Managing Product Usability

How companies deal with usability in the development of electronic consumer products

Jasper van Kuijk

Propositions accompanying the thesis

Managing Product **Usability**

by Jasper van Kuijk

1. In the development of electronic consumer products the four primary drivers for usability are (i) user-centred design proficiency, (ii) knowledge about users, solutions, and usability issues, (iii) prioritization of usability, and (iv) design freedom *(this thesis*).
2. To be able to create usable electronic consumer products, companies should not only adapt their product development process, but also their organization *(this thesis)*.
3. Innovation is bad for usability *(this thesis)*.
4. To reflect the practice of multidisciplinary product development the basic design cycle[*] should be expanded with iterations to simulation and evaluation - in addition to the currently included iterations to analysis and synthesis *(this thesis)*.
5. For a practice-oriented PhD candidate a weblog is a perfect tool for dissemination of research results, dialogue with practice, and reflection on the subject.
6. Designers should be less like gods and more like servants.
7. Ideas are easy; the magic of human flight was in its execution.
8. In its desire for efficiency Dutch academic education is starting to treat students more like buckets to be filled than as fires to be lit[**].
9. Complaints about an unusable product are more effective when directed at the company that made it, rather than at a PhD candidate studying usability.
10. Calling unnecessary aerodynamic adjustments to cars 'spoilers' is a degree of honesty rarely seen in marketing.

** Roozenburg and Eekels (1991) Produktontwerpen, structuur en methoden*

*** A distinction used by Gérard van Eyk (one of IDE’s first professors)*

These propositions are regarded as opposable and defendable, and have been approved as such by the supervisor, Prof.ir. D.J. van Eijk

Stellingen behorende bij het proefschrift

Managing Product **Usability**

door Jasper van Kuijk

1. Tijdens de ontwikkeling van elektronische consumentenproducten zijn de vier drijfveren voor gebruiksgemak: (i) bekwaamheid in gebruiksgericht ontwerpen, (ii) kennis over gebruikers, oplossingen en gebruiksproblemen, (iii) prioriteren van gebruiksgemak en (iv) ontwerpvrijheid *(dit proefschrift)*.
2. Om gebruiksvriendelijke elektronische consumentenproducten te kunnen creëren moeten bedrijven niet alleen hun productontwikkelingsproces aanpassen, maar ook hun organisatie *(dit proefschrift)*.
3. Innovatie is slecht voor gebruiksgemak *(dit proefschrift)*.
4. Om de multidisciplinaire productontwikkelingpraktijk te weerspiegelen zou de basiscyclus van het ontwerpen* moeten worden uitgebreid met iteraties naar simulatie en evaluatie, naast de reeds beschreven iteraties naar analyse en synthese *(dit proefschrift)*.
5. Voor een praktijkgerichte promovendus is een weblog een perfect middel voor verspreiding van onderzoeksresultaten, dialoog met de beroepsgroep en reflectie op het onderzoeksonderwerp.
6. Ontwerpers moeten minder als God willen zijn en meer als Alfred (de butler uit Batman).
7. Ideeën *hebben* is makkelijk; het unieke van de gebroeders Wright was niet hun idee, maar het *uitvoeren* ervan.
8. In haar drang naar efficiëntie begint het Nederlands universitair onderwijs studenten steeds meer te zien als emmers die gevuld, in plaats van als prille vlammetjes die aangewakkerd moeten worden**.
9. Klachten over een onbruikbaar product zijn effectiever als ze gericht worden aan de betreffende producent in plaats van aan de promovendus die onderzoek doet naar gebruiksgemak.
10. Onnodige aerodynamische aanpassingen aan auto's 'spoilers' noemen is van een eerlijkheid die je maar weinig ziet in marketing.

