iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 2 **Issue:** XI **Month of publication:** November 2014

DOI:

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

A Quality Function Deployment Methodology for Product Development

Dr Mohammad Israr[1], Dr Anshul Gangele[2]
[1]Principal, Dungarpur College of Engineering and Technology,Dungarpur (Rajasthan)
[2]Institute of Technology & Management, Gwalior (M.P.) 474001

Abstract: ***A constant challenge for any fast paced industry, such as consumer electronics, is the very short technology life span needed to successfully take a product from conception to market while staying competitive with other industry leaders. There are also a wide variety of customers and market segments. Incorporating these factors into a single product design while maintaining a competitive development cycle is both challenging and time consuming. Customer input is gathered through marketing surveys, market research and previous product feedback. Implementing this paper adds to the overall product lead time due to the difficulty of gathering and analyzing the data. This lead time can be reduced by creating a method to process the voice of the customer for direct use in the development cycle.***

In the consumer electronics industry (similar to other fast paced industries), there are 3 basic types of customers: "early technology adopter", "general consumer", and "last to market" (Rogers, 1962). Currently corporations target either a single customer type with their product family, or choose to make a range of products to meet, hopefully, the needs of each of these types. In a survey of the literature, there are no documented end to- end methods for interpreting and applying marketing survey data (that is generalized and not targeted towards a specific group) and producing product/feature sets that reflect the needs of each customer group that can be input directly into the quality function deployment process. This paper will present an end-to-end process that can take a product concept, gather and analyze customer marketing data, create a product profile/feature set, and use input from the cross functional teams to maximize the end quality, and customer satisfaction. This tool would be extendable to any "fast paced" industry, such as the consumer electronics industry, and reduce development costs lead time, reduce internal decision time, turn qualitative into quantitative reasoning. The following literature review will show the previous research in areas of product development and quality function deployment related to the goal of this paper.

Keywords: Quality Function Deployment, Small-scale project, Software engineering

I. INTRODUCTION

Quality Function Deployment (QFD) is a tool commonly used in product development and quality operations. QFD is a system engineering technique for improving quality by incorporating the voice of the customer in the development process. The QFD methodology consists of a number of tools to support a house of quality and Kano's model. These tools, specifically the house of quality, combine input from a number of different cross functional teams in the product development organization to improve communication and overall end user satisfaction (Akao, 1990).

Product development is critical to fast paced industries where new products define success due to short product life cycles. Products with short life cycles demand new product introductions and innovations at a faster rate in order to keep up with market pressures and competition. During the current recession, many companies are depending on the success of new innovative consumer products (with the cost of failure of these products being exit from the market). Figure 1 shows the result of a survey of the direct impact of new product development on company performance:

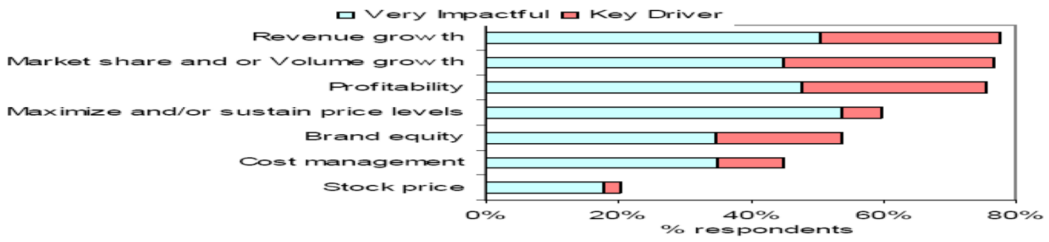


Figure 1.Survey of impact of new product development on company performance.

Source: (Aberdeen Group, 2004)

As can be seen in figure 1, new product development has a critical impact on all measures of company performance, most notably revenue and market share growth. The success of the new product development process depends on factors such as accurate information on customer needs, improved product quality, and decreased bill of material costs (Aberdeen Group, 2004). Figure 2 shows the results of a survey of factors most important to product development firms:

