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Quality Function Deployment Integration with Kano Model for Ergonomic Product Improvement (Classroom Furniture) - A Review

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***Abstract*— Classroom furniture development and improvement needs effective tools especially whenever it comes to have the need of better ergonomically designs while satisfying users. The designing aspects needs to involve various techniques and tools as the way to get high satisfactions towards the users. In order to achieve such goal, it is much advisable to apply integration of techniques like Kano`s Model, Quality Function Deployment without ignoring ergonomics principles. Integration of these techniques enhances customer-oriented design classroom furniture. It must be noted that, Quality Function Deployment is having a major challenge of capturing and understanding thoroughly the customers' needs while Kano`s Model , which studies the nature of customer needs is able to generate a new way for Quality Function Deployment to develop a better understanding of the needs from users. Therefore, integration of Quality Function Deployment, Kano Model and Ergonomics Principles can help to understand the needs of users, satisfy students who spend six to eight hours per day and solve ergonomically design problems in the long run usage of the classroom furniture.**

Keywords— Kano`s Model; Quality Function Deployment; Classroom Furniture;

INTRODUCTION

It is no longer uncovered issue that quality of products (classroom furniture) and services is the major concern for companies which compete in today`s competitive market while trying to achieve high market share of satisfied and delighted customers (users). The habit of companies not trying to satisfy customers can be achieved only for the products or services which are still under monopoly type of market, otherwise all companies need to produce or serve high quality products and services respectively [1]. Currently major companies cannot continue to rely on the strategy of high volume of products and low cost of production, instead companies need to make classrooms furniture which are of high quality [2]. This way can make customers become much satisfied and if possible become delighted as the modern way of attaining large market share.

Despite that various companies can have different way of defining quality, there is a general view that quality does not just mean defect-free. According to Armand V. Feigenbaum, he said that "Quality should begin by identifying the customer`s requirements and ends with a product or service in the hands of satisfied customers" [3]. This shows that whenever companies are defining quality standards then they must make sure that the customers' (users) requirements are well satisfied as one of the key towards remaining in the competitive market.

KANO`S MODEL

Kano model was first proposed by Professor Noriaki Kano and his colleagues in 1984 [4]. Professor Kano pointed out on how it is important to find each attribute performance impacts on satisfaction. Also he said that all product or service attributes have same role in satisfying customer (users) needs. Kano developed foundation for an approach on "Attractive Quality Creation" which is commonly referred as the "Kano Model" and then challenged traditional Customer Satisfaction Models that "More is better", i.e. the more someone can perform on each service attribute the more he or she satisfies the customers (users).

Reference [5] explained the way Kano model introduced the theory of attractive quality, which proposed several perceived quality attributes on the basis of the relationship between the degrees of fulfilment of a quality attribute and customer satisfaction with the quality attribute. This model has been extensively applied as a useful tool for understanding the customers' needs and meeting their satisfactions [6].

The presence and performance of many product features can bring more customer satisfaction if they can be able to meet certain customer needs after

being stated before designing or manufacturing the product. Therefore, it is important to determine all important customer requirements for easy satisfaction of their needs [7]. Now, since customers cannot express all his or her desired product attributes, therefore it is necessary to use some techniques in identifying all relevant customer requirements. The Kano model is one of the best techniques and most effective in categorizing customer requirements [8].

There are three major categories of requirements which can influence user satisfaction in different ways [6][9][10][11][12].

i. *Basic attributes (dissatisfiers or Must-have)*; these are the minimum required features that customer naturally expect from a product or service for fulfilling the basic functions of a product. If they are not present or their performance is insufficient, customers will be extremely dissatisfied. On the other hand, if they are present or have sufficient performance, they do not bring satisfaction. Customers see them as prerequisites [11] [6][9][13]. For example presence of writing space on classroom furniture.
ii. *Performance attributes (one-dimensional attributes)*; these attributes produce both satisfaction and dissatisfaction depending on performance levels, and satisfaction is proportional to the level of fulfillment of these attributes [11] [6][9]. For example Gasoline consumption of a car, lower consumption leads to higher customer satisfaction.
iii. *Excitement attributes (satisfiers or Attractive)*; these attributes are key factors for customer satisfaction. They can produce satisfaction when delivered but cause no dissatisfaction if not delivered and high performance on these has a greater impact on overall satisfaction rather than low performance [11][6][9]. For example (unexpected) promotional offers during classroom furniture selling process. These attributes are neither demanded nor expected by customers.

