AC 2009-631: DEVELOPING PRODUCT DESIGN REQUIREMENTS USING KANO MODEL

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Developing Product Design Requirements Using Kano Model

Abstract

Product life cycles are getting shorter and customers are becoming more demanding such that businesses are looking for ways to meet these challenges with as little cost as possible. For businesses to be able to stay competitive, identifying customer needs accurately and transferring this information to the product designers in a short period of time becomes greatly essential.

To help businesses achieve their goals, this paper proposes teaching Kano model to the engineering and engineering technology graduates. This model is an effective six-sigma tool for classifying and prioritizing customer needs and helping the design and quality engineers to provide products with characteristics needed by the customers. The Kano model is a useful quality measurement tool in providing a level of sophistication not available in existing models of quality.

To prepare the graduates in using this model, it is taught in 'Design for Manufacturing' course offered in an undergraduate industrial engineering technology curriculum. The paper describes the Kano model and how it can be used in product design.

Introduction

Manufacturing industry is looking for ways to reduce product development time and to introduce their products to the market more quickly. Additionally, product life cycles are getting shorter and customers are getting more selective by demanding sophisticated features in products. As a result, identifying customer requirements and transferring this knowledge along to the product development phase is essential for any business to stay competitive in the global manufacturing environment.

Over the past many decades, it has been observed that companies that have provided outstanding products and services have successfully survived the onslaught of competition. Only by designing quality in the products and services and focusing on quality improvements based on customer demands can a company expect to survive and grow in today's market conditions.

For this reason of designing quality into the products, Dr. Walter A. Shewhart, in the 1930s, began developing his definition of quality, now known as Statistical Quality Control. During and after World War II, the tools for quality improvement continued to develop in the United States and Japan with the work of W.E. Deming, Joseph Juran, Kaoru Ishikawa, and Genichi Taguchi to name just a few of the quality gurus of earlier times.

In more recent times, Dr. Noriaki Kano, a very perceptive student of Kaoru Ishikawa, developed an interesting model to address the various ways in which quality practitioners can understand and prioritize customer requirements[1]. This model is well-known as Kano model of customer satisfaction. Even though it has been used in industry to a certain extent, its use has been limited because not many engineering educators are aware of its existence.

Kano model describes the complexities of customer needs and their relationship to customer satisfaction in an easy to understand graphical format. It provides insight into product attributes that are perceived as important by the user population. It is an excellent tool for helping design and quality teams to focus on product features that will set them apart from their competitors. Additionally, the model helps product developers to concentrate on simultaneous design of product families rather than focusing on one product at-a-time.

In the 'Design for Manufacturing' course, students learn the Kano analysis and some students do their course project using this model to a product of their interest. The paper describes the Kano model and how it can be used in product design. Even though the model can be used to define multiple products simultaneously, the content of the model in this course has been kept at a level of applying it to a single product.

Quality Attributes

Quality or attribute as used in this paper refers to a product feature that is useful to the user because of the function(s) it performs and it can be provided at a reasonable additional cost. If a feature does not provide a function at a reasonable cost, it would not be considered as a desirable attribute. This relationship can symbolically be shown as given in equation (1):

$$\text{Attribute} = \frac{F}{c} \tag{1}$$

Where F is the function provided by a product feature, and c is the cost of providing that feature in a product or service. Therefore, the customer satisfaction, as is generally understood, implies the usefulness of a product feature vis-à-vis the marginal cost of providing the attribute in a product or service. The value of an attribute as seen by customer is intertwined with the cost of having the attribute. It therefore becomes necessary at a product development stage not to pursue providing a function deemed attractive by the customers but the cost of that function is prohibitively high. Additionally, attributes may not be of equal importance to all customers.

The first step in product development is to identify the quality characteristics that could typically be vague and nebulous. These are referred to as the voice of the customer (VOC). After the VOC is understood, an attempt can be made to translate it into features or attributes. Once what is important to the customer is identified, the Kano Model can be used to prioritize the attributes.

Kano model

Kano model is a quality measurement tool used to prioritize customer requirements based on their impact to customer satisfaction. The results can be used to prioritize company efforts in satisfying different demands.

Kano stated that there are five categories of customer requirements of quality attributes as shown in Figure 1 [1, 2, 3]. The model can be visualized on an (x, y) graph, where the x-axis represents how good a product or service is functional in meeting the customer requirements. The y-axis

records the customer's level of satisfaction as a result of the level of functionality achieved by a feature.

The five quality attribute categories are[1, 2, 3]:

1. Must-be attributes: Must-be attributes are taken for granted when fulfilled but result in dissatisfaction when not fulfilled. Since customers expect these attributes and view them as basic, it is unlikely that they are going to remember or tell these to a company when asked about attributes in traditional surveys. These attributes are also known as "basic needs" or "basic quality" that customers unconsciously expect in a product or service (the lower curve in Figure 1), such as a product meeting EPA or FAA or UL or other industry standards and governmental regulations. Attaining high levels of customer satisfaction is hard to achieve by excelling in these areas alone.