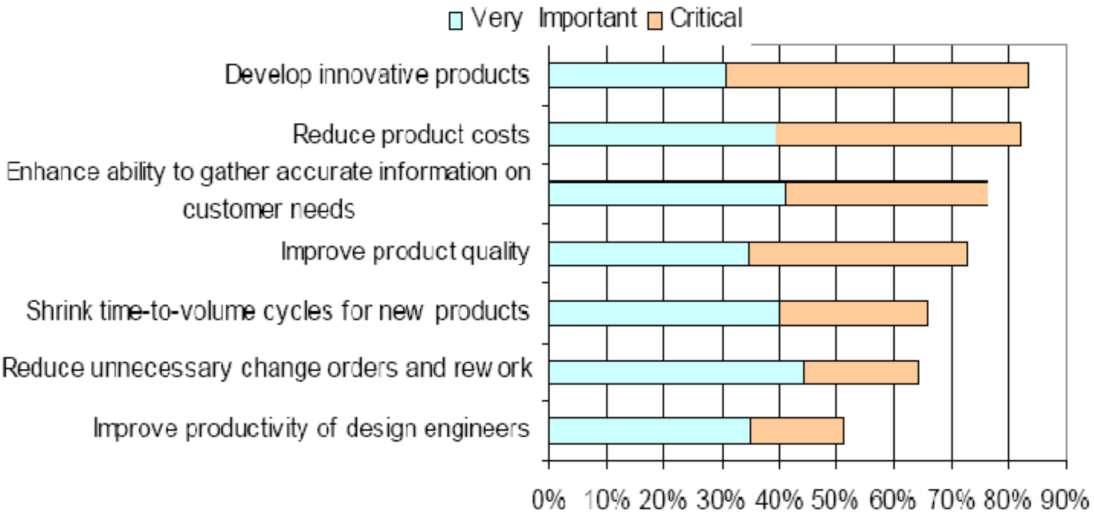


Figure 2.Surveyresults of factors most important to product development firms.
Source: (Aberdeen Group, 2004)

As can be seen in figure 2, product innovation (as well as reducing product costs and enhancing customer input) is critical to the success of new product development activities. Current quality function deployment methods are time consuming, and do not efficiently allow for customer input. There is no end to end methodology for bringing a time sensitive product to market (from concept and consumer input to final design). In this paper a methodology using the house of quality is developed to help address the issues and needs of the new product development process for time sensitive and innovative products. The house of quality builds a matrix of input from all cross functional teams: including engineering, marketing, sales, and management, as well as input from the customer or end user (Griffin and Hauser, 1992).Since the voice of the customer is necessarily from outside the organization, this input has been typically data from customer surveys and marketing data. This data is often difficult to gather and process. And, due to the inherent noise from these external sources incorporating this input into the house of quality can introduce bias and error into the whole QFD process. Despite this shortcoming, there has been little research to improve the customer input, with the goal of improving the house of quality output.

Fast paced industries such as consumer electronics require a short, streamlined development process to release state of the art products at the rate of competitors (Minahan, 2004). The current house of quality methodology helps to improve the development process, but is not optimized for time sensitive products. This leads to the need for an end-to-end tool for developing products with short lead times and life cycles while improving the end quality score.

The goal of this research is to improve existing QFD by developing a methodology to improve the quality of the information incorporated from marketing research. There is no end to end methodology for bringing a time sensitive product to market (from concept and consumer input to final design). The result of this research will be an end-to-end product development process applicable to the consumer electronics product development industry and potentially other product development areas. This process will be compared against current product development methodology for consumer electronics products.

II. LITERATURE REVIEW

This survey of literature will be divided into 3 sections according to the applicable section of this research. A brief explanation of QFD will be presented first, followed by overview literature, and literature relevant to the proposed methodology. All of this information has contributed to realization for need for further research and development of methodology.

A. Quality Function Deployment Overview

Quality function deployment is described by quality expert and developer Yoji Akao as a "method to transform user demands into design quality, to deploy the functions forming quality, and to deploy methods for achieving the design quality into subsystems and component parts, and ultimately to specific elements of the manufacturing process" (Akao, 1990). QFD consists of a number of tools for developing these functions and relationships for the development process. Specifically the house of quality and Kano's model will be used in the proposed methodology

B. The House of Quality

The house of quality (HOQ hereafter) is a matrix of input from all cross functional teams: including engineering, marketing, sales, and management, as well as input from the customer or end user (Griffin and Hauser, 1992). An example completed HOQ matrix for an enterprise product development is shown below in figure 3:

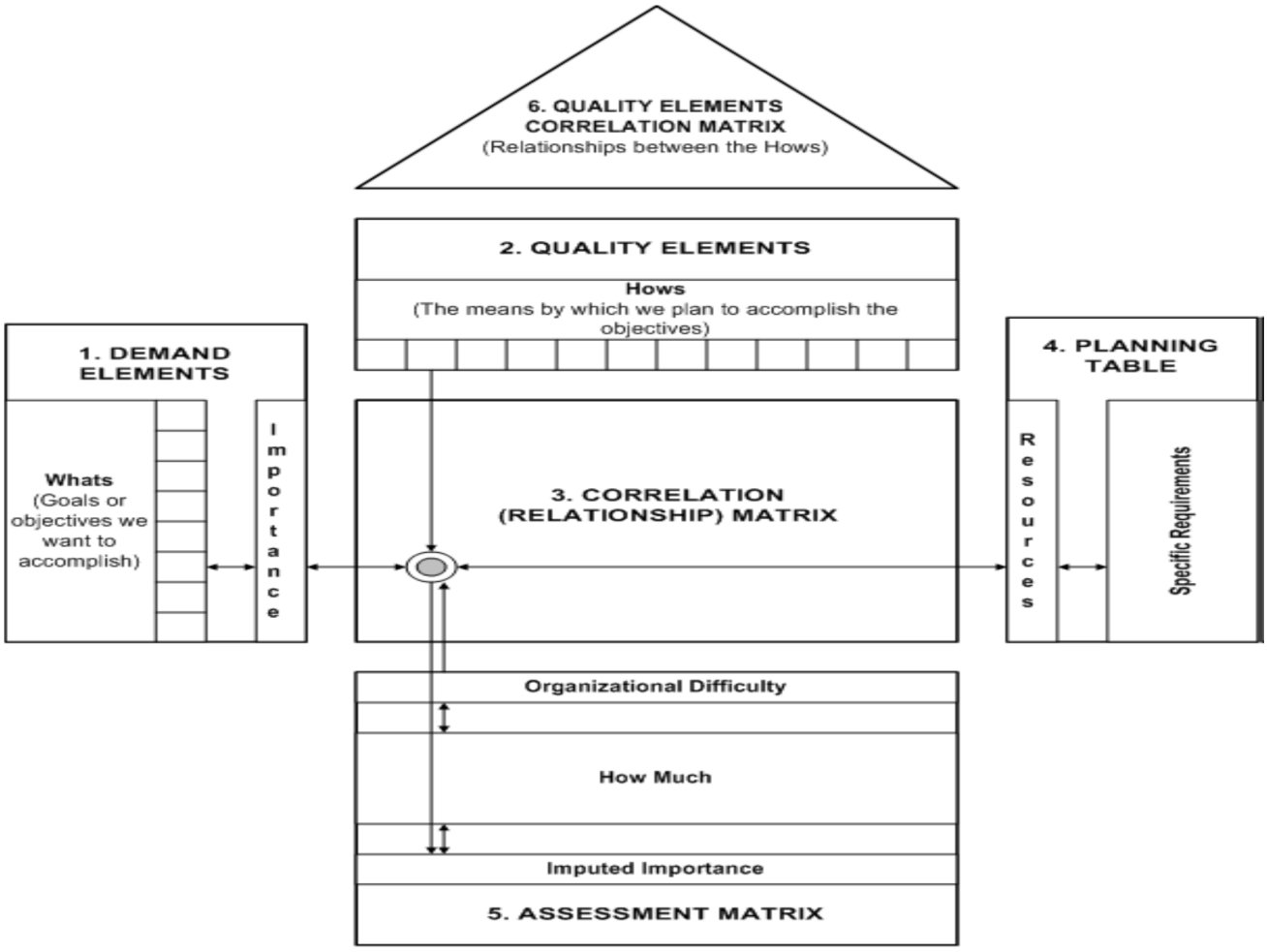


Figure 3.Example House of Quality.
Source: (Corporate Orientation and Training Systems, 2005)

As can be seen in figure 3, the house of quality consists of 5 "rooms." Each of these rooms gathers input from a different part of the cross-functional team. Each input is then compared and contrasted against other team inputs, optimizing the development process and end product. The proposed methodology will optimize the customer input that is used in room 1 of the HOQ to define the voice of the customer, as well as the end quality score that is output to the assessment matrix.

C. Kano's Model

Kano's model is a representation of quality, product features and the voice of the customer.

