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Application of Quality Function Deployment for Prioritization of Customer Needs and Determination of Product Technical Specifications (Case Study: Toos Chini Mashhad Company)

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ABSTRACT

Quality is a term with a long history but without agreed upon and clear definition. It has turned into a critical issue in global competition. Customer satisfaction has gradually affected the concept of quality so much so that the quality is now defined in the terms of customer satisfaction. The present study is an attempt to obtain customer opinions and apply them in product design and production. The objective was to collect customer needs and match them to product specifications by using quality function deployment technique. This study is the first one conducted in Iran porcelain industry. It uses Toos Chini of Mashhad, Iran as its case study. House of Quality was constructed in ten steps with the aim of mapping customer needs and desires to product specifications. Statistical population in this study included all sales representatives actively selling Toos Chini products.

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INTRODUCTION

The early production systems were based on the push generated by mass production systems where product engineers designed products according to company abilities and resources. The products so manufactured were, subsequently, lunched by means of marketing and market creation techniques. Production systems have since turned more toward market pull. In newer production systems such as Just In Time, lean, agile, true-need, and custom-order are designed specifically to fulfil customer needs. Shieh and Wu have stated analyzing customer needs is very critical to an organization's competitiveness since customer needs are dynamic and may vary drastically from time to time. Besides, predicting customer requirements early on could help organizations provide better products, possibly delight customers, and, eventually, increase customer satisfaction. So far, several product design and development approaches have been developed and applied in various areas. These methods include reverse engineering, value engineering, Taguchi method, and quality function deployment (QFD). The first three methods emphasize more on product functions and less on customer requirements and production operations. QFD, by comparison, focuses more on customer demands and coordination in the production process [15]. Toos Chini Company in Mashhad, Iran produces high quality porcelain products. A growing concern had developed throughout the company about the need to introduce customer criterion into production process. Such an undertaking required a tool to provide for matching customer requirements into company production. Quality Function Deployment (QFD) seemed more promising for our purpose as it is specifically geared to the evaluation of customer requirements and incorporating them into production process. This study was conducted to collect information on customer requirements and develop product specifications. The study data was analyzed by quality function deployment process to achieve study objective. As Ramanathan and Yunfeng [12] address, when QFD is used for designing a product or a service, the expectations of customers are related to the main design characteristics of the product and service through a matrix generally known as the "house of quality" (HoQ).

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This report starts with an introduction to and background of quality function deployment technique. A discussion into the ten steps used for constructed House of Quality ensues. The resulting house of quality is, then, analyzed and the study findings are presented in the final section.

Literature Review:

Industrial revolution initiated a process that together with advancements of present societies have contributed to complexity of production systems and the products they manufacture. A customer of a millennium ago would go directly to the sellers of the goods he required. And, sellers could attend to needs of buyers without the help of middlemen. They could provide or produce what customers required according to their specifications. This was only possible in the small communities of those days that were free from the influences and impacts of the world at large.

The interaction and pressures extended from today's global environment make it impractical to operate by means of traditional approaches. Producers are now rarely in direct contact with the end users. Yet, operating under market forces, they have to look for ways to incorporate exact customer requirements into their product if they are to maintain their market standing. Quality function deployment (QFD) technique is one approach that can help producers in this endeavor. This study used QFD to match customer requirements with product specifications.

Quality Function Deployment (QFD):

QFD works based on matrixes that are built on the quality tables. Quality tables were originally produced by Dr. Yoji Akao in 1972 for shipbuilding industries operating in Kobe, Japan. These quality tables were used for the design and production of ocean going tankers. The first introduction of "quality deployment" dates back to 1969 when Akao published his first article. Akao's findings from further research and studies into quality deployment were presented in 1972 when he introduced his concepts in the form of Hinshitsu Tenki System. The completed concepts were finally presented in a book published in 1978 titled "Quality Function Deployment" co-authored by Dr. Yoji Akao and Dr. Shigeru Mizuno.

The principal concepts of quality function deployment have been redefined many times over the four decades since its initial introduction. Many of these definitions overlap but a simple definition is: "a systematic approach for interpretation of customer needs and desires and mapping them into product design specifi

cations and requirements, a process which can be applied in each stage of product development by multi-function groups" [10] QFD is a systematic step by step approach to incorporate customer needs and requirements into final products and services by means of using special matrixes in each step (ibid). American Supplier Institute (ASI) provided another definition for QFD in 1987 as "a system for translating customer needs into proper corporate requirements during each phase of product research and development, production, distribution, installation, marketing, sales, and services."

