Defining Design Subjects According to the Context in Which Problems Occur

Masami Maekawa and Toshiki Yamaoka

Abstract It is necessary to define adequate design subjects to develop attractive and useful products. Not only functional elements but also the ease of use and good affective design are desirable. To bring new values to products, design subjects must be defined without depending on heuristics. However, a problem tends to be the starting point in developing a new product. Problems are relative to the context in which they occur and are typically composed of many causes. Therefore, the study focuses on the context in which problems occur. To make the context easy to be grasped and analyzed, context items were provided. State-keywords were extracted from the descriptions of the context as data for analysis. They were classified into clusters and consequently interpreted to design subjects without heuristics. This chapter shows the process of this method. The results of the experiments used to verify the effect of this method are described and discussed.

Keywords Design subject • Process-state table • Affective engineering • User experience • Context of use • Human-centered design • Task analysis

1 Introduction

Developing a product for solving explicit functional problems is nothing new. In recent years, however, consumers have demanded additional functions, ease of use, and attractiveness. Developers have become confused with planning and

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designing a product, because the design subjects are not as clear as simply solving functional problems. Consumers, meanwhile, complain that there are few products that they want to use.

User's potential needs are paid attention now. However, it is difficult to find them. Marketing activities were useful in meeting the user's existing needs up to now. The existence of need is the key assumption of past and present marketing activities. However, if customers' existing needs or voices are recognized, attractive products cannot be created because they are likely to be designed with neither originality nor attractiveness. Christensen et al. [1] insisted the necessity of paying attention to the user's jobs. He suggested that the potential needs were found by paying attention to the user's jobs. The importance of finding the potential needs of user's jobs has increased.

Computers cannot be excluded from the discussion about attractive modern products. Unfortunately, many computer products have been invented that are difficult to use and embarrass users because the quality of human–computer interaction (HCI) was disregarded for the expansion of functions and performance [2]. Therefore, in last several decades, finding actual usability problems and the solving them were valued in designing HCI field. However, at this time, the improvement in the attractiveness of HCI has become an aim of design. A high quality of user experience naturally creates a user's favorable impression. In other words, a current requested design activity improves the user's experience.

The basic purpose of design activities is to bring a better experience to the user not only for the HCI field but also for the industrial products and services that are used by all of us. However, when defining design subjects, the design activity tends to be conducted through personal skills or the designer's heuristics.

The improvement in the user experience occurs when the design activity pays attention to the user's activity. Gay and Hembrooke [3] identified the activity-centered design as an effective approach to develop adequate usable systems. This includes paying attention to the user's jobs, as mentioned by Christensen. The design activity focused on the user's activity has the possibility of meeting potential needs that were not acquired in past marketing techniques. However, it is obscure to define an appropriate design subject that differs from the achieving functions. The quality of the result depends on the designer's ability, which is naturally variable because the design subject tends to be provided according to the designer's heuristics [4]. The weight of the survey data particularly tends to be biased by the heuristics [5]. As the heuristics are normally derived from past experience, the design subjects tend to follow the current or past paradigm. A design subject that does not depend on heuristics may become a starting point for new paradigms. Therefore, the method of finding an adequate design subject without someone else's heuristics is worthwhile.

Problems do not tend to occur constantly but only in a certain specific context [6]. For instance, an older person may not be able to easily use the product that a young person can use. Mistakes tend to be made when someone is in hurry. Therefore, it can be thought that the problems are relative to the context in which they occur. The relativity of the context to the problem is focused on in this study. This approach is rarely researched. In this chapter, the method of deriving design subjects from the context is described, and the results of the experiments used to verify the effect are discussed.

2 Existing Techniques

One of the general design processes of improving user experience is the process of human-centered design. For instance, ISO9241-part210 shows a representative of the process. Design subjects are defined in the process.

The conventional techniques for defining design subjects are Jiro Kawakita's KJ method and the card sorting method. They are used to classify problems or events and to make affinity diagrams. In addition, users may be interviewed the reasons of the problems or the details of events. These are attempts to clarify the matters hidden behind the problems or the events. However, these techniques depend on personal sensibility, heuristics etc. Therefore, the quality of the results tends to be different according to the person. Additionally, objective validation of the results is difficult.