   The absence of these factors will lead to customer dissatisfaction and can result in complaints and/or lost business. Whatever the quality characteristic is, it must be present, such that if it is not, the customer will be lost. If these basic needs are not met, the result is devastating to the reputation of a business. Customers will express violation of basic quality attributes by complaining. In industry, basic quality is typically measured by customer complaints, warranty data, product recalls, and other such reports.

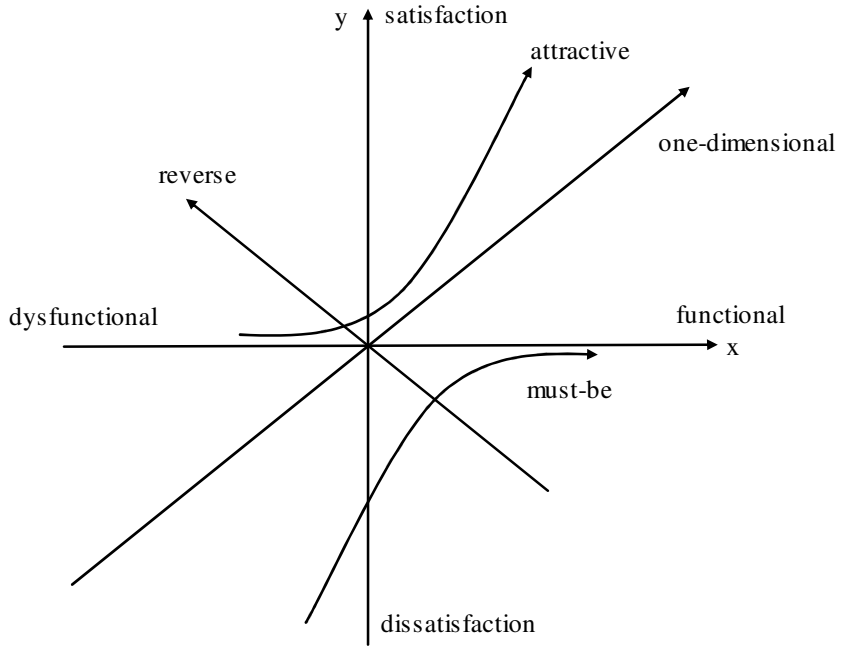

Figure 1. Kano Diagram of Attributes and Customer Satisfaction.

2. One-dimensional attributes: One-dimensional attributes result in satisfaction when fulfilled and dissatisfaction when not fulfilled. These attributes are spoken of, surveyed and measured, and are those with which companies compete. These attributes are also known as *performance* attributes. Companies normally focus their efforts on these attributes using tools such as, market surveys, focus groups, VOC matrix, or through beta tests.

Performance quality attributes generally cause a linear response, that is, generate satisfaction proportional to the performance of the product.

3. Attractive attributes: Attractive attributes can be described as surprise attributes; they provide high-levels of satisfaction when achieved fully, but do not cause dissatisfaction when not fulfilled (the upper curve in Figure 1). These are attributes that are not normally expected. Since these types of attributes are not expected, they are often not spoken of. Customers generally do not articulate surprise attributes in customer surveys, because they do not know that they want them. Hence, this category is often neglected as there is a tendency to focus on *performance* attributes.

   Unlike the must-be attributes, small improvements in providing surprise attributes cause relatively large increases in satisfaction. In competitive situations when products or services provide similar performance, addressing the attractive attributes that delight customers can provide a competitive advantage. In order to generate customer excitement and brand loyalty, companies must leverage their creative resources to identify ideas and innovations that cause customer excitement.

4. Indifferent attributes: Indifferent attributes refer to aspects that are neither good nor bad, and, consequently, they do not result in either customer satisfaction or customer dissatisfaction.

5. Reverse attributes: Reverse attributes arise when customers are dissatisfied with the presence of an attribute and satisfied by the absence of the attribute. This reversal in requirement of an attribute may be due to the fact that not all customers are alike. For example, some customers prefer using manual transmission vehicles rather than go for automatic transmission ones even if they are available at a reasonable additional cost.

The attribute categories can be symbolically summarized as given in equation (2). Thus, relationship similar to equation (2) can be developed for different customer segments:

$$\text{Product Characteristics} = \frac{F_{must-be}}{C_{must-be}} + \frac{F_{performance}}{C_{performance}} \pm \frac{F_{attractive}}{C_{attractive}} \pm \frac{F_{reverse}}{C_{reverse}} \qquad (2)$$

Application of Kano Analysis

Kano's model employs a specific questionnaire format since the type of customer requirement cannot be detected by traditional customer surveys. In order to detect the types of the product or service characteristics, attractive (A), basic (B), and one-dimensional (O) requirements are identified through a specially designed questionnaire that contains a pair of questions for each product characteristic. The question pair includes one functional and one dysfunctional form of the same question and this provides deeper understanding of the customer's opinion about the product attributes. The functional form of the question provides the customer's reaction if the product has a certain characteristic. On the other hand, the dysfunctional form identifies the customer's reaction if the product does not have that characteristic[2].

