International Journal of Research in Humanities and Social Studies
Volume 6, Issue 3, 2019, PP 38-45
ISSN 2394-6288 (Print) & ISSN 2394-6296 (Online)

Capturing and Integrating Sustainable Customer Requirements into Product Design

Lara F. Horani

School of Management, North western Poly technical University, Xi'an, China,

***Corresponding Author:** Lara F. Horani, School of Management, North western Poly technical University, Xi'an, China, E-mail: larahurani@yahoo.com"*

ABSTRACT

Identification of customer needs marks the initiation point in case of design process. Several design methodologies give much attention on technical domains in order to define customer requirements. However, the successful version of product design in today world goes beyond the technical features; it mostly depends much more on multi-facets of customers' needs that includes various business parameters. Moreover, the qualitative and subjective factors including affection, aesthetic appearance, user friendliness and environmental requirements are very much important to the ultimate acceptance of a new product. This paper focusses on capturing and finding what actually are the sustainable requirements for the customers and how to integrate them into the product design and to integrate sustainable customer requirements into product design. A specific tool based on Quality Function Deployment (QFD) has been used in this study to identify the most significant environmental indicators for design and manufacture of environmentally friendly products. The mobile phone is designed based on the mapping of sustainable customer requirements and customer needs.

Keywords: *Sustainable Design, sustainable customer Requirements, Quality Function Deployment for environment.*

INTRODUCTION

A successful product design nowadays has to come up with promising and necessary functions in order to offer sufficient business returns, to development husiasm in the market and to comply with several regulatory standards such as sustainability and safety. In fact, product design has been considered as a fusion of different disciplines and a multiple dimensional task for past few decades, involving the attention of engineers, industrial designers, and business managers along with customers' participation. The interdisciplinary nature of design connecting other diverse fields in engineering, business, sustainability, science and arts has become more prominent than ever.

In order to achieve a holistic and potential design with the consideration of design from all three areas of engineering, business and art, it is more like a positive approach to incorporate traditional and sustainable customer requirements and preferences into design (luo et al., 2008). Traditional engineering design methodologies pose much attention towards technical requirements which are often represented in quantitative and explicit form. On the other hand, customer' perceptions and preferences like appearance, aesthetics, affection, usability, comfort and environmentally friendly for products are considered as subjective and hence can be called as subjective characteristics. These are oftenly ignored in the technical design literature. The inability to include the subjective and qualitative customer preferences have blocked the progress of holistic design methodology. To a certain extent, it can be attributed to the gap being created between the theory and the practice and this has been proved true in dynamic marketplace nowadays. The successful launch of the product design may not depend only on traditional requirements. Instead, the sustainable customer requirements such as energy consumption, less material use, reduce the waste and easy to disposal are also important. Thus, it becomes imperative that design methodology must include not only traditional requirements quantitative data but also sustainable customer preferences.

CUSTOMER REQUIREMENTS ELICITATION IN PRODUCT DESIGN

Unlike most physical phenomena, the goal of meeting customer needs can hardly be

expressed oftenly in objective and quantitative terms, which barriers the possibility of exploring, assessing, and optimizing different alternatives. In the meantime, it has been acknowledged that the most important key to product success relies on better understanding of the voice of the customer and on better links between the preference of the customers, including artistic appreciation, sensory feedbacks, and value judgment with the capability of the companies. These preferences oftenly need to be expressed in subjective and qualitative terms.

It is obvious that there is a need to discover new ways to characterize and incorporate customer needs, particularly, subjective characteristics of customer preferences like environmentally friendly, user friendliness, comfort, etc. However, the integration of the customer requirements into design can be a challenging task due to the following reasons (Lilien et al., 1992);