The evaluation grid method that Sanui et al. [7] developed can draw out the structure of a person's affective needs. This method is an application of Kelly's personal construct theory. The structure of affection is made by reasons of preference when a participant compares the two presented samples. This method is known as a useful tool to obtain potential affective needs. However, there are some notes. At first, the results tend to be different according to the samples, because the difference that the participants are aware of between the samples becomes the elements of the structure of affection. Moreover, the results do not necessarily show accurate reality because they are just experimental results. The quality of the experimental plan relates whether a proper result can be made or not. Main factors are the samples and the participants. Therefore, the result might be insufficient if the experiment was conducted before these factors are set appropriately.

3 Method

This method is based on the real context of use and problems. As mentioned above, there is a relation between the problems and the context of use. There is a fact that the causes of problems or other events in use tend to be contained in the context [6]. This is the method of specifying design subjects based on this fact. The procedure of this method is described here.

3.1 Problem Findings and Context Descriptions

There are several techniques to find problems. For instance, task analysis [8], the three points task analysis [9], observation, and protocol analysis are used to find problems. These are already popular in product developments and take some parts of this in proposed method. The feature of this method is acquiring not only problems but also the context of the problems. Context is described by the content of each context item (see Fig. 1). With paying attention to the context items, it

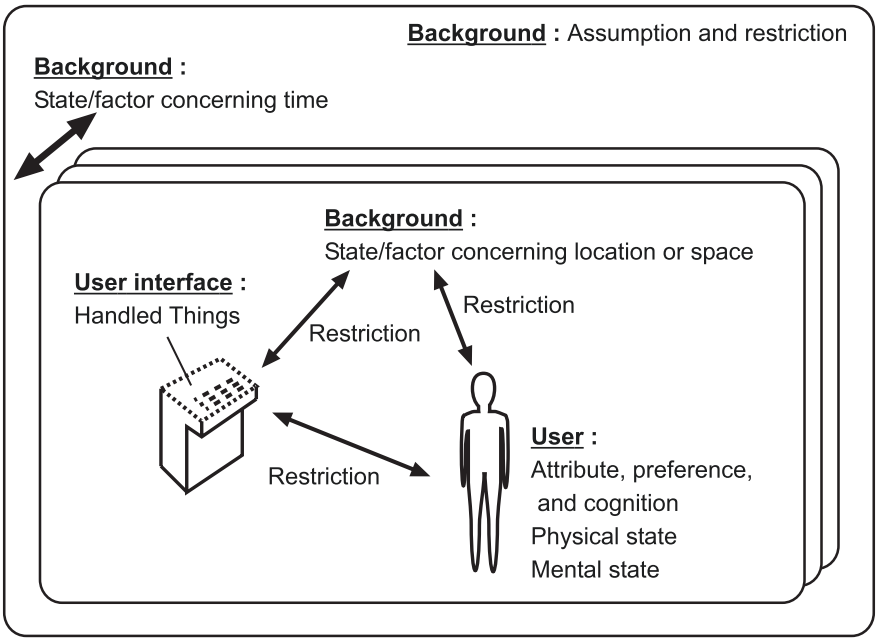


Fig. 1 Context items

becomes easy to search and understand the whole context of the problems. In this method, the data of the context in which the problems occur are more important than the problems themselves.

