A Literature Review on Quality Function Deployment (QFD)

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Abstract: This paper aims at examining the applicability of Quality Function Deployment (QFD) to shift customer expectations into design quality. For this purpose, customer needs and product requirements are determined through direct interviews, observation and data analyses. The quantification and prioritization of customer needs are done on the hierarchy diagram providing accurate ratio-scale priorities. Following the categorization and prioritization of customer needs, the requirements were then converted into quality characteristics. Quality characteristics thus identified are converted in the product design specifications using Quality function deployment (QFD). In this study, QFD methodology, which is used in several industries, is implemented in the Automobile industry. The relationship, which is between product and customer's requirements, is determined. After this step customer requirements and technical details are put in the house of quality (HoQ). The House of Quality Matrix build for the phases product planning, product Design and Process Characteristics respectively, shows the relationship between the various elements and gives a direction to the organization where it can do improvement in the product Quality and in the product design.

Keywords—Quality Function Deployment, House of Quality Matrix.

INTRODUCTION

In the highly competitive environment today, it is imperative for companies to continually know about the changing expectations of its customers. Quality function deployment (QFD) is a powerful technique to know the customer requirements and accordingly design new products and services. It is also useful to modify the features and designs of its existing products according to the changed requirements of the customers. QFD helps to understand the importance that customers attach to their various expectations. It is a challenge to understand what the customers exactly want. In most cases, the number of customers may be too many, having different expectations, some of which may be contradictory to those of other customers. For example, some customers expect high mileage from an automobile, while others want more power. Another set of customers may want both mileage and power. The designers of the engine of the automobile have to satisfy the expectations of this whole group of customers in the best possible way. Customers have their own unique way of expressing their expectations, when required about. QFD helps to convert these expectations, called ‘voices of customers’ (VOCs), into engineering or technical requirements. In our example of automobiles, expectations of high power would technically mean generation of high torque by the engine, while expectation of high mileage would imply the technical need of 4-stroke engine. QFD lets the designers know where their products or services stand vis-à-vis the competitor’s products or services on the customer expectation profile.
QFD aids in objectively determining which technical requirements, if implemented, would result in maximum possible satisfaction of most customers. Also, it lets the designers know which technical requirements, if neglected completely and not implemented, would not affect the satisfaction level of customers much.

QFD has emerged as a useful tool not only in manufacturing, but also in services set-ups. In fact, it is a major constituent of the Six Sigma philosophy. QFD was originally developed and implemented in Japan at the Kobe Shipyards of Mitsubishi Heavy Industries in 1972. It was observed that Toyota was able to reduce start up pre-production costs by 60% from 1977 to 1984 and to decrease the time required for its development by one-third through the use of QFD. Early users of QFD include Toyota, Ford Motor Company, Procter, 3M Corporation, Gamble, AT&T, Hewlett Packard, Digital Equipment Corporation, etc. Besides, the American Supplier Institute (ASI) in Dearborn, Michigan and GOAL/QPC (Growth Opportunity Alliance of Lawrence/Quality Productivity Center) in Methuen, Massachusetts have been the primary organizations offering an overview and workshop type training since QFD was introduced to the United States in the early 1980s. QFD was originally proposed, through collecting and analyzing the voice of customer, to develop products with higher quality to meet or surpass customer’s needs. Thus, these primary functions of QFD are product development, quality management, and customer need analysis. Later QFD’s functions had been extended to wider field such as design, planning, decision-making, engineering, management, teamwork, timing and costing. QFD is a useful tool for developing the requirements of new products, and its benefits are well documented. QFD is a customer-driven design process. Its use is essential in product design. QFD is an overall concept that provides a means of translating customer requirements into the appropriate technical requirements at each stage of product development and production (i.e. marketing, planning, and product design, and engineering prototype evaluation, production process development, production sales). Many QFD methodology development and applications have been published by different authors.

LITERATURE REVIEW

Introduction
This literature review explores the themes includes study and research of published materials like journals, thesis, case study, technical document, and online library. Generally, the purpose of a review is to analyze critical segment of a published body of knowledge through classification and comparison of prior research, reviews of literature, and theoretical articles. This chapter will describe topics that related to quality such as Quality Function Deployment (QFD) methodology.