1. Functional: Rate your satisfaction if the product has this attribute (at a specified cost), and
2. Dysfunctional: Rate your satisfaction if the product does not have this attribute.

Table 1 shows the relationship between the quality attributes and the customer responses to the two paired questions[1].

Table 1. Kano Quality Attributes Resulting from Customer Responses to Paired Questions.

Attribute State	Functional			
Dysfunctional	**Customer State**	Dissatisfied	Neutral	Satisfied
	Dissatisfied	*Inconsistent*	*Must-Be*	*One-Dimensional*
	Neutral	*Reverse*	*Indifferent*	*Attractive*
	Satisfied	*Reverse*	*Reverse*	*Inconsistent*

Both forms of the question include at least three different response options for the customer to choose from as represented by the states of the customer in Table 1:
A. Satisfied.
B. Neutral.
C. Dissatisfied.

Used together, the answers to both questions provide understanding on the Kano category for each product feature. Must-be attributes generally receive the "Neutral" response to Question 1 and the "Dissatisfied" response to Question 2. One-dimensional attributes generally receive the "Satisfied" response to Question 1 and the "Dissatisfied" response to Question 2, and attractive quality attributes receive the "Satisfied" response to Question 1 and the "Neutral" response to Question 2. This often requires a trade-off analysis against cost. As customers frequently rate most attributes or functionality as important, asking the question "How much extra would you be willing to pay for this attribute or more of this attribute?" will aid in trade-off decisions.

The customer responses can then be put into three sets of attributes, *i*, *j*, *k*, and *r* representing the characteristics that fall into the three quality attributes – basic, one-dimensional, attractive, and reverse (R) as shown below:
$(\text{Product Characteristics})_i = [\mathbf{B}]$; $(\text{Product Characteristics})_j = [\mathbf{O}]$;
$(\text{Product Characteristics})_k = [\mathbf{A}]$; $(\text{Product Characteristics})_r = [\mathbf{R}]$
Design and quality engineers can then develop multiple product models based on an appropriate combination of the four distinct requirements of product characteristics.

The information obtained from the Kano analysis, specifically regarding one-dimensional and attractive attributes, provides valuable input for other six-sigma tools such as, Quality Function Deployment process. For making changes in an existing product or service, six-sigma professionals first analyze the efficacy of the product or service in terms of customer satisfaction

levels in must-be and one-dimensional. Changes that offer maximum benefits are then selected and implemented using standard six-sigma tools and techniques.

Since respondents may not rate all attributes included in the questionnaire in these categories, other classifications are also possible such as indifferent (I), questionable (Q), and reverse (R). Indifferent (I) means that the customer is indifferent to this product attribute and is not very interested in whether it is present or not. A questionable (Q) rating indicates that the question was phrased incorrectly, the customer misunderstood the question, or an incorrect response was provided. Reverse (R) means that, not only do the customers not desire that product attribute, but they also expect the reverse of it[2].

Two-dimensional Approach

In traditional customer satisfaction analyses, linearity is assumed between product performance and customer satisfaction. For example, customer satisfaction is assumed to increase or decrease linearly when the product performance is improved or weakened respectively[3]. However, increasing fulfillment of customer expectations does not always mean a proportional increase in customer satisfaction since this change also depends on the "type" of the expectation.

The Kano model is very useful in providing a level of sophistication not available in a one-dimensional model of quality. But, Dr. Kano has integrated quality along two dimensions as has been shown in Figure 1:
(1) The degree to which a product or service performs, and
(2) The degree to which the user is satisfied.

Other Considerations in Kano Analysis

It has also been observed that customers' requirements change over time. Sources of excitement when they were first introduced tend to become expected as the market becomes familiar and saturated with them. In time, attractive quality will become a one-dimensional quality, and, with the passage of time, quite possibly a basic requirement[3].

Kano model can be used to help identify customer segments, based on the relative priority of each segment's requirements of product characteristics. It is therefore possible to develop product families, such as basic, entry-level, advanced products, rather than designing one product at a time. This helps in shortening of product development time.

This approach has the potential to help businesses achieve market success by providing satisfactory products to the customer at different levels and at different costs related to the sophistication of their features. Therefore, it can streamline and improve product development cycles while satisfying customers in various segments.

Conclusion

Kano analysis is a quality measurement tool used to prioritize customer requirements based on their impact to customer satisfaction. Doing a Kano analysis has now become a necessity for

most six-sigma teams to develop best quality products or services because competition has increased manifold in today's globalized world where customers have become more demanding and are more critical of the quality.

Using Kano model, companies approach product development by simultaneous design for multiple products and by accurate identification of customer needs. To help businesses achieve these competitive goals, this study proposes using Kano's model to be introduced in product design, quality, and manufacturing-related curriculum.

This model was taught for the first time in fall 2008, and the overall student feedback was positive in learning this methodology of product design. Some of them selected to use this model in their class project. Where product or service design is taught, Kano model is one of the important models to be included in the course curriculum.

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