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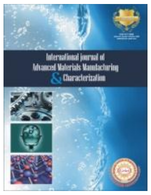

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Design of Office Chair: A Quality Function Deployment Approach

S.S Mahaptra, PragyanParamitaMohanty

Department of Industrial Design National Institute of Technology Rourkela, India.

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ABSTRACT

This paper employs a quality function deployment (QFD) methodology to translate customer requirements into design characteristics to improve the design of an office chair. A factor analysis has been carried out on the responses obtained from a cross sectional survey directed at users through a set of questionnaires. It has been obtained that three factors with twenty two items are loaded with a threshold value above 0.7. Finally, quality function deployment is used to extract important design characteristics satisfying the customer requirements.

Introduction

Quality is a characteristic of a product which has its ability to satisfy the implied customer's needs or in other words it fulfils customer's expectation from a product. Quality function deployment (QFD) provides a means of translating customer requirements into appropriate technical characteristics for each stage of product development and production (i.e. marketing strategies, planning, product design and engineering, prototype evaluation, production process development, production, and sales) [1]. A fuzzy logic based quality function deployment approach has been used to identify the e-learning service provider for effective distance education [2]. To extract bottleneck techniques, some researchers have used quality function deployment to design an assistive device [3]. A QFD technique has been used for management of engineering institutions to provide guidelines to prioritize the improvement policies for their organisation [4]. Some researchers have proposed a fuzzy quality function deployment for determining optimum level of engineering characteristics to randomized customer attributes [5]. Here, an analytical hierarchy process (AHP) has been combined with quality function deployment for the selection of software project [6]. Some researchers present a systematic approach to quality function deployment by addressing the customer's voice using symmetrical triangular fuzzy member [7]. A study has been done by carrying two approaches (crisp and fuzzy approach) of QFD technique to develop a new shampoo [8]. Some researchers focused on QFD to the product development process of contact manufacturing [9]. Some researchers have developed an integrated framework based on Fuzzy QFD and Fuzzy optimization model to determine the product technical requirements [10].

- Corresponding author: PragyanParamitaMohanty
- E-mail address: pragyanmohanty.design@gmail.com
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Data collection

Data are collected from employees of various offices like technical institutes, banks (private and government), hospitals (private and government) and some other organization. A questionnaire is prepared including forty variables for customer requirements consisting of dimensions for design elements (twenty four continuous design elements and thirteen categorical design elements) regarding office chair. One hundred twenty five data are collected from respondents through cross-sectional survey on forty items. The respondents need to answer in likert-type scale (1 for strongly disagree and 5 for strongly agree).

A factor analysis has been done toexamine the validity and reliability of variables to obtain a statically proven identification of customer requirements. The validity was tested by using principal component method following varimax rotation to extract the important customer requirements for model analysis which removes the redundancy and duplication from a set of correlated variables. Total variance explained by three factors was found to be 78.5% which is acceptable value for principal component with varimax rotated factor loading procedure. Ten items were loaded under factor 1, five items under factor 2 and seven items under factor 3. Factors extracted from analysis are named as comfortness (Factor 1), balance (Factor 2) and luxuriousness (Factor 3). Cronbach alpha (α) has been used to assess the internal consistency of the scale. The value of alpha for all dimensions is 0.702, which is just the acceptable value for demonstrating internal consistency of the established scale. The values of α obtained are 0.878, 0.933, and 0.939 for factors 1, 2, and 3 respectively. From Kaiser-Meyer-Olkin test (KMO>0.6), it can be concluded that the matrix did not suffer from multi collinearity or singularity. A list of continuous design characteristics are given (Table 1) and categorical design characteristics are not considered here.

Implementation of QFD

The customer requirements shown under three different factors are found to be in indistinct form. These needs must be converted into design characteristics through a suitable method like Quality Function Deployment (QFD). Quality function deployment (QFD) is a powerful tool for converting indistinct customer voice (customer requirements) into engineering characteristic (continuous design characteristic)[11, 12].Through experts' opinion and brainstorming sessions,three different QFD models named as QFD model 1 (comfortness), QFD model 2 (balance) and QFD model 3 (luxuriousness) are used for correlating customer requirement with design characteristic.Ten, five and seven items (customer requirements) are considered under QFD model 1, 2 and 3 respectively. Similarly for design characteristics, nine, seven and nine items are used respectively for three models 1, 2, and 3 as shown in Table 2. The design attributes extracted from the experts for three models are shown in Table 3. Initial rating of customer requirements for each model is derived using a 1-10 scale as shown for the case of model 1 (comfortness), model 2 (balance), model 3 (luxuriousness) in Figure 1, 2 and 3 respectively.

The customer ratings for each customer requirement were obtained from left correlation matrix using equation 1

Customer rating=

$$Z_i + \left[\frac{1}{n-1} \right] \times \sum_{j \neq 1}^{n} B_{ij} Z_j \qquad \ldots(1)$$

where, B_{ij} denotes the relationship between customer needs, Z_i is the initial customer rating, A_{ij} denote the relative importance of i^{th} characteristic with respect to j^{th} customer's needs in the relationship matrix, X_j represents the importance of j^{th} customer needs and n is the number of customer needs.

$$\text{Design requirement} = \left(\frac{1}{n} \right) \times \left[\sum_{j}^{n} A_{ij} X_j \right] \qquad \ldots(2)$$

The individual rating of each design characteristic is obtained from the central matrix by using eqn. (2)where A_{ij} and X_j denote the relative importance of the i^{th} design characteristics with respect to the j^{th}customer need in the relationship matrix and the importance of j^{th} customer needs (customer requirements) and n is the number of customer requirements. The correlation of customer requirements (left matrix), design requirements (top matrix) and customer requirements with design characteristic (central matrix) are extracted from the experts using scale of 0.8, 0.6, 0.4 and 0.2 for designating relationship "strong", "moderate", "weak", and "very weak" respectively. Finally, initial design requirements and with correlation values shown in top matrix are used in equation 1 to obtain final design ratings. The normalized refined rating of design attributes are obtained by dividing each rating with the maximum available design requirement rating. Three different QFD models are shown in Fig. 1, 2 and 3. Model 1 represents "comfortness", model 2 represents "balance" and model 3 represents "luxuriousness".

