Analysis & Designing an Engineering Course Using QFD

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ABSTRACT

Quality function deployment (QFD) is applied to university education system in this paper. It discusses in detail the various aspects and tools associated with QFD. Now a day's employment competition is fiercer because of global economic crisis. So how to design education program for improving undergraduate competitiveness is focused. QFD theory is applied to education program design for satisfying market requirements. Statistical Quality Control (SQC) is the course which has been analyzed and designed by using QFD. Major stakeholders of Statistical Quality Control (SQC) education were identified as students, faculty and future employers; in which future employers included enterprise, graduate institute and government department according to SQC employment situation in India. Second, a set of design requirements is developed based on the analysis of SQC education program in a University. Furthermore enterprise demands were translated into education program with the house of quality. The designed program satisfies stakeholder requirements well, so that this method can help improve the quality of SQC graduate. It is hoped that the paper can also serve the needs of researchers and practitioners for higher education institutions of QFD studies and applications, and hence promote QFD's future development.

Keywords **- Engineering Institutions, house of quality, Quality Control, Quality Function Deployment, Statistical Quality Control (SQC);**

I. INTRODUCTION

In QFD, the focus is on designing quality in a product or process while in quality assessment; the focus is on assuring quality in the educational process. QFD stresses knowing your customers and meeting their needs; quality assessment stresses meeting the information needs of all constituents. QFD emphasizes the enterprise functioning as a whole; quality assessment emphasizes all aspects of the educational environment. QFD requires multi-disciplinary teams; quality involves representatives from all constituents *of* the academic community. Both approaches stress outcomes definitions

Relevant analytical tools and techniques must be identified and incorporated into the talent training models when applied to study of higher education. Quality Function Deployment (QFD), can be modified to provide a flexible, framework for integrated training models. SQC is concerned with the design, improvement, and installation of integrated systems of people, materials, information, equipment and energy. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results to be obtained from such systems [1].

The importance of adapting to market has been pointed out in [2]. Therefore, it is emergent to innovate the traditional education program, and design market oriented education program, especially under the new economic situation. QFD translates the customer or market requirements into design targets, which achieves market oriented principle and taking customer demands as the exclusive gist. QFD can be applied into many areas. Education is one of those, like in [3]. QFD was applied for education quality planning for SQC students. It showed the stakeholder requirements from SQC education, and than generated an education program. However, it didn't consider that different education program should be designed according to different stakeholders. Therefore, [4] QFD is applied to education program design for satisfying market and student requirements in this paper. Through the house of quality, different stakeholder requirements can be transformed to corresponding education program, which can support university to make adaptive cultivation plan.

II. QUALITY FUNCTION DEPLOYMENT

QFD is a systematic approach to design based on a close awareness of customer desires, coupled with the integration of corporate functional groups. QFD was developed by Yoji Akao in Japan in 1966. By 1972 the power of the approach had been well demonstrated at the Mitsubishi Heavy Industries Kobe Shipyard (Sullivan, 1986) and in 1978 the first book on the subject was published in Japanese and then later translated into English in 1994 **(**Mizuno and Akao,1994).

In Akao's words, "QFD is a method for developing a design quality aimed at satisfying the consumer and then translating the consumer's demand into design targets and major quality assurance points to be used throughout the production phase. QFD is a way to assure the design quality while the product is still in the design stage." As a very important side benefit he points out that, when appropriately applied, QFD has demonstrated the reduction of development time by one-half to one-third. [8] The 3 main goals in implementing QFD are:

1. Prioritize spoken and unspoken customer wants and needs.
2. Translate these needs into technical characteristics and specifications.
3. Build and deliver a quality product or service by focusing everybody toward customer satisfaction

Since its introduction, Quality Function Deployment has helped to transform the way many companies:

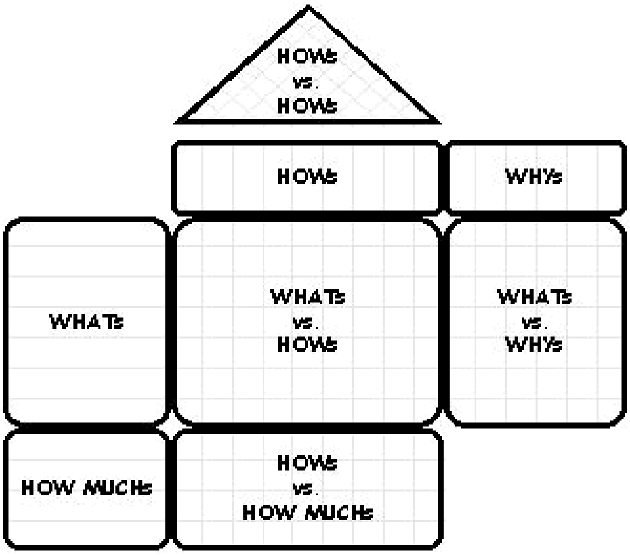
- Plan new products

- Design product requirements
- Determine process characteristics
- Control the manufacturing process
- Document already existing product specifications

