Strategies to design for dynamic usability

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Abstract: Since usability is a property of the interaction between a product, a user and the task that he or she is trying to complete [6], a product's usability can vary when it is used in varying use situations. We define this as dynamic usability. This study is aimed at exploring how practitioners currently deal with dynamic usability. From a retrospective case study research of three design projects different principles and strategies were formulated for dealing with dynamic use situations. In this paper we present solution principles that are applied to accommodate products to dynamic use situations and we discuss two design process issues with regard to dynamic usability, namely the information sources that are used to get insight in the use situations and the means by which designers try to get insight in the consequence of their design decisions with regard to future use situations.

Key words: Usability, Dynamic Use Situation, Design Practice

1. Introduction

In both design research and practice it is more and more acknowledged that usability - the extent to which a product is easy to use - should receive considerable attention in the design process. Moreover, simplicity and ease of use are increasingly used as selling arguments. Design for usability is however not an easy task. Since usability is a property of the interaction between a product, a user and the task that he or she is trying to complete [6], a product's usability can vary when it is used in varying use situations. We define this as dynamic usability. Design for usability therefore requires from designers to anticipate product use within the whole spectrum of likely use situations. It is our aim to support designers in achieving this goal.

This paper presents the preliminary results of a study that is aimed at exploring how practitioners currently deal with dynamic usability. From a retrospective case study research of three design projects different principles and strategies were formulated for dealing with dynamic use situations. We will present solution principles that are applied to accommodate products to dynamic use situations as well as discuss two design process issues with regard to dynamic usability. The next section will however firstly introduce the concept of dynamic usability in more detail.

1.1 Dynamic usability

The standard that deals with the ergonomics of human system interaction, ISO 9241 [5], defines usability as 'the extent to which a product can be used by specified users to achieve specified goals with efficiency, effectiveness and satisfaction in a specified context of use. Therefore, a product's usability is not only defined by the product characteristics, but also by the situation in which it is used. For instance, a mobile phone that has a certain level of usability for someone that uses it occasionally to call home from the car will probably have a very different usability when it is used by a teenager to send text messages secretly in a class room. When the actual use situation, including user, goal and context, of a product is known, its usability can be specified and measured in advance. However, the actual use situation is often very hard to predict and is subject to change. For instance, Jordan [6] states that users' performance with a product is likely to improve significantly in relation to tasks which they repeat with the product over time. Thus, he concludes, the usability of a product for a particular person completing a particular task may change very quickly as the task is repeated. Similarly usability may change for varying environments, goals or users. We call these varying situations dynamic use situations.

We define dynamic use situations as the use situations of products that are used by varying users, with varying goals and/ or in varying contexts of use [2]. Variation in users for example occurs with products that are publicly available such as ticket vending machines and online stores. Varying environmental conditions will be encountered when products are mobile. Moreover, aspects within environments such as objects, persons and information can be dynamic as well. For example, a supermarket checkout meets the dynamic environmental aspect of different types of groceries. Finally, the goals that products are used for increase when more functions are integrated in one product, the most well-known examples being the Swiss Army knife and the Personal Computer [9]. In some cases user, context as well as the goal of use is dynamic, for example in the use situation of an automated museum audio tour which can be used by various museum visitors for multiple purposes (navigation or information retrieval) in various rooms of a museum. We define this variation with regard to user, environment and/ or goal as different types of dynamics. Besides these dynamics of one instance of a product there is always to a certain extend variation in use situation characteristics between product instances, for example a mobile phone belongs usually to one person, but all the mobile phones of one product series will have different owners. In [12] we distinguished these different 'levels' of use situation aspects. Use situation aspects can vary on session level (within a use session), on product level (between use sessions of one instance of a product) and on series level (between product instances of one series).

1.2 Objectives

In an earlier publication [12] we have discussed the complexity of designing for dynamic use situations. Apart from the fact that dynamic use situations are hard to predict, requirements from different use situations can conflict and the priority of these requirements is related to the solutions a designer develops. Although in literature about usability the variance of use situations is often considered an important issue (for example [6, 11]) it is difficult to find literature on how this issue can be taken into account in the design process of consumer products. Therefore this research is aimed at supporting designers in dealing with dynamic use situations by means of a method or tool [2]. Since the success of this support depends on the extend by which it fulfills the needs of practitioners [13], this research will start with an exploration of the issue in the context of product development. The main research question of this study is how designers currently deal with dynamic use situations when usability is an important issue in the design process. The sub questions that will be discussed in

this paper are firstly what kind of solutions do designers create to accommodate products to dynamic use situations and secondly what approaches are used to deal with dynamic use situations. The first question relates to what Dorst [3] calls the 'object' of the design activity: the problem and emerging design solution, the second question relates to the design 'process'.