There are other two other attributes which can be identified in the Kano model namely: neutral and reverse attributes. For Neutral attributes, customers would be indifferent whether the quality is present. For reverse attributes when present, customers would be dissatisfied, and vice versa [9][14]. Reference [15] provided an example related to real estate customers that, “some real estate customers may view having large windows in a house as a reverse requirement and want smaller windows instead for energy-saving concerns”.

This major categories of requirements for products or services can be expressed by Fig. 1 whereby it shows degree of achievement for each part. In the same Fig. 1, there is a section for very satisfied and dissatisfied, attractive, one-dimensional, reverse, must be and indifferent.

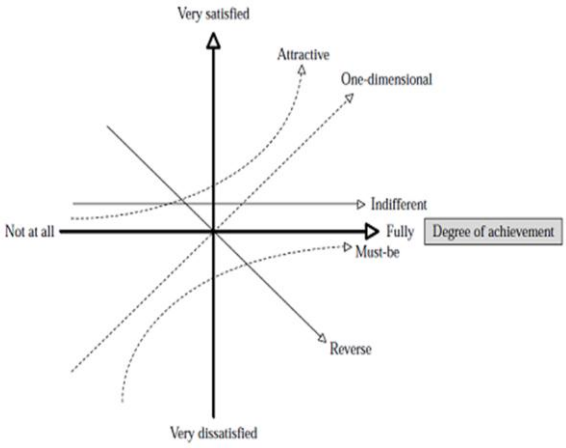


Fig. 1. *Kano Model* [9]

Advantages of Kano`s Model

Reference [16] summarized the advantages of Kano`s Model as follows:

i. Product requirements are better understood through Kano Model. This can be achieved by identifying the product with high influence to customer`s satisfaction. Hence leads to classification of Basic attributes (dissatisfiers or must-have), performance attributes (one-dimensional) and excitement attributes (satisfiers or attractive) [17].
ii. Must-have, one-dimensional and attractive attributes differ, as the rule, in the utility expectations of different customers segments. Then from this starting point, customer-tailored solutions for special problem can be elaborated, which can guarantees an optimal level of satisfaction in the different level of customer segments.
iii. Kano's model promotes discovery and fulfilment of attractive attributes for creating a wide range for possibilities of differentiation. A product which merely satisfies the must-have and one-dimensional requirements is perceived as average and therefore interchangeable.
iv. Kano's model provides valuable guidance in the following trade-off situation: If two product attributes cannot be promoted simultaneously due to economic or technical causes, the attribute with greater importance on customer satisfaction, can be identified.

Kano model can ultimately be integrated with QFD for optimally identifications of customer’s needs, their hierarchy and priorities [18].

QUALITY FUNCTION DEPLOYMENT (QFD)

QFD is defined as a methodology that "converts user demands into substitute quality characteristics (quality characteristics), determines the design quality of the finished good, and systematically deploys this quality into component quality, individual part quality and process elements and their relationships" [19]. References [20][21] explained QFD as a powerful tool in translating the voice of customer (VOC) to fulfils customer satisfaction. QFD has been widely applied to achieve customer needs and improve customer satisfaction in many fields [22][23].