III. QUALITY FUNCTION DEPLOYMENT PHASES

QFD uses some principles from Concurrent Engineering in that cross-functional teams are involved in all phases of product development. QFD process has four different phases. Each of the four phases in a QFD process uses a matrix to translate customer requirements from initial planning stages through production control (Becker Associates Inc, 2000).

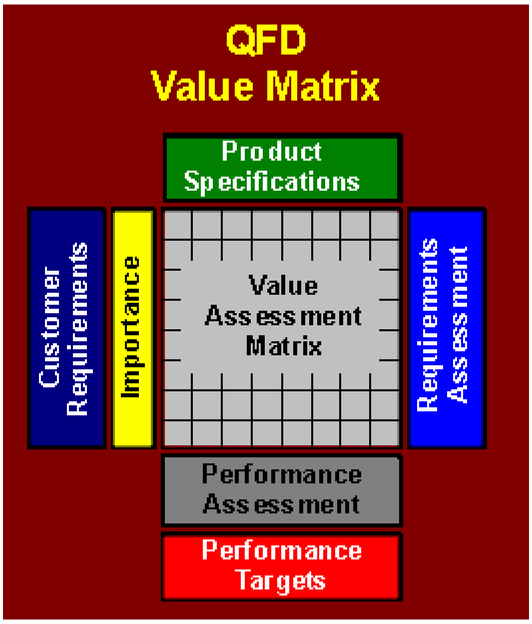
In QFD, each phase's [Ref. fig. 1] important outputs (HOWs), generated from the phase's inputs (WHATs), are converted into the next phase as its inputs (new WHATs). So each phase can be described by a matrix of "WHATs" and "HOWs", which is easy a convenient to deal with in practice.



Figre.1.QFD Model

The four QFD phases include: Phase I to translate customer needs into product design attributes which we will call technical measures; Phase II to translate important technical measures into parts characteristics; Phase III to translate important parts characteristics into process operations; and Phase IV to translate key process operations into day to day production requirements[5].

Each phase, or matrix, [fig. 2] represents a more specific aspect of the product's requirements. Relationships between elements are evaluated for each phase. Only the most important aspects from each phase are deployed into the next matrix. [9]. The different four phases are explained below.



Figre.2.QFD Matrix Distribution

Phase 1, Product Planning: Building the House of Quality. Led by the marketing department, Phase 1, or product planning, is also called The House of Quality. Many organizations only get through this phase of a QFD process. Phase 1 documents customer requirements, warranty data, competitive opportunities, product measurements, competing product measures, and the technical ability of the organization to meet each customer requirement. Getting good data from the customer in Phase 1 is critical to the success of the entire QFD process.

Phase 2, Product Design: This phase 2 is led by the engineering department. Product design requires creativity and innovative team ideas. [Ref. fig. 3] Product concepts are created.

Phase 3, Process Planning: Process planning comes next and is led by manufacturing engineering. During process planning, manufacturing processes are flowcharted and process parameters (or target values) are documented. These correlation coefficients are calculated and represented in the form of symbols which are further quantified by the numbers to show the strength of association.

● = 9 (Strong association)
○ = 5 (Somewhat association/ Medium Relationship)
Δ = 1 (Weak association)

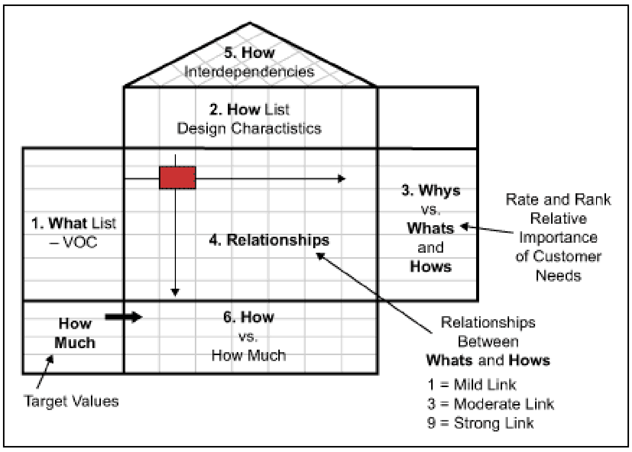


Figure.3.House of Quality to deploy QFD

Phase 4, Process Control: And finally, in production planning, performance indicators are created to monitor the production process, maintenance schedules, and skills training for operators. This phase shows inter-correlations between technical requirements provided by the Institute. The purpose of calculating inter-correlation between them is to show that whether there is association or supporting behavior or conflict between each of the technical requirements