History of Quality Function Deployment (QFD)
Before scrutinizing QFD in detail, we would like to tell its historical development process and design. Quality Function Deployment (QFD) was conceived in Japan in the late 1960s, during an era when Japanese industries broke from their post- World War II mode of product development through imitation and copying mode and moved to product development based on originality. QFD was born in this environment as a method or concept for new product development under the umbrella of Total Quality Control. After World War II, statistical quality control (SQC) was introduced to Japan and became the central quality activity, primarily in the era of manufacturing. Later, it was integrated with the teachings of Dr. Juran, who during his 1945 visit to Japan emphasized the importance of making quality control a part of business management, and the teaching of Dr Kaoru Ishikawa, who spearheaded the Company Wide Quality Control movement by convincing the top management of companies of the importance of having every employee take part.
This evolution was fortified also by the 1961 publication of Total Quality Control by Dr Feigenbaum. As a result, SQC was transformed into TQC in Japan during this transitional period between 1960 and 1965. It was during this time that Dr Yoji Akao first presented the concept and method of QFD. The Japanese automobile industry was in the midst of rapid growth, going through endless new product development and model changes. At that time, the following two issues became the seeds out of which QFD was conceived.

- People started to recognize the importance of design quality, but how it could be done was not found.
- Companies were already using QC process charts, but the charts were produced at the manufacturing site after the new products were being churned out of the line. (QFD Institute 2008) The purpose of Professors Mizuno and Akao was to develop a quality assurance method that would design customer satisfaction into a product before it was manufactured. Prior quality control methods were primarily aimed at fixing a problem during or after manufacturing. The first large scale application was presented in 1966 by Kiyotaka Oshiumi of Bridgestone Tire in Japan, which used process assurance used fishbone diagram to identify each customer requirement and to identify the design substitute quality characteristics and process factors needed to control and measure it.

In 1972, with the application of QFD to the design of an oil tanker at the Kobe Shipyards of Mitsubishi Heavy Industry, the fishbone diagrams grew unwieldy. Since the effects shared multiple causes, the fish bones could be refashioned into a spreadsheet or matrix format with the rows being desired effects of customer satisfaction and the columns being the controlling and measurable causes.

At the same time, Katsuyoshi Ishihara introduced the Value Engineering principles used to describe how a product and its components work. He expanded this to describe business functions necessary to assure the quality of the design process itself. Merged with these new ideas, QFD eventually became the comprehensive quality design system for both product and business process. The first seminar (a 2 day seminar) in Japan was organized in 1983 by Japan Productivity Center, and was followed by many others. The introduction of QFD to America and Europe began in 1983 when the American Society for Quality Control published Akao’s work in Quality Progress and Cambridge Research (today Kaizen Institute) invited Akao to give a QFD seminar in Chicago. This was followed by several QFD lectures to American audiences sponsored by Bob King and GOAL/QPC in Boston.

Today, QFD continues to inspire strong interest around the world, generating new application, practitioners and researchers each year. Countries that have held national and international QFD Symposium to this day include the U.S. Japan, Sweden, Germany, Australia, Brazil, and Turkey (QFD Institute 2008). Dr. Akao is one of the few to receive the prestigious Deming Prize for

Individuals as well as the Best on Quality Award from International Academy for Quality. He was also awarded the inaugural Distinguished Service Medal from the American Society for Quality. He is an author of many published articles and books including Quality Function Deployment: Integrating Customer Requirements into Product Design and QFD: the Customer-Driven Approach to Quality Planning & Deployment. Dr. Akao is chairman of the International Council for QFD and the senior advisor to the QFD Institute. Two distinguished awards have been established in recent years in his honor. The Akao Prize is awarded to individuals around the world who have demonstrated Excellence in their practice and dissemination of QFD for many years (QFD Institute 2008).
QFD Applications in Product Optimization

Early users of QFD include Toyota, Ford Motor Company, Procter, 3M Corporation, Gamble, AT&T, Hewlett Packard, Digital Equipment Corporation, etc. (Cohen 1995). Besides, the American Supplier Institute (ASI) in Dearborn, Michigan and GOAL/QPC (Growth Opportunity Alliance of Lawrence/Quality Productivity Center) in Methuen, Massachusetts have been the primary organizations offering an overview and workshop type training since QFD was introduced to the United States in the early 1980s (Prasad 1998). QFD was originally proposed, through collecting and analyzing the voice of customer, to develop products with higher quality to meet or surpass customer’s needs. Thus, these primary functions of QFD are product development, quality management, and customer need analysis. Later QFD’s functions had been extended to wider field such as design, planning, decision-making, engineering, management, teamwork, timing and costing (Chan and Wu 2002).