1. Context items concerning user
   - Attribute, preference, and cognition
   - Physical state
   - Mental state
2. Context items concerning background
   - State/factor concerning time
   - State/factor concerning location or space
   - Assumption and restriction
3. Context item concerning user interface
   - Handled things

These context items were chosen from the elements of several techniques [10]. Some items are contained in persona [11] or scenario, because these techniques are used to show some parts of the context in which products are used. Therefore, the context items have been extracted from actual examples of these techniques. For instance, “Attribute, preference, and cognition” was chosen from the element of persona that Cooper et al. advocated. As Carroll described that scenarios make the context clear [12], “physical state,” “mental state,” “state/factor concerning

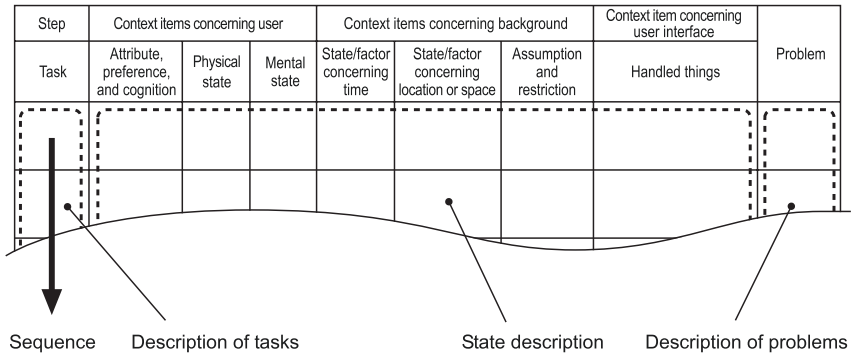


Fig. 2 Form of the process-state table

time," "state/factor concerning location or space," "assumption and restriction," and "handled things" were derived from several scenarios.

The activities are as follows: The contents of the notes and the pictures recorded in surveys are put together and described on the form that is named "process-state table" (see Fig. 2). This is a method that is not only for finding problems in user's activities but also for describing the context according to each of tasks and the context items. The description of each context item in each task is named "state-description." This activity might be seen as a part of a kind of task analysis.

3.2 Extraction of State-Keywords

State-keywords that simply show the state of each context item are extracted from each state-description. Several keywords might be extracted from one state-description. Occasionally, a state-keyword might be state-description itself.

A same matter should be described by same state-keyword, because the keywords are used as category data in the next analysis step. In addition, the state-keywords should be described simple as much as possible like as "borrow the books" or "the map of library."

3.3 Analysis

A categorical data sheet that is composed of the row of state-keywords and the column of problems is made. For a start, the state-keywords are used as category data in the correspondence analysis. Subsequently, the hierarchical cluster analysis is executed with the category score of each state-keyword of some dimensions that is resulted from the correspondence analysis. As the results of the cluster analysis, some clusters are made according to the affinity among the state-keywords.

Descriptions of the problems are used as references to interpret the contents of the clusters. If a concept has been settled before the analysis, state-keywords that do not meet the concept can be excluded from the analysis.

3.4 Interpretation

The state-keywords are classified into some clusters. They are shown in the structure of dendrogram derived from the cluster analysis. The form of the dendrogram is a clue to define clusters, as there is no standard rule to decide the number of clusters. The dendrogram shows the strength of an affinity among state-keywords. The contents of the clusters help us to image the contexts that ought to be concerned in design subjects. If there is a specific problem, it might be easier to image the context. In this case, the descriptions of the problem might be referenced to make design subjects. Finally, the content of each cluster is interpreted to design subjects.

4 Experiments

To determine the effect of this method, two experiments were conducted. And, the results of two experiments were compared. The proposed method was used in Experiment 1, and another existing technique was used in Experiment 2.

4.1 Experiment 1

Three kinds of WEB system that are used to search and reserve to borrow the books of libraries were chosen as objects. Six participants, aged from 22 to 45, who underwent task analysis were designers or students learning design. They were familiar to WEB systems through using various kinds of them daily. The signs of A to F were put to the each participant.

To clarify the differences in the number of state-keywords obtained by between two ways of finding problems, the participants were divided into two groups. Three participants were ordered to find problems, respectively, from another one system. The other three participants were ordered to find problems, respectively, from all of the three systems.

After they found problems from the WEB systems, they described the problems and the context in which the problems occurred according to the context items separately. Some context items were excluded from the description, because the contents of them were judged to have little differences. Three context items of “state/factor concerning time,” “assumption and restriction,” and “handled things” were applied to this experiment.

