DESIGN FOR DYNAMIC REQUIREMENT AND DIVERSE USER EXPERIENCE

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1. Introduction and related problems

Advances in science and technology posed great challenges to the traditional design methods which were faced to the determined requirements and user experiences. For industrial design, especially in household appliances, digital devices, and auto industry etc, user requirements become dynamic and user experiences tend to be diversified. However, little guidance and few methods can be found in literature on the incorporation of dynamic requirements and diverse user experiences (DRDUE).

User requirements are dynamic and changeable with time [Shen et al. 2010], If companies ignore the change of user requirement information, the products launched in the market may not be accepted by the customer, what will cause immeasurable loss. Meanwhile, the trend of diversification and multi-channel interaction result in changeable user experience [Pucillo and Cascini 2014]. There is a time lag from design beginning to the marketing of the final product. It takes a long time to accomplish the design after positioning user requirement and determining user experience ways in product. Therefore, it is possible that the final products can not fully meet the user needs at that time when the products reach the market. To keep the competitive advantage, it is necessary for companies and designers to predict the future user requirements and the way of user experience. From the overall and strategic perspective, updating and adjusting the relevant product to the target in the view of user requirement and product experience, to develop after put into the market to meet customer expectations of products is vital. To solve this problem, the concept of mass customization was proposed and accepted to satisfy customer's demands of product variety and personality in today's customer-directing market. However, mass customization requires a highly flexible production technology, an elaborate system for eliciting customer's wants and needs and a strong direct-to-customer logistics system [Zipkin 2001]. Mass customization, which focus more on continuous improvement of products with modular and standardized design, may possiblely ignore the spirit of invention and innovation of product design. It is clear that mass customization is not for every company, especially the enterprises whose department of design and production are separated. Meanwhile, there is growing evidence that mass customization strategy is transforming into a mass product personification strategy. Customer variability is one of the main drivers of the product personalization, but academic literature and practical application lack the general tool which helps managers to organize the process of creating personalized products to deal with requirement variability, especially in design process. To win market competition, mass customization and product personification pay more attention on user requirement variability, so sometimes the company offer the products merely for satisfying the customers, but not giving a reasonable product with great user experience after rational analysis and design judgment. So as for the company deciders, they should carefully analyze the costs and benefits, the technology and the demands before committing their companies to a customization or personification strategy. This paper presented some cases on how

to take dynamic requirement and diverse user experiences into consideration in product development. We also reviewed the difficulties we faced in designing for DRDUE about the relevant aspects of different user situations and gaps between designer and final decision maker. We concluded that there is a need for guidance in the creation of a more flexible framework and a more executable method in design process of product development, particularly for industries that development time is long but more vulnerable to new technology and aesthetic style such as automotive industry, mobile phone industry and so on. This paper is not a conflict to mass customization and product personification, but a complement and further guidance for dealing with dynamic requirements and diverse user experiences in design process around the relationships of users, designers and deciders.

2. DRDUE in product design

2.1 Dynamic requirement in product design

User requirement is an important factor to drive product design evolution. In order to get higher user satisfaction and achieve better user experience, designers should give full consideration to the aspects in the effective acquirement and analysis for user requirements and technical requirements. In the traditional design process, however, we often began our design according to certain requirements and user situations, which leads to the final production of the products has a time lag relative to the possible new user requirements. At the time the products reached to the market may have been out of date. The dynamic characteristics of requirements in product design are described as follows:

- Inconsistent: Understanding requirements needs insight details in life and specific usage context, while there's a gap and inconsistency between designers and users in design requirement recognition. Meanwhile, user in different market segments proposed diversified requirements in different user clusters. For example, designers believed that kitchen disinfection cabinet is an essential consideration, while in China, disinfection cabinet is just used for storing kitchen appliances, but in other country, this phenomenon does not exist.
- Ambiguous: A product contains different kinds of requirements which have different weight. In other words, they are ranked in order but the order is varying with time. Moreover, there are some differences in users' professional degree and daily usage habits, then the user requirements tend to be ambiguous, even some users don't know what they want. Such as the user liked phones with physical keyboard few years ago because of its Good feedback and accuracy, but now the physical keyboard is almost rarely seen with the popularity of touch screen mobile phone.
- Variable: With the emergence of new materials and new technologies applying in civilian products, user requirements for new product are becoming various, and the changing speed is fast. Such as the HoloLens virtual reality glasses developed by Microsoft company bring users new and robust requirements.
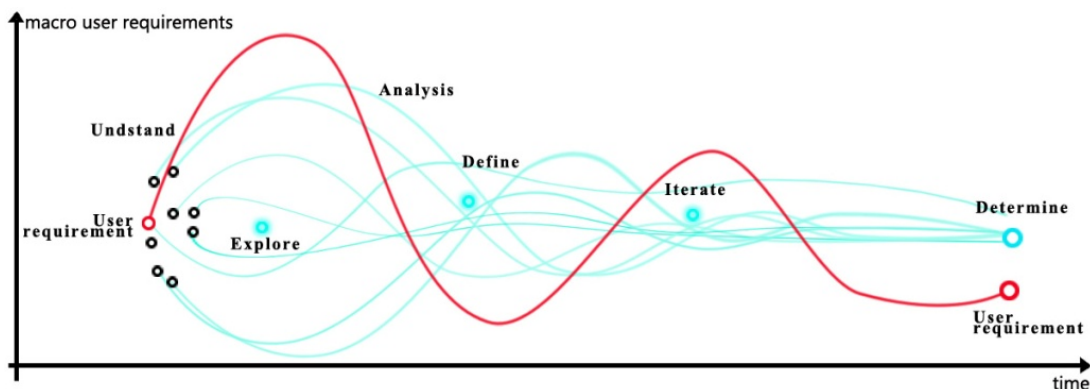
Figure 1. Identifying dynamic characteristics of requirements in product design

The above three characteristics of dynamic requirements were illustrated in Figure 1. The abscissa represented the time axis of early stage of design, and the ordinate represented the macro user

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requirements in a certain point of time. The light blue lines showed the process of understanding, exploring, analysing, defining and iterating until user requirements in traditional design process have been determined. The dark red line standed for one type of users' requirements varies with time [Chong and Chen 2010]. There is a gap and inconsistency in understanding and cognising requirements between designer and user. Designers will eventually determine the user requirements to guide the industrial design, but it is hard to say that requirements are really what the users most want, even the users don't know what they want because of the variability characteristic of requirements.

2.2 Diverse user experiences of human-product interaction

User experience is largely influenced by user characteristics (physical and mental), user situation and user interfaces. The ISO 9241-210 stressed that the design adreesses the whole user experience，and defined user experience as not only a consequence of the presentation, functionality, system performance, interactive behavior and assistive capabilities of interactive system, both hardware and software, but a consequence of the user's prior experiences, attitudes, skills, habits and personality. User experience, to some extent, determines the quality of the products or the services, having a great influence on brand loyalty [Pucillo and Cascini 2014]. However, experiences with products are to be ascribed in part to the products, as the remaining part is due to the context in which the interaction occur and to the users themselves [Pucillo and Cascini 2014]. In other words, interaction produce experiences, and the way of human-product interaction affect product experience in the whole process of using product. The ultimate goal of product design is to satisfy some requirements or to obtain some kind of services through the human-product interaction, including aspects of tangible interaction and the invisible emotional exchange, both from the objective and subjective perspectives, and internal external aspects. However, in order to adapt to the trend of diversification and multi-channel interaction, human-product interaction has developed from a conventional graphical user interface(GUI) to a more intuitive, natural and adaptive interactive interface technology, perception user interface（PUI）technology such as voice interaction, eye-movement tracking, gesture control, virtual reality and brain-computer interface technology makes this natural interactive mode come true. The innovation of interactive technology brings a new experience to the users, and the users gradually formed a new attitude and habits, as well as new skills and personality cognition towards the product.