QFD is identified by the three different views provided by Akao, Makabe, and Fukuhara. QFD, as introduced by Akao, is made of 30 matrixes to be used in whole or in part as required for analysis. Makabe view was first introduced to Ford Company by Donald Clausing and is built around four matrixes, namely, product planning (House of Quality), product design, process planning, and process control programming. The last QFD model was introduced by Fukuhama and is built around 18 matrixes first used by Toyota Company of Japan. Among various QFD models, two models, one with four matrixes and the other with thirty matrixes, have been widely received [14].

QFD is recognized as a modern technique for quality engineering. It begins from market study and customer identification. It proceeds through analysis that uncovers customer needs and desires. It, finally, enters into the process of incorporating the findings into product design and production [3]. The main principle behind using QFD is to make product development process oriented toward customers' quality requirements. Thus, customers' views and opinions become the driving force behind product design and development. In such a system, product designers and experts turn into agents who use QFD concepts and techniques to map customer desires into quantitative specifications that can be used in product design and production.

QFD is a quality tool that helps users to increase their market share through increased customer satisfaction. QFD provides means to design a reasonable process to introduce quality into products. Customers, often, provide their own mental images of a desired product in their evaluations and QFD uses a wide range of tools and methods in order to systematically translate what is expressed by customers into real products.

The application of QFD lie on two end points: customer is at one end and product is at the other end. The objectives for this exercise is to map customer needs into product specification at design stage, to develop the identified specifications into production processes, as well as to establish control and inspection points before going into real production. The outcome of achieving these objectives is products that match customer preferences.

Before development of QFD, quality tables were used to turn consumer demands into quality products. QFD provided a new approach to extend quality specifications to product development processes that extended from design to final manufacturing.

The first step in QFD is product design. The process takes the shape of a house and, therefore, it is called House of Quality. Notwithstanding it complexity and somewhat confused arrangement, it contains important information. If prepared properly and accurately, the information contained in the house of quality of a real QFD project will ultimately provide the picture of a final product. House of Quality is a powerful tool for translating voice of customers and their quality demands into quantitative product requirements. This tool make a significant contribution to the process of following the voice of customer and translating them into real products.

A critical issue in an environment that is facing onslaught of new technologies and innovations is rapid obsolescence. Research literature generally fails to address the issue and there is rarely any mention of it. Raharjo *et al*[11] proposed new modifications to account for this issue when using the original QFD in conjunction with Kano model in product design.

Armon [2] used QFD to determine quality features of products used in the medical industry prioritized by customer needs. She studied chairs produced by Saha Teb Company to itemize the product features that customer felt are critical to draw the technical specification of new products that matched those key features.

Nori and Bakhtiari[9] used QFD for website design. They took website as the final product and applied QFD techniques to define potential user requirements. They studied 25 users who were familiar with website shopping to produce a list of design requirements. The outcome of their study was a website that was easy to use and was highly welcomed, evidenced by huge number of visitors.

Garibay *et al* [4] used Kano model in their study of the digital library at University of Guadalajara in Mexico. They designed a questionnaire for their study to measure voice of customers. They evaluated library visitors' needs in terms of quality services that could be provided by digital library. The collected data was then used in QFD-Kano model to match visitors' needs with library services and finally produced service specifications to meet those needs.

Khatami Firozabadi and Mazroee [8] used QFD in their study to collect customer requirements, prioritize them, produce criterion with help of AHP, and finally produce a prioritized list of requirements for Shayesteh Carpet Company of Kashan. The first house of quality was produced based on the available data. As house of quality matrix is not normally accurate enough, AHP was used to overcome this shortcoming.

Jafarzadeh *et al* used AHP similarly in their study of customer needs for Kivan Company of Hamadan which is a member of confectionary and chocolate industry. The only exception was that they used group AHP because they faced multiple decision makers.

Proposed Design:

This study was conducted to collect information about customer needs and desires with the intention to use them in design of products that match those requirements. The study objective was accomplished using QFD. This section introduces the ten steps used in this process. The outcome of these steps is a house of quality that presents customer requirements as well as product specifications that can very well satisfy those requirements. The study data was collected from two distinct population. The first population included sales representatives of Toos Chini Company in Mashhad. The second population consisted of members of the decision team.

Step 1: Identification of Needs and Demands for Product:

QFD and house of quality design begins by identification of customer needs and their quality requirements. Study data included information collected from several sources including market research and evaluation, individual interviews, employee opinion survey, sales history, customer complains, quality discrepancies, and customers' quality requirements. Table one provides customer needs and expectations.

