Integrating Kano’s Model into Quality Function Deployment for Product Design: A Comprehensive Review

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Abstract: Many methods and techniques are adopted by some companies to improve the competitiveness through the fulfillment of customer satisfaction by enhancement and improvement the product design quality. Over the past few years, several researcher have studied extensively combining Quality Function Deployment and Kano’s model as design techniques by focusing on translating consumer desires into a product design. This paper presents a review and analysis of several literatures that associated to the integration methodology of Kano into the QFD process. Various of international journal articles were selected, collected and analyzed through a number of relevant scientific publications. In-depth analysis was performed, and focused in this paper on the results, advantages and drawbacks of its methodology. In addition, this paper also provides the analysis that acquired in this study related to the development of the methodology. It is hoped that this paper can be a reference for other researchers and manufacturing companies to implement the integration method of QFD-Kano for product design.

Keywords: QFD, Kano, Product Design, Integrated Methodology.

1. Introduction

Product design is very important in the manufacturing sector. Good product design will increase the amount and price, so that it can optimally increase profits. However, product designs fail to produce products that are not sold in the market. It will cause losses not only in design, other areas will also be affected. The design of new or existing products is a major part of all engineering activities. This activity is derived from the perception of human needs, followed by product formation, product design, product development and refinement, and end up with the production and distribution of such products. Product design must meet three important aspects that are often called the triangles of quality product, low cost, and schedule. Next, these aspect are developed to be a requirement in design, the design must be installed, recycled, manufactured, analyzed results, low cost, and exact time. Therefore, in designing a product, it can be done using several product design methods.

Ideally, the company develops products to understand customer needs, so they can develop products to be sold [1]. High quality products is a prerequisite for companies to competitive [2]. In addition, in order to get competitive in the market, it is imperative that products are quickly available in the market and have high reliability at the lowest cost [3]. Therefore, companies need to develop strategic goals, based on achievements [4]. The main factor in product innovation creativity is the development of methodologies, design methods developed for product development and design in various fields [5,6,7,8]. Many academic practitioners and researchers have proposed many design principles and methods to improve the quality of design, and some design methods are implemented as
part of the design activities of some manufacturing companies [9]. Quality Function Deployment (QFD) is one of the widely used approaches today. It can drive a product development process from conception into manufacturing. It is a well-structured methodology and technique tool that combines customers’ requirements with technical requirements which aids designers and manufacturers to produce better products, enhance their competitiveness in the marketplace, and increase customer satisfaction [10,11,12,13,14].

On the other hand, the various problems faced at several stages of QFD implementation, have been widely reported in the study, in particular the traditional QFD method [15,16]. First, The methodological framework of the conventional QFD method is no longer suitable to meet the design and product development requirements [12,9,17,18]. Second, The QFD matrix is too large and Third, the time required for the matrix sequence deployment is too long and the product time to be marketed is not acceptable [19,20]. Then fourth, QFD is difficult to meet the needs of different customer groups or segments [21]. Fifth, customer voice is still qualitative, cannot be measured and often misleading, it is not systematic and the terms of product function too complex (in this case, engineering process) are not easily determined [22]. Sixth, the customer’s requirement translated into engineering terms (technical requirements) obtained from the company is still vague, too subjective, difficult to verify and expressed in linguistic form [23,24,25]. These problems or drawbacks prompted the need for other approaches to be added when applying the QFD method. There are many different methods for generating new ideas and selecting the ideas in order to create a new design or to improve existing ones. Combining QFD with other techniques helps to address these drawbacks and can form the basis of future research. The integrated innovation method, which combines QFD with another technique tool, can precisely solve main contradictory problems in the process from the product demand analysis to the product design, production and application [26].

2. Methodology.

As it could be seen in Fig. 1, shows a flowchart of the methodology, and five majors are taken into account to provide the literature review of this paper. The method and year of publication are the parameters taken into consideration. A screening process to restrict the articles pertaining to combined Kano with QFD. As a result, a total 49 articles were selected from the following nine journals, reviewed and further analysed: Production Research Journal, Institute of Electrical and Electronics Engineers Journal, Journal of Applied Operational Research, Industrial Management Journal, International Journal of Operations and Production Management, Computers and Industrial Engineering Journal, International Journal of Ergonomic, Journal of Engineering Education.

