and numbers used in the comparison matrix as will be shown in the following chapter of application.

### *3.1.1.2. Project constraints*

The project constraints are those areas of the design that are not subject to the VE study. The following constraints were considered:

- 1) Complete work on specific time.
- 2) Do not surpass the overall and specific budget.
- 3) Satisfy safety codes (specially fire fighting).
- 4) Protect the environment.
- 5) Minimize maintenance cost.

### *3.1.1.3. Function analysis*

Functional Analysis Systems Technique (FAST Diagram) is a systematic road mapping of functions. It was used to provide an organized method of exploring complicated processes or assemblies and determines in a step by step method the function required and the means to arrive at that function.

### *3.1.2. Creative phase*

The creative phase of the VE job plan is designed to introduce new ideas to perform the basic function. The creative and judgment phase worksheet was used in the VE study. The creative ideas were listed in order in columns 1 and 2. The creative idea listing was completed before analyzing and judging any of the creative ideas.

### *3.1.3. Judgment phase*

The judgment phase of the VE study is used to screen the ideas previously listed in creative phase. The judgment phase employs three techniques to refine, or combine and evaluate alternatives.

#### **Refine and combine ideas:**

The generation of a quantity of ideas does not, in itself, accomplish a thing if these ideas are not put to use. Before they can be put to use, continued creativity and refinement must be applied.

#### **Establish cost on all ideas:**

As a device or process applying on idea or combination of ideas is being refined, an estimated cost should be calculated, i.e., what is the potential cost of applying this idea and what is the resultant savings implied?

#### **Evaluate by comparison**

As one progresses into this last technique of the judgment phase, it is important to note that

the ideas have been developed only to the point where we believe they will save money, not necessarily work.

#### *3.1.4. Development phase*

The development phase of the VE study takes the ideas remaining after judgment and further develops them into workable solutions.

#### **Weight evaluation**

Decisions that require an analysis of several criteria, including economic and non-economic factors, each carrying a given degree of importance are complex decisions. Weighted evaluation provides the tools for complex decision-making. It is a formally organized process for the selection of optimum solutions in areas involving several criteria.

#### **Procedures**

The recommended procedure for weighted evaluation has been broken down into the following two processes:

- A) The criteria weighting process.
- B) The analysis matrix.

#### *3.1.5. Recommendation phase*

The recommendation phase is important, as it is the step in the process that brings the VE ideas into fruition. Recommendations are essentially a challenge to the original design. The effort in bringing the recommendation to final acceptance is long and hard. However, unless the idea is accepted, the net result is zero.

## **4. VALUE ENGINEERING APPLICATION ON GABE PROJECTS RESULTS**

As mentioned earlier, Value engineering technique was applied on a school building construction of eight classes model (six classes + two classes for kindergarten). The VE job plan was followed from the information phase up to the recommendation phase using data collected through previous questionnaire survey. During the development phase, the decision matrix was used to compare between alternatives. Figures 2, 3 shows both the criteria weighting matrix and decision matrix for the first item; Playground Flooring.

According to the weighted rating of different alternatives, the following alternatives were selected as the most suitable ones:

- 1) Playground flooring: Red gravel soil
- 2) Bathroom flooring: superior ceramic tiles
- 3) Wash basins: lavabo of bricks with a cover
- 4) Lavatory: Lavatory of cast iron covered by china
- 5) Pissiors: Pissior unit: covering wall with marble
- 6) Input pipes: Pipes of Poly Brobleen



VALUE ENGINEERING ANALYSIS FOR THE EDUCATIONAL...

Criteria weighting process			
Design model : 8 classes school		Item : Playground	
	Criteria	Weight	Score
A	Initial cost	1	1
B	Construction duration	1	1
C	Maintenance cost	3	4
D	Constructability	3	4
E	Efficiency ratio	10	13
F	Comfort pupils	10	13
G	Aesthetics	6	7

Criteria Scoring Matrix

	B	C	D	E	F	G	Total
A	A-B	C-1	D-1	E-3	F-3	G-2	1
	B	C-2	D-2	E-4	F-4	G-3	1
		C	C-D	E-2	F-2	G-1	4
			D	E-2	F-2	G-1	4
				E	E-F	E-1	13
					F	F-1	13
						G	7

How Importance:

- (4) Major difference in importance
  - (3) Medium difference in importance
  - (2) Minor difference in importance
  - (1) Slight difference importance
- One point each (letter / letter )

Figure 2. Criteria scoring matrix for playground flooring

Playground		Desired Criteria							Total	Ranking
		Initial Cost	Construction Duration	Maintenance Cost	Constructability	Efficiency ratio	Comfort pupils	Aesthetics		
		A	B	C	D	E	F	G		
Weight Of Importance 0 → 10		1	1	3	3	10	10	6		
Red gravel soil	w. rating	4	4.5	13.5	15	25	40	15	117	1
	Rating	4	4.5	4.5	5	2.5	4	2.5		
Ph in concrete with seperators	w. rating	3	2.5	6	7.5	25	20	12	76	5
	Rating	3	2.5	2	2.5	2.5	2	2		
Grainy chickpes shape tiles	w. rating	2	2.5	6	7.5	30	20	21	89	3
	Rating	2	2.5	2	2.5	3	2	3.5		
Quartztile	w. rating	1.5	2.5	6	7.5	35	20	27	99.5	2
	Rating	1.5	2.5	2	2.5	3.5	2	4.5		
Cement tiles	w. rating	3	2.5	6	9	25	20	15	80.5	4
	Rating	3	2.5	2	3	2.5	2	2.5		

<b>Excellent = 5</b>	<b>V. Good = 4</b>	<b>Good = 3</b>	<b>Fair = 2</b>	<b>Poor = 1</b>
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Figure 3. Decision matrix for playground flooring

## 5. CONCLUSIONS AND RECOMMENDATIONS

According to notes mentioned above, one can conclude the followings:

- 1) Applying value engineering technique to educational buildings construction saves money. Also, makes the GAEB using the most valuable alternatives for construction.
- 2) The most valuable alternative does not mean that of the lowest price, but it means that alternative achieving a great percent of the required functions with lowest cost.
- 3) According to the sixth Five-Year Plan, by applying value engineering technique to school buildings construction in different areas with different criteria will optimize project budget of 3500 school buildings.
- 4) For each school building its own criteria and its alternatives have their own weights against each criterion even if this building has a similar environment or similar users.
- 5) There are still many items in the educational building design , construction and maintenance needs to new valuable alternatives.

Finally this paper presents the following recommendations to be considered:

- 1) General Authority for Educational Buildings should construct a management or a team responsible for applying Value Engineering studies to school buildings in design, construction phase and maintenance phase. This team called value engineering department included in its organization.
- 2) Standardizing the operation and a database system should be built for VE studies and alternatives for different items.
- 3) For primary school eight-classes-model (six classes + two classes for kindergarten), it is preferred to use the suggested alternatives in construction.

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VALUE ENGINEERING ANALYSIS FOR THE EDUCATIONAL...

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