2. Method

The above mentioned research questions require an exploratory research approach. Since we study real-world contemporary events which do not require control over behavioral events an exploratory *case study* approach was chosen [14]. The objects of this case study are design projects. For practical reasons the projects were studied retrospectively.

2.1 Case selection

The cases that were selected for this study had to meet the following requirements:

- They should concern design projects in which usability was an important issue so the focus could be on the importance and dynamics of use situation aspects instead of on usability in general
- The projects should be finished recently so interviewees can easily recall project issues.
- Because of the exploratory nature of the study they should preferably concern design problems with different levels and types of dynamics of use situations, as explained in paragraph 1.1

In this study we have chosen to aim at the types of dynamics of use situation aspects related to the user (experience, physical characteristics, habits etc.) and related to the environment (surroundings, noise, other objects, etc.).

Based on these requirements three cases were selected. Case A concerns the design of a color toner wide format printer by a multinational company that provides digital document management technology and services. Case B concerns the design and evaluation of the installation features of a health monitoring system at home for elderly by a multinational company. Case C concerns the design of a bicycle carrier by a product design and consultancy agency. In all cases usability had a high priority. The types of dynamics of use situations of the cases are indicated in table 1.

Table 1. use situation dynamics of the selected cases

Cases	User characteristics vary on	Environmental characteristics vary on
Case A printer	Product level	Series level
Case B health monitoring system	Series level	Series level
Case C bicycle carrier	Series level	Session level

2.2 Data collection

For each project two or three (depending on availability) actors that played an important role in the usability research and design of the project were involved. The respondents had considerable knowledge about design decisions that were made with regard to usability. The following roles are distinguished: designers, usability specialists and project managers. Designers can make decisions with regard to the product design and in all cases were more or less involved in testing the design. Usability specialists evaluate the usability of the product, but

only have an advisory role with regard to changes to the product design. Project managers coordinate the project and set priorities.

The respondents were first introduced to the concept of dynamic use. Then in a group interview they were asked to write down (on a large sheet) and discuss the use situation aspects that played a role in their design project. Based on an analysis of this discussion, the researcher created 'use aspect cards', which each described an aspect of the use situation, the information source for the aspect, how it influenced usability and the way it was dealt with in the design solution. These use aspect cards were then used in individual interviews with the involved participants to discuss the dynamic use aspects in more detail. Furthermore general questions were asked in the individual interviews with regard to the design process. The main topics that were discussed in the individual interview were the role of the respondent in the project and the role of usability, techniques that were applied to improve usability in this project and the use situation aspects, their information source and their variation.

Using the use aspect cards, the relevance of the listed use situation aspect with regard to usability was shortly discussed. Subsequently the respondents were asked to select the most relevant cards with regard to usability, see figure 1. These aspects were discussed in more detail including the information source, variance of the aspect and solution that was implemented to accommodate to the use situation aspect. In some cases also other possible solutions were discussed.

Figure 1: respondent selecting the most relevant use situation aspect cards

2.3 Data analysis

The group interviews were recorded on a digital voice recorder. The transcripts of these interviews and the overview of use situation aspects that the respondents had created during the group interview were used to create the use aspect cards. The recordings of the individual interviews were transcribed as well. Subsequently relevant sections of the transcripts were identified and assigned to either a specific use situation aspect or a general process issue. For each project use situation aspect, sheets were created in which all quotes with regard to that aspect from the different actors came together. In an iterative process a general solution strategy for each use aspect was assigned based on these sheets. Similar solution strategies and process strategies of the three projects were then clustered and from this clustering more general principles and strategies were formulated.

3. Preliminary results

While data analysis is still in progress the first preliminary results will be presented here. In conformity with the stated research questions we distinguish strategies that relate to the design object (problem and solutions) and

strategies that relate to the design process. The process issues that will be discussed here concern which sources of information are used to get insight in relevant use situation aspects and the means by which a design team can get insight in the consequences of their design decisions on the future use situation.