This paper focuses and considers on only journal articles whose goal was to either develop theoretical–concepts work, or reviews of the literature and a case study.
3. Literature Review

3.1. Kano’s Model

The Kano method was developed by the professor of Kano in the early 1970s to determine the quality of service based on customer satisfaction. As shown in fig. 2.1, in the Kano method, customer requirements are categorized into three groups, namely the basic element, performance, and quality desired [27]. It is based on customer perception and understanding the relationship between product function and customer satisfaction. [28], [29] said that the Kano’s model is generally used to acquire knowledge about the needs of customer[30,31].

![Kano's model of Customer Satisfaction](image)

Figure 1. Kano’s model of Customer Satisfaction

There are several basic elements of the Kano in product development and customer satisfaction, and the Kano model classifies customer preferences into five categories such as attractive, one-dimensional, must-be, indifferent and reverse. [32]. In the Kano’s model, the intent of the quality is attributed to the goal that is actually achieved and these attributes are usually expected. One-dimensional quality features are attributed to quality features that satisfy customers when their expectations are met, and vice versa. Characteristics of quality must be attributed to the attributes that must be met but may result in discomfort if not fulfilled [33].

3.2. Quality Function Deployment (QFD)

QFD was developed in 1996 by Yoji Akao in Japan, and it has been recognized as an effective method for integrated products and process development. QFD is a structured approach to integrate customer voices into design/development products [34]. It is applied in many industries such as automotive, electronics, construction and service sectors. QFD is implemented as a multi-process process, offering the greatest potential to realize significant benefits [35]. The purpose of QFD is to increase customer satisfaction based on customer needs as well as to increase company profits. For the development of new products, QFD is a useful approach to maximize customer satisfaction [36]. In other words, QFD is a tool for changing customer requirements into product design [37]. The common real benefits when the true QFD is used is a 30-50% reduction in engineering changes, a 30-50% shorter design cycle, 20-60% lower start-up costs, and a 20-50% less security claim [38]. Although QFD has been proposed and put in use for several decades, it has been fraught with a number of problems in real application cases. Some of the weaknesses and limitations that have been done by researchers based on the decision of some studies related to the application of the QFD method can be seen in Table 1.

| References | Drawbacks |
|------------|-----------|
| [24]       | The correlation between technical requirements, the relationship between customer needs and technical requirements is often expressed formally in subjective and vague terms and the Variables are linguistic |
| [12]       | Customer needs are often contrary to technical requirements, conflicts between technical measures, and HoQ are too large and cause excessive confusion. |

Table 1. Introduction to the Drawbacks of QFD.
Customer voice is dynamic, and inadequate.

It is not possible to translate individual desires into collective customer demands and the impossibility of translating customer requests into engineering features without the need to violate one or more highly sensitive states.

Determining the exact relationship between customer's desire and technical requirements and amongst technical requirements is done in a subjective. It is because the information, guidelines, and materials that will be used to determine the relationship are often limited and incomplete.

QFD does not fully guarantee customer satisfaction, as activities such as re-designing a product depend on the designer’s interpretation and talent.

The QFD relies heavily on the results of the study. If the study is designed or done poorly, the QFD implementation will not meet its purpose.

4. Integrated Methodology.

The effort to respond to the needs of customers and to compete competitively, various decision-making methods have been developed [45]. For more accurate understanding and identification of customers' needs, the Kano’s model can help QFD in identifying and quantifying customer need. Kano provides an effective approach by classifying product attributes based on customer perceptions and understanding the relationship between product function and satisfaction. [7]. Therefore, in order to better understand and obtain more precise customer requirements, the use of the Kano model has been incorporated into QFD analysis by some researchers. To obtain more accurate, effective and objective customer data or VoC data. [48] suggested that Kano quantitative models be integrated into the QFD method. [6] Argued that an integrated approach involving the Kano and QFD involves a series of activities, from classifying customer traits to prioritizing technical feature priorities. Furthermore [33] said that this combination provide a unique way to differentiate the effects of different customer needs on customer satisfaction at an early stage of product. Table 2 illustrates some relevant literatures in the implementation of the Kano in enhancing QFD capabilities.