QFD is a cross-functional planning tool which can be used to deploy the voice of the customer from product planning, design, engineering and manufacturing into a final product [24][25]. It follows under concurrent engineering and encourages teamwork to work towards a common goal of ensuring customer satisfaction[26]. Since the voice of the customer is much important, hence there is a need of making the house of quality (HOQ) to converts each customer need into one or more technical characteristics (Technical descriptors) [5][27][28]. The main goal of HOQ is to identify customer needs and weights for the product (WHATs) and then to convert these needs into technical characteristics (HOWs) [3][29][30][31].

Reference [32] shown on how customer requirements (CRs) play a vital role in the design of products and services. Hence in order to build good QFD, it is mandatory to capture all necessary customers' requirements without ignoring any among the most important requirements. This should be done for the aim of creating mutual benefit through high satisfaction to the users of the manufactured or designed product as well as getting benefit to the focal firm (manufacturer or designer).

The Customer requirements (CRs) or voice of customers (VOCs) can be captured in the various ways as follows [33]:

- Define direct discussions or interviews with customers or users of the intended product
- Surveys using well prepared questionnaires
- Focus groups which involve many participants
- Customer provided specifications while submitting design
- Direct observation at the targeted place
- Warranty data analysis
- Field reports which be prepared by the people who can visit customers or users and then prepare the report for documentation and so forth.

INTEGRATING KANO`S MODEL INTO QUALITY FUNCTION DEPLOYMENT (QFD)

One of the big challenge of QFD implementation is the difficulties in collecting, understanding and organizing customer requirements [15]. The integration approach of Kano's model and QFD involves a series of activities, from classifying customer attributes to evaluate the priority analysis of technical characteristics [34][35]. Various researchers have recommended some techniques on how to QFD can be enhanced, whereby surveys, focus group, questionnaire and interviews can be used as the traditional ways of collecting customer requirements and to identify the degree of importance for each customer requirement [11][36]. The integration of Kano Model and QFD help furniture designers to ensure that all critical customers' needs are well identified and incorporated into the design [37]. Fig. 2 shows an integrative framework for QFD and Kano Model.

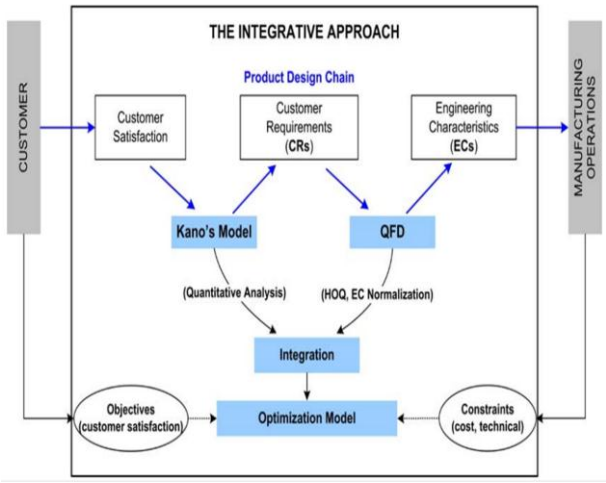


Fig. 2. The Integrative Framework for Quality Function Deployment and Kano Model [38]

Fig. 2 is an illustration of integrated approach which shows a bridge between manufacturing operations or designers operations and customers in the product design process through an integration of Kano`s model into Quality Function Deployment. This integrative approach can be applied in any designing process which requires to achieve high customer satisfaction. Classroom furniture manufacturer and designers can also apply same approach for the aim of understanding thoroughly all necessary users' requirements for better satisfaction during usage of the manufactured furniture.

This can be achieved by following furniture design process which should start by categorization of general user`s requirements satisfaction into individual customer requirements satisfaction through Kano`s Model and translate the customer`s requirements (CR) against engineering characteristics (EC) for manufacturing operation whereby ultimately should be done through QFD analysis.

In today life, there is high increase of integrating various tools or techniques especially in designing aspects whereby the traditional way of designing product is no longer preferable. According to reference [39], the integration of QFD with other techniques can indeed provide the solution to the problem related to integrating ergonomics into product design while satisfying users.

