

An Innovative Dynamic User Requirements Analysis Model

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Abstract: Users' requirements and preferences change constantly over time. To extend the product life cycle, this research introduces the time dimension into the requirements analysis.

Based on the User-Centered Design, this research consists of two stages: first, it reviewed the literature to develop an innovative 8 dynamic user requirements analysis model; second, it invited four designers to participate in confirmatory experiments to verify the feasibility of innovative approaches. For the experiment, they were further divided into two groups. One group applied the new approach (group1), the other group did not (group2). Toddler high chair was treated as the theme for requirements analysis and design. Participants then presented their design proposals and held a discussion.

The confirmatory experiments result shows that group2 generated four proposals while the group1 produced three proposals. There is no obvious difference. The discussion results show that in terms of the design proposals, the group2 thought that the group1 provided more multiple design orientations and extended the product life. In terms of the design thinking, the group2 mentioned that they were often limited by past experiences during design development. The group1 mentioned that the new approach could guide their thinking and help them to think from another perspective.

Key words: *UCD, Requirements Analysis, Design Method, Dynamic Analysis*

1. Introduction

User-Centered Design (UCD) plays a critical role in the product development [1]. The key to UCD is making design based on the user's requirements and benefits [19]. Lin Ying Chien (2010) mentions in the study that the definition of user directly affects the design principle of the entire team. Therefore, it must first learn the definition of user and using requirements prior to UCD.

The users and their requirements are actually changing constantly. For example, in terms of the physiological changes, the children or teenagers have different heights in a very short time during the teens [11]. Under the fast-changing psychological and social environment, and ever-developing technology and products, user will change the product preference and purchasing desire along with the time [9]. Therefore, the using requirements keep changing with the time.

UCD requires getting to know the changes of user requirements in different time points. This is the only way to design the product in accordance with the using requirements.

Therefore, for the purpose of getting to know the changes of user requirements, this study integrates the dynamic concept into the analysis of using requirements. The objectives of this study are listed as follows: 1.

Construct dynamic analysis model of using requirements. 2. Verify the feasibility of dynamic analysis model of using requirements.

2. Literature

2.1 Four steps of UCD

UCD is a design process proposed from the perspective of the user. The user is involved in the entire design process, so that the product will satisfy the user requirements and increase the practicality better. According to ISO 13407 Standard User-Centered Design Activities Development Process, UCD consists of four steps: (1) Know and confirm the use scope, (2) set target users and using requirements, (3) make product design and sample, and (4) evaluate usability.

2.2 UCD literatures related to getting to know requirements

The using requirements analysis of UCD is divided into three dimensions, namely, user analysis, task analysis and environment analysis. Review the related studies home and abroad in the past five years, it's found the user analysis mostly adopts the methods of questionnaire, interview and experiment. The experiment usually uses observation method, so the observation is also a common research method used in the user analysis. [2,3,4,16,12,5,6,17,7,19,10,15,8,13,14] As for the task analysis, the common methods are questionnaire, interview and literature review. [2,3,4,16,19,15,8] In the environment analysis, the common methods are questionnaire and literature review. [2,3,4,16,19] The research methods used in the three dimensions show high similarity, and questionnaire is the most common method. Moreover, it's found that a single research method can't cover all the three dimensions which all aim to seek the using requirements. Nan Tu, et al. (2011) mention in the study UCD process starts from collecting user data with the following common methods, questionnaire, interview and observation. So the said methods are adopted as three basic research methods to get to know the users and using requirements.

Prior to the design, UCD lists the user, task and environment analysis item by item. However, although specific research methods have been used in current UCD related literatures, the requirements analysis may be still unclear. It will integrate the concept of dynamic time axis in the first two dimensions. Based on UCD, it will develop the dynamic analysis, design and evaluation product design method.