QFD is a useful tool for developing the requirements of new products, and its benefits are well documented (Hauser and Clausing 1988). QFD is a customer-driven design process. Its use is essential in product design (Cohen, 1995). Sullivan defines QFD as an overall concept that provides a means of translating customer requirements into the appropriate technical requirements at each stage of product development and production (i.e. marketing, planning, and product design, and engineering prototype evaluation, production process development, production sales). Many QFD methodology development and applications have been published by Kim, Mrad, Persson, Chan and Wu(2002) and Bhattacharya. Various applications within the literature can be grouped under three categories as: QFD implementations before the design stage; QFD implementations during the design stage and QFD Implementations after the design stage.

Quality Function Deployment Methodology

A Quality Function Deployment tool (QFD) uses a matrix process to collect topics that are essential to the planning process. The House of Quality Matrix is a highly recognized and widely used form of this method. This method was used for translating customer requirements into functional design. There are four major characteristics of QFD as a quality system. First, QFD is a quality system that integrates elements of system thinking, e.g. viewing the development process as a system, and the psychology or being able to conceptualize customer concerns, what value is being determined, and how customers or end users become interested, choose, and are finally satisfied. Second, QFD is a quality method of good knowledge or epistemology. This addresses how the needs of the customer are determined, which features are to be incorporated, and what level or degree of performance is to be determined. Thirdly, QFD is a strategy for competitiveness. It maximizes positive quality that adds good worth. It brings outspoken and unspoken customer needs or request and translates them into technical functions. A QFD prioritizes concerns and directs the contributor to optimize those features that will bring the greatest competitive advantage. Finally, Quality Function Deployment is the only Comprehensive quality system targeted specifically at satisfying the customer through the development and business process as from beginning to end.

The steps to developing a QFD are as follows:

- Develop a list of customer requirement,
- Develop a listing of technical design elements along the roof of the house,
- Demonstrate the relationships between the customer requirements and technical design elements,
- Identify the correlations between design elements in the roof of the house,
- Perform a competitive assessment of the customer requirement,
- Prioritize customer requirement,
Prioritize technical requirement, and
Final evaluation

Figure 1 General house of quality structure

- Section I: Customer needs and requirements (voice of customer, VOC)
- Section II: Technical measures
- Section III: Planning matrix
- Section IV: Relationship matrix
- Section V: Correlation matrix
- Section VI: Weights, benchmarks and targets

Standard structure for the House of Quality (HoQ) is shown in Figure 3.1 above. The tool takes customer preferences and demands and then translates them into technical requirements that can be quantified, measured, and analyzed. These results can then be used to determine the focus of experiments and research. The HoQ can be divided into eight different sections. These sections (or rooms) are sometimes referred to as the “What”, Importance and Customer Competitive Assessment, “How”, Relationship, Absolute and Relative Score, Correlation Matrix, Technical Competitive Assessment and Target Value “rooms”. The “What” room is the section that houses customer requirements as seen on Figure 1. The Importance Ratings and Customer Competitive Assessment “room” contains information grouped for analysis, and is located on the right area of Figure 3.1 labeled as Planning Matrix/Customer Perceptions. The “How” room is the area that lists the measurements that will be used for each “What” and is labeled Technical/Design Requirements at the top of Figure 1. The “Relationship Matrix” room or Interrelationship Matrix area of the HoQ explores all of the interactions between the various “whats” and “hows”. The Absolute and Relative Score rooms also known as the Prioritized Requirements area is at the bottom of the HoQ, and is where the total scores for each “how” are evaluated based on several factors. The next area known as the Correlation Matrix is where the relationships between the various “hows” or technical requirements are evaluated. Some of these may benefit each other, or stand in direct contradiction and knowledge of these interactions aids the design process in optimizing the various requirements. The Technical Competitive Assessment room is also known as the Competitive Benchmarks near the bottom of the HoQ, which evaluates how the product compares to similar competing products. The final area is the Target Values or the Technical Targets area at the bottom of the HoQ, which lists the recommended specifications for the given product.
CONCLUSION

The House of Quality Matrices build shows the relationship between the various elements and give a direction to the organization where it can do improvement in the product Quality and in the product design. Following are the major conclusions. Product quality as perceived by individual customers and by the market is critical to the economic success of a company. The easiest way I have found to improve quality is to determine the needs a product fills with customers, determine the product parameters that satisfy the needs of customers and their level of satisfaction creation, determine the conflicting product parameters that need to be optimized by customer group for maximum satisfaction to occur and ensure a sufficiently level of communication between R&D, marketing, production, and legal/standardization departments that a high quality product can be made.

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