Table 1 Number of found problems and extracted state-keywords

	WEB system 1		WEB system 2		WEB system 3		Total	
Participant	Problem	State-keyword	Problem	State-keyword	Problem	State-keyword	Problem	State-keyword
A	12	17	–	–	–	–	–	–
B	–	–	12	22	–	–	–	–
C	–	–	–	–	17	29	–	–
D	13	32	7	16	24	29	44	**50**
E	16	30	14	22	24	29	45	**35**
F	22	34	23	28	14	25	59	**49**
A, B, C Total							42	44
D, E, F Total							148	63
All Total							190	68

Bold indicates average value of 44.67

State-keywords were extracted from the state-descriptions. In this experiment, one experimenter extracted all state-keywords, because a same matter should be described by a same keyword. Therefore, a categorical data sheet that showed the relation between the state-keywords and the problems was made.

Next, the correspondence analysis was executed with the categorical data sheet, and five dimensions of the state-keywords were adopted. Subsequently, the hierarchical cluster analysis on the category score of each dimension was executed. Ward's method was chosen to join neighbor data in the analysis.

A total of 190 problems including repetition were found by the participants, and 68 kinds of state-keywords were extracted. There were 13 kinds of "state/factor concerning time," 26 kinds of "assumption and restriction," and 29 kinds of "handled things." The detailed results of the number of state-keywords and the problems that each participant found in each system are shown in Table 1. As for the total number of state-keywords, repetition was excluded.

The number of state-keywords when the participants found problems, respectively, from one object was shown as follows: The total number of the state-keywords extracted from the results of participants A, B, and C was 44. On the other hand, the numbers of extracted state-keywords were 17, 22, and 29 in each object, respectively.

The number of state-keywords when the participants found problems, respectively, from all systems was shown as follows: The average of each number of state-keywords extracted from the problems that were found by participants D, E, and F was about 44.67. On the other hand, the total number of state-keywords extracted from all problems that were found by participants D, E, and F was 63.

All problems and state-keywords were applied to a categorical data sheet, and the correspondence analysis was executed. Then, state-keywords with five dimensions resulted from the correspondence analysis were put into the cluster analysis. As a result, a dendrogram was made (see Fig. 3). There is no standard rule to decide the number of clusters. In this case, six clusters were adopted according to