From the normalized refined rating for design attributes, "Tilt of backrest" is the most prioritized element followed by "Number of controls" in case of model 1 (Table 3).Finally, four design attributes such as tilt of back rest, number of controls, overall width and overall height are considered out of nine design attributes having normalized refined rating value of 0.85 (threshold). Similarly, other two models have been developed with prioritized design characteristics as shown in same Table 3. For QFD model 2 (balance), four design attributes such as width-height ratio of backrest, width-height ratio of seat pan, width-height ratio of whole body, and width-height ratio of armrest exhibiting normalized refined rating value of 0.80 (threshold) and above have been considered. Similarly, five design attributes such as seat adjustment range, use of pattern, use of cushion, use of decoration, and backrest height showing normalized refined rating value of 0.90 (threshold) and above have been considered for QFD model 3 (luxuriousness).

Conclusion

The major contribution of this paper is to provide an integrated approach for modelling design characteristic of a product (office chair) in an office environment as the interaction between the product and customer varies from customer to customer. An office chair must satisfy the customer's requirements for a wide range of population by selecting a less but important set of design characteristic. So this work provides a QFD approach to improve the quality of the product by identifying important design characteristic.

Table 1. Continuous design characteristics

Sl. No.	Backrest	Seat pan	Arm rest	Whole body	Others
1	Tilt of Backrest (maximum angle of the backrest in relation to the seat pan)	Length of seat pan	Length of arm rest	Ratio of seat pan and backrest	Use of decoration
2	Width of Backrest	Width of seat pan	Width of armrest	Width –height ratio of whole body	Use of pattern
3	Height of Backrest	Thickness of seat pan	Height of armrest	Height of whole body	Use of Cushion
4	Thickness of Backrest	Width and length ratio of seat pan	Width-height ratio of armrest	Size of whole body	Use of curved lines
5	Width-Height ratio of Backrest	Height adjustment of seat pan		No of controls used	No of colours used

Table 2. Design characteristics under three models

QFD model (Comfortness)	QFD model (Balance)	QFD model (Luxuriousness)
Tilt of backrest	Width-height ratio of backrest	Seat adjustment range
Number of controls	Base material	Use of pattern
Width of backrest	Size of base wheel	Use of curved line
Depth of seat pan	Width-height ratio of seat pan	Use of cushion
Height of armrest from floor	Width-height ratio of whole body	Use of colour
Overall height	Thickness of seat pan	Shape of backrest
Overall width	Width-height ratio of armrest	Use of decoration
Low back support		Shape of seat pan
Width of seat pan		Backrest height

Table 3.ranking of important design characteristic for three models

QFD model	Design elements requirements	Initial design requirement rating	Revised design requirement rating	Normalized refined rating	Rank
comfortness	1. Tilt of back rest	5.994	8.642	1.000	1
	2. Number of controls	5.659	8.341	0.965	2
	3. Overall width	5.136	8.045	0.931	3
	4. Overall height	4.778	7.153	0.856	4
balance	1. width-height ratio of backrest	7.185	11.429	1.000	1
	2. width-length ratio of seat pan	7.345	11.376	0.995	2
	3.width-height ratio of whole body	7.394	11.345	0.993	3
	4.width-height ratio of armrest	7.582	11.080	0.969	4
Luxuriousness	1. range of height adjustment	7.486	10.861	1.000	1
	2. backrest height	6.840	10.515	0.968	2
	3.use of pattern	6.624	10.45	0.962	3
	4.use of cushion	6.440	10.040	0.924	4
	5. use of decoration	4.488	7.957	0.733	5
	4.width-height ratio of armrest	7.582	11.080	0.969	4

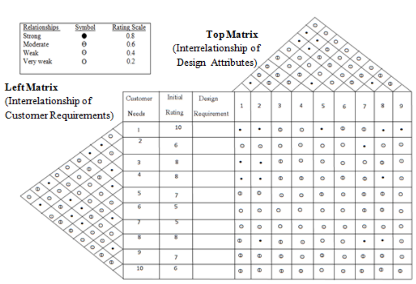

Figure 1. QFD model for comfortness

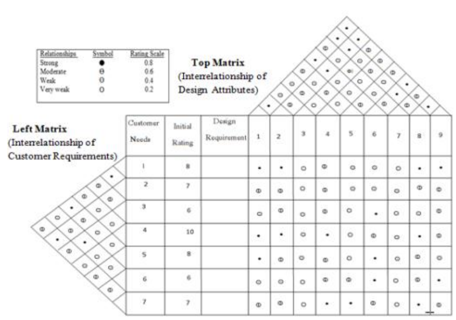

Figure 2. QFD model for balance

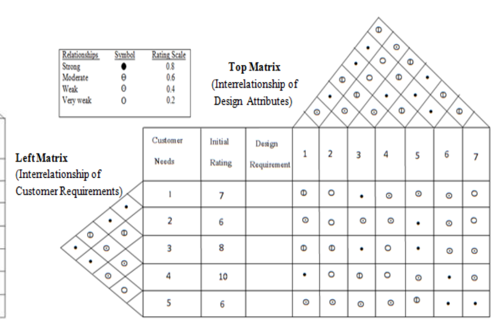

Figure 3. QFD model for luxuriousness

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