A CMF Database Framework Design-A Case of Application of User Mental Model

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Abstract. In this paper, we take the project of CMF network database framework design as an example to explore how to effectively apply the mental model approach to the User-Centered Design process. We firstly build a user mental model to collect user needs by interviewing and observing the target user representatives. Then, we compare the user needs against the capabilities of the competitors' products to get some key design opportunities. And finally, using those key opportunities as an important guidance, we construct a new framework for the CMF database. We hope the design process based on the mental model approach discussed here can set a reference to the User-Centered Design.

Keywords: CMF database framework · Mental model approach · User-centered design

1 Introduction

According to Donald A. Norman, Mental Model is a sort of knowledge existing in user's mind about the concept and behaviors that how a product should possess [1]. It could come from user's experience using similar product. It could also be a user's expectation of a concept and behaviors about a product which links the product goal [2]. It is a kind of forecast about things' development, that is, what you will "think" or "feel" about how things should develop.

Designers must make sure that a product system is consistent with the mental model of users, in order to have them to use the product smoothly. So designers need to know the users' mental model. In 2008, Indi Young researched the mental model from a new perspective. She treated it as a user research methodology, providing researchers and designers a strong approach to knowing users' motivations, thinking processes, as well as emotional views and philosophical views [3]. Based upon Indi Yang's research, we reviewed the process of user mental model construction and refined the process of its application into the human-centered design.

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of CMF Knowledge System and Its Database Framework", involving the areas of Art, Material and Psychology, and with the outcome of the framework of the CMF database. We aim to explore the designers' psychological activities during their searching the information of material and selecting which material they will use while designing, and the application of the mental model approach into the design of the CMF database framework.

2 Procedure, Methodology and Outcome

According to the achievement from the research of "Mental Model Methodology and Its Application in User-Centered Design" [4], we formulated the development process of the CMF network data base, which is divided into two stages: construction of the user mental model and its application into the design. The aim of constructing users' mental model is to identify designers' psychological activities when their looking for information of materials and textures and deciding to select what materials and textures will be used in the design process, as well as their needs during the process of product design. The purpose of the application of the users' metal model is to explore the latent design opportunities, which will be used to direct the design of the CMF network data base framework.

2.1 User Mental Model Construction

User Mental Model Construction includes 4 steps: formulating the research plan, interviewing and thinking aloud, extracting and clustering the tasks, and forming the user mental model (Fig. 1).

Fig. 1. The process of user mental model construction

Formulate Project Plan. In the step of project plan and scheduling, we firstly identify the target users, the methods and contents of research. According to the overall project aims, we selected 3C electronic product designers, transportation designers and environmental designers as the target audience of this research. We should recruit as least total 12 samples including 4 user participants for each user group of the above mentioned. The contents of the research are the activities and the tasks the users accomplish with the products, i.e., the mental activities of the designers during their material search and selection.

Then we schedule the overall research plan, which includes the total 8 steps: project plan, interviewing and thinking aloud, extracting and clustering tasks, forming the

Table 1. The Project plan by weeks

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Work	Formulate Research Plan		Interview & Think Aloud				Extract & Cluster Tasks			Form Mental Model	Compare to Competitors' Products		Info Structure Design	Interface Design	Web Prototyping				Verifying the Solution	Adjusting the Solution

users' metal model, comparing to the competitors' products, information structure design, user interface design, and web prototyping (Table 1).

Interview and Think Aloud. According to the project plan, for the interview and thinking aloud we have finally recruited 17 sample potential users, which include 7 product designers, 6 transportation designers and 4 environment designers.

The purpose of the Interviewing and thinking aloud step is to, by users' language and behaviors, dig the uses' psychological activities while they fulfill some events. We call this process "gathering metal data". Interviewing is the main method for the mental data gathering of this research, which is also the method to be used for the most metal data gathering activities. We formulated the structured outline for the interviews, which is divided into three parts:

1. Users' *basic* information. In this part we plan mainly to understand the uses' professional background and design habits, at the same time, to help the users we interviewed step into the good atmosphere for the further interviewing.
2. Information about users' *searching* the materials they will plan to use. Here we would like to know the channels the users obtain from the information related to the materials.
3. Information about users' *selecting* the materials they will plan to use. In this part, we focus on what factors the users would consider during the process they select the material they will use, as well as the relationship between materials they select and the overall design procedure.