CASE STUDY – A BRIEF REVIEW ON FURNITURE

Methodology for capturing and analyzing Customer Requirements involves the following five major steps.

Step 1: Identification of classroom furniture requirements; Questionnaire or interviews for 20–30 % in homogeneous segments are suffice to capture 90-95% of all necessary classroom furniture requirements [16]. Table I shows the factors with their corresponding qualities and descriptions for each one for classroom furniture.

TABLE I. QUALITY CLASSIFICATION

Factor	*Quality*	*Description*
Size	Broad work surface	Size of the working table to be shared by Two
	Workbench height	Suitable for variety of body sizes
	Stool or chair height	Suitable to work with a fixed working table height
Design	Adjustable furniture	Some suggest to be implemented to the workstation
	Pen holder and bag	Temporary place to put books and bag
Comfort	Leg room	Enough space for leg position
	Back rest	Enough recommended tilt angle for back rest
	Foot rest	A support on which to rest the feet
Safety	Stable workstation	The workstation must be sturdy and robust in design
	Smooth seat pan	Smooth materials should be used
	Safety design	No sharp edges

Source: Partially adapted from [20].

Step 2: Construction of Kano questionnaire, measure classroom furniture attributes based on functional (positive) questions statement and dysfunctional (negative) questions statement. According to reference [40], questions design are like "I like it that way", "it must be that way", "I am neutral", "I can live with it that way", "I dislike it as it is clearly shown in Table II specifically for classroom furniture [4]".

TABLE II. FUNCTIONAL AND DYSFUNCTIONAL QUESTIONS [40]

Functional form of the question (Positive)	If the classroom desk is adjustable, how do you feel?	I like it that way
		It must be that way
		I am neutral
		I can live with it that way
		I dislike it that way
Dysfunctional form of the question (Negative)	If the classroom desk is not adjustable, how do you feel?	I like it that way
		It must be that way
		I am neutral
		I can live with it that way
		I dislike it that way

Step 3: Analysis which measures importance and satisfaction level of classroom furniture from users. It is much important to know the importance and level of satisfaction as from Table IV for each user requirements. From Table III it indicates the combination of positive and negative questions of Table II's. Questionnaires to construct Kano's product requirements are like must-be, one-dimensional, attractive requirements as well indifferent and questionable requirement.

For example, if the customer answers "I like it that way" as regard "If the classroom furniture is adjustable, how do you feel as a functional question; and answer "I am Neutral" as regard "If the classroom furniture is not adjustable, how do you feel" as the dysfunctional questions then the combination in the Table III indicate "A" as an Attractive customer requirements and so forth.

TABLE III. KANO'S EVALUATION MATRIX OF PRODUCT REQUIREMENTS [41][42].

Customer (Users) requirements		**Dysfunctional (Negative)**				
		Like	Must	Neutral	Can live with it	Dislike
Functional (Positive)	Like	Q	A	A	A	O
	Must	R	I	I	I	M
	Neutral	R	I	I	I	M
	Can live with it	R	I	I	I	M
	Dislike	R	R	R	R	Q

Note:
Q= Questionable response, A= Attractive,
O= One–dimensional, I= Indifferent, M= Must-be,
R= Reversal (inconsistence response)

TABLE IV. IMPORTANCE AND SATISFACTION LEVEL [41]

	How Important is this item	How do you rate the present furniture
Customer (Users) requirements	1. Extremely Important 2. Very Important 3. Important 4. Not Important 5. Not very important	1. Not available 2. Poor 3. Fair 4. Good 5. Very Good 6. Excellent

	1	2	3	4	5	1	2	3	4	5	6
1.											
2.											

Step 4: Evaluation and Interpretation, this be done according to frequency. This step can clearly be referred from Table V which should shows customer satisfaction coefficients after having the percentage of replies through the use of prepared questionnaires.