IV. QFD Applied On Engineering Education

Quite a number of studies have been implemented on QFD in engineering education. In the engineering educational area, FD's applications include enrollment [6] and curriculum design [7] in colleges/institutes described the use of QFD in engineering education. Some studies have applied a QFD technical for engineering education. Study shows how QFD be used to evaluate the service quality of undergraduate nursing education. Principles of QFD in engineering education should have four aims:

I. Training objective
II. Training process
III. Training system
IV. Training evaluation

The QFD analysis in curriculum development of engineering education and the models of curriculum design and delivery will definitely help the academic administrators to implement in their curriculum development process.

A. QFD Analysis for Curriculum development

The house of quality is the first name of the QFD charts or matrices that appeared because there is a triangular shaped matrix attached to the top, sometimes called rooftop. The rooftop matrix looks just like a house, hence the name. It is a kind of conceptual map that provides the means for instructional planning and communications.

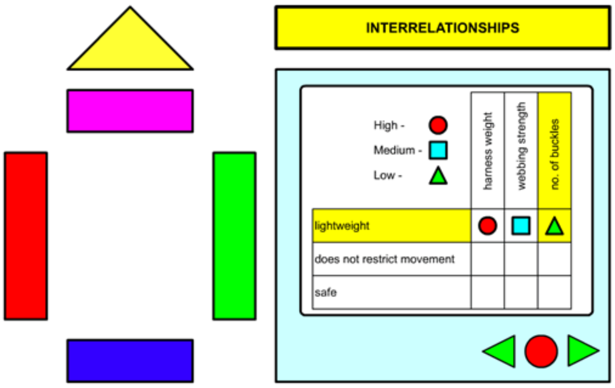
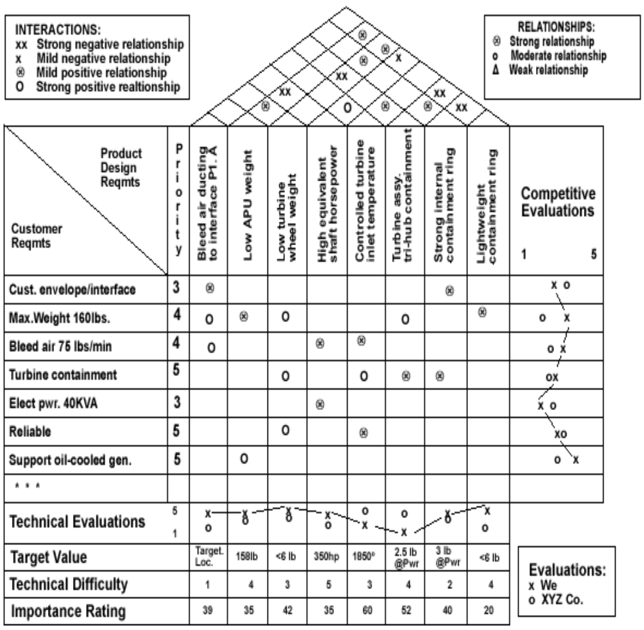