Then, we respectively interviewed the 17 participant users, i.e., 7 product designers, 6 transportation designers and 4 environmental designers, from whom we got the plenty of user mental data to be processed for the next step.

Moreover, in order to further understand the designers' mental activities holistically, we have them to perform some tasks with thinking aloud, that is, let them speak out their thinking, thoughts and feelings while executing a series of tasks we assigned to them.

The task we gave to our participant users in this research is to let them use the competitor's product — material database MATERIA (http://www.materia.nl) — to

select proper materials for their undergoing design project, and speak aloud what they are thinking during the selection process. We didn't set the operational details for the users, as we would like to observe their natural and unaffected thinking process, other than to test the database. Thinking aloud can verify the feedbacks from users in the interviewing on one hand, and can let us observe the detailed behaviors which cannot obtained from the interviewing on the other hand.

Extract and Cluster Tasks. In the process of Interviewing and Thinking Aloud,we recorded the users' speaking and behaviors with the sound and video recorders. Afterwards, we reviewed the recordings and extracted the "tasks" which can represent users' typical mental activities. For example, a student designer mentioned at the interviewing, "I transcribed the material information I saw on the journals and books into notes on my notebook before. But now the most information we found are on line, so I just put it in the Favorite or Bookmark." We have totally extracted 4 "tasks" from it: manually transcribing material information, putting material information webs into Favorite, reading books for getting material information, and reading journals for material information, to see Table 2. For this stage of the research, we obtained 149 tasks.

Table 2. An example of extracting tasks

Citations	**Tasks**
"I transcribed the material information I saw on the journals and books into notes on my notebook before. But now the most information we found are on line, so I just put it in the Favorite or Bookmark."	manually transcribing material information
	putting material information webs into Favorite
	reading books for material information
	reading journals for material information

After that, we clustered the 149 "tasks" to construct the mental model of the users' searching and selecting the materials with KJ method [5], in which we collected the unknown factors, and categorized them according to their inner relationships. This is an approach to find a clue of solving problems from the complicated phenomena and facts. Its function is to help designers to cluster the plenty of tasks to form multiple hierarchies, clarify the logical relationships among the tasks, and then display the users' thinking modes.

Taking the 4 "tasks" above mentioned as an example, we can cluster the 2 tasks of "reading books for material information" and "reading journals for material information" as a task tower, and name it "getting material information from paper media"; then cluster the *task towers* of "getting material information from paper media", "getting material information from internet", "getting material information from manufacturers", "consulting the material experts", "getting material information from people nearby", as well as "getting material information by touching and feeling" to form a *mental space* named "the ways of getting material information", Fig. 2. In this research, we totally have 41 task towers, and then 11 metal spaces.

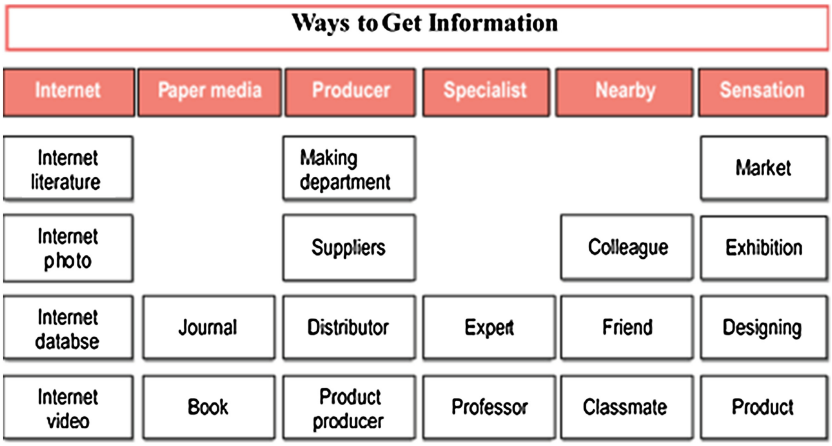

Fig. 2. Example of the metal space: "the ways of getting material information"

During the clustering process, we also used the card sorting [6], which is similar to KJ method, but it is the target product users to execute the sorting. The researchers or designers can get knowledge of the users' understanding of the tasks and sorting modes.