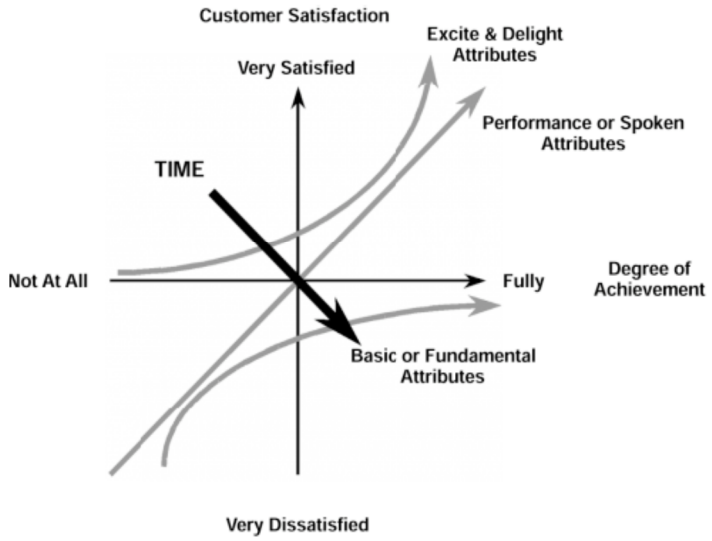


Figure 4 shows Kano's model

Kano's Model shows 3 types of product features as defined by the voice of the customer: basic features, performance features, and excitement features. Excitement features are unknown to the customer, and may be new to the market. These features often apply directly to the 'early technology adopter' as previously mentioned. To the early adopters, excitement features increase the product quality exponentially as features are added. In the case of a typical alarm clock, an excitement feature would be the ability to listen to internet radio upon waking up. Performance features are features that to the general consumer, increase product quality linearly. They are features known to the general consumer and commonly available in the market. In the case of the alarm clock example, a performance feature would be the ability to listen to standard FM radio upon waking up. A basic feature is defined as 'must be' by the consumer. Without this feature, the product is not considered quality, and will not be purchased by the consumer. As these expected features are added, product quality approaches zero. In the case of the alarm clock, a basic feature would be a functioning alarm to wake the customer up in the morning (Kano, 1984). Kano's model will be used in the proposed methodology to divide customers based on desired features into segments, as well as ensure the product has the correct combination of features for marketability.

D. QFD Case Studies and Applications

Rafikul, Mohiuddin, and Masliza discuss their use of QFD and the house of quality to improve viewer satisfaction of visitors to a website for a television station in Malayasia (Rafikul et al, 2007). Technical requirements are related to the voice of the customer as gathered by the television station's website. A house of quality analysis is used to help the organization organize future improvement efforts to the website based on the voice of the customer. The voice of the customer was gathered by using focus groups, online surveys, and website feedback. By using QFD, TV3 Malaysia was able to increase their website traffic and overall customer satisfaction as determined by website feedback and analytics.

Sigal discusses the use of QFD and the house of quality to develop a new consumer electronics DJ product for Numark Industries (Sigal, 2004). Specifically, the relationships that drive the house of quality and QFD were able to be optimized by turning subjective research into objective feedback based on the cross-functional team.

The house of quality is used for all aspects of the product development process. Input is gathered from the cross-functional teams of the organization to be used in the house of quality to determine the optimal product design. Optimization software is used to vary the technical constraints as to best meet the voice of the customer. Special care was taken to ensure that product met market expectations for a product in the DJ segment by adding constraints such as price, margin, and lead times.

E. Conjoint Analysis Overview

Conjoint analysis is a common marketing research technique in which consumers is asked to rate feature sets and make tradeoffs if they were to purchase the product (Curry, 1996). Conjoint analysis is commonly used for marketing surveys, and is featured in the research by Kazemzadeh et al.Conjoint analysis asks users to rate product profiles consisting of all possible combinations of the product features. By using conjoint analysis, large survey sizes are unnecessary. Sample sizes of 100 to 1,000 are typical for commercial conjoint surveys (Cattin and Wittinck, 1982). This allows for a reduction in cost for firms wishing to capture the voice of the customer by means of a survey as larger sample sizes increase survey costs.

Conjoint designs are typically created by statistical software packages such as SPSS. The combinations of the product attributes are transformed into an orthogonal, fractional factorial design as to reduce the overall survey size (SPSS Conjoint Manual, 2005).These combinations are referred to as product profile cards. Survey respondents are asked to rank these combinations and analyze trade-offs.

III. OVERVIEW LITERATURE

Bergquist and Abeysekera discuss the use of Quality Function Deployment for product development, specifically the areas of target values, and scaling scores (Bergquist and Abeysekera, 1996). They use target values for product characteristics and apply QFD methodology to a shoe design ergonomics case study. The case study discusses using safety standards as well as customer requirements as shoe design factors.

Gonzalez et al. discuss marketing intelligence and its incorporation into the overall manufacturing process (Gonzalez, M, Quesada, G, Mueller, R, & Mora-Monge, C, 2004). They propose a methodology to input marketing data into the product development process whilst setting obtainable corporate and quality goals. A competitive advantage can be gained by streamlining the corporate structure in a fast paced industry.

Matzler and Hiterhuber discuss Kano's model and its applicability to the product development process and increasing customer satisfaction (Matzler and Hithuber, 1998). Steps are outlined for using Kano's model in a QFD approach to product development. Questionnaires and other forms of customer data collection are discussed from a management perspective.

Griffin and Hauser discuss the cross functional teams in product development organizations and their relation to the house of quality and voice of the customer (Griffin and Hauser, 1992). The concept of the house of quality is discussed and how each room of the house of quality allows input from the cross functional teams. This input and it's improvement on team unity and productivity is reviewed. This article is critical to the proposed research due to the need for communication between the cross functional teams in the development process.

Hauser discusses engineering product design from a marketing, management, and engineering standpoint (Hauser, 2003). He explains the need for customer input and feedback in product design, as well as a thorough analysis of the house of quality matrix. Hauser discusses communication between members of the new product development team and its importance to the house of quality and customer needs.

Griffin and Hauser discuss the voice of the customer, its importance to the product development process, and the typical steps taken by a marketing manager to capture customer input (Griffin and Hauser, 1993). The authors discuss the 4 “P”s of marketing: product, promotion, price, and place. The 5 “C”s of marketing are also discussed: company skills, customers, competition, collaborators, and context. Griffin and Hauser also discuss the process of identifying customer needs through segmentation, focus groups, interviews, and most notably, marketing surveys. All of these are critical factors to the customer input and marketing approach of this research.