3.1 Solution principles

In [12] we presented general solution principles to accommodate products to varying use situations, based on the level of dynamics, see figure 2. We found examples of the principles of 'one size fits all', 'accessories' and 'adjustable features' in the different cases. However, other principles to adjust products to dynamic use situations were found as well.

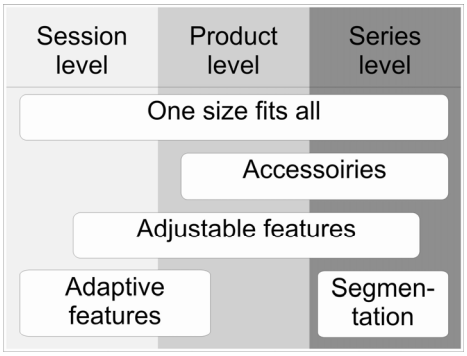

Figure 2 General solution principles for dynamic usability

3.1.1. One size fits all

The 'one size fits all' principle is revealed in the projects in two different forms. Firstly, product characteristics can be designed for extreme use situation aspects, so the less extreme use situations will be accommodated as well. Secondly, versatile solutions can be developed that allow multiple ways of use. The solutions for extreme situation characteristics are widely applied for physical characteristics such as described by Dreyfuss [4], but also for other types of aspects. For example in the case of the bicycle carrier the product was designed to accommodate the most 'extreme' types of bikes, electronic bikes, which are the most heavy and have a different kind of frame (environmental aspect). In the health monitoring system case the installation procedure was designed to fit the extreme cognitive characteristic of short memory by including enough reminders and hints to the manual. Versatile solutions were found in for example the design of the manual of the health monitoring system which allowed multiple ways of use and the bicycle carrier which contained a strap with an eye that users could pull tight with any tool they wanted. The following quotes illustrate these solutions:

Usability specialist (B) … *you should make the manual easy to find and invite people to read it. Actually you should design it double, firstly if you do follow the manual and secondly if you do not follow it...*

Project manager (C): … *we also had this trick. You have to pull tight this strap if there is a bike here and if users could not pull hard enough we made an eye so people could use a tool if they wanted to, for example a hook […] We also thought it would be handy if people could attach a string if they liked it.*

Researcher: *so people are allowed to think up a solution themselves?*

Project manager (C): *Yes, we facilitate something, but we don't know what*

3.1.2 Accessories

A nice example of the principle of accessories to accommodate a product to varying use situations is the ramp that can be purchased with the bicycle carrier which allows another way of putting a bike on the carrier.

Usability specialist (C): *There are all kinds of ways to put your bike on the carrier, for example one wheel first and then tilt the other one with it. Therefore we made a ramp, so you can also drive your bike on the carrier.*

Here the varying user characteristic is the user's preference with regard to placing a bike on the carrier. Users that prefer not to lift their bike but who like to drive their bike on the carrier can buy the ramp.

3.1.3 Adjustable features

Also different types of adjustable features were found. For example the bicycle carrier had adjustable frame holders to adjust the carrier to the bike frame. An aspect that is of influence in many products is the different languages of users as illustrated by the following quote:

Designer (A): *On all GUI's you can choose from about twelve languages, but of these twelve you can also indicate two which are preferred languages. This means that on the local control panel you can switch between those languages. [...] In Belgium maybe French and Dutch.*

So for the language variation between printers (series level) the language can be adjusted in an installation menu and for the more frequent variation of languages between sessions an easier accessible adjustment solution was chosen.

3.1.4 Make situation aspect irrelevant

In our model of solution principles we assumed that the 'contextual' use situation aspects would be independent of the solution. However, some principles we found in the cases showed that another principle of dealing with dynamic use situation aspects is to make the aspect irrelevant. An example that illustrates this principle is the way that was dealt in the health monitoring system with limited knowledge of the use of computers and related terms like 'usb' and 'modem'. This was solved by not using those terms but referring to parts as 'the white box' and 'the blue cable' and using labels. In this way the knowledge about these terms was made irrelevant.

Use situation aspects can furthermore be made irrelevant by 'redefining' the context, or the form-context boundary. According to Alexander [1] the form is a part of the world over which we have control, and which we decide to shape while leaving the rest of the world as it is. The context is that part of the world which puts demands on this form. In case of dynamic use situations the context is made up of all user and environmental characteristics that put demands on the product. In some cases these demands are so contradicting that designers think up solutions to redefine the context. A good illustration of this principle is the varying environmental aspect of the type of TV with the health monitoring system. Users could use their own TV to install the system. However, the variation in types of TV's was so large that it was impossible to explain users in the manual how to install the system. This caused large usability problems. A solution would be to integrate a display in the system itself, so the display becomes part of the 'form' instead of the context.