Rim's (RIMM) blackberries once dominated the smartphone industry, but in recent years the company has been on a fast decline. One of the reasons for the decline of the BlackBerry brand is that the company did not timely adjust product experience strategy, and did not choose the interaction way of touch and the open android system, but the traditional BlackBerry OS system using outdated physical buttons. Letv, a new Chinese mobile phone brand, put forward the concept of super phone and mobile Internet ecosystem, which brought a whole new user experience, finally won the high market share and customer satisfaction through its series of mobile phone.

3. Framework and method of design for DRDUE

This study attempts to answer the question that how designers currently response to DRDUE in a dynamic situation and how to adjust the design process to adapt to DRDUE. Dealing with DRDUE comprises three aspects：how to inspire designers to propose solution for DRDUE and new design process to make up time lag of user requirement and user experience relative to the early stage of traditional design process; how decision makers to deal with DRDUE with design thinking; Identifying new design process in product development to deal with DRDUE.
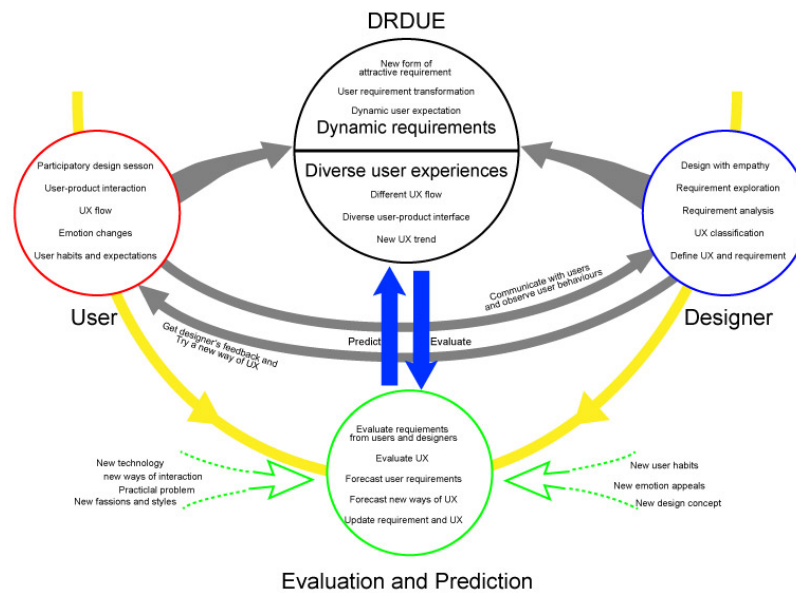
3.1 Solution for designer to deal with DRDUE

Dealing with DRDUE requires designer know more about user habits and expectations or emotion changes that may not be obvious in the user' environment. In order to have a better understanding of the users, more communication and observation is necessary for designers. Participatory design (PD) session initiative to enable users to participate in the process of design and experience in the invisible way to change their lives [Wilkinson and De Angeli 2014]. It is helpful for designers to observe what

users really want. And the focus of PD is not the users themselves, but the way they user or experience the product.

The concept of requirement and experience is in itself a fuzzy one. The behaviour of users can only give limited relevant information to the user requirements [Raharjo et al. 2010]. However, the whole process of user-product interaction convey a lot of information about requirements and user experience, including the established all feeling, perception, and cognitive impression in the process of interaction. Designers understand and analyse the existing user requirements and explore the new or potential use requirements through communicating and observing the process of user-product interaction with empathy. Thus, empathic expertise, which is consists of both emotional as well as cognitive aspects, could be considered a low-risk and low-budget investment for designers to experience what users have experienced. Therefore a change of mentality, the generation of new mindsets, new user experience flow is necessary for achieving empathy to design for DRDUE. Participatory design session reinforces the sense of empathy of the designers to understand the real user requirements and find new attractive way of experience [Wilkinson and De Angeli 2014].

As shown in Figure 2，user is not only the direct experiencer of product, but in turn an important design reference for the next generation products. Through observing, communicating, understanding and analysing in the process of user-product interaction, designers figure out the UX flow, emotion changes, habit of user and expectation to the product, and then classify and define diverse UX and dynamic user requirement and have a feedback to users, Ultimately to achieve the continuous and dynamic interaction between the designer and the user.

Figure 2. Framework of solution for designer to deal with DRDUE

However, It is far beyond enough for dealing with DRDUE with continuous and dynamic interaction between the designer and the user. The ultimate goal of dealing with DRDUE is that the finally product can fully meet the user needs at that time when the products reach the market and win the market competition and get the largest profits. Evaluation and prediction of requirement and UX is the key link to deal with DRDUE [Chong and Chen 2010]. After each interaction and communication between the designer and the user, the defined user requirements and way of UX is to be assessed in order to make the right decision about whether the product meets the needs of users. The important parts of the framework to deal with DRDUE in product design are described as follows:

- Evaluation: New technology and diverse way of interaction, new fashion and style trend are important appraisal references to deal with DRDUE. The influence of new technology and diverse interaction on design should be evaluated. For example, mobile fingerprint recognition technology has a great impact on mobile phone industry for the past 3 years, this technology

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even changed the pattern of the mobile phone industry in some developing countries because of ignoring the impact of this technology on the digital industry. If there's a design evaluation framework of influence of new technology and diverse way of interaction, new fashion and style or other factors causing influence on design, it is possible that the company may get the first chance and gain competitive advantage.

- Prediction: Through observing the user behaviour, the designer can dig out the potential user requirements [Chong and Chen 2010]. Together with the new technology and diverse way of interaction, new emotion appeals and new design concepts may help us predict the user requirements in the near future.

3.2 Make decision with design thinking for decider

Design practices are being applied to a expanding scope of activities from digital product interaction of graphic areas, product design, product service design even to business strategy and social policy. The success of the Internet thinking mode is connected with the rapid iteration under the design thinking, event marketing, fans economy focused on the user's pain points which is small and easy to use, etc. This allows us to realize the influence of design in the business model of enormous, as well as how to design strong leadership formation and implementation of innovation-driven strategic ability to achieve sustainable profitability [Fuller 2010]. Design thinking is not only the important factors for the development of products, services, and experience, but also an important part of business, organization and management. As a tool of strategic innovation, by acting on such levels as enterprise culture and strategy, business process, design thinking give enterprise sustainable competitive advantage [Vinnakota and Narayana 2014]. Designers begin to be involved in business and management through design thinking, and enterprise decision makers transfer to the macro control on product development through the design thinking.

As shown in Figure 3, macro design thinking involves business model, user, technology, and product and so on. In the traditional design concept, designers just concern themselves with the relationship between the user and the design and pay more attention on product design itself. Thus it is possible that the final product is merely good design but can not meet market demand and business strategy，and finally lead the company to losing market share. For decision maker, with experience in commercial and Attaching great importance to the data, they can hardly focus on user's emotional changes and subtle transformation of requirement. So it is likely that the product reached the market can not meet the user requirement and emotional appeals, in turn has a bad influence on the brand loyalty. Macro design thinking requires the designer and the enterprise decision makers together to explore the potential requirement of users and emotional demands, explore the possible impact of new technology on the industry, and ultimately present through the product design expression.
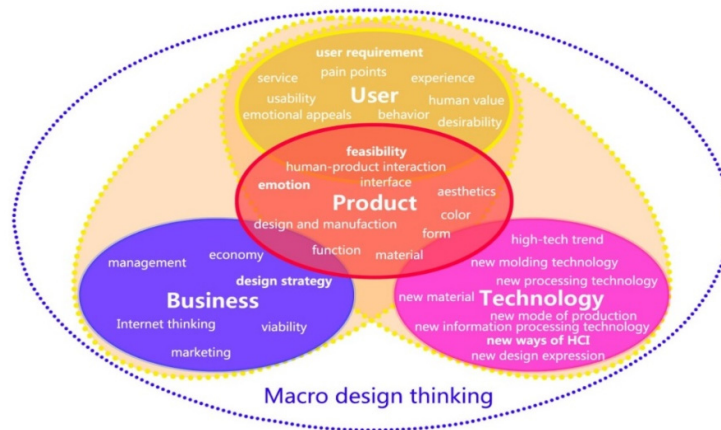

Figure 3. Design thinking concerning about user, product, business and technology for decider

Design thinking provides a new way of macro thinking and management tools for the comprehensive promotion of enterprise innovation and management [Vinnakota and Narayana 2014], which has increased the innovation driving force for enterprise development and pointed out the direction. By breaking to cross-border thinking and using empathy to consider potential demand of the customers and gain insight into the future development needs, design thinking can be highly effective in combination of design and business through the product. The product itself become the media between user and brand spread, service, and business strategy.

3.3 Identifying design processes in product development

Traditional product development process, including concurrent engineering technology, can not completely solve the problem of DRDUE. In recent years, emphasizing a process-oriented and object-oriented process of new product development from concept to production, concurrent engineering has many advantages such as shortening the cycle of new product development, improving quality, reducing cost, and it has been widely adopted by many enterprises in automobile, aerospace and other high-end manufacturing industry [Tsygankov et al. 2015]. However, concurrent engineering doesn't play a significant role like imagination in household appliances, digital, and other low-end manufacturing enterprise because of lacking perfect data exchange and integration system and modeling simulation technology and the trend of separation between design and production in small and medium-sized enterprises.
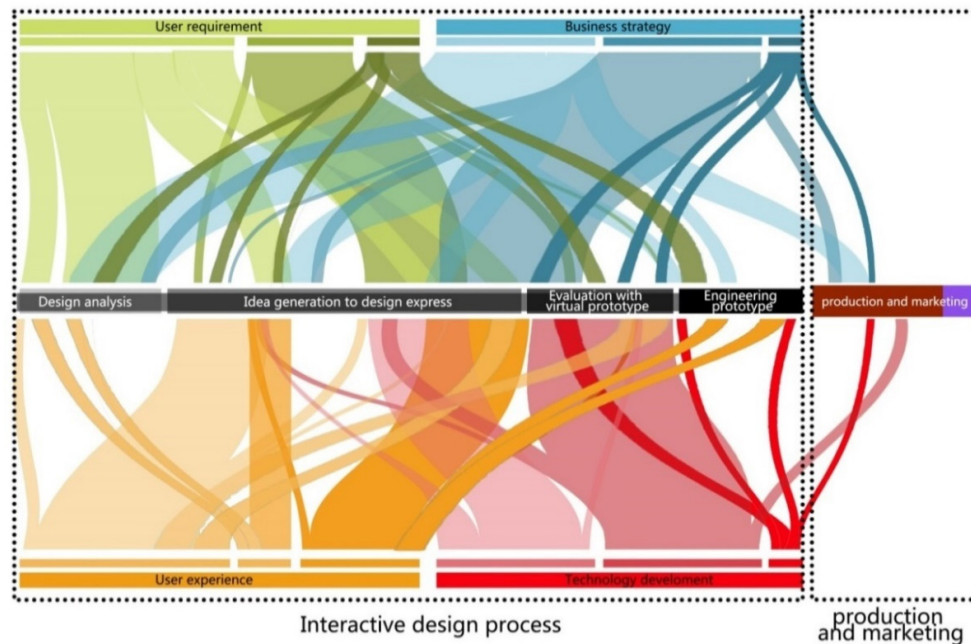
Figure 4. Interactive design process in product development

Figure 4 shows the interactive design process determined by the mentioned four factors. Different coloured ribbons represent the interaction between four factors in different stages and the design process. It demonstrates the influence of four factors on design process and gives an outlook how to play their role in the whole product development process. The meanings of the four types of colour ribbons in interactive design process are described as follows:

- Green ribbons (User requirement): Represent the influence of user requirements of different stage to the process of design. As the characteristics of inconsistence, ambiguity and variability, user requirement has more influence on the stage of design analysis and design express. However, in the stage of evaluation with virtual prototype and engineering prototype, new user requirements should be taken into consideration in product design, so dynamic adjustment

mechanism, as an important precautionary measure to adjust design to dynamic user requirement, is necessary for designers to manage design process.

- Blue ribbons (business strategy): Represent the business strategy for coming into play from design to the time the product reach the market. Business strategy, which will guide the designer to perform commercial analysis and locate product accurately, should be used as an important index to measure the design of the virtual prototype and engineering prototype. Business strategy must show that strategy is not limited to only costing and marketing, but to first make sure that the product is the right thing that consumer desire to get.

- Orange ribbons (user experience): User experience demand that the design activities should be able to meet business needs and user requirements, but also meet these two parties through the best design solutions. In the stage of concept generation to design express, user experience should be designed as the core of design project and be evaluated in the next stage of design until the final production and marketing.

- Red ribbons (technology development): Application of new technology promotes the diversification of user experience and design expression, assisting designer in designing and specifying the best way to user product and then meet their business strategy.

In order to deal with DRDUE, interactive design process emphasizes the process should be geared to the user requirement, UX and business strategy of the whole process or product object. Therefore, it is essential for designers to consider not only the current and former user requirement and UX, but also consider the future voice of user. In the whole period of product development, the market demand, user requirements, advanced science and technology and even business strategy are changing with the gradually accelerating product iteration speed in our times for the characteristics of innovation [Pereira and Baranuskas 2015], fast and personalized. It is the inevitable trend that the interactive design process meets the structural and functional complexity of product or service and diversity of consumption. In the stage of design analysis, designers analyse and define the market demand and user requirements according to the established business strategy and existing technology. However, with the project going on, the designer may find new requirement or different idea to present design concept in the stage of idea generation to design express. In the stage of product prototyping, the interconnections between the four factors should be together to determine the final product that consumer really want.

Compared with the traditional design process, interactive design process has more emphasis on variation feedback, prototype evaluation and interaction between design, user and decider. Guiding by the business strategy and paying more attention on dynamic user requirement and diverse user experience, design team will work with user and engineer together in the whole interactive design process [Shapiro et al. 2015].

4. Conclusions and further work

This paper shows a framework of solution and corresponding interactive design process for designer and decision maker to deal with DRDUE. The aim of this work is to increase the probability of the product meeting the final market and create a more flexible mechanism to deal with the trend of inconsistence, ambiguity and variability of user requirement and diverse UX.

Product development is indispensable to strengthen the core competence, but also a critical activity to maintain the long term survival and enhance the steady development of a company. While in the era of rapid changes, variation feedback, prototype evaluation become a effective way to capture the new user requirements and new way of product experience. The core of product is meeting the users' specific requirement with the best and comfortable way to use product.

The framework includes user, designer, decider, and relevant design process. Participatory design is used to observe, understand and analyse the user requirement for designer with empathy. Besides, macro design thinking, as a tool of strategic innovation, requires the designer and the enterprise decision makers together to explore the potential requirement of users and emotional demands, explore the possible impact of new technology on the industry, and ultimately present through the product design expression. However, the ultimate goal of the frame is to guide the company to design product which can fully meet the user needs and then win the market competition, so it is important for designer and decider to evaluate and predict the user requirement and way of user experience to make the right

decision about whether the product is really what the user wants or not. Compared to mass customization and product personification, this method and framework is more flexible and universal for both the large and medium manufacture enterprises and even the small start-up companies. Meanwhile, interactive design process underlines that user requirement, user experience, technology and business strategy should participate and interact with the whole design process other than merely the initial stage of design.

It is imaginable that the new and popular user requirement appeared after the design expression can influence the late design stage of engineering prototype and generate a new design scheme through flexible mechanism. Through variation feedback and flexible mechanism, designers can adjust their design to meet the user requirement and new way of user experience.

In addition, the framework and method to deal with DRDUE have no conflict but even well compatible with other product development technology such as Concurrent Engineering technology, Quality Function Deployment technology and so on.

Nevertheless, it is to be said that there is still a long way to provide a detailed framework to give a elaborate description on functioning of different factors on design process. This work states the basic frame and method which should to be processed in order to achieve the intended outcome and verify its feasibility and advantages in product development.

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