Yee, Dahan, Hauser, and Orlin discuss the marketing research technique of

conjoint analysis and its importance to the new product development and voice of the customer process (Dahan, Hauser, Orlin, and Yee 2007.) They discuss the development of a handheld GPS system using conjoint analysis techniques and web based consumer surveys. An ordinal ranking system is used in a web graphical survey for the customer to determine which feature tradeoffs are necessary to meet their desired price point. An orthogonal design of experiment method is discussed for evaluating feature sets and designing the web based graphical questionnaires. Also presented are software options for conjoint analysis such as Systat, and Sawtooth software.

IV. METHODOLOGY

In order to develop the required end-to-end process, a number of existing tools will be combined, as well as improved, to fit the needs of fast paced industries and products. As previously stated, the current methods for input to the house of quality do not allow

for direct marketing survey data to be used. Kazemzadeh, Behzadian, Aghdasi, and Albadv's method for taking conjoint analysis based marketing surveys will be used as a front end for preparing the data for input to the house of quality. The marketing survey data will then be analyzed using various clustering processes. For clustering processes, 3 clusters will be used (as to meet the desired 3 customer groups as previously mentioned) as in the research by Kazemzadeh, et al. Their two stage clustering process used simple k-means to then define the features associated with each customer group. Clustering and a conjoint analysis method will be used to better translate the web survey for use in the house of quality. This improvement will help to better capture the voice of the customer, therefore increasing the probability of product sales. After running the clustering algorithm, a product feature set will be ready for input into the house of quality.

After inputting the customer data into the house of quality, Sigal's methodology of product development will be used. Sigal's research is tailored to the consumer electronics industry, and fits the goal of a methodology for fast paced industries. With the voice of the customer input data input into the HOQ, the cross functional teams will provide their input (technical, management, and marketing). With the HOQ matrix completed,

The product design with the maximum quality score is then chosen and built. This methodology streamlines the product development process, and produces a product that directly represents the voice of the customers as well as the input of the cross functional teams.

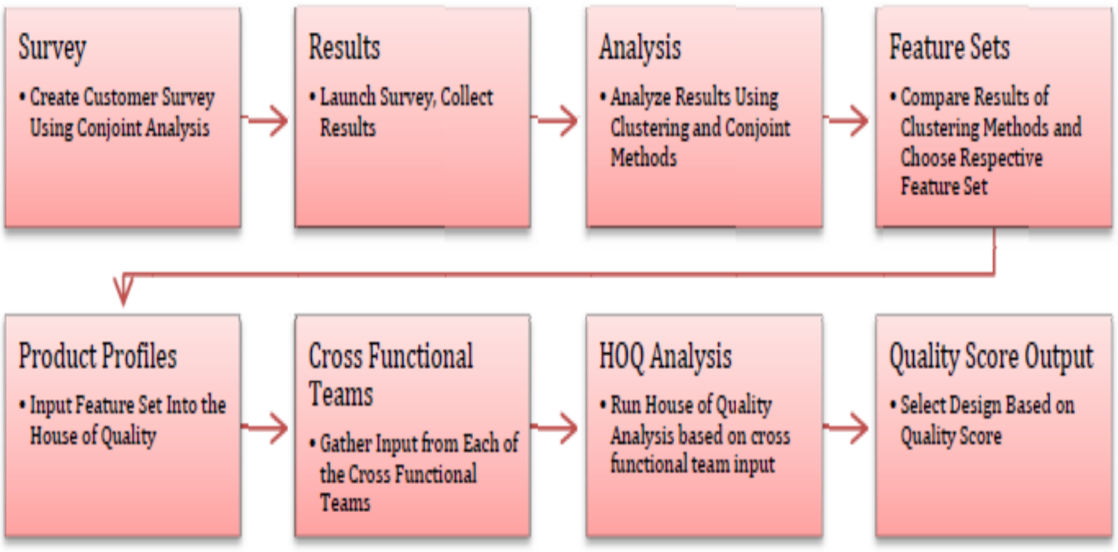


Figure 5. Complete methodology process map.

The detailed description of methodology will be divided hereafter according to the process map shown above.

A. Methodology Implementation

The methodology detailed below was tested using the development of an actual product. Myine Electronics, developer of home audio consumer electronics, participated in the testing of the methodology with the upcoming 2nd version of the Livio Pandora radio. The Livio radio is the first internet radio with dedicated "thumbs up, thumbs down" controls for the Pandora service. The 1st version of the device was launched in April of 2012 and featured the following technical specifications:

1. Wired Ethernet internet connectivity
2. Wireless 802.11g internet connectivity
3. Access to over 11,000 internet radio stations
4. Access to Pandora internet radio

5. Included remote control
6. Easy setup process

The 2nd version of the device has a number of proposed benefits to the customer. In order to determine what features should be included in the upcoming product concept, a web based survey will be used to capture the voice of the customer.