Designer (B): … *we approached the borders of the system. […] Look, inside you can solve things, there you have control. But on the borders you have a given thing. And you have to accept that and take care of it or if that does not work there is only one thing left and that is to pull it into your product. That's the structural solution*

3.2 Gathering information about use situation aspects

The solution principles that were described in the previous section relate to the object of design: the problem and solution. In this section we will discuss a process strategy of dealing with dynamic use situations, namely the way that the project teams gather information about use situation aspects. The sources of information that were used for this goal were personal and organizational domain knowledge, experts, end-users and environments, after sales information and standards and norms.

3.2.1. Personal and organizational domain knowledge

Most participants indicated to often make use of their own knowledge about the use situation, either from personal experience with the domain or from previous projects they had worked on. Company A, which has been developing the same kind of products for years, keeps records of relevant use situation aspects, for example the sizes of environments and the types of documents that are printed as explained in the following quote:
Designer (A): *we have a reference set, hundreds of drawings, this is what our clients are going to print, so it contains everything.*

3.2.2 Experts

Although end-users and environments are the most direct source to gather use situation information, it seems more efficient to consult experts that have insight in the variations between use situations. For example the design team of the bicycle carrier gathered many insights from the consultation of bicycle dealers. Not only did they have a wide knowledge of types of bicycles that should fit the bicycle carrier, they also knew a lot about the different needs of users with regard to using the bicycle carrier. For example, as mentioned earlier users have different preferences with regard to putting the bike on the carrier. Just consulting end-users might have given a biased view on these issues. An interesting type of expert is the client of the project. Although in this study no use situation aspects were found that came from the client, designers indicated that often the clients have knowledge about use situation aspects when they have developed products for similar use situations previously.

3.2.3 End-users and environments

In all the projects that were studied end-users and environments were used as a source of information for several use situation aspects. The techniques applied to get to this information ranged from observations during in situ user testing and interviews to field visits and cultural probes. On-line information sources were consulted as well. Because case C is about a product that is used in a common environment, the design team could make use of information sources close to the company. For example they used their own 'fleet' of cars and bicycles.

3.2.3 After sales feed back

With participants of project A and C the use of after sales feedback as a source of information was shortly discussed. Since the future use situation can never completely be predicted - we cannot design the user experience [10]) - after sales feedback gives new insight in new use situation aspects. A study by van Kuijk [8] showed that this phase can be a very valuable source of information in the development process.

Two means were mentioned to use this information. A designer from company A claimed that they know that they do not know everything when the product is introduced to the market, but that they can use after

sales information to improve a next version of the product. This corresponds with the findings of van Kuijk who states that much of the information that is collected can be re-used in a next version of the product. Another goal of this information source emerged in the discussions with company C who said that the first signs from the market were now used to adjust the manual of the product without actually changing the design. The manual shows how users should deal with a certain use situation aspect, in this case an irregular size of the tow hook to which the bicycle carrier should be attached.

3.2.4 Standards and norms

The last information sources that were mentioned were standards and norms. Some norms prescribe which types of users the product should accommodate, for example the American section 508 law which describes accessibility to people with disabilities, that was used in the printer case. Others describe the test conditions of conformity assessments for standards, for example, in the case of the bicycle carrier the RDW (Dutch governmental road safety council) conducts a test that reflects various road and driving conditions.

3.2.5 Relation of information source to design context and problem

The sources of information that can be used to gather information about use situation aspects depend to a large extend on the context in which the project takes place and the nature of the project. When the product is developed in a context in which the project is preceded with projects for similar use situations, a designer can rely on organizational knowledge such as was described for case A. Furthermore, resource and schedule issues determine the extent to which external sources like experts and end-users can be consulted. When the project concerns use situations that are common, for example in the case of many consumer products, a designer can rely to a certain extend on his personal domain knowledge.

