Proceedings of ICAD2004
The Third International Conference on Axiomatic Design
Seoul – June 21-24, 2004
ICAD-2004-01

CONNECTING CUSTOMERS IN AXIOMATIC DESIGN

Sri Hartati KURNIAWAN
ling@ust.hk
Department of Industrial Engineering and Engineering Management
The Hong Kong University of Science and Technology

Mei ZHANG
iezm@ust.hk
Department of Industrial Engineering and Engineering Management
The Hong Kong University of Science and Technology

Mitchell M. TSENG#
tseng@ust.hk
Department of Industrial Engineering and Engineering Management
The Hong Kong University of Science and Technology

ABSTRACT

Design process starts with customer needs identification. With companies' shifting attention from the traditional emphasis on manufacturing capabilities to customer centric, connecting customer into the design process becomes an important issue. This paper presents a systematic approach to connect customers in the product design and development process based on Axiomatic Design. It includes methodologies to capture customer needs, bring different levels of customer needs into the same level of abstraction in the form of product attributes, and prioritize those needs. Customers' needs can then be mapped into the functional requirements (FR) domain. Based on the proposed approach, manufacturers are able to provide a platform for customers to directly participate in product design and get products that suit their personal preferences, which is termed as Design by Customer. Design by Customer provides not only an effective means to cater to individual customers' needs but also an avenue to systematically connect customers into the design process.

Keywords: Customer Needs, Design by Customer, Axiomatic Design

1 INTRODUCTION

'Design-make-sell' has traditionally been accepted as a logical flow in manufacturing industries to introduce new products to the market place. Manufacturers, via marketing and sales, capture and aggregate customer needs to market specifications, pass the information to the engineering designers to design the product with manufacturability in mind, produce it and finally display it on the shelf or in the catalogue for sale. This sequential methodology has some inherent drawbacks. Firstly, nearly 70% of product development cost has been committed in the design stage [Syan and Menon (1994)]. Any modification made during the later stages incurs heavy penalty. Secondly, the sequential process was evolved in the days when the equipment and systems are geared toward high volume production; the long cycle time will not be responsive to the needs of today's dynamic and competitive markets. Last but not the least, by concentrating on one or a few final products, instead of designing a family of products, it may increase the risk of misjudging customer needs, which can lead to significant economic distress.

Recent advancement in computing and communication technology has already made significant reduction of "time to market" through wide acceptance of CAD/CAM/CIM in product development. Looking forward, we see the untapped opportunity of involving customers in the product development process. This offers new possibility to facilitate customers' direct participation in the product development process. Identification and clarification of customers' needs early in the design stage have been a major challenge to overcome in our quest to reduce time to market.

Today, most of companies still rely heavily on conventional marketing research to acquire customers' needs. Though there is significant progress in the field of marketing research, it can not replace the effectiveness and efficiency of direct incorporation of customer needs. In the last decade, the development of concurrent engineering between design and manufacturing proved that it significantly reduces the back and for the iterations of trials and errors between two functional groups. Further expansion of concurrent engineering to include customers will yield similar, if not further advantages,

Particularly, the recent development of Internet and web pages, customers can access the knowledge base of product development and provide their requirements with more meaningful context, which hence facilitates informed choices. For example, customers can formulate comparisons among the available options before making a final purchase decision. In the mean time, it makes consumers more demanding in expecting better products and services as well as voting and quoting for their preferences in the product definition. The low switching cost and increasing customer bargaining power are additional reasons that the manufacturers have to rethink their product design methodology in order to get customers more actively involved and put more focus on the effectiveness of meeting customers needs.

However, there are several issues that need to be overcome in order to effectively engage customers in the product development process. To begin with, customers, very different from designers, are often not familiar with the language and context that used by

engineers in the product design. Furthermore, customers may not even be aware of the implicit needs that may be obvious in their understanding but difficult for them to articulate.

Mass customization formally proclaimed the ever-increasing importance of involving customers in the design process. The demand for product customization has increased rapidly compared to non-customized orders [Suh (2001)]. Consumers' satisfaction becomes strongly correlated to the fulfillment with their specific product needs. Meanwhile customers also want them delivered in a short lead-time with a lower price. In order to best satisfy individual needs, intense interaction between customers and manufacturer and involving customers in product definition become a "must" for every company.

Summarizing the above, there is a need to eliminate organizational boundaries between the participants in the design and development process. Customers are the initiation point of the whole product value chain; therefore it is very important to correctly capture the customer needs and provide them with sufficient information to facilitate their decision-making process. The rest of the paper is organized as follows: section 2 reviews the methods for customer needs identification; section 3 proposes the approach to structure customer needs by applying the methods reviewed in section 2 for the purpose of Design by Customer, which is detailed in section 4; section 5 concludes the paper.

2 CUSTOMER NEEDS IDENTIFICATION

In non-impulsive buying, consumer needs are antecedent of purchase decisions [Blackwell, et. al. (2001)]. Some needs are explicit and consumers can state them very clearly. However, most of the times consumers do not know how to express their implicit needs or they are even not aware of the existence of these needs [Kurniawan *et. al,* (2002)]. Eliciting customers' need is one of the biggest challenges for manufacturers [Bailetti and Litva (1995)], especially if the manufacturer offers mass customized products [Zipkin (2001)].

Many research attempts have been made to identify consumer needs using a psychological approach to clarify the notion of 'good taste' [Katz (1951); Helander *et al.* (1998); Khalid and Helander (2001)]. However, at the end of the day, it is the consumers that define their own needs. There are many different ways to elicit consumer needs, and we will list some representative methodologies that have been commonly used in the research and industry fields. These methods are well known and structured, and facilitate eliciting and structuring consumer needs that in turn could be used by product provider to design their product or offering alternatives.

a. Voice of Customer

Voice of Customer (VoC) is a set of customer needs arranged in a hierarchical manner in which customers assign priority for a given set of needs [Griffin and Hauser (1993)]. To accomplish this, product providers usually first identify their customer needs by group or one-to-one interviews, then use group consensus to sort, cluster, and structure the needs, and in the end establish an importance rating that represents the attributes' importance to customers. In this way, the manufacturer is able to provide the right product that consumers want. The understanding of consumer needs also provide feedbacks for the manufacturer to revise the range of the product offering in order to better serve the consumers.

b. Quality Function Deployment (QFD)

Quality Function Deployment (QFD) is a visual, connective process that helps the product development team to focus on customer needs throughout the product development process [Clausing (1994)]. It is normally presented as a structured planning tool to determine the incorporation of an attribute based on customers' expectation [Syan and Menon (1994)].

Customers' requirements are mapped into the design process and eventually into manufacturing processes. QFD is usually represented as a set of matrices describing the relationship between data. The starting matrix, linking the voice of customers to the production operations on the factory floor, is usually known as House of Quality [Clausing (1994)].

The House of Quality can be further described using several relationships that facilitate different linkages throughout the product development process. They are [Griffin and Hauser (1993)]:

- Linkage between customer needs to design attributes
- Linkage between design attributes to the actions the firm can take
- Linkage between actions to implementation decisions (e.g. manufacturing process operations)
- Linkage between implementation (manufacturing process operations) to the production planning

QFD facilitates translation of consumer needs into the product design and propagates throughout the manufacturing process by mapping the consumer needs into product attributes and their respective manufacturing processes. This method helps manufacturers to design and streamline manufacturing operations to perform only activities that are related to the consumer needs fulfillment.

c. Conjoint Analysis

Conjoint Analysis is a method developed by marketing professionals. It is designated to measure and analyze consumers' preferences by assessing consumers' values on various attributes of the product [Caroll and Green (1995)]. Consumers have to make trade-offs by prioritizing their choices in order to reveal consumer utility values for each product alternative. By understanding consumers' utility value of each attribute, the product provider can offer the best product that maximizes consumers' total utility value. The product utility function can be described by the following equations [McCullagh (1989)]:

$$U_r = \sum_{m=1}^{M} W_m \left(\sum_{l=1}^{Lm} d_{ml} X_{rml}\right) = \sum_{m=1}^{M}\sum_{l=1}^{Lm} U_{ml} X_{rml} \qquad (1)$$

$$U_{ml} = W_m * d_{ml} \qquad (2)$$

$$X_{rml} = \begin{cases} 1 \text{ if attribute m is on } l^{th} \text{ level;} \\ 0 \text{ otherwise} \end{cases} \qquad (3)$$

These equations explain that a product can be represented as having M attributes, Z_1, Z_2, …, Z_M, and each attribute can have L_m levels. The consumer's utility for profile r is represented by U_r, r = 1, 2, …, R. W_m represents the importance of attribute Z_m, d_{rml} represents the desirability for l^{th} level of attribute m, l=1, 2, …, L_m; m = 1, 2, …, M; and U_{ml} represents the utility of attribute m's l^{th} level. X_{rml} is a dummy variable denoting whether the particular level of an attribute is being selected or not.

Conjoint analysis can help to capture and analyze consumer needs and preferences in an indirect way. When asked explicitly, consumers may not be able to tell manufacturers what they exactly want.

d. Kano Diagram

Kano Diagram is a tool used to capture and categorize the customer needs into three different regions based on the level of customer satisfaction related to the absence/presence of the features. The three customer need categories are [Kano *et al.,* (1984)]:

- Expected (dissatisfier, must-be requirements): features that customers do not express, but expect them to be present in the product. The absence of these features will make customers become dissatisfied.
- Revealed (satisfier, one-dimensional requirements): features that are expressed, and customers' satisfaction increases with the increase of fulfillment of the feature.
- Exciting (delighter, attractive requirements): features that customers do not expect, but the presence of them brings delight to customers.

The product provider measures consumers' reaction to the absence or presence of the product attributes/features. The results are used for identifying and categorizing different consumer needs based on whether the product attributes/features belong to the expected, revealed, or exciting features [Sauerwein (1999)].

This method helps in capturing and categorizing consumers' preferences and needs. By understanding expected, revealed and exciting needs, product provider can focus their strategy to suit different segment of consumers. Mass customization has recognized the advantages of presenting delighter attributes as add-ons attributes in which consumers have to pay certain premium to get additional attributes that they like.

e. Kansei Engineering

Kansei Engineering is a methodology to involve customers in the product development process by eliciting and integrating customers' needs and feelings into product design [Nagamachi (1995)]. The term 'kansei' refers to customers' psychological feelings toward certain products. For example a customer may have feeling that the clothes she wants to buy should be 'graceful and look intelligent, but not so expensive [Nagamachi (1998)].

In capturing kansei, manufacturers first investigate consumer behavior in using a specific product. Customers are asked to describe the product in their own words based on their subjective perceptions. These words are then broken down into sub-concepts continuously until the sub-concepts can be translated into physical traits of the product. Ergonomic experiments are conducted in order to find the most appropriate product specification design [Nagamachi (1998)]. The process is usually supported by a computer system that semantically differentiates the words, and translates them into combinations of product design elements, such as component and attribute design.

f. Web-based consumer elicitation method

With the recent advances in information technology, web-based elicitation processes become feasible. A web-based survey allows speedy communication and low cost as well as a larger sampling size of consumers' opinions.

The study of consumer decision-making process can now be done in-situ. Various web statistic software programs are available to analyze consumer behavior via the log file. These types of data give accurate information about consumer needs, preferences, and buying behavior in real time and can be done in an unobtrusive way.

Today where speed is one of the most crucial issues, the role of Web-based consumer elicitation method is very important. Product providers need real-time information, instant updates and feedbacks, and continuous communication with their consumers. Internet has provided a media to realize them.

3 STRUCTURING CUSTOMER NEEDS IN AXIOMATIC DESIGN FOR DESIGN-BY-CUSTOMERS

Most of current research in Axiomatic Design has been heavily leaning toward Functional and Physical Domains. There are few papers presented in the Customer Domain. With the growing attention to customers in the product development process, we attempt to propose a framework to incorporate customers in the Axiomatic Design based product design process. The concept can be traced back to our earlier work in structuring customer needs for the purpose of supporting Design by Customers (DBC) in mass customization [Tseng and Du (1998)]. The framework is shown in Figure 1. The process is divided into three stages. Stage one is to elicit customer needs. Customer needs can be tacit, implicit or hidden. Often, customers may use very dissimilar language with very different context and semantics. Thus, the challenge is to synchronize this discontinuity between providers and customers. For example, some of the needs may be in natural language such as "I want a shirt that makes me look slim" while some may be already in terms of functional requirements or even design parameters such as "I want a shirt of size eight". Stage two is to convert customer needs into more engineering-oriented customers' requirements and get structured following the thread of "attribute–value" for describing a product. Kansei Engineering and Quality Function Deployment (QFD) can be used for the translation. Stage three is to characterize customer needs and enhance its clarity. Tools such as conjoint analysis and other statistical analysis tools are applied to set the customization space for Design by Customers. In the following subsections, we take an example with the product of a women dress shirt to illustrate how the framework works.

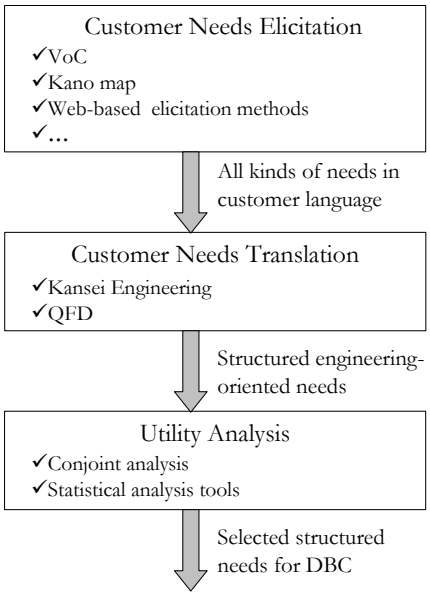

Figure 1: Framework of structuring customer needs for Design by Customer (DBC)

3.1 STAGE ONE: CUSTOMER NEEDS ELICITATION

The objective of this stage is to elicit customers' requirements that may be implicit, hidden or tacit. How to engage customers to articulate their needs that can be captured by the product development team has been a topic of study in the marketing research. A lot of methods have been proposed in this field as reviewed in section 2. By taking the methods listed in stage one of Figure 1, we get a list of customer needs for the women dress shirt product as shown in figure 2 (the list is truncated due to space limit).

1. Slimness appearance
2. Feminine appearance
3. Elegance appearance
4. Easy to iron
5. Fit (or size)
6. Name embroidery
7. …

Figure 2: The list of customer requirements in customer language

This list of requirements is the starting point for the customer needs structuring process for the purpose of Design by Customers.

3.2 STAGE TWO: CUSTOMER NEEDS TRANSLATION

The objective of stage two is to get a structured engineering-oriented customer needs so that further analysis can be done. The translation process with Kansei Engineering is depicted in Figure 3 for the listed customer requirements in Figure 2. From the translation process we can see some of the original customer needs have to be translated from customer's language into engineering-oriented language such as "slimness appearance"; while some of the original customer needs can directly linked to the needs in engineering-oriented language such as "name embroidery". After this translation, the customer needs are also structured in the way that the requirements are represented by the attributes and their values. For example, "waist line" is an attribute to achieve slimness appearance with two values "straight" and "curve". By having this structure, the stimuli in conjoint analysis can be easily constructed based on the combinations of possible values of the attributes.

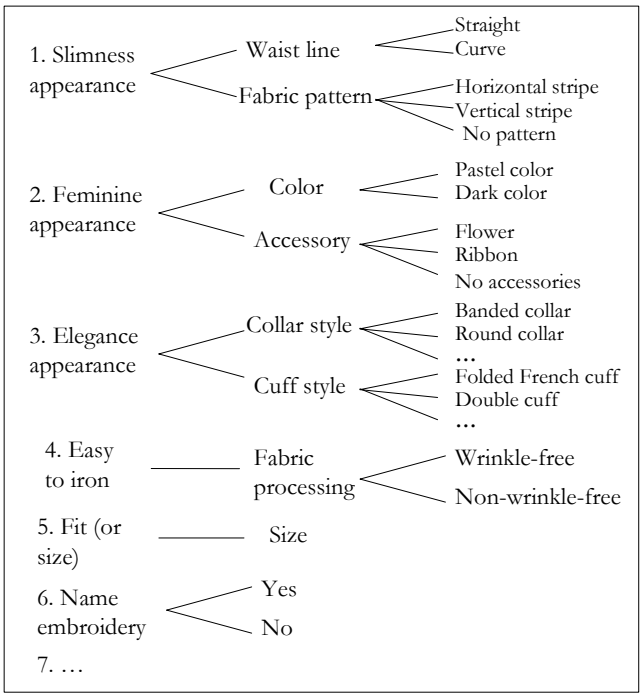

Figure 3: Customer needs translation

To get the translation process well conducted, professional knowledge about the product is required.

3.3 STAGE THREE: UTILITY ANALYSIS

Stage three is to analyze customer needs in order to set the customization space for this product. Conjoint analysis is applied in this stage. Meanwhile some pictures about the possible visible outcomes of the choices can be presented to help customers' responses such as colors and styles (based on existing product offerings and the professional knowledge). The difference from normal conjoint analysis lies in the two aspects that we concern: (1) whether a certain attribute requires to be customized or not; (2) what are the possible values to be provided and which is the default value for each attribute (for those attributes that do not need to be customized, the default value is the only value in the product family design). In this paper, we discuss two different cases. In the two cases, if it is believed that there exists interaction between two attributes (for example, each having two values), a compound attribute (for example, of four values) is created to eliminate the interactions in the analysis [Green and Srinivasan (1978)].

Case 1:

As shown in Figure 4, customers' utilities of attribute P follows the same or similar pattern among the four values of attribute P.

In this case, the attribute does NOT need customization since customers have the same preference, say the first value P1 of attribute P, which is the default value of attribute P, of course. In the women dress shirt example, the attribute "fabric processing" exhibits this characteristic because the targeted market of the women dress shirt is of high-end and almost every customer requires "wrinkle-free". The manufacturer then decides to provide the women dress shirts all of wrinkle-free.

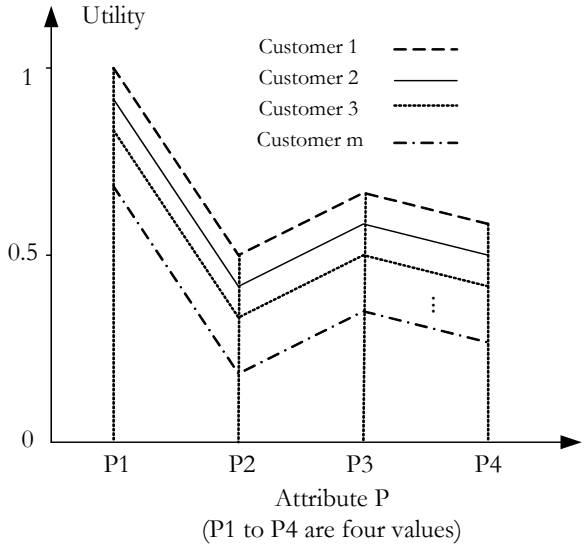

Figure 4: Utility analysis (case 1)

Case 2:

Contrary to case 1, case 2 shows the diversity of customer requirements in a certain attribute, as depicted in Figure 5. In this case, it is meaningful for the manufacturer to provide customization in this attribute. In the women dress shirt example, quite a few attributes such as "color", "accessory", "collar style" and "cuff style" exhibit this characteristic. The default value of the attribute is the one that has the highest frequency that customers give it the first priority.

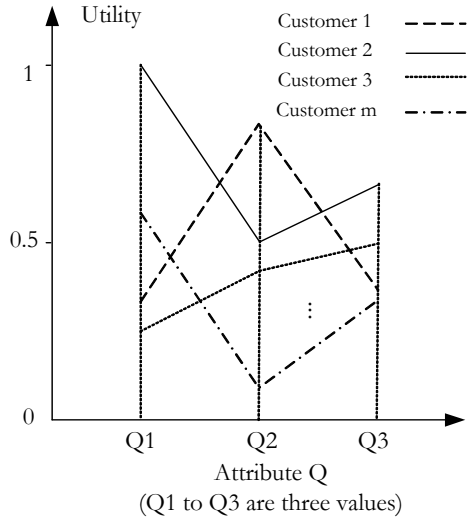

Figure 5: Utility analysis (case 2)

The proposed framework provides a systematic way to structure and analyze customer needs, from which manufacturers can attain necessary information to determine the customization space. The Design by Customers process can then be organized in a systematic manner.

4 DESIGN-BY-CUSTOMERS (DBC)

Design by Customers (DBC) is a process in which customers are allowed to express their product requirements and carry out the mapping process to the physical domain of the product [Tseng and Du (1998)]. The customers here refer to the end consumers. The DBC process is an interactive process between the product provider and customers. It is composed of two phases: Customer Needs Acquisition and Structuring and Product Design, as shown in Figure 6.

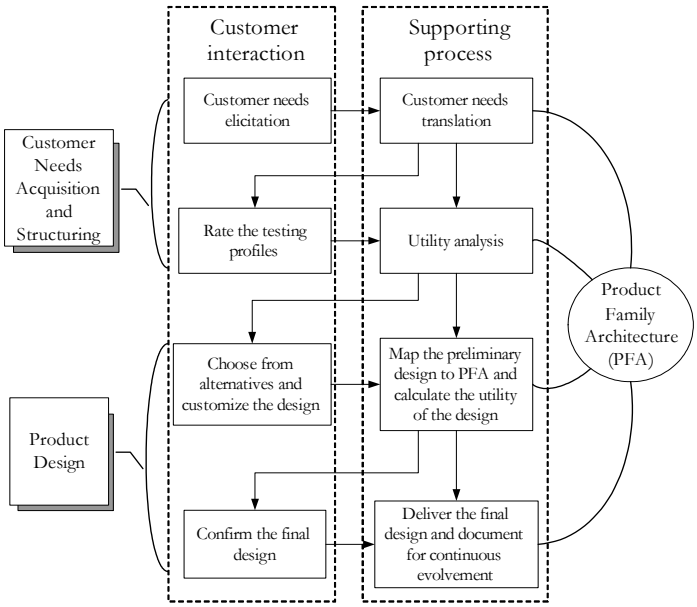

Figure 6: Design by Customer

The first phase, Customer Needs Acquisition and Structuring, is to establish a database of customer needs in terms of product attributes and their possible values. It starts from customer needs elicitation in customers' language, followed by the customer needs translation from customers' language into engineering-oriented language, and ends with utility analysis (see details in section 3). During this stage, customers are involved in the customer needs elicitation process and rate the testing profile process for conjoint analysis. The output of this phase provides customer needs and preferences for the product family design, which is represented by the Product Family Architecture (PFA) [Tseng and Jiao (1996)]. The PFA consists of three elements: the common base, differentiation enablers, and the configuration mechanism. The common base includes the common and shared elements among different products in a product family. The differentiation enablers are elements that differentiate one product from another. The configuration mechanism is a set of rules defining the generation of product variants [Tseng and Jiao (2001)]. The PFA represents the product provider's capability.

The second phase, Product Design, is to support customers to design products interactively and to improve the PFA continuously. Customers are presented a product configurator, in which a set of product attributes and their possible values are presented for customers to select and make modifications. Customers then prioritize attributes according to the relative importance among the attributes and express their desirability of the attribute values. Based on the preferences captured in this loop, a set of product design alternatives will be presented to customers for feedbacks and modifications. The iterative process in selecting and fine-tuning of customer's needs will be used in finalizing product design for customers. Meanwhile, the PFA is continually updated according to different customers' interactions and decisions. Effectively, the second phase serves the purpose of online marketing research to systematically accumulate customer requirements in order to guide the capability development of the product provider.

The realization of Design by Customer concept brings end consumers to participate in the product definition process. The process of consumers choosing different attributes and attribute values and combining them into a final product is known as product configuration process. In product configuration, consumers act as co-designers of the product. It is a two-way continuing exploration and interaction process between product provider and consumers. A study shows that product configuration process enables consumers to learn about their preferences and enhances customer satisfaction in terms of both the "buying" process and the decision about the product [Kurniawan (2004)].

The Design by Customer process can be extended beyond configuration. Consumers can actively participate as a product innovator. It usually happens when consumers have a strong need towards innovating or enhancing the current products, or known as lead users [Von Hippel (1986)]. Lead users are users whose present strong needs will become general in a marketplace months or years in the future [Von Hippel (1986)]. Research demonstrated successful product development processes initiated by lead users, especially in the area of applications-specific product [Herstatt and Von Hippel (1992); Urban and Von Hippel (1988)]. From traditional buying process to configuration process and to lead user innovation process, consumers' roles are changed from passive buyers to semi-active co-designers and to active designers, developers, and innovators. In this evolvement, manufacturers are able to gain advantages of shifting the product design and development process to the consumers, reducing amount of iterations caused by unsatisfactory products, and building up a knowledge base in the new product design. Although the configuration and innovation has been around for some time, only recently it can be made available to end consumers. User toolkit or configurator software provides a platform for end consumers to perform iterative trial and error designing and freely express their creativity in product design [Von Hippel (2002)]. User toolkit is a software system that manages a set of product variants and presents structured choices for consumers in selecting and building their products.

5 SUMMARY AND CONCLUSION

In order to enhance the effectiveness of product development process and to reduce time to market, it has become imperative to connect customers directly as an integral part of the design process. With the advent of pervasive connectivity, this paper proposes a systematic approach to elicit customer needs and get customers involved in the design process.

In the elicitation process, customers' tacit needs are explored by applying methods and tools developed in recent years. These needs are then characterized and refined to form the basis for preparing an environment for direct customer involvements in the design process, namely, the Design by Customer process. Customers are able to directly participate in the product design by expressing their preferences in selecting product attributes and their values. This approach allows customers to be actively involved in the product definition process rather than passively receive the end product designed by the product provider.

Active involvement of customers into the product design has been recognized as a critical source for innovation. Essentially, it enables consumers to be on the center stage of product design and development. Consumers' knowledge and direct participation in the design process not only leverages product and product-related information, but also facilitates real-time marketing research and brings different customers' attitudes towards buying decision making. As a consequence, the paradigm of design-make-sell will be replaced by the concept of design-sell-make. Consumers design the product, buy it, and send the order to be manufactured; this will create a brand new product design and development process, which benefits both customers and manufacturers.

6 REFERENCES

[1] Bailetti, A. J. and P. F. Litva. 1995. "Integrating Customer Requirements into Product Designs" Journal of Product Innovation Management, 12: 3-15.

[2] Blackwell, R. D., Miniard, P. W., and Engel, J. F. Consumer Behavior, Ft. Worth, Tex. : Harcourt College Publishers, 2001.

[3] Carroll and P. Green (1995),"Psychometric Methods in Marketing Research: Part I, Conjoint Analysis," Journal of Marketing Research, 32 (November), 385-391.

[4] Clausing, D., 1994, Total Quality Development: A Step-By-Step Guide to World-Class Concurrent Engineering, ASME.

[5] Green P.E., Srinivasan V., Conjoint analysis in consumer research: issues and outlook, Journal of Consumer Research, Vol.5, September, 1978, pp. 103-123

[6] Griffin, A. and J. R. Hauser. 1993. "The Voice of the Customer" Marketing Science, 12 (1): 1-27.

[7] Helander M. G., Khalid H. M., and Tseng M. M., 1998, Mapping Customer Needs in Web-based DIY Design of Consumer Products, Proceedings of the 3rd International Conference on Industrial Engineering: Theories, Applications and Practice, HKUST, Hong Kong

[8] Herstatt, Cornelius, and Eric von Hippel (1992), "From Experience: Developing New Product Concepts Via the Lead User Method: A Case Study in a "Low Tech" Field",

Journal of Product Innovation Management, 1992;9: 213-221.

[9] Kano, N., N. Seraku, F. Takanashi, and S. Tsuji. 1984. Attractive Quality and Must-Be Quality, The Journal of the Japanese Society for Quality Control, 14 (2): 39-48 (English Translation).

[10] Katz, A, Gestalt Psychology, its Nature and Significance, London: Methuen, 1951.

[11] Khalid, H. M. and M. G. Helander, 2001, Facilitating Mass Customization and Web-based Do-It-Yourself Product Design, Proceedings of the First World Congress on Mass Customization and Personalization, HKUST, Hong Kong.

[12] Kurniawan, S. H., Consumer Decision-Making in Product Configuration and Product Selection, PhD thesis, Hong Kong University of Science and Technology, 2004

[13] Kurniawan, S. H., K. L. Wong, M. M. Tseng, and R. H. Y. So. 2002. "Facilitating Design-by-Customer Process for Mass Customization" Proceedings of 2002 Int'l CIRP Design Seminar, 16-18 May 2002 in Hong Kong.

[14] McCullagh, P., Nelder, J.A., 1989, Generalized Linear Models (2nd Edition), Chapman and Hall

[15] Nagamachi, M. 1995. "Kansei Engineering: A New Ergonomic Consumer-oriented Technology for Product Development" International Journal of Industrial Ergonomics, 15: 3-11.

[16] Nagamachi, M. 1998 "Kansei Technology", Kaibundo Publication.

[17] Sauerwein, E. 1999. "Reliability and Validity of the Kano-Model for Classifying Customer Requirements", Proceedings of the 4th International Conference on ISO 9000 & TQM, Hong Kong.

[18] Suh, N. P. 2001. "Design for Mass Customization", Keynote speech, The First World Congress on Mass Customization and Personalization, HKUST, Hong Kong.

[19] Syan, C. S. and U. Menon. 1994. Concurrent Engineering: Concepts, Implementation and Practice, London ; New York : Chapman & Hall.

[20] Tseng, M. M. and J. Jiao. 1996. "Design for Mass Customization" CIRP Annals, 45(1), 153-156.

[21] Tseng, M. M. and J. Jiao. 2001. "Mass Customization", Handbook of Industrial Engineering, G. Salvendy, Ed. New York: Wiley. pp. 684-709.

[22] Tseng, M.M. and X. Du. 1998. "Design by Customers of Mass Customization Products" CIRP Annals, 47(1), 103-106.

[23] Urban, G.L., and Von Hippel, E., 1988, "Lead User Analyses for the Development of New Industrial Products," Management Science 34, no. 5 (May), pp. 569-82.

[24] Von Hippel, E., Shifting Innovation to Users via Toolkits, Management Science, Vol. 48, No. 7, July 2002 pp. 821–833.

[25] Von Hippel, Eric (1986) "Lead Users: A Source of Novel Product Concepts," Management Science 32, no. 7 (July):791-805.

[26] Zipkin, P. 2001. "The Limits of Mass Customization" MIT Sloan Management Review, 42(3), 81-87.