- The problematic situation of characterizing the customer subjective preferences: product subjective characteristics are not well defined as components or tangible attributes. Each individual customer perceptions for the product are dependent largely on complicated internal and external factors and differ from person to person.
- For example, when selecting Chinese tablet, different customers may have extremely different perceptions about performance, comfort and easy-to-use in case of the same product. The levels of subjective preferences and the corresponding scales may vary significantly with the wide range of customers.
- The wide variation complexity of customer preferences: customer preferences and requirements are mainly context-dependent (Wang and Tseng, 2008). Customers may vary in their preferences and decision making criteria due to the change in purchase situation. The external factors like mood, emotion and the increase in their weariness towards the environmental issues can also affect their preferences and requirements.
- The difficulty in eliciting and integrating the subjective preferences into design: one of the reasons that let the design teams get disconnected, lies in the difficulties in eliciting customer needs towards product's subjective characteristics which are usually latent, as opposite to known function-based physical requirements. Although various techniques such as weighting ratio and data mining can identify personal profiles based on previous purchasing information details and personal backgrounds to extrapolate personal preferences,

In the research of product design, the understanding of consumer requirements and preferences becomes more critical with the passage of time because the customer centric product design and manufacturing has become the mainstream in academia and industrial practice (Tseng and Du,1998)

In engineering design, customer preferences are expressed in functional requirements or design of parameter language. Customer preferences elicitation task can be considered as the specification definition procedure, i.e., customers only need to specify the alternative of each product attribute. This process is also referred to as product configuration process, with the purpose of translating subjective customer needs into tangible specifications. However, the configurator based customer needs elicitation system requires customers to express their needs in a specific design parameter domain. The methods cannot capture customer's perceptions and preferences on the subjective characteristics.

With the passage of time, the focus shifted towards product impacts via the concept of 'eco-design', which is also known as 'Design for Environment' (DfE). This field of design addresses the environmental concerns associated with production and consumption processes (Crul and Diehl, 2008). Many designers have applied it at early stages of product development phases that leads to improved design specifications (Vinodh and Rathod 2010; Cerdan et al. 2009; Gehin et al. 2008). This process can include all the drawings, dimensions, and documentation; environmental, ergonomic, and aesthetic factors; costs; and maintenance, quality, and safety requirements that describe the product details. From the manufacturer's perspective, however, environmental considerations have often been linked to increases in costs.

Thus, good plans and strategies are needed to be implemented to ensure that the concept of design for sustainability would be achieved. Product sustainability is concerned with the purpose of finding different ways of thinking and making products. Figure 1 shows the

shifting paradigm from traditional design to sustainable design (White et al., 2008).

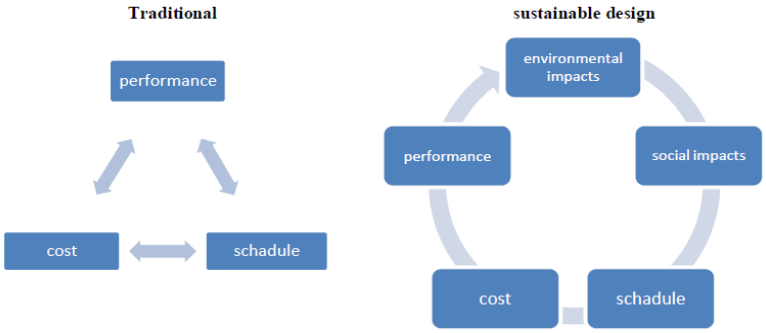

Figure1. *The shift to sustainable design*

INTEGRATING SUSTAINABLE CUSTOMER REQUIREMENTS INTO THE PRODUCT DESIGN USING QFD

During the past years, several methods have recently been developed with the aim of integrating the sustainable customer requirements into the Product Design. The Figure below elaborates about some recent sustainable design tools and their individual applications contributing towards to the design process. These tools can generally be generally classified into three categories: tools based on checklists, tools based on life cycle assessment (LCA), and tools based on quality function deployment (QFD). But, among these three tools Quality function deployment (QFD) is well-known because it has been used in most of the cases and is a powerful method in the product design and development and it has been employed successfully in many manufacturing industries.