Step 2: Prioritization of Quality Requirements versus Current Standing:

In this step we rate every customer satisfaction criterion in terms of importance and measure current company standing in terms of customer satisfaction.

Step3: Sales and Performance Measurements:

Sales points represent the rate of impact each factor has on sales and profitability. It shows the competitive advantage of the company under study relative to customer needs and expectations. A one to five scale is used to rate competitiveness. A score of 1 is for low competitiveness and a score of 5 is for high competitiveness. The same one to five scale is used to rate company performance in terms of customer satisfaction. A score of 1 represents poor customer satisfaction and a score of 5 represents high customer satisfaction. Company objective is achieved with the highest possible customer satisfaction subject to the existing resources and limitations.

Completion of house of quality from this step on requires a decision team. The decision team in study consisted of Quality Manager, Production Manager, Business Manager, and one other top manager.

Table 1: Customer Needs and Expectations.

No	Customer Needs and Expectations	Symbol
1	Light Weight	CR1
2	Product Durability	CR2
3	Permanent Decorations	CR3
4	Perfect Decorations	CR4
5	Spotless Finish	CR5
6	Catalogue and Price List	CR6
7	Product Availability	CR7
8	Proper Packaging	CR8
9	Prompt Customer Services	CR9
10	Reasonable Pricing	CR10
11	Stable Prices	CR11

Step 4: Improvement Ratio:

Improvement ratio is calculated by the following formula.

$$\text{Improvement Ratio} = \frac{\text{Planned Performance}}{\text{Existing Performance}}$$

Step 5: Raw Weight of Each Need:

Raw weight for each customer need and expectation is calculated using the following formula and entered in the corresponding column in house of quality.

Raw Weight = Sales Point * Improvement Ratio * Importance Weight

Step 6: Need's Relative Weight:

Every calculated raw weight is normalized and its relative weight is calculated. This is achieved by calculating the sum of raw weights, dividing raw weight of each need into the sum of raw weights. The result is stated in percentage.

Step 7: Product's Technical Specification:

Products specifications are presented as *hows* and the approaches undertaken to satisfy customer needs and expectations are presented as *whats*. These factors were taken from decision group and entered in table two.

Table 2: Product Specifications.

No	Product Specifications	Symbol
1	Material Quality	EC1
2	Package Design	EC2
3	Suitable Glaze	EC3
4	Quality Control	EC4
5	Design Implementation	EC5
6	Production Saving	EC6
7	Mold Design and Production	EC7

Step 8: Relationship Matrix:

The effect of technical specifications (*hows*) on customer needs and requirements (*whats*) is determined and presented into the relationship matrix. Table three shows the relation types and their corresponding scores.

Step 9: Correlation Matrix:

This matrix makes the roof section of house of quality. It shows the underlying relations between various product specifications.

Table 3: Relation Types and Values.

No Relationship	0	Weak Relationship	1
Medium Relationship	3	Strong Relationship	10

Table 4: Correlation Types, Symbols and Values.

Strong Relationship	•	9	Weak Relationship	Δ	1
Medium Relationship	o	3	No Relationship		0

Step 10: Product Specifications Weight and Relative Importance:

Weight and relative importance of each product specification is calculated. As example, the weight of Material Quality calculated.

Table 5: Relative and Raw weight of Material Quality.

No	Customer Needs and Expectations	Material Quality	Relative Weight	Raw Weight
1	Light Weight	10	9/92	99/2
2	Product Durability	10	6/22	62/2
3	Permanent Decorations	3	5/33	15/99
4	Perfect Decorations	3	6/82	20/46
5	Spotless Finish	3	8/30	24/9
6	Catalogue and Price List	0	12/24	0
7	Product Availability	0	11/69	0
8	Proper Packaging	0	6/38	0
9	Prompt Customer Services	1	15/98	15/98
10	Reasonable Pricing	10	6/92	69/2
11	Stable Prices	1	10/20	10/20
Sum				318/13

Weight and relative importance of each product specification is calculated and entered into matrix.

Table 6: Relative and Raw weight of product specification.

	Material Quality	Package Design	Suitable Glaze	Quality Control	Design Implementation	Production Saving	Mold Design and Production	Sum
Raw Weight	318/13	356/62	270/27	223/84	182/96	186/56	87/39	1625/77
Relative Weight	19/57	21/93	16/62	13/77	11/25	11/48	5/38	100

With considering ten step and calculation in each step, the complete matrix of House of Quality is drawn.

