Design Process and Knowledge Searching Model Based on User Creativity

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Abstract. With the rising of the open innovation notion, satisfying user's creative needs of has become a focus in new product development. Products that facilitate user's creativity can be regarded as a kind of creative platform. Extending the concept of user innovation, this study explored two issues based on "user creativity orientation". First, a design process based on user's creativity platform (UCP) is proposed for designers and enterprises, which includes eight steps: (1) explore user's creativity needs, (2) classify functionality of the product, (3) develop primary and secondary components, (4) design a creativity-friendly interface, (5) prototype components, (6) examine UCP product features, (7) evaluate user's creation experience, and (8) assess the potential creativity of the user's outcomes. Through the process, a set of school-aged toy allowing user successive design are developed for children. The proposed model is feasible and effective and can elevate the idea of design from the level of pure product design to a creative platform and experience design, assist industries in developing platform products and meeting the users' needs for self-accomplishment. Additionally, in order to explore the user's search behavior for design knowledge in self-design activity, this study proposes a methodology and tools and takes the highly-involved LEGO players as the subjects to construct a "model of user's search behavior for design knowledge". With the proposed method, the users can be categorized by length of involvement and breadth of experience content into four kinds of status types of users, and nine essential knowledge attributes and eight key search approaches can be gained. According to the constructed model, the enterprise's role as enabler and users' role as designer can be further explored in design research and marketing strategy of products. The design knowledge and skills of highly-involved users will advance form a few individual hobby to a creative experience industry. It is also anticipated to offer enterprises with effective applications of users' design resources and create new energy on knowledge economy.

Keywords: User Creativity-Oriented, User Involved Design, Design Knowledge, Search Behavior.

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1   Background

As the course of the economic evolution follows the changes of consumption, from the previous agricultural economy, industrial economy and service economy to the age of experience economy, the gradual progress of economic value is divided into four stages: commodities, goods, services, and experiences. Users are getting more and more interested in "the involved experience and emotion gained from the interaction with products" instead of the products themselves. It is increasingly common for user's participation or involvement in new product and new service development (Morrison, Roberts, and von Hippel, 2000). E. von Hippel (1998, 2005) pointed out that users have become a major source of innovation in the process of product innovation.   The wide variety of information available has sparked a lot of creativities in the new generation of users. Users often have creative ideas in their daily lives and want to design and show individual unique creativity through themselves creations. Therefore, Luh and Chang (2007) proposed the concept and characterization of "user creativity-oritented" and called "User Successive Design (USD)". "User creativity-oriented design" gradually becomes one of the key points of product and service innovation (Holbrook, 1996, Thomke and von Hippel., 2002, Moreau and Dahl, 2005) and many entrepreneurs start to learn to trust, opening up part of the right of design and creation to the users.

Some highly-involved users possess design techniques and knowledge to redesign the appearance and function of products, gradually, users' creativity and design knowledge is increasingly discussed as the potential and ideal resources to design new product and develop new service (Szmigin and Carrigan, 2000, Ulwick, 2002, Kristensson et al., 2004, Chu and Chan, 2009, and Essén and Östlund, 2011). The roles users play are from simply consumers upgrade to contributors for creativity and design knowledge.

According to the above literature review, the products which facilitate user's creativity can be viewed as a creativity platform. Users can create and recreate new products to a certain degree and become a successive product designer. At this moment, one of the most feasible ways to achieve users' own creativity is for designers to develop the platformizaton products, which can then direct the user to freely create and successively design. Due to the lack of a design process and methodology for explore how user search for design knowledge that concerns users' creative needs, this study proposes two potential issues to meet the above expectations.

