

A Dynamic Product Design Concept on Users' Physiological Changes

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Abstract. Nowadays many products have longer service lives. However their long-time use might also lead to users' physiological discomfort. One of the examples is in-home furniture whose service life can very often reach up to over 20 years. Humans' physiological changes are dynamic and so are their postures. Therefore, the design of furniture should also adopt a dynamic approach. This article aims to develop a dynamic product design concept based on a user-centered design (UCD) concept that can take into consideration users' physiological and psychological changes. The first stage of UCD is to understand and specify the context of use, which include user analysis, task analysis and environment analysis. User analysis is included in the first stage to establish a new analytical model. In the end, a dynamic analysis model is used to develop a new product – a new seating chair for pregnant women. Pregnant women's physiological and psychological changes are divided into four stages, and a design is put forth based on the needs in each stage. Through this case of product development, a design that is capable of adjusting to users' physiological and psychological changes is presented to verify the feasibility of the dynamic product design concept.

Keywords: dynamic, design concept, furniture, user-centered design.

1. Introduction

The field of design can cover almost everything from lipsticks to locomotives, from paper clips to space shuttles (Hubel & Lussow, 1994) [1]. Product designs with different considerations have different orientations for their processes and goals. Market-oriented product design makes possible the combination of art, technology and market, and the combination of product development and economic benefits (Ren et al., 2009) [2]. On the other hand, manufacture and cost-oriented product design takes into account the recovery of costs and the reduction of production costs (Liu et al. 2009) [3]. Whereas user-centered design (UCD) focuses on the consideration of users' operability, comfort and participation to develop products that can best satisfy users' needs.

The initial observation of the study found that long-time use of products with longer service lives might lead to users' physiological discomfort or the problem of unsuitable functions. One of the examples is furniture whose service life often reaches up to 20 years (Wang & Lin, 2008) [4]. Nearly all of the in-home furniture are of fixed type and users will have to accustom themselves to the original design of the furniture which cannot be adjusted according to the changes of times environments. This may lead to the problems of users' discomfort or furniture's unsuitability.

To solve the problem of the discomfort caused by long-time use of furniture, this article attempted to come up with a dynamic design concept for furniture that can take into consideration users' physiological changes. It is hoped that through the development and application of an innovative approach, a UCD method and its application can be established.

2. Theory

2.1. User-Centered Design (UCD)

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UCD is a design process put forth from users' viewpoint. The purpose is to enable products to better meet the needs of users and increase their practicality through the participation of users in the design process. According to ISO 13407 Standard User-Centered Design Activities Development Process, UCD contains four key processes (see Fig. 1):

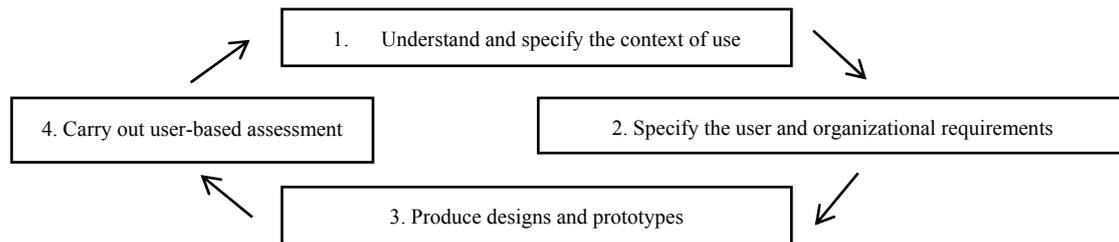


Fig. 1: ISO 13407 Standard User-Centered Design Activities Development Process

2.2. User-machine relationship – the relationships between user body and furniture

Furniture design is closely associated with users' bodies. Gordon et al. (2006) [5] argued that variable factors that can cause the seating surface to produce the feel of being compressed and affect interface pressure include personal factors (such as anthropometric factors), postural factors and chair's design factors. Gordon (2006) pointed out in one of his studies that personal factors (such as anthropometric factors) have an obvious influence on the interaction between sitters and chairs. Sitters' heights and interface pressure are closely related to each other, and pressure will increase with the weight of the sitter (Yang et al., 1984) [6]. The height of the sitting surface, the length of the backrest, the properly match of the angle of a chair and the size of the sitter are all important factors to a good chair (Weng, 2008) [7]. From the above, it is known that factors to a comfortable chair include personal factors, postural factors and design factors. Sitting is a dynamic process, so are sitter body's changes and sitters' postures. Therefore, a seating chair should also be "dynamic" so that it can adjust to the changes of the sitter's physiological conditions.