** Roozenburg en Eekels (1991) Productontwerpen, structuur en methoden*

*** Onderscheid gebruikt door Gérard van Eyk (een van de IO hoogleraren van het eerste uur)*

Deze stellingen worden opponeerbaar en verdedigbaar geacht en zijn goedgekeurd door de promotor,
Prof.ir. D.J. van Eijk

Managing Product **Usability**

How companies deal with usability in the
development of electronic consumer products

Managing Product Usability; how companies deal with usability in the development of electronic consumer products

PhD thesis
Delft University of Technology, The Netherlands
Faculty of Industrial Design Engineering

ISBN: 978-90-816468-1-9

Subject headings: product development, innovation management, human-product interaction, usability, electronic consumer products, consumer electronics

December 2010

j.i.vankuijk@tudelft.nl / jasper@vankuijk.com

Managing Product **Usability**

How companies deal with usability in the
development of electronic consumer products

Proefschrift

ter verkrijging van de graad van doctor
aan de Technische Universiteit Delft,
op gezag van de Rector Magnificus prof.ir. K.C.A.M. Luyben
voorzitter van het College voor Promoties,
in het openbaar te verdedigen op maandag 13 december 2010 om 15:00

door

Jasper Ivo VAN KUIJK

ingenieur industrieel ontwerpen,
geboren te Den Haag

Dit proefschrift is goedgekeurd door de promotor:

Prof.ir. D.J. van Eijk

Copromotor:

Dr. H.H.C.M Christiaans

Samenstelling promotiecommissie:

Rector Magnificus, *voorzitter*

Prof.ir. D.J. van Eijk, Technische Universiteit Delft, *promotor*

Dr. H.H.C.M. Christiaans, Technische Universiteit Delft, *copromotor*

Prof. D.A. Norman, PhD, Korea Advanced Institute of Science and Technology

Prof.Dr.-Ing R. Bruder, Technische Universität Darmstadt

Prof.dr. P.P.M.A.R. Heugens, Erasmus Universiteit Rotterdam

Prof.dr.ir. P.H. den Ouden, Technische Universiteit Eindhoven

Prof.dr.ir. J.A. Buijs, Technische Universiteit Delft

Reservelid:

Prof.dr. P.J. Stappers, Technische Universiteit Delft

Drs. H. Kanis heeft als begeleider in belangrijke mate aan de totstandkoming van dit proefschrift bijgedragen.

The research described in this thesis was supported by the Netherlands Ministry of Economic Affairs, Agriculture and Innovation under the Innovation-Oriented Research Programme 'Integrated Product Creation and Realization' (IOP IPCR).

They’re using only half of what we’re giving

We can put a lot of functionality into a product, but if people are not able to use that product, all that functionality is useless. As the CEO of TeliaSonera (Scandinavia’s largest telecom provider) put it:

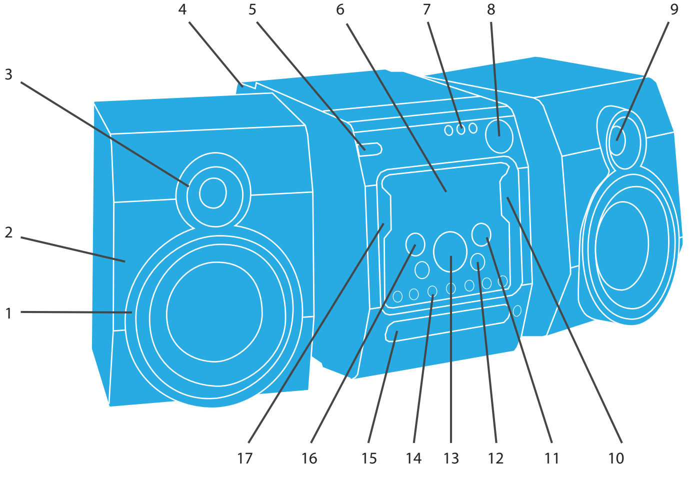
”It's great that a mobile phone has a built-in camera, but it's far too complicated. Sometimes you have to use up to 12 keys. A client that's not able to do this the first time, is lost forever."

Contents

I may not have all the answers; I wouldn’t have it any other way

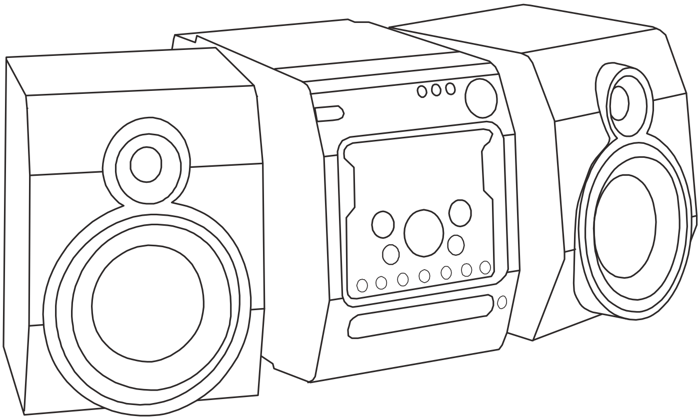
(as sung by Ilse de Lange, written by K. Halpin)