TABLE V. FORMAT OF CUSTOMER SATISFACTION COEFFICIENT [40]

Furniture requirements	Percentage of replies							Category	CS	CD
	A	O	M	R	Q	I	Total			
1										
2										

According to reference [43], there are relationships which was developed for calculating customers satisfactions and dissatisfactions as given by equations (1) and (2) [41][44][7].

Customer Satisfaction (CS)

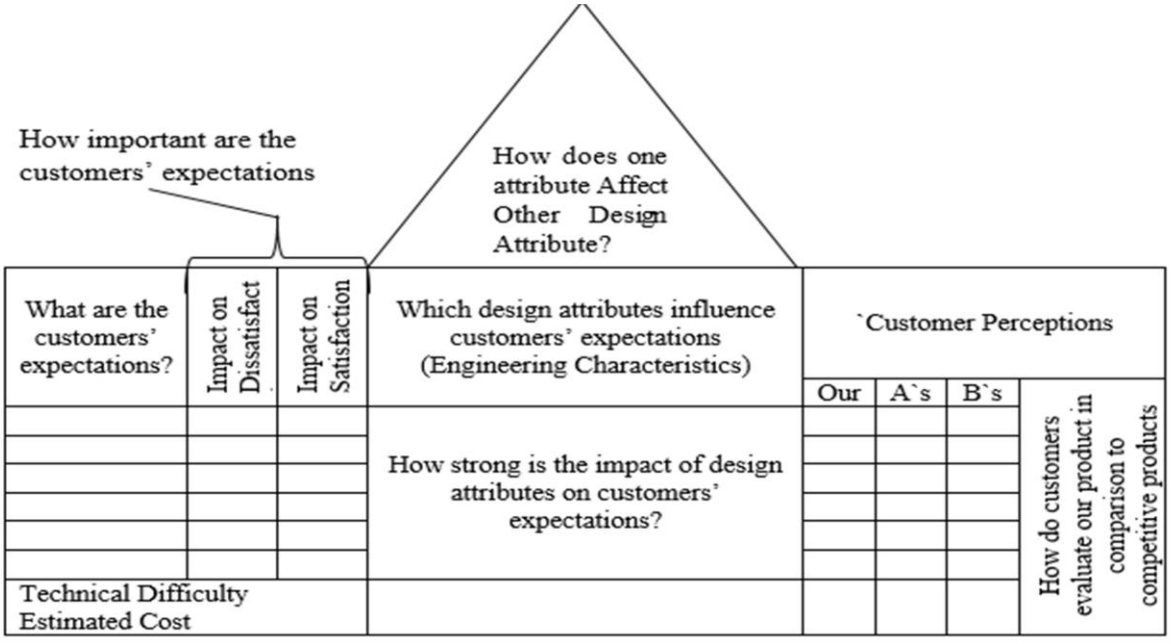
$$\text{CS (better)} = \frac{A+O}{A+O+I} \quad (1)$$

Customer Dissatisfaction (CD)

$$\text{CD (better)} = -\frac{O+M}{A+O+M+I} \quad (2)$$

In computing customer dissatisfaction, the minus sign is being put for the aim of emphasizing its negative influence on customer satisfaction whenever the product quality is not fulfilled [16].

Step 5: This step involve construction of combined QFD with Kano Model which be done by the use of House of Quality as it can be refereed in Fig. 3. In this Fig. 3 there is combination of both QFD and Kano Model. On the side of Kano Model there is involvement of Impact on Dissatisfactions and Impact on Satisfaction which are clearly being taken from Table V. In the way to compute, it is compulsory to get customer perception by comparing the company product (Our) with other two competitors' products (A`s and B`s) whereby ultimately this will show how customers evaluate our product compared to competitive product.



Source: Partially adapted from [20][16]
Fig. 3. House of Quality development

The higher the value in Customer satisfaction, CS (better), the higher the better in competitive advantage in the perceived classroom furniture quality from the customer`s view point, the higher the Customer dissatisfaction, CD (worse) the higher the better in competitive disadvantage. Therefore it is important to improve this classroom furniture requirements.