The service life of fixed-type furniture can be as long as over 20 years. However, during this period of time users would also experience a big change in their physiological conditions, which might also lead to fixed-type furniture becoming unsuitable. But neither "adjustable" nor "mobile" seating chairs are the best resolution. As a result, how to come up with an optimized design that can suit a sitter's different physiological conditions has become an important task for this article.

2.3. The concept of dynamic design

As mentioned above, the act of sitting is in fact a dynamic process, in which the sitter's physical conditions, posture and the chair are all dynamic. However, our literature review found that nearly all of the ongoing researches focus only on a single user need at a certain point of time, involving neither the concept of time line nor the analysis of user needs from a dynamic viewpoint.

Now, the topic will be shifted to the application of UCD concept in other fields and the existing dynamic thinking modes. In the US and European countries, the UCD concept of dynamic identity was present in the field of visual design.

Dynamic identity is based on the thinking that the identity logo for a reputed brand should be able to change (dynamic) to satisfy the changing needs of a corporate or market, and it should be an identity that is able continue to innovate. Dynamic identity can be divided into basic logos and changing logos. Corporate spirit can be embedded in the basic logo to present many different images on the media. Although the identity logo is different each time, its basic image and corporate spirit can still be clearly identified. Dynamic identity has been adopted by Saks Fifth Avenue in the US, Channel 4 in Britain and Obama's presidential primary campaign in the Democratic Party. All of these are application of dynamic identity design (Wheeler, 2011[11]).

From the viewpoint of visual design, "dynamic" design is a concept put forward to respond to the changing environment. When applied to the design of furniture, the dynamic design concept also involves the variable factors of time and users' physiological changes. The purpose is to adjust to the ever-changing conditions. To this end, this article turns the innovative furniture design into a dynamic mode, in which the

results of the dynamic analysis of user needs are applied to the design of furniture to maintain their suitability over a long time.

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2.4. The needs of users whose physiological conditions would change with time

Physiological change is a concept related to time line. The physiological conditions of the following groups of people will change with their ages, and those changes can relate to furniture, for example the pregnant women.

It would become more and more difficult for pregnant women to rise up from a chair during their pregnancy. This kind of biomechanics could inflict harm to muscles (Gilleard et al., 2008) [8]. Studies related to pregnant women’s rising up from a chair and standing showed that in the later stage of pregnancy, the act of rising up would increase not only the flexion of hip joints, but also the dorsiflexion of ankle joints (Lou et al., 2001) [9], the exertion (Ellis et al., 1985) [10] and flexion (Lou et al. 2001) of knee joints, and the flexion of hip joints. In a study by Gilleard et al. (2008) [8], pregnant women were divided into five groups (before 18 weeks in pregnancy, 24 weeks pregnant, 32 weeks pregnant, 38 weeks pregnant and 8 weeks postpartum) to observe the act of their rising up from a chair and standing. The results showed that the acts of women in different groups varied from one another, suggesting that the requirements for pregnant women’s seating chairs would also vary with their physiological conditions. In light of the physiological changes, it is important to explore the relationships between furniture and pregnant women’s physiological conditions.

The above discussion is related to people whose physiological conditions would experience big changes with time. However, very few furniture products on the market can meet the requirements to provide adjustable functions according to users’ physical changes. In other words, their designs fail to satisfy the needs of users.

3. The application of dynamic design concept

3.1. A dynamic design concept for innovative furniture

The first stage in UCD process is “understand and specify the context of use”, i.e. the item-by-item analyses of users, tasks and environments. The purpose of the dynamic concept’s being incorporated in the first stage of UCD process is to establish a new analysis model for the development of products. Fig. 2 shows the adoption of dynamic analysis in UCD for user analysis, task analysis and environment analysis.

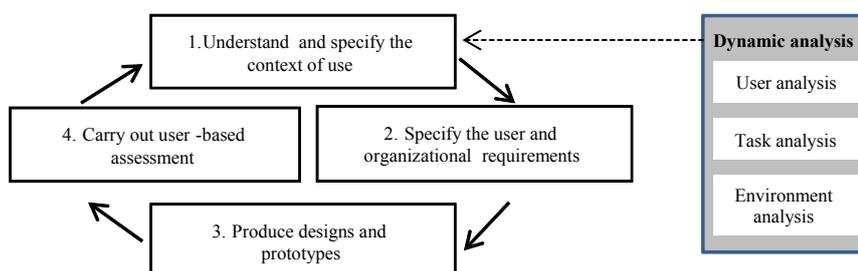


Fig. 2 UCD process that includes Dynamic Analysis

3.2. The application of dynamic analysis model to product design

In this stage, a dynamic analysis model is applied to product design and development. In this article, the design of a seating chair that can be adjusted according to the needs of pregnant women’s physiological changes is explored. In addition, entries on the shortlist of 2012 YODEX Design Competition are also discussed. During the 9-month pregnancy, pregnant women will experience worries in early stage, the difficulty caused by physiological changes in late stage and the inconvenience in postpartum breastfeeding.