Form User Metal Model. In this research, the 11 mental spaces we clustered in the previous step are: "motivations to search material", "ways to get material information", "search material", "browse material", "sort and record material", "means to record material", "material factors", "design factors", "pilot study", "generate solutions", and "internet experience". For the reason of the big number of the metal spaces, we decided to further comb to identify the relationships among them. The 4 mental space of "motivations to search material", "ways to get material information", "search material", "browse material" can be classified as the mental space group of "get material information"; "sort and record material" and "means to record material" as "record material information"; "material factors", "design factors" as "select material". This 3 mental space groups have the closest relationship with "material search and selection". But "pilot study" and "generate solution" are close related to "design process", which has relative minor relationship with "material search and selection". And the metal space of "internet experience" can be the reference to the design of the website. Eventually we got the overall mental model as seen in Fig. 3.

2.2 Application of User Mental Model

This stage also has 4 steps: compare to competitors' products, information architecture, user interface design, and prototyping (Fig. 4). For this paper, however, we only focus on the information structure of the CMF network database, so here we will ignore both steps of interface design and Prototyping.

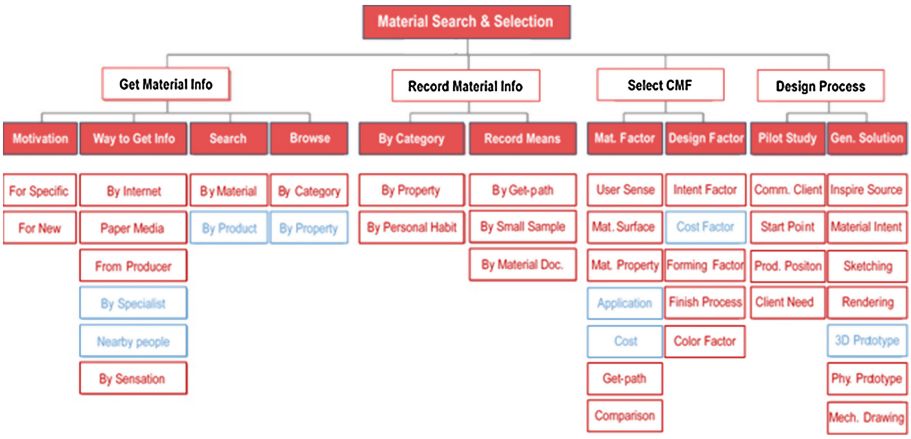

Fig. 3. The metal model for CMF material search and selection

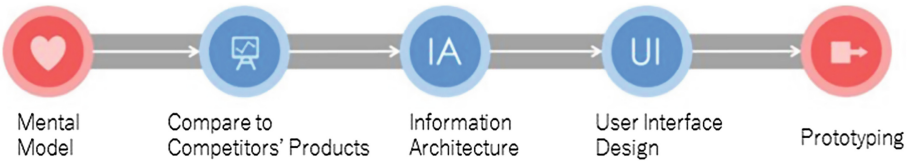

Fig. 4. The process of the user mental model application

Compare to Competitors' Products. After forming the mental model, we compared the model to 3 major competitors' products, to see which requirements of users the competitors' products have fulfilled. This could explore and discover some potential design opportunities. The competitors' products of our CMF network database we collect include "http://www.materia.nl", "http://www.materialconnexion.com", and "http://www.grantadesign.com".

We firstly analyzed the functions of the competitors' products, named them, and made the function lists. Then, we aligned those functions under related task towers, forming the *comparison chart* between the metal model and the competitors' products, as seen in Fig. 5. And finally, we reviewed the overall comparison chart, to clearly see the relationships between the user needs and the current competitors' products, and discovered the unmet needs and latent opportunities of design.

Through the comparison, we identified 8 design opportunities in 3 aspects, as seen in Table 3.