| References | Methods Applied in | Limitations |
|------------|--------------------|-------------|
| [50]       | Road mapping technology (TRM) with Flex Cold Start case study | The House of Quality undescribed systematically and integrate Road mapping technologies into product development processes. |
| [51]       | Web site design | This research uncategorized variable that is categorized as must, one-dimensional, simple, and attractive, and do not display conclusions about the responses of schoolchildren to the design system of the workstation and the desired furniture for the design of the repair. |
| [27]       | Notebook Computer Design | The development of a developed integration method has constraints, that is, the method of integration is difficult to apply to a completely new product that has never been introduced in the market. In addition, the product and cost development of each module are not considered in this study, and measures developed by the system are not systematic, structured and gradual, and improvements to SUV car designs through QFD integration with Kano are only performed on phase 1, not forward to the next phase, the product design phase. |
| [52]       | Workstation Design | The combination of both methods requires mathematical |
methods for selecting technical conditions to optimize the product design process

Design and Development of Pencil products

Do not explained about the validity tests for questionnaire data used and unexplained data sources in determining the technical requirements and conditions of the product.

Tractor Brake Design

This research does not categorize variables that belong to the category of must, one dimension, simple, and attractive, and do not display conclusions about customer response to the desired brake system for the design of the repair, and only focus on CS correlations and benefits.

Static Bike Design

Case study with a combination of these Kano-QFD methods does not display quality homes and the implementation of the QFD extension, so that the QFD preparation stage is not detailed in detail.

As seen in Table 2, a number of studies related to the application of Kano’s model in the QFD process are widely applied in product design, focusing on customer desires and satisfaction. In this case [50] conducted a combination of QFD method with Kano to choose whether Technology A or Technology B was able to satisfy most of the customer's needs and over achieving today's technological performance. Meanwhile, [27] prioritized the renovation elements implemented in new ergonomic workstation planning successfully identified and given priority based on information from users and technical requirements to develop modified workstations based on ergonomic approaches. Besides, [53] found that Kano divided the needs of customers into QFD into three categories that are coordinated with categories of quality initiative programs such as maintaining, improving and innovating.

A combination of QFD with Kano to provide some obstacles from previous works by using adjusting factors to improve the improvement phase of the QFD Matrix was addressed by [55]. Adaptive factors are based on satisfaction or dissatisfaction. Meanwhile, [54] through his research he argued that combinations of Kano quantitatively with QFD resulted in the optimum product design of notebook computers in maximizing customer satisfaction under constraints of cost and technical constraints. In maximizing customer satisfaction under constraints of cost and technical constraints. Moreover, [52] has successfully developed the innovative design of the new 'static bikes' and 'fitness equipments such as horse riding' have been successfully designed based on QFD combinations with Kano quantitative methods.

Although Kano method is often combined with the QFD method in many studies, it is unclear how Kano should be integrated into the QFD process. Several studies only recommend that the customer's interest is included in the line of matrix of HoQ. Meanwhile, other researchers advised to include three categories of Kano into HoQ, and then make a difference how the functional requirements generated will be disseminated. It seems as if in many years QFD researchers are talking about Kano method, but none of them really explain where Kano categories are included in the QFD process. In addition, to the integration method developed only in phase 1 of QFD (product planning phase), does not extend to phase 2 (product planning). Moreover, the steps of the integration method developed are not stage, unsystematic, unstructured and the analysis is more qualitatively and subjectively.

5. Discussion and Conclusion.

The objective of this paper is hopefully achieved as expected, which is contains the important result, such as success to improve the design of the product case study by applying the selected methods and also develop a product that have maximized value, convenience, suitable and easy to use by the consumer. Customer’s need, design requirements, product characteristics, technical operation and producing requirements become the important design procedures. These procedures are organically linked through House of Quality, so they can support the product innovation design processes.
effectively. The Kano combined QFD model is the most techniques used to explore the customer needs and engineering requirements. From the literature review investigated in this paper, the application system of integrating QFD and Kano's model has some benefits and advantages that are as follows:

- Kano integrated QFD effectively help QFD in the process of the development of product design;
- The combined QFD-Kano is one of the best ways to meet the challenge of satisfying customers' inconstant demands and then to thrive in business.
- The combination of QFD and Kano's model can be a very powerful tool for any manufacturing organization in developing new products or optimizing existing products.
- Manufacturing organizations today need to be able to apply new technology to their products and processes to be successful in the highly competitive global marketplace, and the usage of Kano in combination with QFD can help them meet this objective.
- QFD-Kano combination methodology could provide guidance and relevant information to designers on aspects that should be considered already during the product design and development process.
- The integration of QFD–Kano is one of the most commonly used techniques to deal with incomplete and imprecise information from customer.
- For understanding and more accurate identification of the voice of customer, the use of Kano can help QFD in identifying and determining the required number of customers.

However, shortcomings for this combination methodology should be noticed. First, from point of view this study and investigation of some such case studies, we have found that the respective combination used method in several studies was not tested statistically. Second, the costs of component product development are not included, and Third, systematic framework in combining methods are not described in detail.

References

[1] Khalid HM, and Helander MG 2004 A Framework For Affective Customer Needs In Product Design Journal Theoretical Issues in Ergonomics Science. Volume 5, Pages 27-42.
[2] Augusto, Paulo and Cauchick M 2007 Case Research In Production Engineering: Structure And Recommendations for Its Conduction Produção, v. 17, n. 1, p. 216-229, Jan./Abr. 2007.
[3] Lai X, Tan KC, and Xie M 2007 Optimizing Product Design Using Quantitative Quality Function Deployment: A Case Study Quality and Reliability Engineering International, 23(1), 45 – 57.
[4] Felice FD 2015 A Multiple Choice Decision Analysis: An Integrated QFD–AHP Model For The Assessment Of Customer Needs International Journal of Engineering, Science and Technology, Volume 2, No. 9, 2010, pp. 25-38.
[5] Yamashina H, Ito T, Kawada H 2002 Innovative Product Development Process by Integrating QFD with TRIZ. Journal of the Japan Society for Precision Engineering, 66(11), 1705 – 1710.
[6] Hsu CH, Chang TM, Wang SY and Lin PY 2007 Integrating Kano’s Model into Quality Function Deployment to Facilitate Decision Analysis for Service Quality. Conference on Mathematics and Computers in Bussiness and Economics, Vancouver, Canada, 19 – 21.
[7] Yeh CH, Jay, Huang CY and Yu 2011 Integration of Four-Phase QFD and TRIZ in Product R&D: A Notebook Case Study. Research in Engineering Design, 22(3), 125 – 141.
[8] Liu HT 2011 Product Design And Selection Using Fuzzy QFD and Fuzzy MCDM Approaches. Applied Mathematical Modelling. 35 (2011) 482–496.
[9] Sakao T 2013 A QFD-Centred Design Methodology for Environmentally Conscious Product Design International Journal of Production Research, 45(18–19), 4143 – 4162.
[10] Mendoza, Horacio N and Molina A 2003 Case Studies in the Integration of QFD, VE and DFMA during the Product Design Stage The Proceedings of the 9th International Conference of Concurrent Enterprising, Espoo, Finland, 16-18 June 2003.

[11] Prasad B 1998 Review of QFD and Related Deployment Techniques Journal Manufacturing System, 17(3), 221–234.

[12] Chan LK, and Wu ML 2002 Quality Function Deployment: A Literature Review European Journal Operation Research, 143, 463–497.

[13] Lai CJ, Hsu CH, Kuo HM 2012 An Empirical Study of Constructing a Dynamic Mining and Forecasting System for the Life Cycle Assessment-based Green Supply Chain. Wseas Transactions On Systems, ISSN: 2224-2678.

[14] Farsi JY and Hakiminezhad N 2012 The integration of QFD Technique, Value Engineering and Design for Manufacture and Assembly (DFMA) during the Product Design Stage Journal of Advances in Environmental Biology, 6(7), 2096 – 2104.

[15] Law HW and Hua M 2007 Using Quality Function Deployment in Singulation Process Analysis. Engineering Letters, 14:1, EL_14_1_6, (Advance online publication: 12 February 2007), pp 1 – 5.