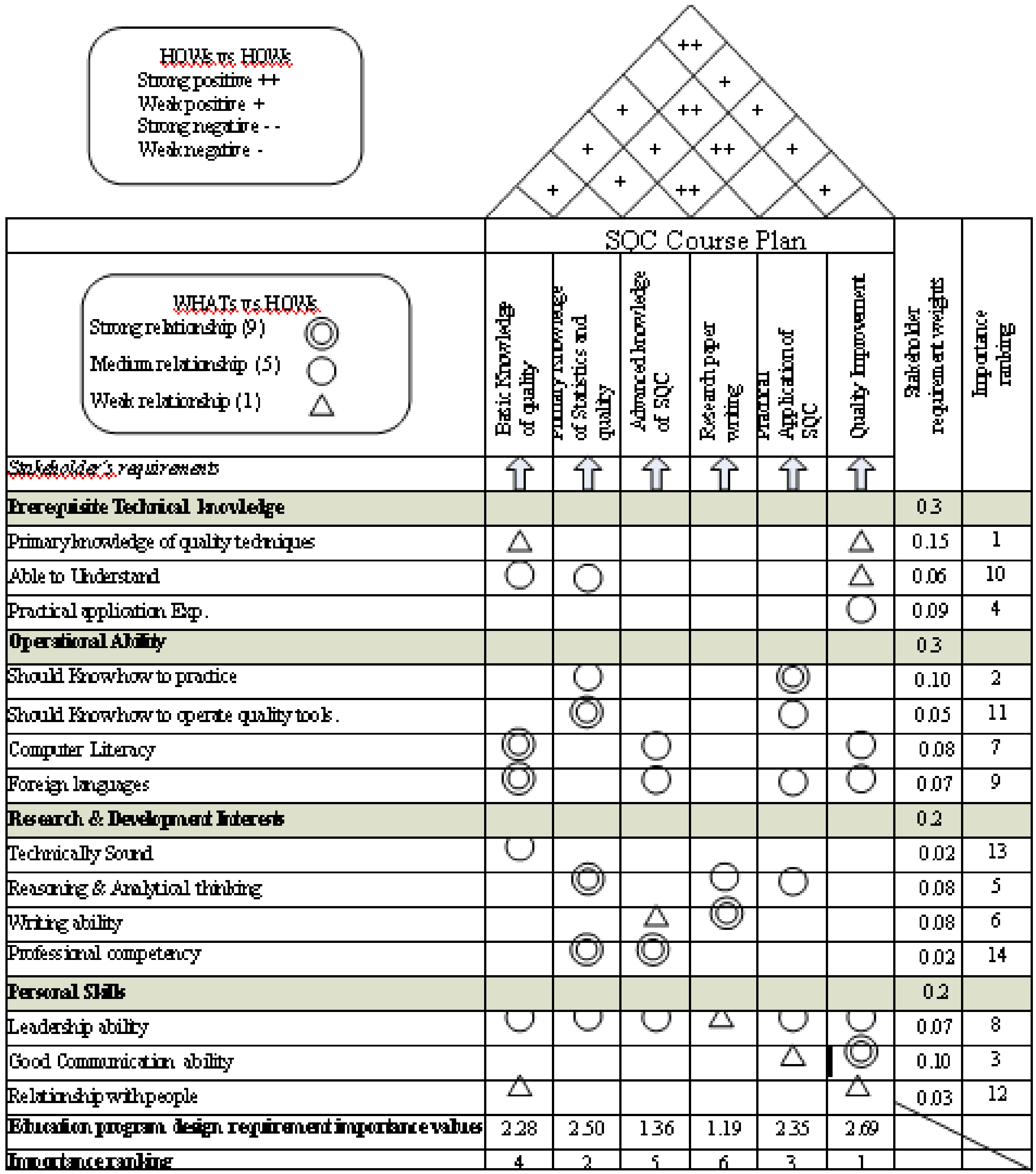
Figure.4.Matrix Relationship Model

The general model for curriculum design requires 4 matrices. The first matrix is what's matrix it is also called needs matrix. Here the customers needs for the course is developed. In order to satisfy those needs, a set of required skills should be developed and the relationships between the two sets are evaluated. Once it is validated the skills can be carried into the second matrix namely skills matrix, to match a set of primary topics. On the development of topics matrix, the primary topics are broken down into secondary topics [Ref. fig. 4] and this now creates subjects for which the instructional hours are assigned. This becomes the third matrix. The fourth matrix will be on delivery of the subjects and knowledge.

The QFD technique is used for the identification of various procedures or how's [Ref. fig. 5] for satisfying the primary requirements' of the students and the details of QFD analysis is furnished below.



Figre.5.QFD Sample Matrix Solution



FIGRE.6.QFD MATRIX ANALYSIS FOR SQC

V. METHODOLOGY

QFD is the method proposed for the design and improvement educational program in an engineering Institute based on student requirements and benchmarks obtained from its competitor Institute B and A. The primary planning tool used in QFD is the House of Quality [10].

Step-1 This is the first step to begin the QFD process where the university seeks to capture the needs and expectations of the students. The voices of the students are taken from students . These Students requirements are verified by collecting the data through questions, in depth interviews, and focus group discussions with students who are enrolled in different engineering Institutes. Following are the student's requirements for a particular course is

Step-2 deals with the technical requirements that are associated with the student's needs and expectations: Basic

Knowledge of quality, Primary Knowledge of Statistics and quality, advanced knowledge of SQC, Research paper writing, Practical Application of SQC, Quality Improvement

.Step-3 This step is relationship matrix showing the level of association/influence between each student needs and each technical requirement the institute is providing. These correlation coefficients are calculated and represented in the form of symbols which are further quantified by the numbers to show the strength of association.