3.3 Predicting use

As Redström [10] has argued designing is not about determining the use of objects in detail. There will always be a difference between intended use and actual use. Therefore use cannot be predicted completely. This does not mean that designers should not be concerned about the consequences of their design decisions with regard to use. The question is how use can be anticipated in the design process. Although it is important to get insight in the situation in which the product will be used, just information about user and context characteristics alone will not give any insight in the actual actions that the user will perform. This is shown for example in a study of Kanis [7] who showed that user characteristics can set boundary conditions by indicating what users will not do, but they do not give insight in what users will do. This was also acknowledged by the participants of this study

Designer (B): *What surprised me [...] was that the concept of a computer was unfamiliar to them. [...] and maybe you know that, but it is a surprise how it impacts use. That stays surprising, because if you understand that you would not have to do user tests.*

According to Kanis [7] user testing is an obvious way of getting insight into variations of use actions. In fact, all participants in this study acknowledged the importance of early evaluation. Different means to get insight in future use were discussed. A designer can build models to test the design himself quickly. Prototypes can be tested inside the company with colleagues who are outside the project and with experts or intended users.

3.3.1 Internal use evaluation

About testing yourself an interviewee indicated the following:

Designer (C): *just doing things yourself with the design can give you a lot of information. It is important to quickly make prototypes and models so you can have something in your hands and work with it. For example the grip, make foam models and look what it means. […] It is important to have it in your hands as soon as possible.[…] I think for that matter that if you design a product for a professional market, for example doctors, you would use other techniques, but when the product is so close to you, you can learn from testing yourself.*

Obviously testing yourself does not give insight in variations in use and it can only be applied to domains that are well known to the designer personally. Furthermore it seems to be limited to testing physical actions. In early design phases more insight in variations in actions can be gathered by testing early prototypes with users inside the company. Interviewees gave the following remarks about this means:

Usability specialist (B): *Before going outside we did some early tests with secretaries to be able to remove the basic problems. So you usually firstly test inside..*

Designer (C): *... well, we did user tests with people here about carrying the product and how is it placed on the tow hook. So we tested with a colleague who is female and small and we tested with a colleague who is a typical user of bicycle carriers.*

Designer (A): … *I organized a test with people from the R&D department, because it was very difficult to show it to people outside, but who did not know the project at all and did not work in the business unit...*

3.3.2 Use evaluation with experts

In project B and C the developers deliberately chose different types of users to test the product with to get insight in variations of use. In tests with experts this variations of use can be revealed as well, because apart from their personal preference of performing an action they also can have a broad view on types of use. For example:

Usability specialist (C): *Another fact that came forward during evaluation with bicycle dealers was how people place their bike on the carrier. We thought, well, you just lift the bike and put it on the carrier, but the dealers showed that there are various ways to do it for example put one wheel in first and then lift the other wheel.*

3.3.3. Use evaluation with end-users

Finally tests with different types of end-users in situ or in a lab can reveal variations of use. In project B tests with nine elderly persons and couples were conducted in their home. In project A apart from earlier user tests inside extensive user tests were conducted in situ with five representative clients who could use the product for three months. In project C no extra tests were conducted with end-users because they had gathered enough information from the evaluations with the experts (bicycle dealers) and the client. In the other projects tests with end-users were applied in later design phases when working prototypes were available and the first problems with the design had been removed based on internal tests.

5. Conclusions

This paper presented preliminary results of a study of how designers deal with dynamic usability. Without claiming to be complete this study revealed some interesting principles and strategies that are followed by companies to achieve this goal. Firstly, solution principles were presented to accommodate products to dynamic

use situations. They included the principles of 'one size fits all', 'accessories' and 'adjustable features' that we presented in an earlier study. A new principle that was found concerned making use situation aspects irrelevant by choosing other sub-solutions or redefining the context. With regard to the design process, strategies were formulated with regard to information sources to get insight in (individual) use situation characteristics and with regard to anticipating use as a whole. The information source that can be consulted depends firstly on the context of the project including available organizational knowledge and project resources and priorities and secondly on the nature of the design project. Use can be anticipated through use evaluation with different stake-holders. Interesting to see is that although only the tests with end-users seem to be considered as 'actual use' by the developers, the internal tests are of great value in the iterative design process as well. Further data-analysis will extend the results that were presented in this paper. These completed strategies and principles will serve as a basis to develop a method or tool that supports designers in dealing with dynamic use situations.

6.Acknowledgements

The authors gratefully acknowledge the support of the Innovation-Oriented Research Programme 'Integrated Product Creation and Realization (IOP IPCR)' of the Netherlands Ministry of Economic Affairs.

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