Advantages for Integrating Kano`s Model and Quality Function Deployment

The integration of QFD with Kano`s Model have many advantages with regard to understanding the customer-defined quality [16]. First, it help deeper understand of customer requirements and problems. Second, trade-of within product developments can be managed effectively. Third, help to start with fewer problems. Fourth, competitive analysis is easier hence it improve market research [25]. Firth, reduced development time and planning [10]. Sixth, facilitate effective communication within department (divisions). Lastly, help to build quality in upstream.

LITERATURE OVERVIEW

An overview of the reviewed literature on the Kano model and QFD is given in Table VI, with information on how the authors defined the Kano Model as Important Performance Analysis (IPA), Customer Requirements (CR), Customer Satisfaction (CS), Kano Model (KM), Quality Function Deployment (QFD), and Model of Quality (Q).

TABLE VI. SUMMARY OF LITERATURE REVIEW ON KANO`S MODEL (WITH OTHER TECHNIQUES)

Authors and Year	Industry or Product or Service	Assessment of Kano Quality elements	Model Type
Kano et al, 1884	Technical Products	KM	Q
Berger et al. 1993)	Technical Products	KM	CR
Zhu et al. 2010)	Digital Camera	IPA, CS and KM	None
Xu et al. 2009	Dashboard in automotive design	KM	Analytical Kano (A-Kano)
Hashim & Dawal 2012	School workshop's workstation design	KM and QFD	CR
Yuan & Guan 2014	Wheelchairs	AHP and KM	Personalizing the design
Hsu et al. 2007	Analysis for Service Quality	KM and QFD	Customer Satisfaction
Mikulic & Prebežac 2011	-	PRCA	-
Gard & Kumar 2014	A Case Study	QFD	Flexible framework
Sulisworo & Maniquiz 2012	Healthcare Service Quality	SERVQUAL and KM	Customer satisfaction improvement
Sauerwein et al. 1996	Sports Industry	KM	How to Delight customer
Paraschivescu & Cotîrleț 2012	-	KM	Theory of attractive quality
Berger et al. 1993	-	KM and CR	Customer-defined quality
Wu et al. 2010	3C retailers	IPA and KM	dimensional view of quality
Kuo 2004	Web-community service	KM	Q
Tan & Pawitra 2001	Tourism Industry	SERVQUAL, QFD and KM	Service excellence development
Saadon 2012	-	SERVQUAL, QFD and KM	Service Quality Model
Llinares & Page 2011	Kansei Engineering	Regression analysis and KM	Influences the property purchase decision

3C = (computer, communication and consumer electronics), AHP = Analytic Hierarchy Process, SERVQUAL = Service Quality Model, PRCA = Penalty-reward-contrast analysis

CONCLUSION

In this review paper, the authors have tried to show on the way Kano Model can be integrated with QFD as the best way to capture customer (Users) requirements for achieving high satisfactions. It is now clear on the way integration of QFD and Kano Model can be done for better capturing all necessary customer requirement and hence help to design the classroom furniture from the customer`s perceived view point. Whenever the designer or company is aware on how extent does the customer be satisfied and to what extent does the customer be dissatisfied, then it is easy to make suitable actions or measures so as to capture large market share after taking the required measures. Same application now can be applied in designing classroom furniture by considering much the users of the classroom furniture since they are the one who can use them.

In today's life it is advisable not to ignore any important users requirements, failure to do so can result to dissatisfaction of customers or users. For the effective implementations of Kano`s Model integration with Quality Function Deployment, it is better to be integrated with ergonomics design for enhancing customer satisfactions while reducing all risk of getting un ergonomic related problems. As the result the integration of Quality Function Deployment, Kano Model and Ergonomics Principles can help to satisfy students who spend six to eight hours per day and ultimately solve ergonomically design problems which might have to occur if the students use the classroom furniture in the long run.

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