However, until now there are no seating chairs designed for those women. In this design case, a seating chair was developed based on the dynamic design concept to according to pregnant women's physiological conditions and needs in different stages identified through a dynamic analysis model. Below is the discussion of a product development case that follows UCD process.

- Understand and specify the context of use

Dynamic analysis is incorporated in UCD process. Women's pregnancy was divided into early, middle, late and postpartum stages for physiological and psychological analyses to identify their needs. Table 1 shows the dynamic analyses model before the design of a seating chair for pregnant women, including user analysis, task analysis and environment analysis.

Table 1. The application of dynamic analysis model to the seating chair for pregnant women

| Pregnancy | User analysis | Task analysis | Environment analysis |
|------------------|--|--|--|
| Early stage | Worried about miscarriage, moody | Provide physical support to increase their sense of security | A space that is safe, comfortable, peaceful and quiet |
| Middle stage | Waist soreness and back pain, swollen lower limbs, varicose veins, discomfort | Exercise and increase physical fitness to prepare for childbirth | The functions of workout and muscle training |
| Late stage | Weight gain, back pain, difficult to bend or straighten one's waist | Provide physical support to help them relax and rest | Alleviate their physical stress and help them move smoothly |
| Postpartum stage | The care of their bodies and the intimate relationship with their newborn babies | Rest, breastfeeding | An efficient, safe and comfortable environment for breastfeeding |

- Specify the user and organizational requirements

Different user situations are considered for different stages in pregnancy based on the above analyses.

- Early stage 1-3 months pregnant: Pregnant women's sense of security needs to be increased and their stress needs to be alleviated.
- Middle stage 4-6 months pregnant: Waist soreness and feet edema need to be relieved.
- Late stage 7-9 months pregnant: Support is needed to help them rise up from a chair.
- Postpartum stage: Help is needed make their breastfeeding easier.

- Product designs and prototypes.

This chair is designed according to the physiological changes of pregnant women in their pregnancy which is divided into four stages: the first stage - 1-3 months in pregnancy: for this period, a soft mattress can be used to cover the pregnant woman to increase their sense of security; the second stage - 4-6 months in pregnancy: for this period, the front part of the seat can be broadened so that they can sit with their legs crossed to reduce their waist soreness and alleviate feet edema, and train their leg muscles for a smooth delivery; the third stage - 7-9 months in pregnancy: for this period, the angles of the chair feet can be adjusted to facilitate pregnant women's rising up from the chair; the fourth stage - postpartum breastfeeding: for this period, multiple layers of soft mattress can be added to make their breastfeeding easier(see Fig. 3).



Fig. 3: The chair is designed according to the physiological changes of pregnant women.

4. Discussion and conclusion

A prototype of the chair was completed and exhibited in May 2012. The chair's creative design is well received by experts in both academic and industrial circles. In the future, more pregnant women will be invited to participate in experiments to complete its UCD process. After that, a dynamic design evaluation method would also be put forth to further examine the feasibility of dynamic design.

Before the beginning of a UCD process, an item-by-item analysis should be conducted for user analysis, task analysis and environment analysis. However, it was found that the user analysis adopted by most of the past studies were either questionnaire or experimental observation which only focused on the needs at a certain time point, not involving the concept of time line. Considering that both users' physiological and psychological conditions would change with time, the concept of "dynamic" should be incorporated in the product design. It is suggested that, the concept of "dynamic" be incorporated into the first stage of UCD – understand and specify the context of use – to establish a new dynamic analysis method. User analysis, task analysis and environment analysis were conducted in the stage of "understand and specify the context of use". In this design case, the product's use was divided into pregnancy period and postpartum breastfeeding period on a two-year time line. Users' physiological changes were divided into four stages, for each of which the product was designed according to their physiological and psychological conditions at the time. After that, users' needs in each stage were analysed to develop a seating chair for pregnant women. Lastly, experts from academic and industrial circles were invited to evaluate the product to further examine the innovation and feasibility of this dynamic analysis model.

In this article, a dynamic analysis method is put forth in the analysis stage of the UCD process. In the future, the concept of "dynamic" should also be included in other stages to come up with a more comprehensive UCD-based product design concept that can combine dynamic analysis, design and evaluation.

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