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House of Quality: An Effective Approach to Achieve Customer Satisfaction & Business Growth in Industries

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Abstract: ***House Of Quality (HOQ) is one of the matrices of an iterative process called Quality Function Deployment (QFD). it is the nerve center that drives the entire QFD process. The House of Quality Matrix is the most recognized and widely used tool for new product design. It translates customer requirements, based on marketing research and benchmarking data, into an appropriate number of engineering targets to be met by a new product design. It is performed by a multidisciplinary team representing marketing, design engineering, manufacturing engineering, and any other functions considered critical by the company. HOQ has been widely used at industry in Japan and America like Toyota, Ford, GM, Hewlett-Packard, AT&T, ITT and other renowned industries in various fields like Automobiles, Electronics, Integrated Circuits, Apartment Layout Planning, Home Appliances, Clothing etc. In this paper, an attempt is made to propose a methodology to establish House Of Quality and to reduce the complexity of constructing HOQ. The general format of HOQ is made up of six major components. These include customer requirements, technical requirements, a planning matrix, an interrelationship matrix, a technical correlation matrix, and a technical priorities or benchmarks and targets section.***

Keywords: House of Quality, Competitive evaluation, Planning matrix, Interrelation matrix, Benchmarking.

1. Introduction

In the early days by adopting product driven approach, manufacturing industries or businesses were introducing their goods into market place without considering the customer views and needs. But in successful product development, understanding of the customers‟ needs and requirements is regarded as a key issue (Engelbrektsson, 2002). Now-a-days manufacturing industries are looking for changing their business operations from a product oriented approach to marketing - oriented approach in order to meet the expectations of customers and long term success in the competitive business environment (Lai, 2003) [2].

Quality Function Deployment (QFD) uses a matrix format to capture a number of issues that are vital to the planning process. The QFD product/service development process or methodology is based on the development of a sequence of matrices known as „House of Quality‟ (Bernal et al., 2009). QFD applies four phases of HOQ to integrate informational needs of customers (Clausing & Hauser, 1988; Hauser, 1993). The House of Quality Matrix is the most recognized and widely used to achieve higher customer satisfaction. According to Hauser and Clausing, it is “a kind of conceptual map that provides the means for interfunctional planning and communication.”

According to Bailom et al. (1996), analysis of service user perceptions or desires can help the organization managers identify expectations which the user or consumer is aware of, but which have not yet been fulfilled by the current services offered. Thus, the house of quality offers an important source for potential improvements as well new investments (Bailom et al., 1996).

Bernal et al. (2009) suggests that it can be used to calculate benchmarking index, prioritization index, as well as quality improvement index (Johnson, Muller, Sieck & Tapke, n.d). The quality improvement index has extreme values which are very important when making decisions about quality. The extreme values are indicative of how important the service requirements are. According to Bailom et al. (1996), the higher the value of the positive range, the higher the relative significance in the perceived service quality from the service user‟s viewpoint. Conversely, the higher the negative value of the quality improvement index, the lower the relative significance of the service quality (Bailom et al.1996). Similarly, Johnson et al. (n.d) noted that high priority quality characteristics signify that investing in the identified service user needs will deliver great value to the people or the community they serve [13].

Managers can also use the house of quality metrics to conduct benching. Keegan and O‟Kelly (2004) therefore defined benchmarking as “a continuous, systematic process for comparing performances of organizations, functions or processes against the „best in the world‟, aiming not only to match those performance levels, but to exceed them”.

The house of quality tool allows organization managers to carry out a competitor assessment from the customers‟ perspectives (Bernal et al. 2009, p. 17). Lankford (2001, p. 59) referred to this as reverse engineering Benchmarking, which simply means analyzing “the entire customers‟ path of organization‟s competitor”. The house of quality‟s two steps of evaluation can be used to by managers to benchmark. The first step is known as customer (service user) competitive assessment, in which the service users assess the relative performance of the organization‟s services and its main competitors in the private sector or „best in the world‟ organizations on the service user‟s needs identified (Chan & Wu, 2005). In the second step, the evaluators perform

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technical competitor comparison, in which the design requirement fulfillment is compared. Bernal et al. (2009) emphasized that the second step should be done specifically by the personnel in charge of the product and/or service design [13]. Customers‟ (or service users‟) perceptions are very important in determining what to offer to consumers as well as how to offer it. The "House of Quality" tools can be used by managers in public organizations as: quality improvement; benchmarking; and prioritizing.