Extending the concept of user innovation, this study explored two issues based on user's creativity-oriented. As the platformization of products has become the trend, first, this study targeted at physical products and proposed a design process of platform. Incorporate the concept of assessment rarely seen in general product design models, and add evaluation items, criteria and methods into the development steps. Second, we proposed the methodology to explore the user's search behavior in self-design activity. Figure 1 illustrates the relevance of two user creativity-oriented issues.
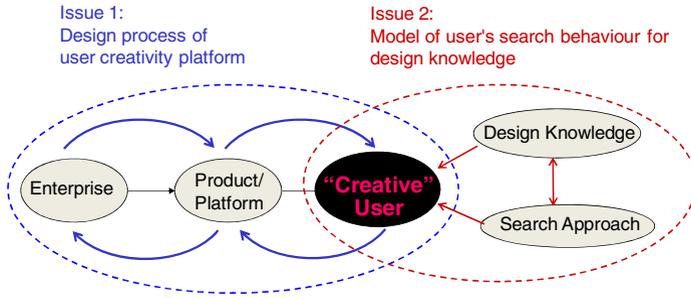
Fig. 1. The relevance of two user creativity-oriented issues

2   A Design Process of User Creativity Platform

User creativity platform is combined with different units rather than with a completed product. The process of User Creativity Platform (UCP) consists of eight steps (Fig.2), the resulting designs allow users to successively design and control part of the right to further re-invent the forms and functions of the product. Following the design process of User Creativity Platform, a school-aged toy is successfully developed.

Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
Explore user creativity needs	Classify functionality of the product	Develop primary and secondary component	Design creativity-friendly interface	Prototype component	Examine UCP product features	Evaluate user's creation experience	Assess creativity potential of user's outcomes
Method: •observation, •Interviews, •Questionnaire, •Product Analysis, … ↓ Define creativity need ↓ Set design target	Common functionality → Specific functionality →	Primary component Secondary component	Physical interface Cognitive interface	•3D rendering •Rough model •Function model	**Who:** Design expert **What:** UCP product **Criterion:** Four features of UCP	**Who:** Target user **What:** User's creation process **Criterion:** •User-friendliness •Accomplishment of Targets •Self- satisfaction	**Who:** Domain expert **What:** User's outcome **Criterion:** •Originality •Flexibility •Fluency •Elaboration
Development stage					Evaluation stage		

Fig. 2. A design process of user creativity platform

1. Explore user's creativity needs: Conventional design analysis methods, including user observation, questionnaires, product analysis, in-depth interviews, and ethnography, among others, can be applied to define user's potential creativity needs for future products. Design targets of products can be set accordingly.
2. Classify functionality of the product: Based on degree of shared abilities, functionality of a product can be classified into two categories. The "common functionality" refers to functionality that can simultaneously achieve more than two design targets. The "specific functionality", however, can only suit specific targets.

3. Develop primary and secondary components: The "primary components" can individually show the main functions based on common functionality. The "secondary components" can be attached to primary components to be capable of showing their own specific functions based on specific functionality.
4. Design a creativity-friendly interface: A creativity-friendly interface encourages users to create and design with their previous knowledge and capabilities without extra learning and training. With proper design management of product semantics, the interfaces are designed for maximal connections among all components so that users can redefine component relations and their functionalities to greatest extent.
5. Prototype components: The primary, secondary components and creativity-friendly interfaces are prototyped for further testing. They can be in form of a functional model for operation testing or an appearance mockup for perception validation.
6. Examine UCP product features: Inviting design professionals to check whether the product conforms to the requirements, namely reconfigurable components, creativity-friendly interfaces, open right design, and tolerance of unerror (Chang and Luh, 2009). If any of them is unmet, return to Step 2.
7. Evaluate user's creation experience: Target users are invited to successively design the product then evaluate the friendliness of the product interface, the degree of accomplishment of targets and self-satisfaction. This assessment should be according to user's own cognition and experience during the creation process of redesigning the product.
8. Assess creativity potential of user's outcomes: Domain experts compare the creativity potential of the user's outcomes from the developed UCP product and from other products with similar functionalities. In theory, a UCP should stand out in at least one of the four common creativity aspects of originality, flexibility, fluency and elaboration (Torrance and Orlow, 1984).

Based on the above UCP process, an innovative toy design was developed. Prototypes of the new design were tested by 20 pre-school kids. From their creative works, advancement of the proposed process can be seen. The toy can not only support 2D and 3D form designs, but also 4D form creations, for instances, wearable features and interactive functionalities.