[16] Mohammadi F, Sadi MK, Nateghi F and Abdullah A 2014 A Hybrid Quality Function Deployment And Cybernetic Analytic Network Process Model For Project Manager Selection. Journal of Civil Engineering and Management Volume 20, 2014 - Issue 6, pp 795-809.

[17] Akao Y and Mazur GH 2003 The Leading Edge in QFD: Past, Present And Future International Journal of Quality & Reliability Management, Vol. 20 Issue: 1, pp.20-35.

[18] Brad S 2004 Complex System Design Technique (CSDT) International Journal of Production Research, pp 1 – 28.

[19] Prasad B 1998 Review of QFD and Related Deployment Techniques Journal Manufacturing System, 17(3), 221–234.

[20] Kao, Su E and Wang B 2002 IQFD: A Blackboard-Based Multi-Agent System For Supporting Concurrent Engineering Projects International Journal of Production Research, 40(5), 1235 – 1262.

[21] Kim JK, Hun CH, Choi SH, Kim SH 1998 A Knowledge-Based Approach To The Quality Function Deployment Computers Industrial Engineering Vol. 35, Nos. 1-2,233 – 236

[22] Law HW and Hua M 2007 Using Quality Function Deployment in Singulation Process Analysis. Engineering Letters, 14:1, EL_14_1_6, (Advance online publication: 12 February 2007), pp 1 – 5.

[23] Zhou M 1998 Fuzzy Logic and Optimization Models for Implementing QFD Computer Industrial Engineering, 35(1-2), 237–240.

[24] Kim KJ, Moskowitz H, Dhingra A and Evans G 2000 Fuzzy Multi-criteria Models for Quality Function Deployment European Journal Operation Research, 121(3), 504–518.

[25] Fung RYK, Chen Y, Chen L and Tang J 2005 A Fuzzy Expected Value-Based Goal Programing Model for Product Planning Using Quality Function Deployment Engineering Optimization Vol. 37, No. 6,633 – 647

[26] Ginting R and Amir AY 2016 TRIZ or DFMA Combined With QFD as Product Design Methodology: A Review Pertanika J. Sci. & Technol. 24 (1): 1 - 25. ISSN: 0128-7680.

[27] Hashim AMD and Dawal SZM 2012 Kano Model and QFD Integration Approach for Ergonomic Design Improvement The 2012 International (Summer) Conference on Bussiness Innovation and Technology Management. 57, 22 – 32.

[28] Hsu CH, Chang TM, Wang SY and Lin PY 2007 Integrating Kano’s Model into Quality Function Deployment to Facilitate Decision Analysis for Service Quality Conference on Mathematics and Computers in Bussiness and Economics, Vancouver, Canada, 19 – 21.

[29] Seyedi SM, Shirazifar M, Dalvand MR and Zohdi MH 2012 Optimal Examination And Prioritization Of The Factors Affecting Customers’ Satisfaction Using Integrated Quality
Function Deployment (QFD) and Kano’s model: Case study of Shiraz’s Refah bank. 
African Journal of Business Management Vol.6 (35), pp. 9762-9772.

[30] Chen YH and Su CT 2006 A Kano-CKM Model for Customer Knowledge Discovery. Total Qual Manage 17: 589–608.

[31] Gerson T 2003 Development of Customer Needs in the QFD Using a Modified Kano Model. J. Acad. Bus. 27(5):482-500.

[32] Kano N 2001 Life Cycle And Creation Of Attractive Quality Paper presented at the 4th International QMlod Conference Quality Management and Organizational Development. Linkopings Universitet, Sweden, pp 1 – 28.

[33] Raharjo H, Brombacher AV, Goh TN and Bergman B 2009 On integrating Kano’s model dynamics into QFD for multiple product design. Quality and Reliability Engineering International, 351-363.

[34] Mendoza N, Horacio A and Molina A 2003 Case Studies in the Integration of QFD, VE and DFMA during the Product Design Stage. The Proceedings of the 9th International Conference of Concurrent Enterprising, Espoo, Finland, 16-18 June 2003.

[35] Naseri K 2014 Algorithm for Cost-optimized QFD Decision-Making Problem Evolutionary Intelligence, Volume 9, Issue 1-2, pp 21–36.