2. Related works

This paper presents the real case study at manufacturing using "House of Quality" to create environmentally friendly products. This work was supported in part by the "Directorate of Higher Education Indonesia" (DIKTI) and University of Muhammadiyah Gresik, East Java, Indonesia under Grant Beasiswa Luar Negeri (BLN) DIKTI. Nowadays, the green manufacturing issue is pushing every industry to increase their awareness of the environmental issues by developing and creating environmentally friendly products. In the above work several experts from cross function of industry are involved (marketing, design, manufacturing, environmental field etc.). Based on the literature review, historical data, brainstorming and a deep discussion with some experts at the manufacturing company, the team design identify 14 customer and environmental requirements (CER). They are: waste reduction, pollution, impact reduction, less material usage, easy to transport, easy to process, less energy usage, easy to reuse, easy to smash, easy to sort, safe to incinerate, safe to landfill, harmless to the living environment, safe emission and possible to dispose of at ease. CER weights were used in conjunction with "House of Quality" to determine the priority order of environmental indicators [1].

This paper presents a case of designing refrigerator family using "House of Quality". The customer needs priority structure obtained by using the proposed methodology helps a product development team to design product family to meet the expectations of the customers. "HOQ" was developed by adopting marketing research techniques such as factor analysis, cluster analysis and conjoint analysis. A questionnaire was developed which was administered to 200 respondents of various categories. Factor analysis is performed by conducting questionnaire survey and the analysis is made with the help of SPSS package. SPSS conjoint was used. Cluster Analysis and Conjoint Analysis for each customer segment. Results shown that the highest priority is given to energy consumption for overall customer group and the customer segment1also. Customer segment 2 has given highest priorities to preservation. For customer segment 2, preservation, price, energy consumption, storage volume, service reliability and refrigeration effect are in the order of priority. Customer segment 3 has given more priority for service reliability. By considering these customer needs priority structures in "HOQ", it was possible to develop domestic refrigerator family to delight the customers [2].

Four star hotel of Zanjan used "House of Quality" to improve service quality. In today‟s competitive world, customer satisfaction is a vital goal to be accomplished at an affordable cost. In the presented research a HOQ matrix was developed to satisfy customer requirements. In the research customers` satisfaction of the services and importance degree of each need was investigated using survey method. Sample of 150 customers were selected. Information was collected from two different community. First statistical community was the customers, employee and managers of Zanjan hotel to determine the factors affecting customer satisfaction. Second statistical community or decision team consisted of four managers and top employees whose opinions were applied when completing the HOQ. On the basis of absolute weights and relative weights priorities were determined which are responsible for customer satisfaction. The results shows that from the view point of customers, offering qualified food, existence of sauna and swimming pool, friendly behavior and attitude of personnel and their proper appearance are more important [3].

Manufacturing operations in the "Thai furniture industry" are currently very competitive. A plywood wardrobe was selected as a study vehicle for this research. "House of Quality" was employed to design and produce new types of prototype plywood wardrobe for product shape, pattern, color, functionality, and quality of materials used. A total of 58 questionnaires were collected equally 29 each from product users and sales agent stores. The significance levels of the absolute and the relative technical requirements were calculated and House of Quality was created. The results revealed that the average satisfaction values for all new types of products increased over those of the current products, from a level of 2.71 to 4.08 (54.87%). Hypothesis testing of the average customer satisfaction between the current and the new designs was found to significantly increase with regard to this approach. This highlights the effect of new product features that better meet customer demands, leading to an increase in customer satisfaction [4].