3   A Model of User's Search Behavior for Design Knowledge

The study qualitatively proposes a feasible method to establish a framework which explores the user's search approaches for the needed design knowledge in the "design by user-self" process. The method can be applied to modular products with the "user's creativity-oriented" characteristic such as handicraft products, system furniture, assembled toy, and so on. The LEGO players are used as subjects for explanation. Following this method, a model of highly-involved users' searching approaches for design knowledge can built. The practice contents of methodology are introduced as follows:

1. Identification of design attributes and search approach: Identification of design attributes and search approach: Through KJ method, design knowledge stated by related studies are categorized into Product knowledge, Technique knowledge, Thinking knowledge, Experience knowledge, and Inspiration knowledge. Similarly, based on current information communication channels about LEGO, four aspects of information searching and searching approaches were identified.
2. Questionnaire development: Based on the characteristics of the LEGO bricks and LEGO players' cognition, the Design Knowledge Questionnaire (Table 1) and the Information Search Questionnaire with encoded items were developed (Table 2).

Table 1. Design Knowledge Questionnaire

Category	Design knowledge attributes
Product knowledge	A1.Component shape
	A2.Component color
	A3. Component size
	A4. Component material characteristic
	A5. Component price
Technique knowledge	B1.Component connection method
	B2.Component connection step
	B3.Object construction technique
	B4. Auxiliary tools application method
	B5. Structure constitution principle
Thinking knowledge	C1. Freehand sketch presentation method
	C2. 2D CAD presentation
	C3. 3D presentation method
	C4. Form esthetics concept
	C5. Color scheme skill
	C6. Design development step
	C7. Design thinking method
Experience knowledge	D1. Object operation intuition
	D2. Personal practice experience
	D3. Fellows' experience exchange
	D4. Expert instruction
Inspiration knowledge	E1. Intentional inspiration
	E2. Unintentional inspiration

3. Items Convergence: Three highly-involved users without institutional design educations were invited to do pre-test to increase the validity of the questionnaires and to converge the items.
4. Subject selection: The ideal subject has to meet the basic requirements with at least continuous five years of LEGO creation experiences and one of the following four qualifications: having LEGO works approved by peers, having LEGO works exhibited in public, having managed LEGO related groups or organizations, and having received LEGO creative contest awards.
5. Categorization of status type of subject: According to the above four qualifications, the statuses of highly-involved users were classified into four types: (1) Junior Expert (JE), who has works admired by peers, (2) Exhibition Participator (EP), who has works exhibited in public, (3) Business Manager (BM), who has managed LEGO related organizations, and (4) Award Winner (AW), who has received LEGO related creative contest awards. If a subject has two or more experience qualifications, only the most unusual one will be selected as his/her status type.

Table 2. Approach of information search

W. Self-learning	X. Fellow group	Y. Enterprise and society resource
W1. Instructional manual	X1. Joining fellow group	Y1. Themed books published by enterprise
W2. Related books	X2. Visiting exhibition held by fellow group	Y2. Regular magazine
W3. Newspaper and magazine	X3.Themed books published by fellow group	Y3. Membership club
W4. Internet knowledge searches	X4. Fellow group's electronic bulletin board	Y4. On-line simulation
W5. Physical store/online store	X5. On-line interactive forum (e.g. face-book)	Y5. Electronic newspaper
W6. Expert's blog	X6. On-line work exhibition	Y6. Contest sponsored
W7. Related television program	X7. Personal communication	Y7. Training course
W8. Advertisement	X8. Group gathering	Y8. Expert on-site demonstration
W9. Personal past experience	X9. Regular magazine published by fellow group	Y9. Expert on-line teaching
W10. Leisure activity		Y10. Upload system of enterprise
		Y11. Themed exhibitions
		Y12. Themed museum
		Y13. Themed park

6. Sampling: Three local professional LEGO users were taken as the initial subjects in snowball sampling. Each subject was asked to recommend at least two qualified subjects for each of the four status types as the next subjects, and the recommendations continued until two or more subjects in the same status type do not add or modify any opinion. Consequently, each of the four status types had four valid subjects when the information was saturated.

7. Interview with questionnaires: In the Design Knowledge Questionnaire, each subject was asked to select twelve comparatively important design knowledge attributes out of twenty-three. In the Information Search Questionnaire, the subject was asked to choose the effective search approaches. Each subject was interviewed about the reasons behind their answers in accordance with the results after finishing all questionnaires.