Besides, if the development is for the second or third product, we can use the mental model as a criteria of evaluation to find the shortages of the existing product to be improved.

Information Structure Design. According to the website positioning by CMF Innovation Lab of Tsinghua Academy of Arts & Design and the design opportunities we discovered in the early step of this research, we divided the contents of the website into

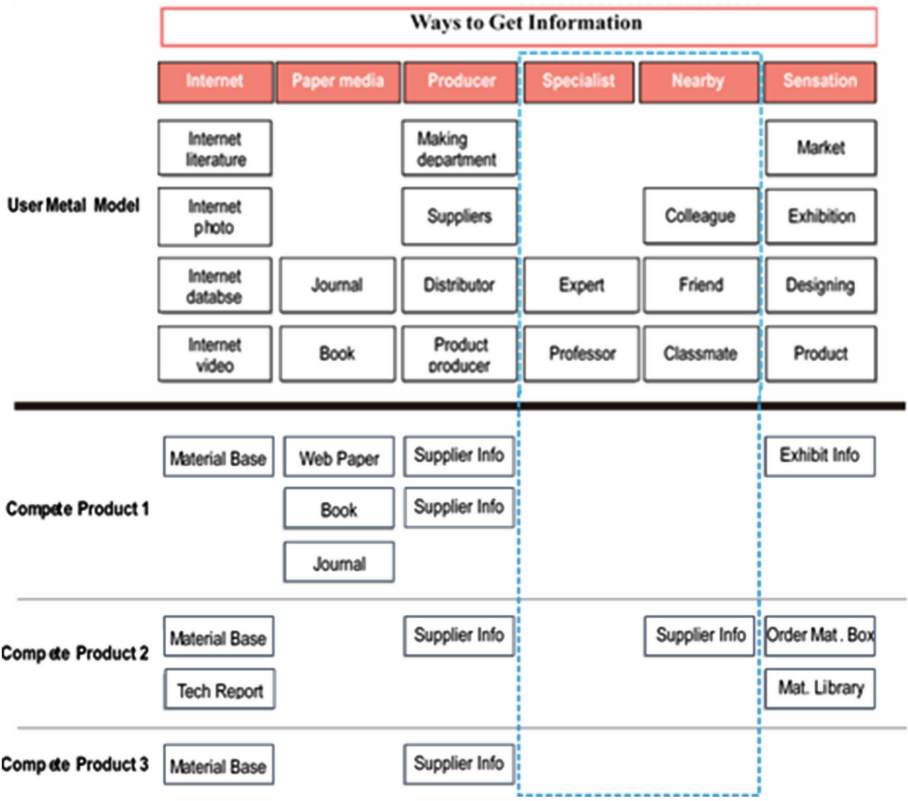

Fig. 5. Comparison between the metal model and the competitors' products

Table 3. The design opportunities identified through comparison

During getting material information, designers hope:	*(1) To get advices about material selection from the experts.*
	(2) To know new materials by communicating with the people around.
During material search, designers hope:	*(3) To search the materials can be used for the specific products.*
	(4) To search the materials though the adjective words.
During material selection, designers should reference:	*(5) The users' feelings about the materials.*
	(6) The cases about the material application.
	(7) The cost about the material application.
	(8) The virtual three-dimensional modeling effects.

7 parts: (material) Database, Events, Publications, Blogs, Contact Us, About Us, and Favorite (Fig. 6). The Events and Publications are mainly the activities and research achievements by the CMF Innovation Lab. But the Database and Blogs are the key

Fig. 6. The information structure of the CMF Network Database

parts of the website and also the key points of this research. According to the design opportunities, we made some innovative arrangements for the ways of browsing material, the contents of the material presentation, as well as the ways of communicating the material information.

In the design of material database, the materials are traditionally classified by their physical Properties, but we innovatively classify the materials by their application areas and their subjective sensations of users (Fig. 7). We summarized areas of the material application as 3C electronic products, transportation products, environment design; and there will be a list of commonly used material in each area. The subjective semsations of the materials can be divided by visual sense, tactile sense, smelling and gustation. Each category has a related descriptive word, and each descriptive word has a matching material.