B. Survey

Myine Electronics (and other consumer electronics developers) uses web surveys to help capture the voice of the customer for developing upcoming products. By capturing the voice of the customer, and the desired benefits, technical attributes can be determined to meet those needs. After discussion with the cross functional team (management, marketing, and engineering departments) of Myine Electronics, the following options were defined as desirable functions for the 2nd version Livio product:

A. Sets up automatically out of the box when you plug it in
B. Connects to internet wirelessly
C. Connects to wired Ethernet internet
D. Can be moved around the home or office freely
E. Includes 11,000 internet radio stations for free including news, sports, and talk radio from around the world
F. Has technology to improve the sound of your music
G. Connects to your home stereo via S/PDIF and Optical outputs (in addition to the standard RCA (red/white) box aux Input

The product concept according to Myine product management is for a internet radio remote similar to a Logitech Harmony multifunction, programmable media remote with the addition of internet radio connectivity in line with version 1 of the Livio radio. Myine product management and marketing developed the above list of potential benefits to the customer in according with industry trends and expert knowledge. Using the aforementioned potential benefits to the customer, a web survey was created by using the method for integrating conjoint analysis survey design into the house of quality as researched by Kazemzadeh, et. al. Each benefit was input into SPSS statistical software in order to create the conjoints. Refer to Appendix A for documentation on using SPSS statistical software to create an orthogonal design and consequently, a fractional factorial design.

Using a fractional factorial design allows comparison of multiple benefit attributes, while keeping the actual experimental design smaller. In the Livio V2 example, 8 attributes were tested, leading to a fractional factorial design (as created by SPSS software) of size.

Each survey question is based on a profile card, a combination of the attributes in the factorial design. SPSS creates an orthogonal design of size 7 (based on 8 attributes in the Livio V2 example), and designates each attribute by a binary number in the matrix. This binary number denotes if the particular attribute is to be included (and tested) in that profile card/question. Table 1 shows the orthogonal design as created by SPSS:

Table 1Orthogonal design as created by SPSS

	Q1	Q2	Q3	Q4	Q5	Q6	Q7
Card 1	2	1	2	2	2	1	1
Card 2	1	2	1	2	2	2	1
Card 3	2	2	1	1	2	1	2
Card 4	1	1	2	1	2	2	2
Card 5	2	2	2	1	1	2	1
Card 6	2	1	1	2	1	2	2
Card 7	1	2	2	2	1	1	2
Card 8	1	1	1	1	1	1	1

SPSS designates that the attribute is included on the profile card by a “1”. A “2” designates that the attribute is not included for that profile card.

Using the profile cards created by SPSS, a total of 8 survey questions are created. Each question consists of each of the attributes as indicated by the conjoint matrix. An example of the question created by profile card 2 is shown below:

Please read each question carefully. Each product presented is different from the last (although the questions look similar)

If you could purchase a home audio product that allows you to listen to Pandora internet radio without a computer that does the following:

1. Connect wirelessly to your internet
2. Can be moved around the home or office freely
3. Includes over 11,000 internet radio station for free including news, sports, and talk radio around the world
4. Has technology to improve the sound of your music

How likely would you to be purchase this product?

The survey respondent is presented with all of the survey questions created by the profile cards via a web based survey. For the Livio example, Qualtrics web survey design services were used due to educational availability. Qualtrics has a number of features designed to increase the accuracy of the survey results as to better capture the voice of the customer. One of these features is the ability to randomize the order of particular questions as presented to the respondent. In order to increase the accuracy of the survey, all questions (profile cards) were randomized with the exception of profile card 8. Profile card 8 presents the product concept to the user without adding or changing any of the attributes. Presenting this question first helps capture the respondent's initial opinion of the product concept.

Respondents are asked to rate each product concept (profile card) on a scale of 1- 7, 7 being most likely to purchase, 1 being very unlikely to purchase. Using a scale of odd numbered ordinal values helps the respondent to discretely evaluate the question due to the central value acting as a neutral response.

Survey Results

The survey was advertised by means of Face book, Twitter, and viral social media. An estimated 10,000 people viewed ads to take the survey, with only 119 actually following through to the Qualtrics survey portal. The view count was estimated by following means: 5,000 people were invited to the Face book survey group, 3,000 were reached by means of Twitter, and 2,000 were is the average for all means of blogging combined. 119 respondents participated in the survey over a period of 3 weeks. 19 of these respondents did not finish the survey, and the respective data was not included in the analysis. 100 surveys total were completed. Based on the estimated number of views and actual completed surveys, a response rate of 1% was calculated. For the general population, the average survey response rate is 1-20% (Ray, 2006).