Turkey‟s leading mobile communication operator used "House of Quality" to design a smart phone as a new product development in accordance with customer expectations. This study was selected from International Symposium on Engineering Artificial Intelligent and Applications ISEAIA 2013 (Girne American University).In 2010 the firm started to launch its own smart phones to the market while it had been going on marketing world renowned smart phones such as iPhone and Samsung Galaxy series in Turkey. T11, T20, T21 and T30 were the smart phone models launched with the operator‟s own brand in 2011 and 2012. First "House of Quality" was constructed and analyzed, and development areas and necessary technical specifications have been determined. Later on the Kano Model has been included in order to prioritize the significance of customer necessities, and the new House of Quality has been built. According to the analyses "Long battery life" is found to have the most weight. The usage of newer versions of Google Android operating system, The design of a user friendly interface, Installing a higher capacity battery, preserving the hardware design, Higher touch-screen sensitivity via IPS technology, The addition of shortcuts to the main screen (like Google) were

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the main priorities to compete. Hence HOQ matrix gave important features for new smart phone design to improve the customer satisfaction [5].

Toyota and Honda motor cars used "House of Quality" for development of car dashboard. Car industry plays the role of back bone for the economy of any country. Dash board is an important part of the car interior used for controlling different functions in the car. Two important developments, in the car dashboard, the forced exhaust system and the multipurpose cup holder are made according to the customer‟s expectations. customer needs are identified by market survey. The HOQ for car dashboard shows that the characteristic of "size of the blower" received the highest score. The second highest characteristic is "speed of the blower". A questionnaire was used for getting „Voice of the Customer‟ (VOC). „Voice of the Customer‟ was translated into customer needs which are then converted into technical specifications. Finally output from House of Quality (HOQ) was used in concept generation [6]. Kazakhstan Institute of Management, Economic & Strategic Research (KIMEP) used "House of Quality" to improved the standards of management education. The student needs and requirements were identified to develop the foundation in delivering quality curriculum and services in higher education. The House of Quality (HOQ) illustrates the transformation process from student requirements to instructional development. The data analysis suggests that the curriculum needs restructuring. The number of tutorial sessions needs more time; exam needs restructuring, while the weight of the quizzes should be increased. The technical resources are necessary to deliver courses effectively. [7].

3. Major reasons to employ House of Quality in Industries

1) Complexity of product development.
2) Extended development time caused by excessive redesign, problem solving, or fire fighting.
3) Customers are complaining or aren‟t satisfied with the product or service.
4) Lack of efficient and effective product / process development teamwork.
5) Market share has been consistently declining.
6) Lack of structure to the allocation of product development resources.

4. Design flow for House of Quality

1) Customer attributes portion of matrix (Horizontal),
2) Engineering Characteristics matrix (Vertical),
3) Customer Competitive Evaluation
4) Relationship matrix Between (Central portion),
5) Co-relationship matrix (Triangular shaped Roof)
6) Competitive Technical Analysis
7) Absolute importance, Relative Importance &Target.

4.1 Customer Attributes

First prepare the questionnaire and collect the customer attributes (Response of customers) for selected sample size on likert scale. The house of quality begins with the customer, whose requirements are called customer attributes (CAs). Customers use to describe products and product characteristics through each stage of the product development and production process, that is, through the product realization cycle. CAs are often grouped into bundles of attributes that represent an overall customer concern. CAs are generally reproduced in the customers‟ own words. These requirements are the collection of customer needs, including all satisfiers, exciters/delighters, and dissatisfiers. CAs can include the demands of regulators ("safe in a side collision"), the needs of retailers ("easy to display"), the requirements of vendors ("satisfy assembly and service organizations"), and so forth. Methods are: Market Research, Survey, Focus Groups etc [11].

4.1.1 Data Collection Techniques

Information can come from a range of sources. The most common data collection methods are:
1) Observations
2) Focus Groups
3) Ethnographies,
4) Oral History and Case Studies,
5) Documents and Records,
6) Observation and Experimentation.

4.1.2 Types of surveys

The most common methods of survey are:
1) Mail survey,
2) Telephone surveys,
3) Personal survey
4) Internet survey.

4.1.3 Types of Questionnaires

1) Open ended questions: Respondents are given complete freedom to answer in their own words.
2) Closed ended questions :
   a) Yes – No Questions: Respondents are limited to a positive or negative position.
   b) Multiple Choice Questions: Respondents are limited to choice of more than two positions.
   c) Rating Scales: Respondent rates an attribute using the provided scale. EG. Intensity: the Likert Scale of 1-5.
   d) Semantic Differentials: Respondent's evaluation ranges between opposites.
   e) Rankings: Respondent ranks preferences among a group of alternatives.
   f) Filter (Split) Question: Question designed to direct respondents to different sections of the questionnaire [12].