●=9 (Strong association)
○ =3 (Somewhat association)
Δ=1 (Weak association)

Step-4 This step being the roof of the house of quality shows inter-correlations between technical requirements provided by the university. The purpose of calculating inter-correlation between them is to show that whether there is association or supporting behavior or conflict between each of the technical requirements. These correlation coefficients are calculated and represented in the form symbols which are further represented by the numbers to show the direction and the strength of association.

● = 9 (Strong association)
○ = 3 (Somewhat association
Δ = 1 (Weak association)
* = -3 (Negative association)

Step-5 This step is used for developing the desires/priority based students requirements These are categorized into columns of the house of quality i.e. importance to the customer, scale-up factor, target value, sale point and finally the absolute weight. In case of the importance to the customers for instance, the student's focus group assigns each of the student requirements by assigning a rating. These ratings are assigned 1 through 10 i.e. 1 indicating the least important to students while 10 for the very essential to students. Target values are set on the scale 1 through 5 with 1 'no change ', 3 'improvement is needed' and 5 'make it better than the competitor'. The column of scale up factor is another important factor which is obtained by dividing the column of target value to the rating of Institute in the student's competitive assessment column. Lastly, the absolute values were calculated by two ways as follows:

Absolute Weight = (importance column)*(Target Value)*(Sale point) Or Absolute Weight = (Importance to customer)*(Scale up Factor)*(Sale point) [Ref. fig 3]

***Step*-6** This step deals with developing a prioritized technical requirements corresponding to each of the technical descriptors. This includes the technical difficulty level, relative and absolute weights. Here absolute weight is obtained for each of the technical requirements through the scalar product of the relationship matrix column and the importance to student's column. [Ref. fig. 6]

$$T_j = \sum_{i=1}^{n} R_{ij} C_i$$

T_j =Absolute weight row vector for the technical requirement.
Rij =Strength of association assigned to the relationships matrix (i=1...n and j=1…m)
Ci =Importance to the student's is column vector for the student requirements. (i=1…n)
m =number of technical requirement and *n* =number of Students requirement

The relative weights are found by calculating the sum of the products of the relationships between students and technical requirements and absolute weight of the student's requirements.

$$S_j = \sum_{i=1}^{n} R_{ij} d_i$$

Where S_j =Relative weights for the technical requirement row vector

d_i = Absolute weights for the student's requirements column vector.

According to the calculation results, the most important design requirement is quality development. Therefore, education program should focus on it. Besides, primary professional knowledge is the second important design requirement. In addition, as to the characteristics of SQC education, practice and application is also very important while we design an education program. In all, the outcome of the design method well satisfies enterprise's requirements. Another five stakeholders' requirements can be translated into design requirement with the same method. And the characteristics of each education program are:

- To satisfy student's requirements, Primary Knowledge of Statistics and quality, Practical application of SQC should be the most important elements in education program.
- Considering student's needs, more emphasis should be paid on advanced knowledge of SQC, practice and application.
- Primary Knowledge of Statistics and quality teaching and research paper writing are highlighted in the education program under Faculty's expectation.

VI. CONCLUSION

This study suggests that the QFD technique can be used to fulfill Student's expectations in the engineering education system. In this regard, the customer expectations mean the "voice of the customer". And the customer means the student in this study. QFD have been applied to be very powerful when designing engineering education. The universal acceptance of QFD in education after industry highlights how important it is to raise the standards of education on universities in conformity with requirements of customers. Since the present study is concerned with exploration of the possible application of QFD to design and improve the quality of engineering course. Quality Function Deployment (QFD) theory is applied to education program design for satisfying market and student requirements. Major stakeholders of Statistical Quality Control (SQC) education are identified as graduates, undergraduates, enterprises, graduate schools, government departments and faculty. Different stakeholder does not value the same quality of SQC graduates, therefore, requirement oriented education program for SQC students are designed through QFD. Besides, it acquires design requirements of SQC engineering course based on data analysis. And it has also been observed that the designed education program well satisfy stakeholder requirements, so that the quality of SQC graduate can be improved. Moreover to find what factors the Institute should focus and to Identifying the critical factors that are needed to be enhanced in order to improve the engineering education based on the student's expectations/needs.

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