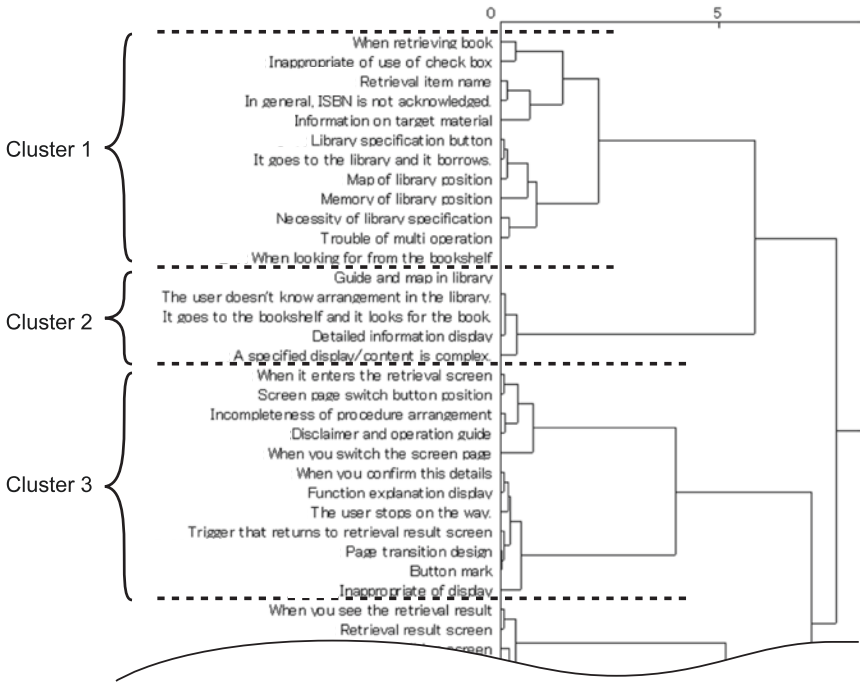


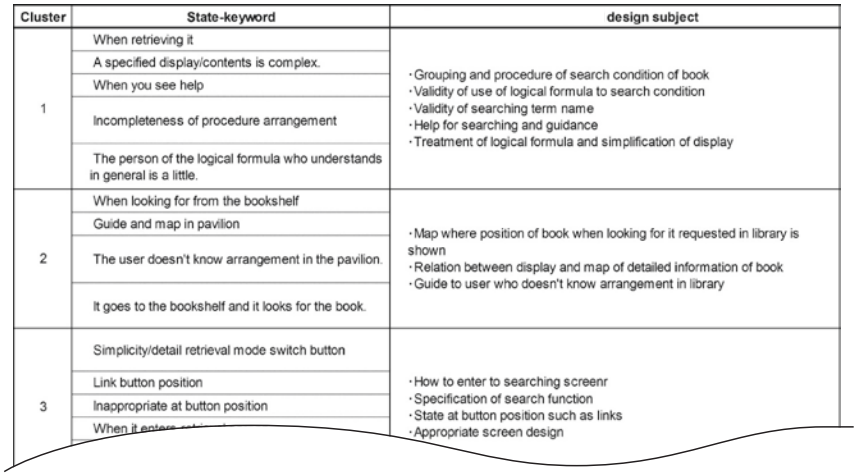
Fig. 3 Dendrogram

the form of the dendrogram. Examples of state-keywords and interpreted design subjects were shown in Fig. 2.

4.2 Experiment 2

An experiment to define design subjects according to heuristics was executed for the comparison with the results of Experiment 1. Using heuristics is a common and convenient technique on the site of design activities. Four participants, aged from 22 to 46 who did not relate to the Experiment 1, were chosen. The descriptions of the 190 problems that were found in the Experiment 1 were used as the data of problems in the Experiment 2. However, neither the state-descriptions nor the state-keywords of the Experiment 1 were used in the Experiment 2. After roughly checking the WEB systems, the participants began to classify the problems to define design subjects.

Some aspects of the problems, for example, external/internal, procedure, and functional/non-functional etc. were tried to classify the problems. Four participants discussed together about the problems with writing some words and drawing figures on a white board. Consequentially, the problems were classified by the



Cluster	State-keyword	design subject
1	When retrieving it A specified display/contents is complex. When you see help Incompleteness of procedure arrangement The person of the logical formula who understands in general is a little.	·Grouping and procedure of search condition of book ·Validity of use of logical formula to search condition ·Validity of searching term name ·Help for searching and guidance ·Treatment of logical formula and simplification of display
2	When looking for from the bookshelf Guide and map in pavilion The user doesn't know arrangement in the pavilion. It goes to the bookshelf and it looks for the book.	·Map where position of book when looking for it requested in library is shown ·Relation between display and map of detailed information of book ·Guide to user who doesn't know arrangement in library
3	Simplicity/detail retrieval mode switch button Link button position Inappropriate at button position When it enters ...	·How to enter to searching screenr ·Specification of search function ·State at button position such as links ·Appropriate screen design

Fig. 4 Classified state-keywords and defined design subjects

seven classification items. They were "searching books," "visual representation," "transferability of meanings," "layout in the screen," "procedure," "map," and "help."

Design subjects were defined by focusing on functional buttons or indications that related to the problems directly. For instance, design subject was defined as adding sufficient functions for the problems of deficient functions. For the problems of usability, design subject was defined as making existing functions easy. On the other hand, there was no subject aiming to delete or validate existing functions. The design subjects tended to be derived from very narrow classification of the problems based on affinity according to heuristics overall. Eventually, most of them were not the design subjects but the ideas to solve the problems.