4.1.4 Collection of responses

It can be collected on Likert scale (5 point scale, 7 point or 9 point scale) from strongly disagree to strongly agree on a particular question.

4.1.5 Customer Importance Ratings

On a Likert‟s scale customers rate the importance of each requirement. This number will be used later in the relationship matrix. House of quality measures the relative importance to the customer of all CAs. Weightings are based on team members‟ direct experience with customers or on

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surveys, statistical techniques or revealed preference techniques. Weightings are displayed in the house next to each CA. The next step is to prioritize the list by assigning a numeric value called degree of importance to each need. The improvement ratio is obtained by dividing the anticipated level value by the current level rating. The further step is to determine the importance weight of the customer needs. It is calculated by multiplying the value of degree of importance times the value of improvement ratio.

4.2 Engineering Characteristics

The Engineering Characteristics are attributes about the product or service that can be measured and benchmarked against the competition. It is also called Technical attributes. Engineering characteristics tell how to change the product. Along the top of the house of quality, the design team lists those engineering characteristics (ECs) that are likely to affect one or more of the customer attributes. If a standard engineering characteristic affects no CA, it may be redundant to the EC list on the house, or the team may have missed a customer attribute. A CA unaffected by any EC, on the other hand, presents opportunities to expand a product‟s physical properties. As the team defines the Engineering characteristics, a determination must be made as to the direction of movement for each characteristic. EC should describe the product in measurable terms and should directly affect customer perceptions. In many Japanese projects, the inter functional team begins with the CAs and generates measurable characteristics for each, like foot-pounds of energy required.

4.3 Customer Competitive Evaluation

The planning matrix is the most important part of the House of Quality diagram which looks at the competitive Analysis of a certain company and its competitors. This evaluation shows the opinion and satisfaction of customers for a particular customer attribute for different competitors. The planning matrix uses a scale of 0 through 5 to analysis how each company is being rated. In this case 0 is the worst rating and 5 is the best. Companies that want to match or exceed their competition must first know where they stand relative to it. So on the right side of the house, opposite the CAs, we list customer evaluations of competitive products matched to “our own”. It identifies the opportunities for improvement. Marketing professionals will recognize it as a “perceptual map.” Perceptual maps based on bundles of CAs are often used to identify strategic positioning of a product or product line. This section of the house of quality provides a natural link from product concept to a company‟s strategic vision.

4.4 Relationship Matrix

The relationship matrix is where the team determines the relationship between customer attributes (CAs) and engineering characteristics (ECs). Relationships can either be weak, moderate, or strong and carry a numeric value. For each CA there should be some relationship with given EC.

Those relationships are depicted by the symbols like;
Θ – Strong relationship
O - Moderate relationship
Δ – Weak relationship.

The numeric values for Δ is 1, O is 3 and Θ is 9. Numeric value will be used in further calculations. The inter functional team now fills in the body of the house, the “Relationship Matrix,” The team seeks consensus on these evaluations, basing them on expert engineering experience, customer responses, and tabulated data from statistical studies or controlled experiments.

4.5 Correlation Matrix

The house of quality‟s distinctive roof matrix helps engineers specify the various engineering features that have to be improved collaterally. Roof matrix facilities engineering creativity. This matrix is a big help to the design engineers in the next phase of a project. Team members must examine that improving a particular Engineering Characteristic will cause to improve or decline the other Engineering Characteristic. These relationships are shown with the help of symbols like:
O – Positive relationship, X – Negative relationship.
Ⓞ - Strong Positive, Xx - Strong negative
The team should document strong negative relationships between Engineering Characteristics and work to eliminate physical contradictions. The roof matrix also facilitates necessary engineering trade-offs.

4.6 Competitive Technical Analysis

To better understand the competition, comparison is made among the engineering characteristics of all the competitors. This process involves reverse engineering. For the same EC how much score is obtained my proposed company and all the competitors. It is better shown by the graphical representation using color code specified for each competitor. It depicts the leading or lagging position of the company so it gives a direction to improve engineering characteristics.