[36] Gupta S and Okudan GE 2012 Computer-Aided Generation of Modularised Conceptual Designs with Assembly And Variety Considerations Journal of Engineering Design, 19(6), 533 – 551.

[37] Pourhasomia MH, Khamseh AA and Ghorbanzad Y 2012 A Hybrid of Kano and QFD for ranking customers’ preferences: A case study of bank Melli Iran.

[38] Lai CJ, Hsu CHH, Kuo HM 2012 An Empirical Study of Constructing a Dynamic Mining and Forecasting System for the Life Cycle Assessment- based Green Supply Chain Wseas Transactions On Systems, ISSN: 2224-2678.

[39] Kao P, Su E and Wang B 2010 A Blackboard-Based Multiagent System for Supporting Concurrent Engineering Projects International Journal of Production Research (Impact Factor: 1,46), 1235 – 1262.

[40] Hung HF, Kao HP and Juang YS 2008 An Integrated Information System For Product Design Planning. Journal Expert Systems with Applications: An International Journal, 35, 338 – 349.

[41] Lim PC, Nelson KH and Tang 2000 The Development of A Model for Total Quality Healthcare Managing Service Quality Volume 10 . Number 2, 103 – 111

[42] Bouchereau V and Rowlands H 2000 Methods and Techniques to Help Quality Function Deployment (QFD) Benchmarking: An International Journal, Vol. 7 No. 1,8 – 19

[43] Partovi FY and Corredoir RA 2002 Quality Function Deployment For The Good Of Soccer European Journal of Operational Research, vol. 137 (3), pp. 642–656.

[44] Mehrjerdi YZ 2010 Quality Function Deployment and Its Extensions International Journal of Quality Science merged into International Journal of Quality & Reliability Management. Vol. 27 Issue: 6, pp.616-640.

[45] Erkarslan, Onder, Yilmaz and Hande 2011 Optimization of The Product Design Through Quality Function Development (QFD) and Analytical Hierarchy Process (AHP): A Case Study in a Ceramic Washbasin Turkish : Izmir Institute of Technolog

[46] Jaiswal ES 2012 A Case Study on Quality Function Deployment (QFD) IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) 3(6), 27 – 35.

[47] Somadatta B, Karanjekar, Ramesh R, Lakhe and Deshpande VS 2013 Integration of Quality Function Deployment and Value Engineering in Furniture Manufacturing
Industry for Improvement of Computer Work Station International Journal of Basic and Advanced Research, 124 – 132.

[48] Matzler K and Hinterhuber HH 1998 How to Make Product Development Projects More Successful by Integrating Kano’s Model of Customer Satisfaction Into Quality Function Deployment Technovation, 18(1), 25 – 38.

[49] Poel IVD 2007 Methodological Problems in QFD and Directions for Future Development Research in Engineering Design, 18(1), 21 – 36.

[50] Paula Jr GA, Trabasso LG, Souza MCF 2009 Combining the Kano model, p-Diagram and Quality Function Deployment (QFD) To Build An Adapted Technology Roadmapping (A-Trm) Process 20th International Congress of Mechanical Engineering Copyright © 2009 by ABCM November 15-20, 2009, pp 1 – 10.

[51] Chauda A, Jain R, Singh AR 2011 Integration of Kano’s Model into Quality Function Deployment Int. Journal Adv. Manuf. Technol, 53:689 – 698.

[52] Wu CZ, Wang MT, Liu NT and Pan TS 2015 Developing a Kano-Based Evaluation Model for Innovation Design Mathematical Problems in Engineering, vol. 2015, Article ID 153694, 8 pages.

[53] Suef M, Suparno, Singgih ML 2013 Quality Initiatives as QFD-Kano Technical Responses: a Conceptual Model Proceeding of Industrial Engineering and Service Science. IESS G12-1. 1 – 6.

[54] Ji P, Jin J, Wang T and Chen Y 2014 Quantification and Integration of Kano’s Model Into QFD For Optimising Product Design International Journal of Production Research Volume 52, 2014 - Issue 21 6335-6348.

[55] Telang, Samir, Vichoray and Chandan 2004 Development in Agricultural Tractor Brakes through QFD Application-A Conceptual Analysis IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 55-59 International Conference on Advances in Engineering & Technology (ICAET-2014).