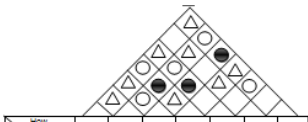
Data Analysis:

House of quality in this study is prepared after completion of a 10-step program. QFD process identified 11 customer needs and desires. They are listed in table one. The decision group provided the product specifications that could match and provide for the customer requirements. Table 2 lists these specifications.

Company strength and weakness are recorded in the existing performance column of house of quality. A questionnaire designed on five Likert scale was used to collect data for and complete this column. Scale three is the medium score. A score above 3 is indicative of customer satisfaction for that specific item. Study findings singled out product durability, permanent decoration, perfect decoration, and proper packaging as items that meet customer satisfaction. An improvement plan had to be devised for other items in order to elevate overall customer satisfaction. Importance rating column of house of quality was used to determine which one of customer needs and desires are more critical from customers' point of view. This column shows that stable prices and proper pricing are the two most important factors for customers. Economic conditions has generated repeated price increases which has aggravated customers and brought down their level of satisfaction. Other customer needs listed on table 7 based on their importance.

RESULTS AND DISCUSSIONS

This study was conducted to collect customer needs and preferences as means to determine product specifications that match them. A ten-step Quality Function Deployment technique was used as an aid to achieve study objective. QFD was selected for this study as it is especially designed for mapping customer needs into product specifications. Study data was collected in the form of census from two populations. The first population included company sales representatives. The second population consisted of members of the decision team. This exercise revealed customers expectation and product specifications that could satisfy those expectations. The present study was the first of its kind conducted in Iran porcelain industry. A complete QFD exercise will ultimately turn customer needs and preferences into tangible products that are specifically designed to meet those needs and expectations.



How / What	EC1	EC2	EC3	EC4	EC5	EC6	EC7	Importance	Existing Performance	Planned Performance	Sales Point	Improvement Ratio	Raw Weight	Relative Weight
CR1	10	1	1	1	0	1	3	3/27	2/82	5	1/5	1/77	8/68	9/92
CR2	10	3	10	3	1	1	1	3/91	3/46	4	1/2	1/16	5/44	6/22
CR3	3	0	3	10	10	1	1	4	3/09	3	1/2	0/97	4/66	5/33
CR4	3	1	10	1	10	1	1	4/18	3/36	4	1/2	1/19	5/97	6/82
CR5	3	3	10	10	1	0	1	4/27	2/36	4	1	1/70	7/26	8/30
CR6	0	3	0	1	0	3	0	3	1/64	5	1	3/57	10/71	12/24
CR7	0	10	0	0	0	3	0	3/36	2/46	5	1/5	2/03	10/23	11/69
CR8	0	10	0	3	0	3	0	3/91	3/36	4	1/2	1/19	5/58	6/38
CR9	1	3	0	0	1	1	0	3/82	1/64	5	1/2	3/05	13/98	15/96
CR10	10	3	3	3	3	3	3	4/27	2/55	3	1/2	1/18	6/05	6/92
CR11	1	1	1	0	1	3	1	4/46	2	4	1	2	8/92	10/20
Weight&Raw Importance	31/13	39/62	27/27	22/84	18/96	18/56	87/39							
Weight&Relative Importance	19/57	21/93	16/62	13/77	11/25	11/48	5/38							

Fig. 1: House Of Quality (HOQ).

Table 7: Customer Needs and Expectations ranking table.

Customer Needs and Expectations	Rank	Symbol
Light Weight	10	CR1
Product Durability	6	CR2
Permanent Decorations	5	CR3
Perfect Decorations	4	CR4
Spotless Finish	3	CR5
Catalogue and Price List	11	CR6
Product Availability	9	CR7
Proper Packaging	7	CR8
Prompt Customer Services	8	CR9
Reasonable Pricing	2	CR10
Stable Prices	1	CR11

It is recommended that Toos Company:

1) To employ a customer requirement management software for continual monitoring of customer attitude changes in order to incorporation then into future product design and production processes.
2) To arrange for a training program in order to develop the right corporate attitude toward QFD among managers and employees as well as to strengthen organizational knowledge base.
3) To form self-managed teams in order to create cross-sectional relationships and communication that are required for implementation of techniques such as QFD.
4) To develop companywide organizational support for accurate and long-term implementation of QFD.

This study used only one phase of QFD. Therefore, it may be prudent to apply all QFD phases in future studies. For instance, it is necessary to complete the competition matrix get a better picture of the existing situation and deciding what actions to be taken. It may be necessary to use QFD along with other techniques such as fussy QFD, QFD-Kano, or QFD-AHP in future studies. This study limited itself to company's active sales representative in Mashhad. The next study should better be extended to include sales representatives from all over country.

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