INTEGRATION OF VOICE OF CUSTOMER QUESTIONNAIRE SURVEY FOR DEVELOPING THE CUSTOMER'S NEEDS QUALITY FUNCTION DEPLOYMENT (CN-QFD) ON A SUSTAINABLE NEW PRODUCT DEVELOPMENT

Thanyatorn Fongsatitkul
Graduate School of Systems Design, Tokyo Metropolitan University, Tokyo, Japan 191-0065, E-mail: thanyatorn_f@hotmail.com

Yasutaka Kainuma
Graduate School of Systems Design, Tokyo Metropolitan University, Tokyo, Japan 191-0065, E-mail: kainuma@tmu.ac.jp

ABSTRACT

Questionnaires are effective tools which are commonly used for collecting survey data regarding the actual customer's needs. Such information is required to develop the customer's needs quality function deployment (CN-QFD) for creating a new product, namely; a sustainable one-handed lipstick packaging. On-line questionnaire/satisfaction surveys are indispensable to obtain accurate results concerning the customer's needs. Such surveys use a combination of Telrad's questionnaire procedure to include or exclude the questionnaire in accordance with the mission requirements and the Hybrid QFD Framework to develop a new product. A detailed analysis of the satisfaction survey results reveals the actual customers' needs which can be further incorporated into the engineering characteristics. After excluding a number of the questionnaires, the remaining ones can be further modified and become the critical parts to construct the final QFD to form the House of Quality (HoQ). In this study, several designed alternatives were considered and the best resolution alternative for the sustainable one-handed lipstick packaging was selected and prototyped accordingly. The round-shape casing encourages keeping the lipstick in the palm of the hand, thus enabling the easy use of the slide-up and -down mechanism. Moreover, the twisting and pulling off of the plastic ring are designed to reduce waste. The cap lid flips up conveniently using only one-hand, which provides a better opportunity to be used suitably and effectively at all times. Finally, the lipstick casing can be reused and the severed ring at the sleeve can also be twirled and removed conveniently which minimizes the waste of lipstick content.

Keywords: Voice of customer questionnaire survey, customers' needs, Telrad's questionnaire procedure, Hybrid QFD framework, customers' needs quality function deployment (CN-QFD), sustainable new product development.

1. INTRODUCTION

Business success is nowadays critically depended on the development and distribution of new products. In parallel with this endeavor, the growing and spreading of green manufacturing that relates to environmental issues in various industrial sectors has significantly increased. Manufacturers generally cannot afford a costly-redesign and full-cycle operation in the long term. Product acceptation is based on the qualities of product design with integration of engineering needs derived from consumer's requirements and environmental considerations into the QFD

methodology to design and create eco-friendly products, namely; the House of Quality (HoQ). In such cases, QFD can be effectively used to incorporate all customer requirements in engineering specifications for designing a new sustainable product. Questionnaires are commonly designed and employed to accumulate the survey data for many different purposes in accordance with the customers' needs. Generating suitable survey questionnaires in both open-ended and close-ended ones and creating an appropriate analytical methodology are the two most important devices to gain accurate results. This study, therefore, aimed to: 1) create an effective voice of customer (VOC) questionnaire survey and analysis in conjunction with the CN-QFD, and 2) construct the final CN-QFD in the form of House of Quality (HoQ) and identify and evaluate all possible options of packaging with respect to minimizing the non-used lipstick content in accordance with the required criteria. The best resolution alternative of the sustainable one-handed lipstick packaging was chosen and prototyped accordingly.

2. RELATED LITERATURE REVIEWS

The NPD process has been extensively studied and reported in the literature, including initial product selection and development, commercialized evaluation, and product manufacturing and marketing. Wu and Pagell (2011) indicated that a shift towards green products and production processes which, in turn, implies that environmental factors may become the norm in the near future regarding manufacturing. To maintain such a platform, manufacturing should focus on producing environmentally-friendly products with a minimal usage of non-renewable resources, climate-change free emissions, and sustainable disposal systems (Wolf and Seuring 2010). Williams and Kennedy (2017) indicated that sustainable supply chain management (SSCM) appeared to be an effective strategy to survive in the future global market. Nowadays, industries across the world have effectively integrated SSCM into their all-inclusive systems (Hassini and Surti 2012). Lin and Tseng (2016) indicated that SSCM practices, for example, environmentally supportive packaging, 3R (reuse-recycle-recovery) of the already-consumed products and an effective disposal system, could encourage society to move towards sustainability.

Curtis and Ellis (1998) specified that a successful product development depended on a proper understanding and focusing the actual customer needs, especially in time-limitation and high-competition environments. Dimancescu and Dwenger (1996) also indicated that one of the most common problems concerning the customer requirements was how to identify and describe them clearly and effectively. It is crucial that systematic and comprehensive techniques be created to obtain and analyze the customer's needs and reduce the possibility of process collapse. Survey questionnaires are an effective tool to help solving such a problem, however; a reliable survey questionnaire should be carefully developed to avoid potential pitfalls. Parasuraman (1991) descripted several key components in constructing a survey questionnaire, including a number of tips and tricks to enhance its reliability. Kainuma and Amano developed the new product development method applying the Kano's Quality model. The method is able to lead to high customer satisfaction (CS) considering the quality model.

To evaluate survey questionnaires effectively, QFD is widely considered an efficient tool to establish proper product specifications. Sullivan (1986) indicated that QFD is a conceptual strategy to transfer the customers' requirements into technical ones at all stages of production processes and development. This led to the introduction of the House of Quality (HoQ) – a matrix generating a conceptual map to help processing the product blueprint. Traditionally, QFD practices were constantly disregarded to determine the target values of engineering characteristics. To overcome such shortcomings, several QFD supporting tools, namely; Case-Based Reasoning (CBR), Analytic Hierarchy Process (AHP), Fuzzy logic, and the Kano questionnaire have been

utilized under different schemes and conditions. In addition, Telrad's questionnaire methodology has been commonly used for generating or eliminating the questionnaire in accordance with the required procedures. A combination of CBR, AHP and fuzzy logic has been also employed jointly in the case of Hybrid QFD (HQFD). CBR is an experience-based method which adapts previously satisfactory solutions to solving a new problem with the support of artificial intelligence techniques (Kolodner, 1993). An AHP can be applied to reveal the significance of customer's needs with pairwise comparisons (Chuang, 2001). Fuzzy logic has been employed to convey linguistic data to crisp scores for further calculation of the inclusive customer satisfaction (Bouchereau and Rowlands, 2000).

To help tackle the deficiencies of the traditional QFD strategy it is necessary to incorporate the customer's requirements as much as possible by using the HQFD planning tool (Tsai, Chin and Yang, 2002) as well as the Telrad's questionnaire methodology (The elimination and addition procedure) (Glushkovsky, Florescu, Hershkovits and Sipper, 1995), known as the customer's needs quality function deployment (CN-QFD). Wang, Hsiao and Sung (2019) identified the survey issues on the questionnaire and the satisfaction scores of the final important ratings of customer requirements regarding a simple food product. This was achieved by employing fuzzy logic both in surveys and group interviews, as well as substituting the absolute values of relative technical ratings with priority rankings.

3. METHODOLOGY

A combination of the strength of the Telrad's questionnaire methodology and certain appropriately modified procedures of the hybrid QFD were considered and developed as a novel supporting tool, named "CN-QFD" with the integrated support of a Fuzzy logic process. The details can be summarized as follows:

3.1 Questionnaire survey and Analysis of customer requirements

3.1.1 Open-ended questionnaire survey and Data analysis

Survey questionnaires relating to both product and package were initiated and distributed with non-likelihood sampling to Thai women aiming to collect the data of about 30 respondents. The questionnaires, intending to document the user's experiences and opinions as precisely as possible, were composed of 3 major portions: (1) Demographic data, (2) Consumption habits, and (3) Idea, attitudes and suggestions, focusing on an assessment of the user's background and behavior, attitudes, motivation, and actual requirements. Those evaluating the user's preferences and product discernment were used to pinpoint the real user requirements and corresponding importance. Some questions relating to the product, for example; asking about "What kinds of functions do you expect from lipstick packaging?" or "Have you ever concerned about the rest of lipstick's content after running out?" were discussed step-by-step among the members of the focus group to finalize the lists of all quality dimensions. These included the issues identified from customers' needs concerning the one-handed lipstick as well as the target customers' lists of the

positive examples of each quality dimension. A set of appropriate questions and engineering characteristics was established to further explore the correlation between questions and engineering objectives by putting interrelationship symbols with an elimination of the questions according to the procedure.

3.1.2 Close-ended questionnaire survey and Data analysis

Designed satisfaction survey questionnaires were distributed on-line and generated approximately 90 individual responses. The survey results were collected and analyzed with the integrated support of Fuzzy logic processes. Afterwards, satisfaction levels were counted as the respondent number per level, followed by calculating the category average (C_j) and response quality (Q_k). A comparison between C_j and Q_k was then made with each C_j variation and finally the usable engineering specifications for design purposes were initiated accordingly.

3.2 Customer's needs quality function deployment (CN-QFD)

A voice of customers (VOCs) survey was conducted and then analyzed and interpreted with respect to the customers' needs and priorities. The final usable specifications were pinpointed according to each customer's needs and the relationship matrix of each customer's needs and specification was established. This was followed by a comparison among the conventional and competitors' products. A technical assessment comparing the existing specifications available in the market was then initiated, aiming to finalize the product target. Typically, the highest rank specifications are significantly related to the customer's requirements, serving as the important product features. Subsequently, the corresponding matrix presenting the relation among each specification was established. Furthermore, several possible design alternatives of the new lipstick compartment were made and compared by calculating the scores in accordance with those of the required criteria. The best possible alternative of the sustainable one-handed lipstick packaging was selected and prototyped accordingly.

4. RESULTS AND DISCUSSION

4.1 Customer's needs and satisfaction questionnaire surveys and data analysis

Quality dimensions related to the customer's requirements for the sustainable one-handed lipstick packaging were categorized as accomplishment, attributes, trustworthiness, conformance, aesthetics, and recognizable quality. Target customers identified the lists of the positive issues under each quality dimension which can further serve as the input for the development of QFD (Survey questionnaire design: having approximately 25 closed-ended questions). The 8 remaining questions (after eliminating about 17 questions from the total of 25 according to the procedure) = The combination of 8 customer's needs and 7 engineering objectives comprised the finalized set of usable engineering specifications to develop the sustainable one-handed lipstick packaging. The seven engineering objectives include: lipstick case dimension, lipstick weight, applying time requirements, minimum time needed to open the lid or twist up, life time, resistance to the environment, and resistance to scratches. Details of the satisfaction score survey on the sustainable one-handed lipstick packaging, including demographic data and consumption habits are illustrated in Figure 1. These parameters were used as crucial inputs for the development of CN-QFD.

4.2 Customer's needs quality function deployment (CN-QFD)

The important keys of customer's needs were prioritized and ranked in accordance with the required criteria and procedures. This included the following keys: easy to use, easy opening methods, reduce lipstick waste, sustainable, and follow material industry standards and

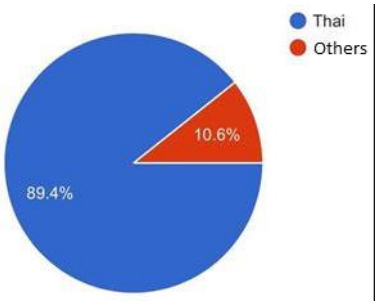
specifications. Representative examples of data analysis of the sustainable one-handed lipstick packaging, named the House of Quality (HoQ), are illustrated in the Figure 2. Based on these key elements, all possible alternatives of 12 different designs using classification trees and combination table techniques were generated. The best possible design alternative according to the evaluation criteria was selected and prototyped as shown in Figure 3. The round-shape casing is persuasive to keep it in the palm of hand, which encourages the use the slide-up and down mechanism. The twisting and pulling off of the plastic ring were also designed reduce the waste. The cap lid was designed to flip up conveniently by using only one-hand which provides a better opportunity to be easily used all day long. Finally, the lipstick casing was designed to be reused, while the severed ring at the sleeve can be twirled and removed conveniently which minimizes the waste of lipstick content.

Table 1. Positive issues under different quality dimensions and customer's needs for further integration as engineering specifications to develop the sustainable one-handed lipstick packaging

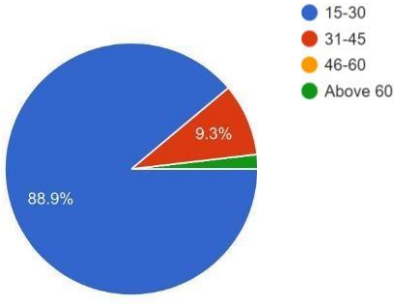
Quality Dimensions	Positive issues	Customer's needs
Accomplishment	Reusable lipstick case Easy to hold (doesn't roll) Refillable lipstick case Safety to use	Reusable lipstick case Easy to hold (does not roll) Refillable lipstick case Safety to use
Attributes	Opening methods (Twist up, Sliding up and down and Flip-open cap) Short opening time Light weight Lock methods	Easy opening methods Light weight Portable Compact size Compact shape
Conformance	Material meet industry standards and specifications Environmental-friendly	Environmental-friendly
Trustworthiness	Be durable Long-life usage Have a certification (Certified by FDA, ISO9001:2008 or etc.)	Durable Follow material industry standards and specifications: Have a certification (Certified by FDA, ISO9001:2008 or etc.)
Aesthetics	Modern and beautiful lipstick case Multi-color lipstick case Luxury design	Modern and beautiful lipstick case
Recognizable Quality	Reasonable price match with quality Brand name with high quality lipstick case Easy to use Reduce lipstick waste	Reduce lipstick waste Easy to use

Part 1: Demographic data

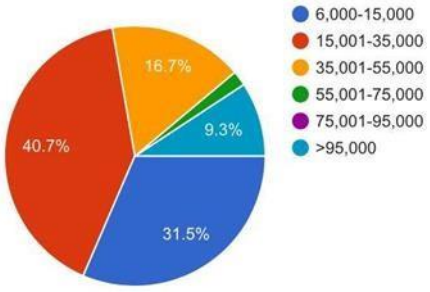
Nationality



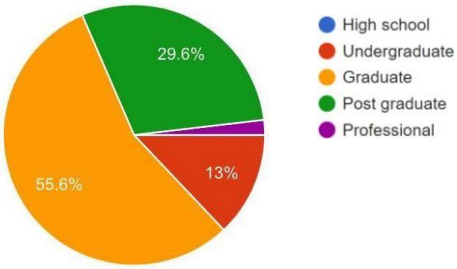
Age (years)



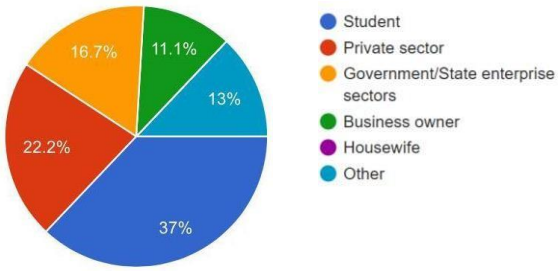
Monthly income (Baht)



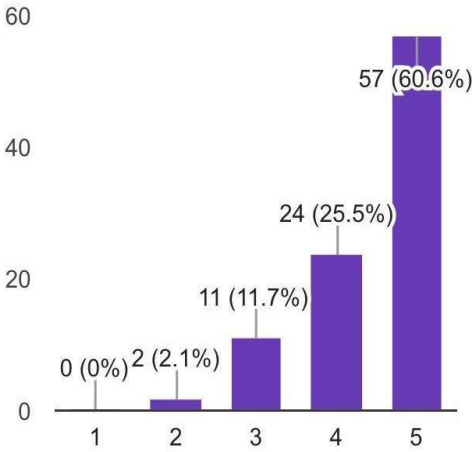
Educational qualification



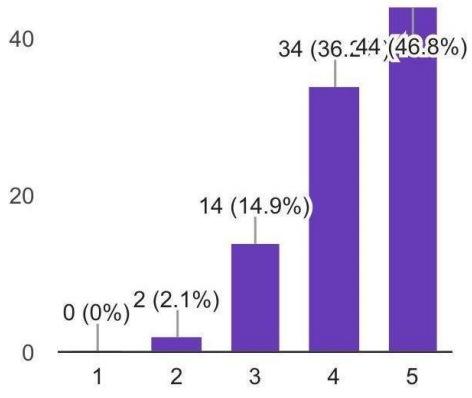
Occupation



Part 2: Consumption habits: Please give the satisfaction score if the one-handed lipstick has "The followings"

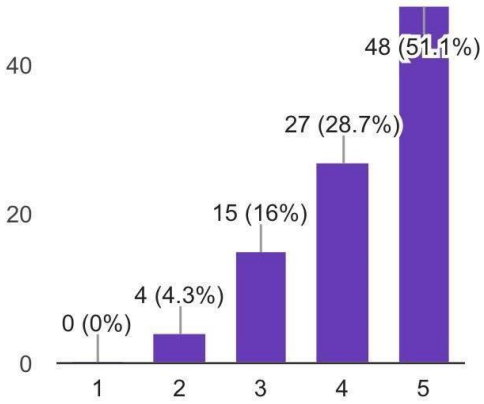


"Easy to use"

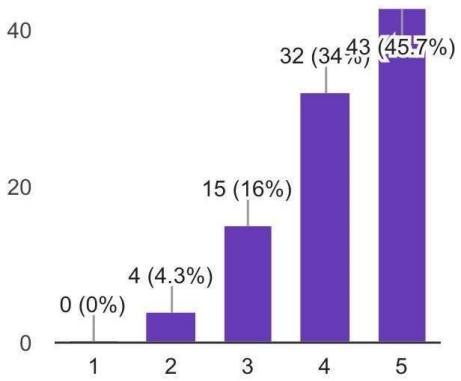


"Following industry standards and Specifications"

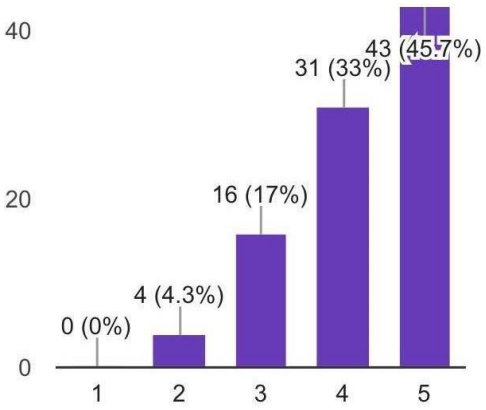
Figure 1. Satisfaction survey on the sustainable one-handed lipstick pɑckaging



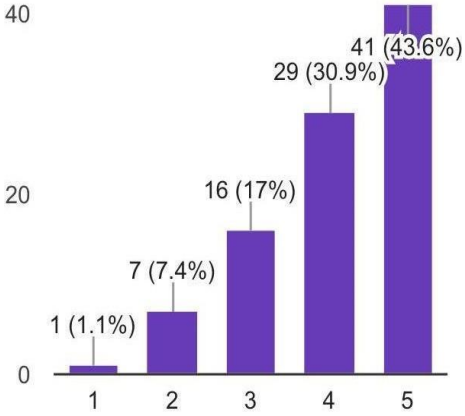
"Easy opening method"



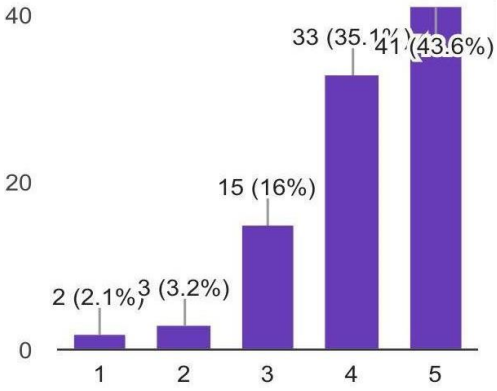
"Modern and beautiful lipstick's case"



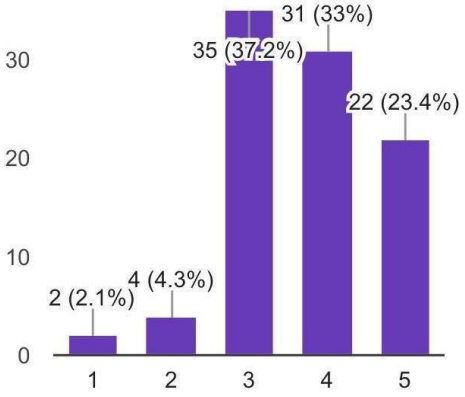
"Environmental-friendly"



"Reduce lipstick waste"

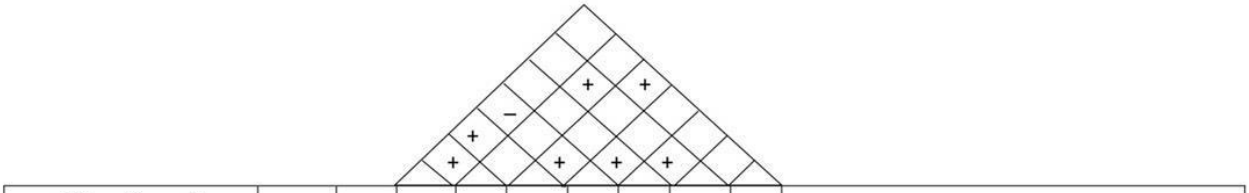


"Light weight"



"Reusable lipstick's case"

Figure 1. Satisfaction survey on the sustainable one-handed lipstiek packaging (Cont'd)



Direction of Improvement				▼		▼	▼	▲		▼	Competitive Assessment								
Engineering Specifications		Average of category (C_j)	Importance rating	S1: Dimension of lipstick case	S2: Weight of lipstick	S3:Time to complete applying	S4: Minimum time to open lid or twist up	S5: Life time	S6: Resistance to the environment	S7: The resistance to scratches	Current Product	New Product	Competitor 1 (Stiks Cosmetiks)	Competitor 2 (Avon Cosmetics)	Improvement Ratio	Sale impact	Overall weight	Normalized score (%)	Rank
Customer's Needs	Easy to use	4.4	9	●	●	●	●				5	8	6	8	1.60	1.3	18.72	18.22	1
	Standards and Certification	4.3	9					●	▽		7	7	7	7	1.00	1.3	11.70	11.38	5
	Easy opening methods	4.0	9	●	●		●	○			5	7	6	7	1.40	1.3	16.38	15.94	2
	Modern and beautiful lipstick case	4.2	9	○						●	7	7	6	7	1.00	1.3	11.70	11.38	5
	Environmental-friendly	4.2	9					●	●		7	8	8	8	1.14	1.3	13.34	12.98	4
	Reduce lipstick waste	4.0	7	●		○	○				4	7	6	8	1.75	1.1	13.48	13.12	3
	Light weight	4.1	7	●	●						5	8	5	7	1.60	1.1	11.20	10.90	6
	Reusable lipstick case	3.7	5	●	▽		○	●			4	5	4	4	1.25	1	6.25	6.08	7
Response quality (Q_k)				4.0	4.2	4.2	4.1	4.0	4.2	4.2									
Technical Assessment	Score			360	149	183	198	234	90	81									
	%			27.80	11.51	14.13	15.29	18.07	6.95	6.25									
	Rank			1	5	4	3	2	6	7									
	Units			mm.	g.	sec.	sec.	year	swipes	scratches units									
	Stiks cosmetiks			12.7x20.3 x76.2	5.7	5	2	2	721	n/a									
	Avon cosmetics			17x17x92	1.8	3	2	2	225	n/a									
	Target value			20x20x90	4.0	3	2	2	500	n/a									

Relationship	Symbols	Score
Strong relationship	●	9
Medium relationship	○	3
Weak relationship	▽	1

Attribute of Specification	Symbol
Higher the better	▲
Lower the better	▼
Target the best	(Blank)

Sale Impact	
1	No Impact
1.1	Small Impact
1.3	Big Impact

Relationship	Symbol
Positive Relationship	+
Negative Relationship	-
No Relationship	(Blank)

Figure 2. House of quality (HoQ) for customers' needs quality function deployment (CN-QFD)

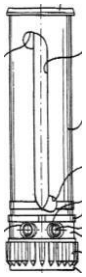
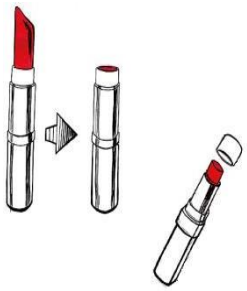
Easy opening method	Easy to use		Reduce lipstick waste
	Shape	Mechanism	
 Flip-open	 Round shape	 Slide-up Mechanism	 Detach/twist off the plastic ring
A new design of one-handed sustainable lipstick package		To pieces of component (Outer case and sleeve)	 Outer case

Figure 3. The most suitable design for a sustainable one-handed lipstick packaging

5. CONCLUSION AND RECOMMENDATION

This study revealed that a combination of Telrad's questionnaire methodology to produce or exclude the questionnaire in accordance with the mission requirements and the Hybrid QFD Framework to develop a new product. Effective analysis of the satisfaction survey results pinpointed to the actual customer‘s needs, which were integrated into the engineering characteristics and formed the critical parts of the House of Quality (HoQ). The modified QFD (named CN-QFD) was then established. Several possible sustainable, one-handed lipstick packaging alternatives were considered and the best one was selected and prototyped accordingly.

6. ACKNOWLEDGEMENT

The authors would like to sincerely thank all staff and members of Kainuma Research's laboratory, Faculty of Systems Design, Tokyo Metropolitan University, Japan, for their support while developing this publication. Special thanks are also due to the Tokyo Human Resources Fund for City Diplomacy for the financial support.

7. REFERENCES

Bouchereau, V., Rowlands, H., (2000). Methods and techniques to help Quality Function Deployment (QFD). *Benchmarking:An International Journal* 7(1), 8-19.

Chuang, P.T., (2001). Combining the analytic hierarchy process and quality function deployment for a location decision from a requirement perspective. *International Journal of Advanced Manufacturing Technology* 18(11), 842–849.

Curtis C.C., Ellis L.W., (1998). Satisfy customers while speeding R&D and staying profitable.

Dimancescu, D., Dwenger, K., (1996). Benchmarking Best Practices of Agile Manufacturers.

Glushkovsky, E. A., Florescu, R. A., Hershkovits, A., & Sipper, D., (1995). Avoid a Flop:Use QFD With Questionnaires. *Israeli Electronics Company.*

Hassini, E., Surti, C., and Searcy C., (2012). A literature review and a case study of sustainable supply chains with a focus on metrics. *International Journal of Production Economics* 140, 69-82.

Kainuma, Y., Amano, D., (2018). New Product Development Method based on Customer Satisfaction, In Japan Industrial Management Association (JIMA) Research Division of Management Mathematics (ed), *Advanced Management Science and Its Application*, Izumi Syuppan, 48-67.

Kolodner, J., 1993. Case-Based Reasoning. Calif.: Morgan Kaufmann, San Francisco.

Lin, Y.H., Tseng, M.L., (2016). Accessing the competitive priorities within sustainable supply chain management under uncertainty. *Journal of Cleaner Production* 112, 2133-2144.

Parasuraman, A. *Marketing Research - 2nd Edition.* Addison-Wesley Publishing Company, Inc., 1991. *Res. Technology Management* 41, 23-24.

Sullivan, L.P., (1986). Quality Function Deployment: A system to assure that customer needs drive the product design and production process. *Quality Progress* 2, 39-50.

Tsai, Y. C., Chin, K. S., & Yang, J. B., (2002). A Hybrid QFD Framework for New Product Development. *Asian Journal on Quality* 2002:3(2), 138-158.

Tzu-Yun Wang, Hsin-I Hsiao, Wen-Chieh Sung, (2019). Quality function deployment modified for the food industry: An example of a granola bar. *Food Sci Nutr.* 7, 1746–1753.

Williams, A., Kennedy, S., Philipp, F., Whiteman, G., (2017). Systems thinking: a review of sustainability management research. *Journal of Cleaner Production* 148, 866-881.

Wolf, C., Seuring, S., (2010). Environmental impacts as buying criteria for third party logistical services. *International Journal of Physical Distribution & Logistics Management* 40, 84- 102. *World-Class New Product Development* p. 276.

Wu, Z., Pagell, M., (2011). Balancing priorities: Decision-making in sustainable supply chain management. *Journal of Operations Management* 29(6), 577-590.