2.3 Construct 8 types of dynamic analysis models of using requirements

Among the four design steps of UCD, "know and confirm the use scope and "get to know using requirements" are added with the dynamic analysis concept, hoping to obtain the using requirements more completely. By referring to the product design idea, the dynamic concept is added with the variables of time and changes. It integrates the dynamic idea of changing time axis into the requirements analysis, which is added into the dimensions of user, task and environment for the discussion of using requirements. The three dimensions have their respective fixed analysis and new dynamic analysis. As shown in Table 1, it works out 8 different dynamic analysis models. And the 8 different dynamic analysis models show in Figure 1.

Table 1. Definition of dynamic analysis

Dimensions of using requirements analysis	Dynamic and static concepts	Description
User analysis	Dynamic	Consider the user's physiological changes with the time
	Static	Consider the user's physiological condition at a single point in time
Task analysis	Dynamic	Consider the user's changes on the major features of product with the time
	Static	Consider the user's requirements of a single task at a single point in time
Environment analysis	Dynamic	Consider the user's changes on the environmental configuration or position for product operation with the time
	Static	Consider the user's configuration or position for product operation at a single point in time

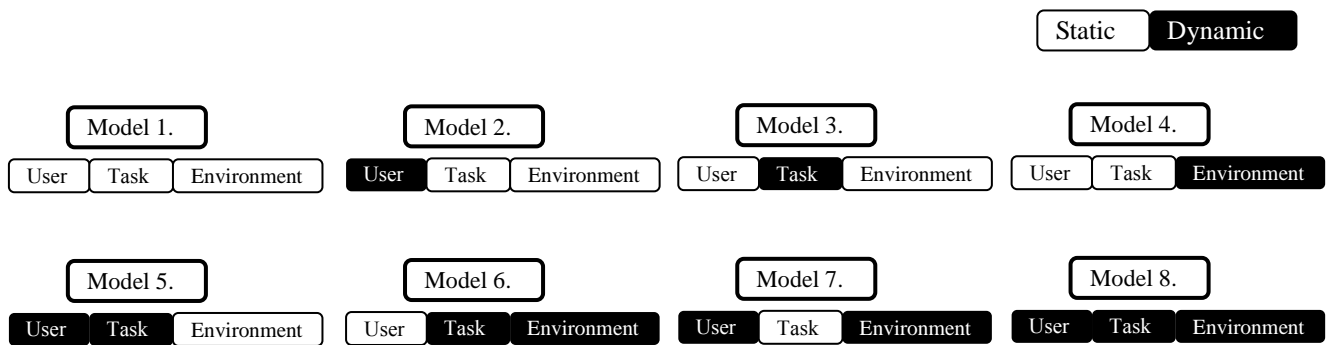


Figure1. eight model of dynamic analysis method

2.3.1 Case study of dynamic product design

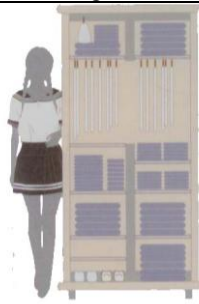
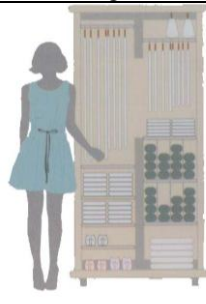
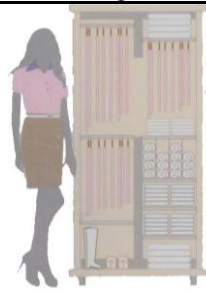
It develops and illustrates the design by case study on the design of three products, so as to verify the feasibility of the dynamic analysis models. The cases are the graduation works from the students(Academic year of 2008) of Furniture & Interior Design Team, Industrial Design Department, National Taipei University of Technology, as shown in Table 2, 3 and 4.

(1)Case 1: Wardrobe (Model 2)

a. Target group: Females aged 15-30. b. Product: Female-use wardrobe. c. Dynamic time axis: Females aged 15-30.

The collected data and literatures are conducted with a dynamic analysis, so as to design and develop innovative products based on the actual requirements. Table 2 is the dynamic analysis content and using scenarios.