For the data obtained by the survey, the mean response value for each question was computed. Table 2 shows the mean results of each question:

Table 2 Mean results of survey

Question #/ Card #	1	2	3	4	5	6	7	8
Mean Response	4.84	5.32	5.19	5.13	4.95	5.09	4.96	4.25

The survey responses were also analyzed using the mode, but proved to provide no useful data. Using these calculated averages and results, the data can be analyzed in preparation for input into the house of quality.

V. CONCLUSIONS

The conjoint analysis methodology proved to be a simple, efficient way for translating the voice of the customer into hard requirements for use in the house of quality. The orthogonal design helped to reduce the overall survey size, increasing the number of customers that will take it to completion. The part-worth utility method of analyzing the orthogonal design and survey results also proved to be efficient and simple for preparing the data for use in the house of quality.

Although a number of data analysis methods were used to interpret the results of the consumer survey, others exist that could improve accuracy. K-means++ was explored for use, but lacked proper documentation and a robust software implementation. Other

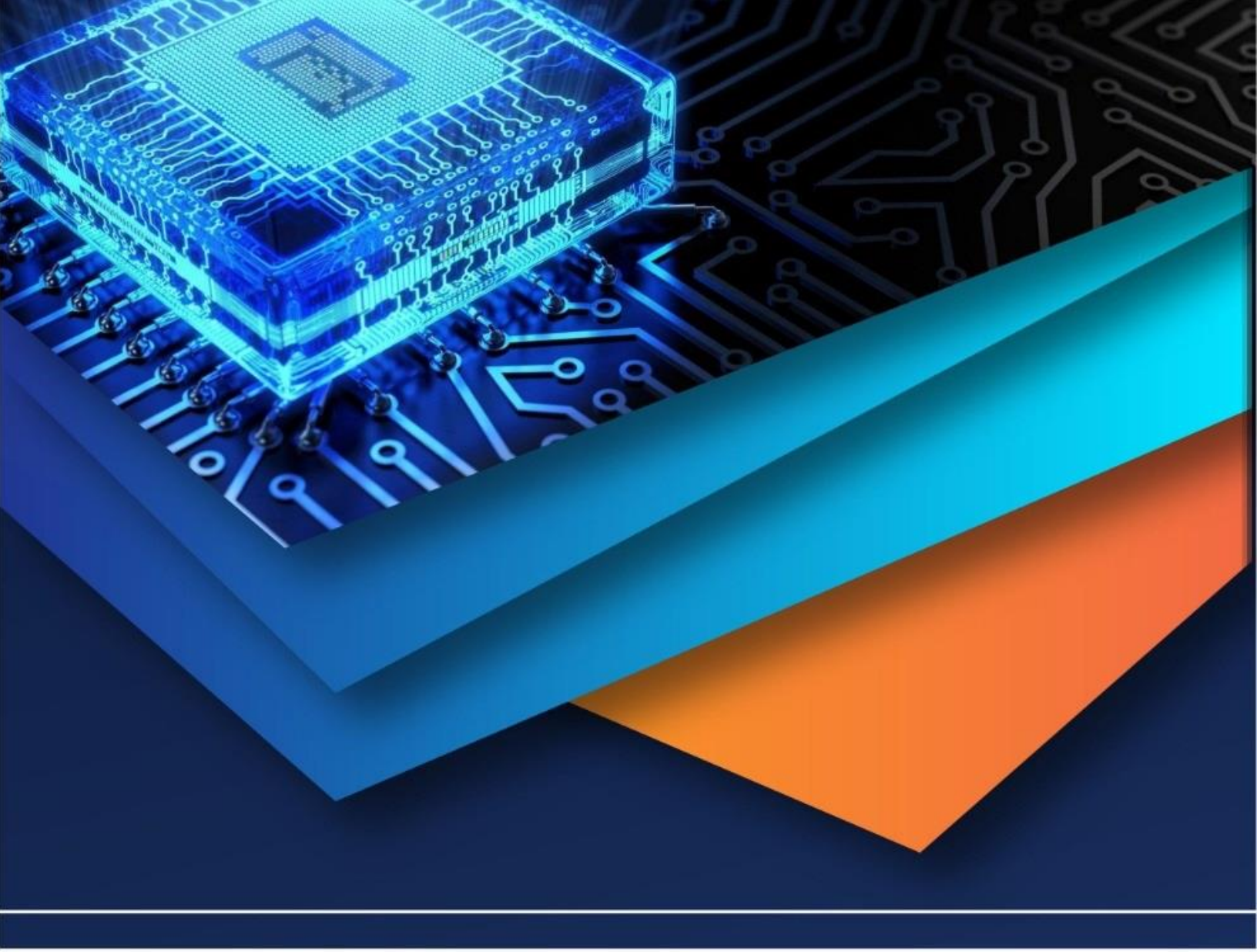
methods for designing experiments also exist, and upon exploration could improve the accuracy and decrease the size of the web survey.