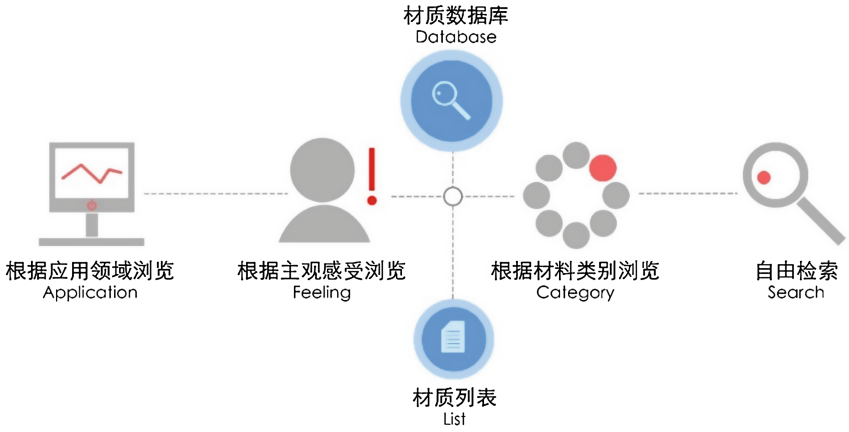

Fig. 7. The ways of browsing and searching material

In the content presentation of each specific material includes 9 aspects: Material Colors, Material Base, Material Finishing, Material Sensing Properties, Material Physical Properties, Material Forming Process, Material Application Cases, Information of Material Manufacturers, Cost of Material Application (Fig. 8).

Fig. 8. Presenting way of the specific material

In the design of Blogs, we divided the website users into the role of general designers and the role of CMF specialists, but the two roles can also leave messages to each other. That is, they can communicate between designer and designer, designer and CMF specialist, CMF specialist and CMF specialist (Fig. 9). This will provide more professional suggestions for the designers during their material selection.

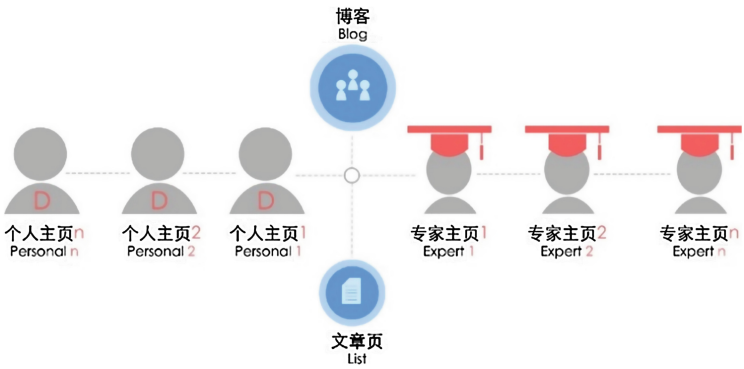

Fig. 9. The way of setting user roles for Blogs

After identifying the functions and information architecture of the CMF Network Database, we began to design for the specific user interfaces, and set about making the high simulation prototypes of the website, as well as determine the interactive ways of

the website. On the style of the interfaces, we tend to have a simple and elegant textures, and hope to bring to users a visual sensation of neat and orderly and feelings of professional and authoritative. In the process of prototyping, we would as far as possible follow the users' operational habits, lay emphasis on new experience that the website brings to the users.

3 Conclusion

Through constructing the users' mental model, this paper presents designers' metal activities during their searching and selecting materials. This makes the functions of the CMF network database more fit the users' needs, and the operational process more rational and more suits the users thinking and behaving customs. In the meantime, we also summarize the application methods of the users' metal model during the database design process.

As for the scope of application, however, mental model cannot probe users' perspectives to the existing products and their usability problems. Therefore, it is not suitable to being applied into improvement design projects, but more suitable to the application into innovative design projects. As for the application procedure, it requires design and development team to have more reasonable personnel to cooperate and more rigorous project process, as it needs to deal with a plenty of data during the construction of the mental model. Moreover, in order to communicate with the people inside and outside of the team, it needs to lay emphasis on the presenting way of the metal model.

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