Table 2. Content and scenarios of dynamic analysis model 2(Changing user X unchanged task X certain environment)

Period	Females aged 15-20	Females aged 20-25	Females aged 25-30
			
User analysis	Students in uniform Dramatic growth of body size	Students in casual clothes Slight change of body size	Office workers Slight change of body size
Task analysis	Hold clothes	Hold clothes	Hold clothes
Environment analysis	It requires holding school uniforms	It requires holding large amount of foldable clothes for different dress-up styles	It requires holding work uniforms and hanging suits.





The work is designed by student Peng Tzu Yu (Academic year of 2008) of Furniture & Interior Design Team, Industrial Design Department, National Taipei University of Technology

(2)Case 2: Pregnancy chair(Model 7)

a. Target group: Pregnant women. b. Product: Pregnancy chair. c. Dynamic time axis: Before and after childbirth.

The collected data and literatures are conducted with a dynamic analysis, so as to design and develop innovative products based on the actual requirements. Table 3 is the dynamic analysis content and using scenarios.

Table 3. Content and scenarios of dynamic analysis model 7(Dynamic user X unchanged task X dynamic environment)

Period	1-3 months in pregnancy	4-6 months in pregnancy	7-9 months in pregnancy	Breastfeeding after childbirth
				
User analysis	It requires improving the sense of safety and relieving the stress for the pregnant women.	It requires relieving the pains on waist and edema on legs.	It requires supporting to stand up.	It requires facilitating breastfeeding.
Task analysis	Sit	Sit	Sit	Sit
Environment analysis	Living room	Living room	Living room	Bedroom




The work is designed by Hsu Chia and Lin Ho Fan (Academic year of 2008) of Furniture & Interior Design Team, Industrial Design Department, National Taipei University of Technology

(3)Case 3: Urban shopping trolley (Model 8)

a. Target group: Elderly supermarket group. b. Product: Shopping trolley. c. Dynamic time axis: Supermarket group aged 65-85.

The collected data and literatures are conducted with a dynamic analysis, so as to design and develop innovative products based on the actual requirements. Table 4. is the dynamic analysis content and using scenarios.

Table 4. Content and scenarios of dynamic analysis model 8(Dynamic user X dynamic task X dynamic environment)

Period	Supermarket group aged 65	Supermarket group aged 75	Supermarket group aged 85
			
User analysis	With free motion, this group requires convenient-to-drag.	With limited strength, it requires assistance and support to relieve the burden.	With motion disability, this group requires assistance for walk.
Task analysis	Go out to buy food with the shopping trolley	Go out to buy food with the shopping trolley	Go out for a walk with the aid of shopping trolley
Environment analysis	Food market	Food market	Surrounding areas

The work is designed by Yu Po Tsung (Academic year of 2008) of Furniture&Interior Design Team, Industrial Design Department, National Taipei University of Technology

The user changes on the time axis result in different requirements. If the UCD research and analysis data could be transformed into practical ideas, it will help us approach to new opportunities. Moreover, it will also help to improve the speed and efficiency of creating solutions [19]. Therefore, the requirements could be learned from the user more completely, and more design solutions could be proposed to achieve higher benefits.

3. Method

3.1 Designers participating in the design of verification experiment

This experiment is mainly to verify the feasibility of the method developed in this study. During the 4-step development of UCD, it only aims at the design proposal of the requirements analysis that is emphasized by the method developed in this study, and conducts presentation and discussion through the sketch proposal.

3.1.1 Experiment purposes

To confirm the feasibility of the innovative and dynamic analysis model of using requirements, it invites some designers to use the method and make designs, and records the whole process for results discussion.

3.1.2 Experimental variables

1. Independent variable: It is divided into two groups based on whether the method developed in this study is used or not. One is experimental group who uses the method developed in this study; the other is control group who doesn't use the said method.

2. Control variable:
 - Respondents: Each group consists of one male and one female with more than 3 years of experience in the related design field.
 - Condition: Start the requirements analysis from the second step of UCD, and conduct design development for 2 hours.
3. Dependent variable:
 - Quantity: It is evaluated based on the number of design proposals.
 - Quality: The respondents discuss with the researcher about the experience of using the method and the design process, which are recorded and analyzed.