Future research could explore larger sample sizes for the initial survey, use of software other than SPSS for analyzing data and creating the orthogonal design, and the use of other data mining algorithms.

Overall, the use of conjoint analysis and the house of quality proved to be a powerful, useful tool for product development. It helps to decrease lead time, better capture the voice of the customer, and decrease costs. Firms wishing to implement this methodology can look to increases in customer satisfaction and product development efficiency. Consumers can benefit from this methodology when firms are able to produce a better product based on the consumers requirement.

REFERENCES

[1] Aberdeen Group. (2004). Product development in consumer industries benchmark (1st ed.) [Brochure]. Boston, MA: Tim Minihan.
[2] Akao, Y (Ed.). (1990). Quality function deployment Integrating customer requirements into product design. Cambridge, Massachusetts: Productivity Press.
[3] Akao, Y. and Mazur, G. (2003) 'The leading edge in QFD: past, present and future', International Journal of Quality & Reliability Management, Vol. 20, pp. 20-35.
[4] Arthur, D. and Vassilvitskii, S (2006). k-means++: The Advantages of Careful Seeding. Symposium on Discrete Algorithms (SODA).
[5] Bergquist, K, and Abeyesekera, J (1996). Quality function deployment (QFD) — A means for developing usable products .International journal of industrial ergonomics.18, 269-75.
[6] Box, G.E.; Hunter, J.S., Hunter,W.G. (2005). Statistics for Experimenters: Design, Innovation, and Discovery, 2nd Edition. Wiley. ISBN 0471718130.
[7] Cattin, P., and D. R. Wittink. (1982). Commercial use of conjoint analysis: A survey. Curry, J (1996). Understanding Conjoint Analysis in 15 minutes. Sawtooth Technologies, Retrieved June 22, 2009, from http://www.sawtoothsoftware.com/download/techpap/undca15.pdf
[8] Dahan, E., Hauser, J., Orlin, J.B. and Yee, M. (2007). Greedoid-based noncompensatory inference.Marketing Science. 26, 532-549.
[9] Gonzalez, M, Quesada, G, Mueller, R, & Mora-Monge, C (2004). QFD strategy house: an innovative tool for linking marketing and manufacturing strategies. Marketing Intelligence & Planning, 22, 335-348.
[10] Griffin, A. and Hauser, J. (1993). The voice of the customer.Marketing Science, 12, 1-27.
[11] Griffin, A., & Hauser, J. (1992). Patterns of Communication among Marketing, Engineering, and Manufacturing - A Comparison between Two New Product Teams." Management Science. 38.3, 360-373.
[12] Hauser, J (2003). Note on Engineering Product Design. Retrieved April 1, 2009, from MIT Sloan Courseware Web site: http://web.mit.edu/hauser/www/Papers/NoteonEngineeringProductDesign.pdf
[13] Journal of Marketing, 46:3, 44–53.
[14] Kano, N (1984).Attractive Quality and must-be quality. The Journal of the Japanese Society for Quality Control. April, 39-48.
[15] Kazemzadeh, R.B., Behzadian, M, Aghdasi, M, and Albadvi, A (2009). Integration of marketing research techniques into house of quality and product family design .The International Journal of Advanced Manufacturing Technology, 41, 1019-1033.
[16] Matzler, Kurt and Hinterhuber, H. (1998). How to make product development projects more successful by integrating Kano's model of customer satisfaction into Quality Function Deployment.Technovation. 19, 25-38.
[17] Mohr-Jackson, I. (1996) 'Quality Function Deployment: a valuable marketing tool', Journal of Marketing Theory & Practice, Vol. 4, pp. 60-67.
[18] Rafikul, I, Mohiuddin, A, and Masliza, H (2007). Application of Quality Function Deployment in redesigning website: a case study on TV3. International Journal of Business Information Systems, 2, 195-216.
[19] Ray, Ann (2006, March 20). Typical response rates. Retrieved June 22, 2009, from Query Group Web site: http://www.practicalsurveys.com/respondents/typicalresponserates.php
[20] Rogers, Everett M. (1962).Diffusion of Innovations. Free Press of Glencoe, Macmillan Company.
[21] Sigal, J (2004).Creating a market paradigm shift with quality function deployment.
[22] Weissa, Genna. May 27, 2009. How Delphi Corporation Leveraged Conjoint Analysis to Produce Innovative and Award Winning Results. Six Sigma and Process Excellence @ IQPC Podcast. Podcast retrieved from http://www.sixsigmaiq.com/podcenter.cfm?externalid=67
[23] Witten, I., and Frank, E. (2005). Data Mining: Practical Machine Learning Tools and Techniques.San Francisco: Morgan Kaufman Publishers.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY