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User-experience based product development for mass personalization: a case study

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Abstract

Nowadays, with the rapid development of information technologies (e.g. web 2.0, cloud computing and virtual reality) and manufacturing technologies (e.g. additive manufacturing), users become more actively involved in the product development stage to create personalized products with higher efficiency. This emerging manufacturing paradigm is known as mass personalization, of which *user experience* (e.g. emotional factors and product utility), *co-creation* (e.g. user participation), and *product change* (e.g. modular design) are regarded as three key characteristics. In previous studies, researchers often treat each characteristic separately with an illustrative example to demonstrate its significant effect respectively. They, however, cannot fully reflect the product development process for mass personalization, and may cause inconsistency in implementing the existing methods into real cases. To fill the gap, this work proposes a three-model based (i.e. physical model, cyber model and user experience model) generic framework for conducting user experience based product development for mass personalization. A case study of a personalized smart wearable product development is described, of which the three key characteristics are considered collectively. It can also be seen as a typical case integrating the frontier techniques to enable mass personalization. The authors hope this work can provide some useful guidance to product designers and engineer-to-order companies.

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1. Introduction

Owing to the fast development of information and manufacturing technologies, products become more and more information densely (i.e. smart) and personalized (i.e. low volume in high variety) to meet user's individual requirements. In personalized product development stages (or innovative design process), users are more actively involved in the co-creation process even without much design knowledge. To facilitate it in a user-friendly manner, companies often provide co-design toolkits (e.g. product configurator) [1] in a virtual environment or embedded toolkits (e.g. product with built-in-flexibility) in a tangible way so as to achieve better user experience (UX) and satisfaction [2]. Moreover, product itself provides not only pragmatic functions, but also social and emotional interactions with the users [3]. As pointed out by [3], UX-based product design should emphasize the exploitation of implicit data (e.g., purchase history) aiming to predict users' unexpected needs.

In order to describe this manufacturing paradigm, several academic concepts have been proposed, two of which are widely accepted: mass personalization [4] and mass individualization [5]. The major difference lies in the consideration of sustainability and extendibility of a product in mass individualization. Nevertheless, three key characteristics of personalized product development are defined coherently, i.e. product change, co-creation and UX.

Though plenty of research works have been done in this area, each characteristic is addressed separately. For example, product change was studied by introducing adaptable, modular and scalable design methods [6]; co-creation was conducted by utilizing product configuration system and

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embedded open toolkits [2]; while user experience was elicited by marketing strategies in a certain context-of-use (e.g. questionnaire and focus group) or by digital equipment (e.g. virtual-reality headset and eye tracker) [3]. None of them can fully reflect the UX-based product development process for mass personalization and may cause some inconsistency in implementing the existing methods into real cases. To fill the gap, this paper offers a case study of a personalized smart wearable product development (i.e. respiratory mask) in a start-up business, of which three key characteristics are jointly considered. The rest of this paper is organized as follows. Section 2 gives a detailed review of related works of product development for mass personalization. Section 3 depicts an overall process of personalized product development with regards to the three key characteristics and proposes a conceptual framework. Section 4 describes the case study in details. At last, the conclusion and future work of this research are given in Section 5.

2. Related work

2.1. User experience

ISO 9241-210 defines UX as "*a person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service.*" [7]. It is usually latent and difficult to exploit through marketing analysis. It originates from evolution of the user's affective states triggered by stimuli (events) along with a chain of cognitive tasks which is the most profound feature of mass personalization [8]. UX realization is based on product's functional performance, so that the elicitation of cognitive and affective needs can also lead to identification of unexpected performance related requirements. Thus, for personalized product development, both affective and cognitive requirements should be accompanied with functional requirements (FRs) concurrently [4], and users care more about the value, the identity and the experience of creating the personalized product rather than product itself [9]. Another important thing is the context-of-development, designers should pay more attention to the specific scenarios which are capable of influencing UX. Moreover, to create long-lasting hedonic products, it is suggested that designers should emphasize more on the experiential aspect of the interactions between users and products, so as to understand potential UX and to implement design for experience [10].

2.2. Product change

Generally, product change can be achieved by modular design in macro-level (i.e. functional modeling) and scalable design in micro-level (i.e. parametric optimization) [11]. For the former one, one of the prevailing method is the adaptable design which was firstly proposed by Gu, et al. [6] with product lifecycle sustainability concerns. It stands for the ability of a design or a product to be adapted to new requirements and reuse it when circumstance changes by adding or replacing certain modules through pre-defined adaptable interface [12]. Levandowski, et al. [1] utilized the design adaptability principles to develop a two-stage product platform for 'engineer-to-order' (ETO) product configuration. Koren et al. [5] adopted the adaptable design concepts in an open product platform development.

For the latter one, scalable design focuses on offering a wide range of functionality to different customer groups by changing the parameters of existing attributes in a vertical manner [13]. In such a way, changes of CRs can be postponed to the latter stage of product development so as to lower the cost. One of the most accepted method is Claesson's configurable component (CC) concept [14] and it was further developed to involve concepts such as: bandwidth [15] (i.e. the total range of parameters of design solution) and geometry interface modelling [16] (i.e. determine the geometric parameters of the interfaces between features).

2.3. Co-creation

In literature, there are two typical ways of enabling co-creation effectively and user-friendly. The first one is the online configuration system (e.g. NikeID and Dell), which plays a significant role in offering tailored products with shorter lead time to market [17]. It consists of a set of predefined attributes with constraints (rules) for customer to select within the product family scope [18]. Generally, it operates in a 'configure-to-order' (CTO) model, which utilizes customers' specifications as input, and the system would derive the recommended or target product fulfilling customer needs as output. In such ways, it bridges the gap between CRs and the end-product by a series of attribute selection process [19]. The main challenge is to effectively define personalized modules beyond the existing product family in an ETO model.

The other is the embedded toolkits for user co-creation [2] (e.g. Adidas One) which is proposed to design products with build-in flexibility by shifting some specifications of the product into the domain of the user. It is known as a postponement method to increase design flexibility. According to Gross and Antons [20], it should contain: 1) *a flexible architecture* where design parameters are adaptable; 2) *a set of rules* to verify the feasibility of possible combinations; 3) *an interface* for individual users to manipulate the values according to their own preferences. Moreover, Bénade et al. [21] combined the modern C-K theory to develop a theoretical framework for use generation of smart products with built-in flexibility.

3. A generic framework of UX-based personalized product development process

Personalized product development process, similar to the innovative design process, aims to deliver unique product with specific values to achieve customer satisfaction [22]. Fig. 1 gives an overall picture of personalized product development in regards to the three key characteristics (i.e. product change, co-creation and UX).

The co-creation process can be seen as a two-type innovation: 1) *utilitarian innovation* process which emphasizes on the use generation (e.g. airbag for human protection); and 2) *hedonic innovation* process which focuses on the specific meaning delivery (e.g. fancy appearance) [23].