The objectives of a traditional quality function deployment are to change or transfer the customers' needs into engineering characteristics, and to improve the product quality. By introducing the environmental impacts of the product itself and on its life cycle into QFDs as new customer needs, a set of sustainable design tools has been developed so far. These include QFD for the environment, green quality function deployment, and House of Ecology. In general, application of these tools starts from collecting both customer needs and environmental needs and developing the correlation between these needs and quality characteristics. A functional analysis is then performed in order to identify and determine how quality characteristics are correlated with engineering characteristics (including structure or components) and hot spots from both environmental as well as traditional quality points of view. It can be observed that QFD-based tools are significantly different from LCA-based tools since the focus is made on the product specification development stage. One serious drawback of these QFD based tools similar to traditional QFD is that the development of correlations between environmental needs and quality and engineering characteristics is completely based on the designers, and usually the correlations developed are based on knowledge from the traditional environmental engineering discipline without the consideration of life cycle (Bouchereau and Rowlands 2000). Among these three types of eco-design tools (checklist, LCA, and QFD-based), QFD based tools are the most suitable for early product development, when specifications are being established and concepts get generated. Besides the traditional QFD, several different approaches combine environmental issues into the QFD, such as green quality function deployment, eco-QFD, and quality function deployment for the environment. Masui *etal*. Highlighted the environmental voice of customer (VOC) and environmental engineering metric (EM) for QFD to develop QFD for environment (QFDE). (Kuo et al, 2009) developed Eco-quality function deployment (Eco-QFD) in order to include the environmental consideration into QFD as a quality system tool to enhance the customer satisfaction to a greater extent.(Masui et al. 2003) and other QFD-based methods incorporating the environmental issues are also available. (Cristofari et al. 1996; Zhang et al. 1999; Bovea and Wang 2005; Mehta and Wang 2001; Dong et al. 2003) used green QFD in their research studies. The starting point of the GQFD methodology is to set alternative designs from the customer and apply the QFD methodology in the House of Quality (HoQ). (Pusporini et al., 2012) proposed environmental performance as a

key performance indicator in the lean six sigma methodology for achieving the overall competitiveness of the product. According to Chan and Wu (2002) the details of House of Quality of the QFD with environmental concern can be described in figure 2 as follows:

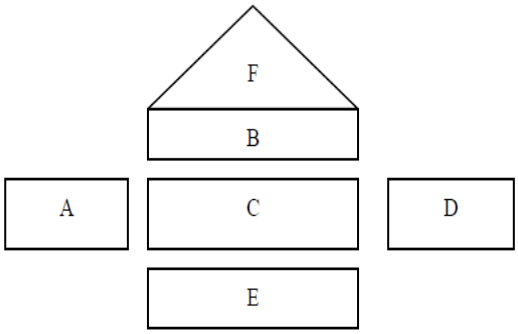

Figure2. *House of Quality of the QFD for environment A is customer requirements (traditional and environmental) (Whats)*

B is engineering characteristic (Hows)

C is the relationship between Whats and Hows

D is planning matrix

E is prioritizing characteristic engineering and target value

F is interrelationship between each engineering characteristic

RESEARCH METHOD

This study proposes the integration of sustainable customer requirements into QFD for identifying the most significant environmental indicators for design and manufacture of environmentally friendly products. Sustainable customer requirements must be considered at the early stage of product design and development processes. And collecting the customer's information through one-on-one interview and a questionnaire survey to investigate their requirements and the importance rating for the requirements which related to the mobile phones.

Data Collection

The primary step in the product planning process is to determine the user or customer requirements, the detailed information about the customer requirements and their priorities can be achieved through various marketing methods, e.g. questionnaires, interviews, and brainstorming techniques.

The VOC data were collected through one-on-one interview, and questionnaires conducted over a sample of people belonging to different Ages, education marital status and Income groups, The Primary data collected through a questionnaire survey conducted over a sample of 320people belonging to different Ages, education, marital status and Income groups in Xian, China. It aims to investigate the opinion of the participants, ideas, requirements and desires related to the mobile phones.

Quality Function Deployment for Environment

The QFD method with the sustainable consideration would help the team of product design at the manufacturing company to identify the priorities of sustainable customer requirements that have to be targeted mostly, considering it as the improvement effort for creating the environmentally friendly product. The algorithm of the QFD with environmental concern can be described as follows:

Identify Traditional Customer Requirements and Sustainable Customer Requirements

The first step of the customer input is to determine what are the needs of customers for the product they are concerned with. Customer needs are usually expressed in customer terms that can be collected by focus groups or individual interviews. According to Griffin and Hauser (1993) , individual face-to face interviews may be more cost effective than focus groups, and at least 20- 30 customers should be interviewed to obtain 90- 95% of all the possible customer needs (Griffin and Hauser, 1993; Chan,1999). Mail/ telephone surveys are not suitable for collecting qualitative data such as customer needs due to the difficulties in controlling the scope of responses. Customers' words are usually too general and/or too detailed to be directly used as customer needs. In order to facilitate analysis and application, the words collected through different methods are usually organized as a tree-like hierarchical structure to help in the formation of various (usually three) levels of customer needs and according to the situation, those at a specific level are chosen as the final customer needs.

For the first step in case of QFD method, this is important to know the customer needs and their priorities. And how to identify the voice of our target customers (which are the green customers) that can be called what is on the HOQ. Due to the sustainable consideration, the identification of the voice of customer is not only based on the customer traditional needs like (Health, Taste, Reuse, status, convenience, Quality, Value for cost, Easy access,

Appearance, freshness and smell), but also it is necessary to involve the sustainable customer requirements. The sustainable customer requirements for environmentally friendly product like energy consumption, less material use, reduce the waste and easy to disposal are possible to be considered. The VOC data were collected through one-on-one interview, and questionnaires. After collecting, structuring the customer requirements (CRs), these customer Requirements can be further categorized into five levels such as; cost, performance, easy to use, structure and environment.

The customer requirements for mobile phones are as follow:

- Price or Cost
- Network Performance
- Battery Life
- Call and Message quality
- Resolution
- Big Memory
- Reliability
- Touch Screen Sensitivity
- Social Media Applications
- Compatibility
- Weight
- Screen size
- Recyclable
- Energy Saving
- Easily Maintenance
- No Toxically Material Released
- Durability
- less waste

Identify Technical Attributes with Environmental Concern

The second step in case of the QFD approach deals with, how to identify the technical attributes or technical characteristics, technical requirements used to represent the voice of developers, so called as Hows. The identification of technical attributes (Hows) is, how to reply to the customer sustainable customer requirements (Whats).

The process to identify technical attributes is wide, complex and uncertain. A systematic approach is required to help the product development team in order to identify the technical attributes or technical characteristics. The determination of the technical requirements was done by reviewing the literature, consultation and discussion with experts in the respective products related to t and mobile phones field. The technical requirements for mobile phones are as follow:

- Engineering Characteristics
- Material Reduction
- No Dangerous Material
- Pollution Control
- Low Energy Exhausting
- Modularization
- Tools Usage
- Package Reduction
- Energy Saving
- Maintenance
- Reuse or Recycled

Determine the Relationship between the Customer Requirements and the Technical Requirements

In order to identify the relationship matrix between Whats and technical attributes (Hows), this process involves the participation of some experts at manufacturing company that could be from the mixed functioning in the organization like marketing, design and manufacturing.

The process of determining the relationship between the customer and technical requirements was completed through discussions with the engineering experts. The relationships were represented by several categories such as strong (9), moderate (3), weak (1), and there is no relationship (0).

The Weights of Customer Sustainable Customer Requirements

This step deals with the process about how to allocate weight to sustainable customer requirements (Whats).

Scale used for the design of the questionnaire is a Likert rating scale with a range of 1-5 for the assessment is not important (1) to very important (5)

Determine the Priority of the Technical Requirements

The process of determining the priority value of each technical requirement was performed by evaluating the results of multiplication of the customer important ratings with the score of the relationship between the customer requirements and the technical requirements.

Presentation of QFD with Environmental Concern

The main viewpoint of QFD with environmental concern is about how to construct the house of quality (HOQ) that includes the weight allocation to customer sustainable customer requirements and to identify the relationship matrix between customer sustainable customer requirements and technical attributes that are being provided. The completed HoQ for the mobile phones is shown in Figure 3.

ENGINEERING CHARACTERISTICS / CUSTOMER REQUIRMENTS		Importance Rating	Material Reduction	No Dangerous Material	Pollution Control	Low Energy Exhausting	Modularization	Tools Usage	Package Reduction	Energy Saving	Maintenance	Reuse or Recycled
environment	Recyclable	**3.41**	9	0	3	9	9	1	9	3	9	9
	Energy Saving	**3.95**	3	0	1	9	9	0	3	9	9	1
	Easily Maintenance	**3.51**	3	1	1	3	3	9	0	3	9	9
	No Toxically Material Released	**3.65**	1	9	9	0	0	1	0	0	9	3
	Durability	**3.69**	3	0	0	3	1	3	0	1	9	9
	less waste	**3.58**	9	0	0	1	0	3	9	3	3	9
easy to use	Touch Screen Sensitivity	**2.98**	1	0	0	3	9	3	0	1	3	3
	Social Media Applications	**3.76**	0	0	0	0	1	3	0	3	3	0
	compatibility	**3.13**	0	0	0	0	3	1	0	1	0	0
Structure	Weight	**3.42**	3	0	0	1	3	1	3	9	3	3
	Screen size	**3.43**	3	0	0	1	3	3	9	3	3	3
Performance	Network Performance	**3.85**	0	3	0	0	9	3	0	9	1	1
	Battery Life	**3.40**	3	9	9	0	0	0	0	0	3	0
	Calls and Messages quality	**3.25**	3	0	0	0	0	0	9	0	3	0
	Resolution	**3.37**	0	0	0	3	1	0	0	3	3	0
	Big memory	**3.51**	0	0	0	3	1	3	0	9	0	0
	Reliability	**3.18**	3	0	0	9	0	3	0	9	3	0
Cost	Price or Cost	**4.00**	9	0	0	3	1	1	1	9	3	9
Priority Values			178.74	78.51	81.14	168.47	186.51	133.14	149.1	270.	270.	211.9
Rank			**10.34**	**4.54**	**4.69**	**9.74**	**10.78**	**7.70**	**8.62**	**15.62**	**15.66**	**12.26**

Figure3. *The HoQ for the mobile phones*

DISCUSSION

The customer importance ratings show clearly that the major requirements in the mobile phones design according to the customers is the Price more than any other related category and its shows how much the customer care for the cost of the product when they buy the Chinese tablet and this give it the most important competitive prevalence. Then the sustainable customer requirements come next in the important ranking, which shows how the customer requirements changing towards the sustainable customer requirements and became more aware to the important of reduction of the environmental crises and the pollution spicily with saving energy requirements which was the highest among the sustainable customer requirements then the Durability after that the customer give their preferences to the performance category and the Network Performance was the highest then the tablet memory, and at the end structure and easy to use categories were the lowest in the ranking.

And regarding the engineering characteristics, the Maintenance requirement comes first in the priority values then the energy saving and they were very close which mean they have the highest priority in the mobile phones then to the reuse or recycled requirement which reflect the importance of sustainability in producing the tablets to get competent product then modularization material reduction and

requirements came next in the Priority Values for the sustainable customer requirements for the engineering characteristics

CONCLUSION

QFD is an effective methodology for product design and development involving the main aim to enhance the customer satisfaction and it has been conducted successfully in many industries so far. This research study proposes the integration of sustainable customer requirements into QFD method for designing environmentally friendly products. The weights in this research study were used in conjunction with HOQ to determine the priority order of sustainable indicators.

REFERENCES

[1] Bouchereau V., and Rowlands H., (2000). Methods and Techniques to Help Quality Function Deployment QFD. Benchmarking: An International Journal, 7_1_, pp. 8–20.

[2] Bovea M.D., Wang B., (2005). Green Quality Function Deployment: a methodology for integrating customer, cost and environmental requirements in product design. International Journal of Environmentally Conscious & Manufacturing 12 (3-4), 9-19.

[3] Bovea M.D., Wang B., (2003). Identifying environmental improvement options by combining life cycle assessment and fuzzy set theory. International Journal of Production Research, vol. 41, no. 3, pp. 593-609.

[4] Cerdan C., Gazulla C., Raugei M., Martinez E., Fullana-i-Palmer P., (2009). Proposal for new quantitative eco-design indicators: a first case study. Journal of Cleaner Production, 17(18), 1638–1643.

[5] Chan L., Kao H., NG A., WU M., (1999). Rating the importance of customer needs in quality function deployment by fuzzy and entropy methods, int. j. prod. res., vol. 37, no. 11, 2499- 2518

[6] Chan L., Wu M. (2002). Quality function deployment: A comprehensive review of its concepts and methods," Quality Engineering, vol. 15, no. 1, pp. 23, 2002.

[7] Chan L., Wu M., (2002). Quality function deployment a literature review. European Journal of Operational Research, 143, 463–497

[8] Chen J., Liu C., (2003). An eco-innovative design method by QFD and TRIZ tools. International conference on engineering design, ICED Stockholm Cristofari M., Deshmukh A., Wang B., (1996).

[9] Green Quality Function Deployment. Proceedings of the 4th International Conference on Environmentally Conscious Design and Manufacturing Clevel and. Crul M., Diehl C., (2008).

[10] Design for Sustainability. A step-by-step approach. Dong, C., Zhang, C., Wang, B.(2003). Integration of green quality function deployment and fuzzy multi-attribute utility theory-based cost estimation for environmentally conscious product development. International Journal of Environmentally Conscious Design & Manufacturing 11, 12e28.

[11] Fargnoli M., Kimura F., (2006). Sustainable Design of Modern Industrial Products. Proceedings of the 13th CIRP International Conference on Life Cycle Engineering, pp. 189–194.

[12] Gehin, A., Zwolinski, P., and Brissaud, D. (2008). A tool to implement sustainable end of-life strategies in the product development phase. Journal of Cleaner Production, 16(5), 566–576.

[13] Griffin, A., Hauser, J. (1993). Voice of the customer. Marketing Science, 12, 419–425.

[14] Koffler, C., Krinke, S., Schebek, L., and Buchgeister, J.(2008). "Volkswagen SlimLCI: A Procedure for Streamlined Inventory Modeling Within Life Cycle Assessment of Vehicles," Int. J. Veh. Des., 46_2_, pp. 172–188.

[15] Kuo T., Wu H., Shieh J., (2009). Integration of environmental considerations in quality function deployment by using fuzzy logic," Expert Systems with Applications, vol. 36, no. 3, part 2, pp. 7148-7156.

[16] Lilien G, Kotler P, Moorthy K. (1992). Marketing Model. Prentice-Hall Inc., New Jersey.

[17] Luo L., Kannan P., Ratchford B. (2008). Incorporating Subjective Characteristics in Product Design and Evaluations. Journal of Marketing Research 182 Vol. XLV: 182–194.

[18] Masui K., Sakao T., Kobayashi M., Inaba A. (2003). Applying quality function deployment to environmentally conscious design. International Journal of Quality & Reliability Management 20 (1), 90-106.

[19] Mehta C., Wang B., (2001). Green quality function deployment III: a methodology for developing environmentally conscious products. Design Manufacturing 4, 1-16.

[20] Pusporini P., Abhary K., Luong L. (2012). Environmental performance as key performance indicators in the lean six-sigma methodology," Advanced Materials Research, vol. 488-489, pp. 1082-1086.

[21] Todd, J. A., Curran, M. A. (1999). Streamlined Life-Cycle Assessment: A Final Report From the SETAC North America Streamlined LCA Workgroup SETAC.

[22] Tseng M. and Du X. (1998) Design by Customers for Mass Customization Products. CIRP Annals 47/1:103–106.

[23] Vinodh S., Rathod G. (2010). Integration of ECQFD and LCA for sustainable product

design. Journal of Cleaner Production, 18(8), 833–842.
[24] Wang Y., Tseng M. (2008). Incorporating Probabilistic Model of Customers Preferences in Concurrent Engineering. Annals of the CIRP 58/1:137–140
[25] White C., Stewart E., Howes T., Adams B., (2008). Aligned for Sustainable Design. An A-B-C-D Approach to Making Better Products. Business for Social Responsibility.
[26] Zhang Y., Wang H.P., Zhang C., (1999). Green QFD-II: a life cycle approach for environmentally conscious manufacturing by integrating LCA and LCC into QFD matrices. International Journal of Production Research 37, 1075-1091.

Citation: *Lara F. Horani." Capturing and Integrating Sustainable Customer Requirements into Product Design". (2019) International Journal of Research in Humanities and Social Studies, 6(3), pp. 38-45*