4.7 Absolute Importance, Relative Importance & Target Values

At this stage team begins to establish target values for each Engineering Characteristic which acts as a base-line to compare against. It adds objective measures at the bottom of the house beneath the ECs to which they pertain. i.e. ideal new measures for each EC in a redesigned product. First identified the EC then tests to measure benchmark value is the best way to improve. Finally, the team calculates the absolute importance (absolute weights and relative weights) for each engineering characteristic. This numerical calculation is the product of the cell value and the customer importance rating. In setting targets, it is worth noting that the team should emphasize customer-satisfaction values and not emphasize tolerances. So it reveals that which engineering characteristic of the given product matters the most to potential customer.

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5. Analysis for House of Quality

5.1 Analysis for Customer Competitive Evaluation

First calculate the Relative weight for each customer attribute by the formula given: Relative weight = (weight of importance of particular CA/ Total sum of weight of importance) * 100. Then place customer attributes priority wise On the basis of Relative Weights. Highest score CA is ranked 1st and will be placed at first position whereas lowest score CA will be placed at the last position. Now for Planning Matrix calculate the weight of importance for company in consideration and all the competitors. Then calculate Relative weights for each company by applying the formula: Calculate relative weights for all customer attribute for all the competitors. Results of customer competitive evaluation are depicted by graph on a suitable scale. Different colors for different companies like Orange color line shows "Company in consideration", Green color line shows "competitor A" and light blue color line shows "competitor B". Evaluation shows the leading and lagging position for competitors for a particular CA. Results show the actual need and expectations of customers from company. The company considers all calculated demands in the product launched will win the race among the competitors and achieve the satisfaction of customers.

5.2 Analysis for Competitive Technical Analysis

First calculate "Absolute weights" for each Engineering Characteristic (EC) by "Sum of multiplication of weight of importance and relationship value for the whole column.". It gives the absolute weight for that particular EC. Now calculate and record absolute weights for each Engineering Characteristic under the corresponding columns. Thereafter calculate "Relative weights" for each Engineering Characteristic. Results of Competitive Technical Analysis are depicted by graph on a suitable scale. Colors used for the competitors are mentioned earlier like Orange color line shows "Company in consideration", Green color line shows "competitor A" and light blue color line shows "competitor B". Evaluation shows the leading or lagging position of company in consideration on engineering/Technical efforts with respect to its competitors Upward arrow shows the direction of betterment of technical efforts for each competitor. Results show that where company in consideration stand now i.e. technical efforts are sufficient or to be improved. Corrective measures should be improved how much to meet customer requirements so that complete customer satisfaction is achieved. Using these methods company move towards the successful product, winning over competitors and remarkable growth of business.

6. Symbols used in House of Quality

6.1 For Relationship matrix

Θ – Strong relationship
O - Moderate relationship
Δ – Weak relationship.

6.2 For Co-relationship matrix

O – Positive relationship
Ⓞ - Strong Positive relationship
X – Negative relationship.
Xx - Strong negative relationship

6.3 Direction of improvement of Engineering Characteristics

O - Meeting Target,
↑ - Maximize,
↓ - Minimize

6.4 For Customer Competitive Evaluation:

Plot graph for Absolute weights and Relative weights using customer attributes for all the competitors called as Customer Competitive Evaluation. Similarly for Engineering Characteristics for Competitive Technical Analysis. Graphical Symbols :

(Select Different colours for different competitors) Ex.
Orange color line - Company in consideration
Green color line - competitor A
Light blue color line - competitor B

6.5 Formula Used

Improvement ratio = (Anticipated level value / Current level rating).

Weight of Importance of customer need = (Value of degree of importance * value of improvement ratio).

Relative weight = (weight of importance of particular CA/ Total sum of weight of importance) * 100

Absolute weights = Total sum of (Weight of importance * relationship value of the corresponding cell).

7. Risk Factors to be avoided in HOQ

1) Blank rows
2) Unfulfilled customer wants
3) Blank columns
4) Unnecessary requirements
5) Rows or columns with only weak relationships
6) Immeasurable "HOWs"
7) Too many relationships
8) Difficult to do what can't be measured
9) Negative correlations

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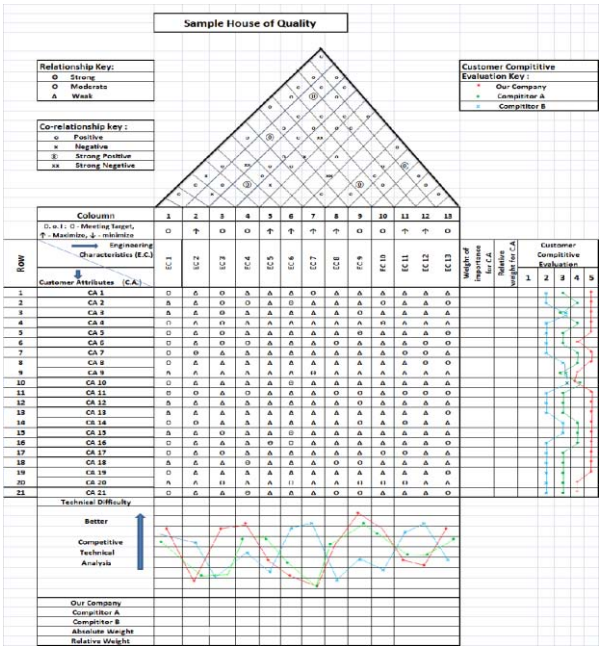
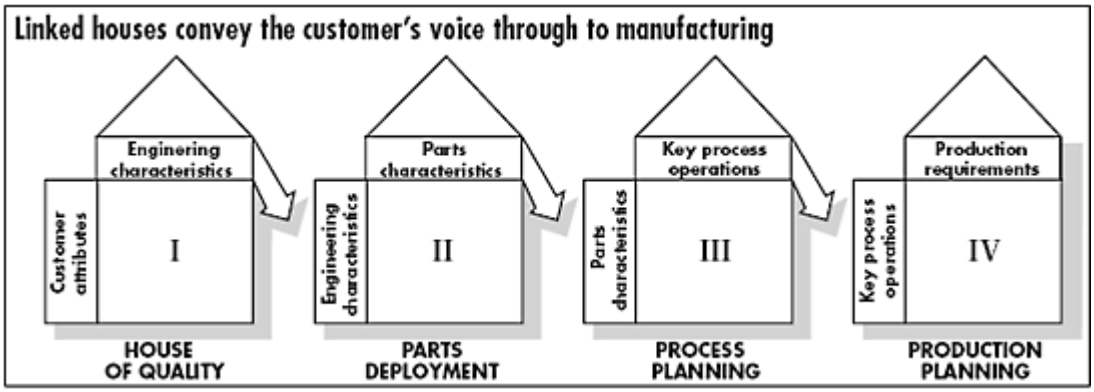
8. Build up House of Quality Model



9. Linked House of Quality

House of quality process starts with collecting customers attributes, covers the whole process of design specifications, manufacturing planning and ends at production planning. Process of developing the House of quality is repeated for the next phases of project called Linked House of Quality. Linked houses of quality convey the customer‟s attributes through to manufacturing Source and process continues to a second, third and fourth phase. in Phase 2 the process becomes a translation of the engineering characteristics in to the voice of the part design specifications. Then, in phase 3, the part design specifications get translated into the voice of manufacturing planning. Finally, in phase 4, the voice of manufacturing is translated into the voice of production planning [11].



Source: https://hbr.org/1988/05/the-house-of-quality

10. Conclusion

The principal benefit of the house of quality is “quality in-house”. Proactive product development is better than reactive product development or designing and manufacturing products that delight customers and fulfill their unarticulated desires. For most U.S. companies, this alone amounts to a quiet revolution. HOQ is a methodology that gets the right people together, work efficiently and effectively to meet customers‟ needs and facilitate better decision making. House of Quality promotes cross-functional teamwork which reduces the uncertainty involved in product and process design. Like in Phase 2 HOQ becomes a translation of the engineering characteristics in to the voice of the part design specifications, in phase 3 outcome is voice of manufacturing planning and finally, in phase 4 House of quality gives the voice of production planning. Further House of quality is not restricted to only customer attributes but it links the whole process like Customer attributes, Engineering characteristics, voice of the part Design specifications, voice of manufacturing planning to the last phase voice of production planning. In short House of quality has a very wide scope. It can be used for various types of industries, institutions and service sectors to achieve business growth with better customer satisfaction.

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