5 Discussions

Most of clusters that were derived from the Experiment 1 contained several classification items of the Experiment 2. For instance, cluster 1 that was defined in the Experiment 1 contained the state-keywords concerning "searching books," "procedure," and "help" of the Experiment 2. Similarly, cluster 3 contained the state-keyword concerning "searching books," "visual representation," and "layout in the screen." Therefore, the proposed method was assumed to make design subjects extensive, while heuristics made narrow groups of ideas to solve the problems directly.

In the Experiment 1, it was assumed that the problems were understood in detail by using the context items as the viewpoints. Understanding the problems deeply with the contexts was expected to make design subjects efficient.

In the Experiment 1, the design subjects were derived from 68 state-keywords of three context items. However, it was suggested that the state-keywords could be few when an extremely narrow context was supposed, and this method could have little benefit. The limitations of this method like this ought to be clear by next experiments and investigations.

The state-keywords become elements of design subjects. As a matter of course, the state-keywords that are not extracted are not included in the contents of the clusters. Therefore, it is important to record enough problems and the contexts in which the problems occur, and to extract state-keywords appropriately.

About the number of state-keywords of each context item, the reason of the result that there were few state-keywords of "state/factor concerning time" was thought that the book search systems had a simple procedure. On the other hand, many kinds of state-keywords of "assumption and restriction" were extracted, because the participants could image many reasons in the background of problem occurrences. Additionally, because "handled things" were the operational objects for the most part of WEB systems, many state-keywords of this item were extracted.

About the relation among the number of persons who found problems, the number of objects, and the number of extracted state-keywords, the following results came out in the Experiment 1. The number of state-keywords extracted from one object tends to be less than the number of them from several objects. The reasons were thought as follows: Since the each object was designed with supposing each unique context and restriction, each of them had unique weak points and strong points, respectively. Therefore, the context in which the problems occurred was different between the objects. As a result, more various state-keywords were extracted from three objects than from one.

About the number of state-keywords that were extracted from three objects between by one person and by three, there was a significant difference. The reason was surmised that each person found problems from their unique viewpoints. Therefore, collecting problems by several persons was suggested to be better to obtain various kinds of state-keywords.

Intention was necessary to classify the state-keyword even if the dendrogram was resulted from cluster analysis objectively. And, creative ideas were necessary to interpret state-keywords. Therefore, the design subject could not be defined by numerical data analysis only. However, it was confirmed that the matters that were recognized to make design subjects were more extensive by concerning the context than by paying attention to the problems only. The data of state-keywords were expected to be effective materials in defining design subjects.

Moreover, obtaining materials of design subjects by numerical data analysis was expected to be suitable for in the situation of developments that objective criteria were requested. This feature was seen to be an advantage of this method.

6 Conclusions

The aim of this study was to develop a method that defined design subjects for creating attractive products and improved user experience without depending on a designer's heuristics. This chapter showed the process of determining problems, extracting state-keywords and analyzing, interpreting, and defining design subjects. The results of the experiments were shown and discussed.

Consequently, the following matters were confirmed: More various state-keywords could be extracted by finding problems from plural objects or plural persons. Design subjects could be obtained by interpreting the state-keywords classified on the basis of the dendrogram that was the result of a hierarchical cluster analysis.

The following effects were expected: The design subjects obtained by this method have a possibility of bringing a new value to the product because they are different from the understanding of problems through heuristics based on someone's past experience. Though affective elements have tended to be excluded from the paradigm by solving only the functional aspects of problems, they can now be included in the new value. In this method, the design subjects are considered in the product use. When a person uses the products, the person's affection influences the occurrence of problems [13]. It is natural that the matter that relates to user affection is included in the problems and contexts in use. Therefore, it is expected that the design subjects that implying elements that relates to user affection will be defined when the mental state of the user is included in the state-keywords. In addition, the design subjects can be explained with evidences because they were derived from numerical analyses. Therefore, this method is an effective technique that can be used in the early stage of product development. This method is expected to be useful and effective for designing almost all artificial objects that have user interfaces. This method will be applicable in the design of most industrial products, software, and services.

However, it is too early to assume that the conclusions obtained in this study have general applications. It is necessary to conduct more product developments with this method and advance additional research on its applicable conditions and limitations in the future.

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