3.1.3 Experiment steps

- Grouping & Illustrating experiment steps
- Explaining "UCD"
- Describing "innovative design method of using requirements analysis "(For the group using the method)
- Requirements analysis & design development
- Presentation(15 minutes for each group)- with sketch drawing
- Brief interview and focus group discussion

3.1.4 Background interview of respondents

It mainly focuses on the background of designers and their experience of using design method previously.

1. Design background:
 - Design field: working in the design of product, furniture, metalworking...
 - Years of experience in related design field.
2. Design method:
 - Whether the respondent receives the instructions of design methods: Whether the school conducts teaching and practice of design method during the school years.
 - Opinion towards design method: Opinion and perception towards the operation method learned from the previous teaching or experience of design development.
 - Whether the respondent is accustomed to using design method in design development.

3.2 Discussion and verification

The discussion is divided into two parts, namely, design proposal and design thinking.

1. Design proposal: discussion after design presentation.
 - Quality and quantity of design proposal: Conduct discussion and review based on the number and presentation of design proposals.
 - Pros and Cons of the design proposals: Respectively describe the pros and cons of the design proposals presented by the two groups.
2. Design thinking: Discussion of trains of thought from the analysis to design process.
 - (1) The group using the method
 - Requirements analysis: Whether it is helpful to the requirements analysis.
 - Design development: Whether it is helpful to the design development.

- Feedback: How to understand the operations of design method more easily.
- (2) The group not using the method
 - Requirements analysis: Whether any difficulties are encountered during the requirements analysis.
 - Design development: Whether any difficulties are encountered during the design development.

4. Results

4-1 Background records of respondents

After the designers participate in the verification experiment, this study conducts brief interviews on the related background of the designers, as listed in the table below.

Table 5. Results of brief interview

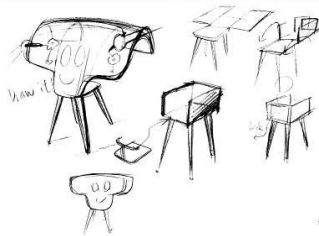
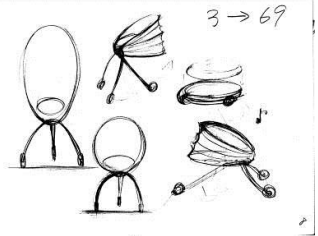
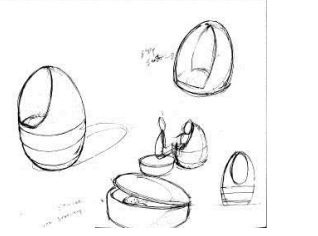
	The group using the method(group1)		The group not using the method(group2)	
Question	Designer 1	Designer 2	Designer 3	Designer 4
Gender	Male	Female	Male	Female
Design field	Product	Product	Product	Product
Years of experience in related design field	7	4	4	4
Whether the respondent learns design methods	Yes	Yes	Yes	Yes
Opinions towards design method	<ul style="list-style-type: none"> • The designer may be restricted by the pre-learned method. • The designer is unable to use a method clearly and separately. • The designer can't know whether the used method is correct. 		<ul style="list-style-type: none"> • They add their own ideas into the method instead of merely using the original method. • They have communication difficulties in discussing design method. 	
Whether the respondent is accustomed to using design method in design development	Yes, but they can't tell which method is used.		Yes, but they can't tell which method is used.	

4-2 Verification of innovative method

4-2-1 Design proposal

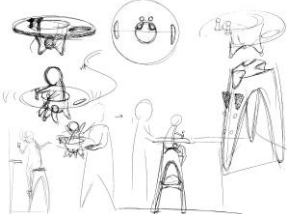
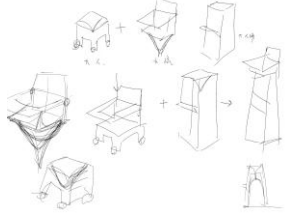
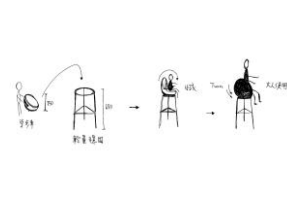

As for the number of design proposals, the group using the method proposes 3 ones, while 4 ones for the group not using the method. Table 6. list the discussion results of quality, pros and cons of the group using the method.