8. Content confirmation: The items selected by majority were regarded as the representative design knowledge attributes in a status type. For items selected by less than majority, the interviews about the subjects' answers were reviewed to determine if the items should be excluded.

9. Information integration: The results of design knowledge attributes selected by each user status type were illustrated via the Venn diagram (Fig 3). Based on the convergence number of user status type, four design knowledge gradations were identified: Essential Knowledge (EK), Main Knowledge (MK), Secondary Knowledge (SK), and Peculiar Knowledge (PK). Applying the same procedure, the distribution of search approaches selected. The search approaches selected by all status types of users were regarded as key search approaches which serve as the threshold for becoming highly-involved, consisting of eight items.

10. Matrix integration: the matrix of design knowledge gradation and search approach of highly-involved users was established. For simplification, duplications were merged (Table 3. Clearly, nine EK attributes and eight key search approaches are shared by all four user status types.
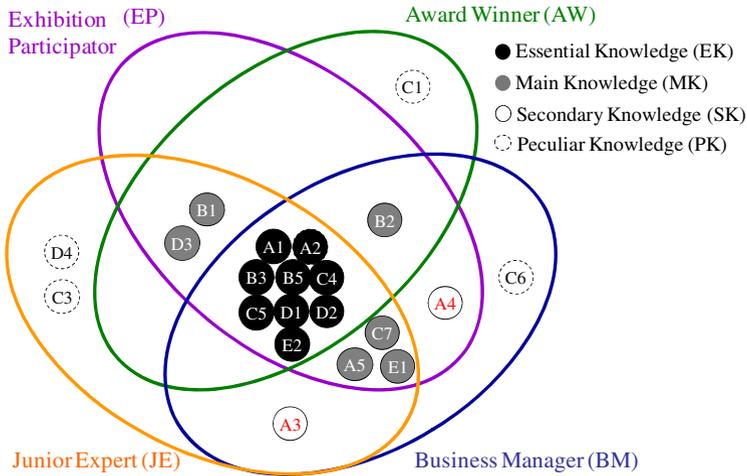
Fig. 3. Distribution of knowledge attributes for the highly-involved users

Table 3. Matrix of design knowledge and search approach of highly-involved users

Knowledge gradation		Status type of user			
		Junior Expert	Exhibition Participator	Business Manager	Award Winner
Peculiar Knowledge	Attribute	C3, D4	n/a	C6	C1
	Approach	n/a	n/a	n/a	n/a
Secondary Knowledge	Attribute	A3	A4	A3, A4	n/a
	Approach	n/a	Y4	n/a	n/a
Main Knowledge	Attribute	A5, B1, C7, D3, E1	A5, B1, B2, C7, D3, E1	A5, B2, C7, E1	B1, B2, D3
	Approach	n/a	W6, X7	W6, X9	X6, X9, Y6, Y11
Essential Knowledge	Attribute	A1, A2, B3, B5, C4, C5, D1, D2, E2			
	Key approach	W1, W4, W5, W9, X1, X2, X5, X8			

11. Concept generalization: Regards all status types of highly-involved users as a whole, based on the "Matrix of design knowledge and search approach for highly-involved user" (within the "attribute" column of the same knowledge category, merge the knowledge attributes that have similar meaning and propose an integrated conceptual name. Applying the same procedure, generalized concepts of search approaches were obtained. (Not listed, due to the exceeding amount of information.)

12. Framework construction: At knowledge gradation, four kinds of gradations were placed from its left to right based on their levels of importance. The generalized concepts of design knowledge attributes were sequentially filled in according to their knowledge gradations. At search aspects, them were put along relations with users between self and communities from left to right. The generalized concepts of search approaches were filled in proper positions. Consequently, a framework of searching design knowledge of highly-involved users can be established in Fig 4.
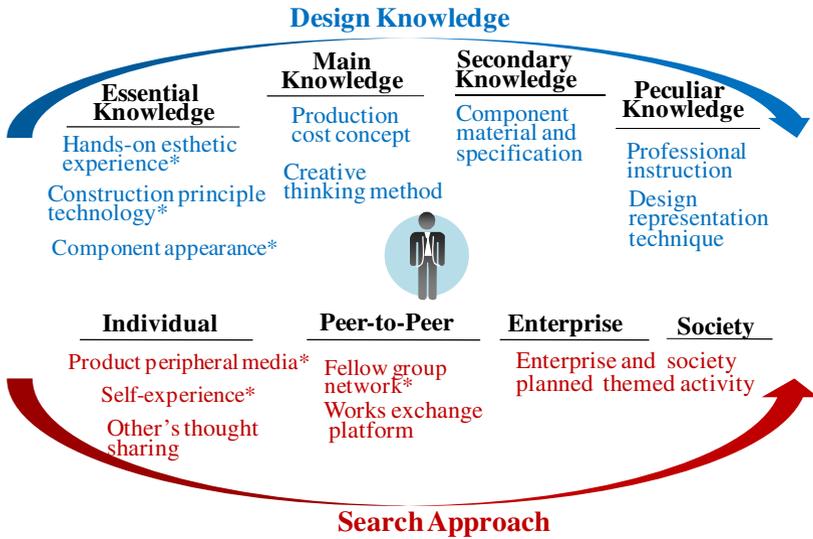
"*" indicate the necessary design knowledge concepts and core search approach concepts

Fig. 3. The model of highly-involved users' searching approaches for design knowledge

4   Discussion and Implication

4.1   Meaning of UCP Design Process

Compared with the original site-simulation assembly toys of the manufacturer, the components of UCP toys developed by the study possess higher sharability, and the creativity interface is highly user-friendly. Users' creation outcomes are not only rich in design and functionality, but also go beyond the scope of the site-simulation. The proposed UCP design can help the manufacturers in opening new product lines, developing innovative products that meet users' creativity needs, and eventually elevating the innovation value of the enterprises.

The UCP design process elevates the idea of design from pure product design to the level of creativity platform and experience design, creates new value of design, assists industries to develop platform products, and meets the users' needs for self-accomplishment.

4.2   Implication of the Model of Highly-Involved Users' Searching Approaches for Design Knowledge

From the design knowledge in Figure 4, it can be found that level of the Essential Knowledge is the most important due to design knowledge with the most "*". Hands-on esthetic experience, Construction principle technique, and Component appearance are the most fundamental design knowledge that highly-involved users adopt first.

These can be regarded as the main principles for evaluating the maturity of user's design ability. In Main Knowledge, Creative thinking method helps group brainstorming and arouses diversified creative inspirations; whereas Production cost concept helps estimate product development time and costs from the design inspiration stage to the completion stage. As for Peculiar Knowledge, Design presentation technique can help users not only record creative ideas and construction steps, but also express ideas to other. When users provide design consulting services to others or enterprises by utilizing personal design knowledge and skills, their works and individual values also upgrade. The user innovation model may gradually replace professional model and users have the potential of personal brand.

The proposed model demonstrates the process difference between users and designers in applying design knowledge chain. The application value of this model can be described from three aspects: (1) Enhancing the importance of user innovation mode, (2) Helping establish the companionship between enterprises and users, and (3) Developing creative resources of industries and design knowledge chain.

5   Conclusions

As a result, a model of highly-involved users' searching approaches for design knowledge was established. The highly-involved LEGO is taken as the subjects to verify the feasibility and usefulness of proposed methods and tools, and this can be regarded as a fundamental study on exploring users' design knowledge.

13. Introduce the concept and four features of user creativity-oriented products: open design rights, tolerance for unerror, reconfigurable components, and creativity-friendly interfaces. Conceptually speaking, acceptance of "unerror" is greater than the allowance of error in essence.
14. The design process effectively develops toys more advanced than other products of the same category in the aspects of allowing innovation of the outcomes, improving interpersonal interaction, and the high sense of ownership.
15. The proposed research method and tools are feasible in exploring the user's search behavior for design knowledge. Following the method and tools, a model of highly-involved users' searching approaches for design knowledge can be established.
16. Hands-on esthetic experience, Construction principle technique, and Component appearance are found the most essential knowledge attributes, and Product peripheral media, Self-experience, and Fellow group network are identified as core search approaches for highly-involved users.

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