Table 6. Three design proposals for the group using the method

Proposal 1	Proposal 2	Proposal 3
		
Self-evaluation	They can come up with more ideas from diverse aspects.	
Comments from the group not using the method	With thinking from multiple perspectives, the counterpart could work out many proposals. Some of proposals don't come into their minds during the design development.	

The group using the method think that they can get with more ideas that they don't think about before from diverse aspects. And the comments from the group not using the method is that they think their design proposals don't come into their minds during the design development, and their design thinking from multiple perspectives. Table 7. list the discussion results of quality, pros and cons of the group not using the method.

Table 7. Four design proposals for the group not using the method

Proposal 1	Proposal 2	Proposal 3	Proposal 4
			
Self-evaluation	Most consists of two parts in combination or in changing shapes, which are derived from the same idea.		
Comments from the group using the method	The counterparts think carefully with more lateral thinking.		

The group not using the method think that their proposals most consists of two parts in combination or in changing shapes, which are derived from the same idea. And the comments from the group not using the method is that they think their thought is careful and with more lateral thinking.

4-2-2 Design thinking

Below table lists the results of focus group discussion during the design thinking process of requirements analysis and design development. Table 8. Process of design thinking.

Table 8. Process of design thinking

	The group using the method	The group not using the method
Requirements analysis	<ul style="list-style-type: none"> • Clear minds • Logic thoughts 	<ul style="list-style-type: none"> • The ideas are restricted or controlled easily • Follow the existing experience and ideas
Design development	<ul style="list-style-type: none"> • More thinking perspectives • Few restrictions • Divergent thinking during the initial brainstorming • Be inclined to guiding direction 	<ul style="list-style-type: none"> • Being less creative • Without the method, they may be restricted by themselves • The advantage is fast convergence

The feedback of the group using the method: Case analysis helps to understand the method of operation.

The innovative method of this study is helpful to more diverse and logic thoughts. If you have to use design method allows unrestricted thinking.

5. Conclusions and Discussion

5-1 Confirming the dynamic model of using requirements

The eight dynamic analysis models of using requirements developed from the literatures include one fixed analysis model, three single-dynamic analysis models, three dual-dynamic analysis models and a fully dynamic analysis model. After the case study, it's found the eight models have the existence possibility. Moreover, through the designer's participation into the verification experiment, it verifies the innovative design method for the innovative and dynamic analysis of using requirements is feasible.

5-2 Interview and discussion results

From the interview of the respondents' background, it's learned they all received the instructions of design methods, and they used the design methods in practical design. However, they can't tell which method is used, and they use different methods by themselves. Moreover, they feel the thoughts are restricted by the design methods they've learned.

In the focus group discussion, regarding the design proposals, the group using the innovation method of this study propose 3 ones, while 4 ones for the group not using the method, which don't show great difference in terms of the number. However, the design proposals proposed by the group using the method have diverse concept dimensions, while three of the four design proposals proposed by the counterpart are developed from the same lateral thinking. As shown in Table 8, proposal 1, 2 and 3 are all in the form of stacks though they change the stacking patterns and functions. As for the design thinking, the group using the method think the innovative method of this study is helpful to more diverse and logic thoughts. The group not using the method also admits they don't come up with the direction of proposals proposed by the counterpart during the design development, and their thoughts are often restricted by the previous experience. During the discussion, the group using the method thinks the thoughts of the counterpart is a relatively concentrated one with lateral thinking, while the other group thinks the proposals of the counterpart are more diverse.

The method of this study can help to think in a more logical way and develop in a more diverse way during the design development, which is applicable to the initial divergent thinking in design.

6. Acknowledgements

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