Chapter 1 | Introduction



Chapter 1

Introduction



Steam is pouring out of my colleague's ears. I look up: "What's the matter?" Angrily he points at a stereo set. "I'm supposed to be able to listen to Internet radio on this thing. I've just spent an hour and a half on it, and I still can't get it to work." I ask my colleague, a PhD in electrical engineering, whether he had problems connecting the thing to the network. "No way, I had that figured out in no time. I just don't know how to use it. I don't know what buttons to push."

The stereo looks spectacular. A well known, premium consumer electronics brand, renowned for its user-centred attitude, developed it. But upon close inspection the device reveals design choices that are causing the problems my colleague is experiencing: technical terminology in button labels, buttons that don't look like buttons, and styling elements that look like buttons but are not.

How does a company that is so design and user-focused, end up developing a product with such poor ease of use that my colleague, who can be labelled fairly technology-savvy, cannot figure out how to operate it? Was there no time for a usability test? Did the designer not have enough knowledge of interaction design? Was usability not part of the product requirements? In short: what happened? This PhD thesis is about answering those questions. The focus is on electronic consumer products, because in that sector usability is pressured more and more by increasing complexity, commoditization and speed of development.

1.1 What is usability and why is it important?

1.1.1 The concept of usability

Whether a product is easy to use or not is referred to as its usability, a construct that originates from the field of human-computer interaction where it was applied to 'visual display terminals' (Shackel, 1984). Many perspectives on and definitions of usability have been developed over the years (Hertzum, 2010). Each of these views has its backgrounds and implications. A number of definitions of usability and their implications are discussed in chapter 2 (page 39), based on which a working definition for usability in this thesis was chosen, namely the definition of usability as formulated in the ISO 9241-11 Standard (ISO, 1998, p.2). In this ISO standard usability is considered to specifically addresses whether people are *able* to use a product, at what cost (time, effort) and to what extent they are satisfied wit using the product. The ISO 9241-11 standard contains what is considered the most widely accepted definition of usability (Jordan, 1998b; Jokela *et al.*, 2003): "*the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*[1]."

Usability as a construct was developed to evaluate human-product interaction. When adapting Shackel's (1984, p.51) framework for human-machine systems to the situation for electronic consumer products – the focus of this research – human-product interaction can be said to rely on the properties of the user, the product s/he interacts with, the symbiotic products with which the product interacts, other people that influence or are influenced by product usage (e.g., bystanders or people that you call with your mobile phone), and the environment in which the interaction takes place, see Figure 1. Usability is influenced by each of these elements.

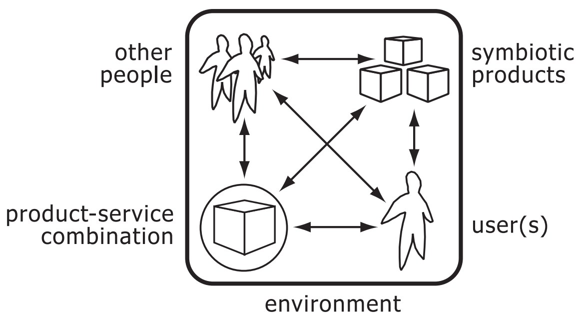


Figure 1: Framework for human-computer interaction of electronic consumer products.

First of all, there is the user that interacts with the product in order to reach a certain goal (ISO, 2006), and who has certain physical, sensory and cognitive capabilities (Rooden, 2001, p.2), but also previous

[1] As the application of the term 'the extent to which' in the definition suggests, usability is not bipolic; a product is not either usable or not. Usability is a scale; products can be usable to a certain degree. In this thesis I use the term 'usable' or 'high level of usability' for the positive end of that scale and 'unusable', 'less usable' or 'poor (level of) usability' for the negative end of the scale.

experiences (Doane *et al.*, 1990; Sauer *et al.*, 2000) which can result in expectations about how to interact with a product (Norman, 2002, p.16; Standaert, 2004, p.160). In addition to variety in user properties, there is also a variety of contexts of use (Wilson, 2000): the symbiotic products can differ per situation, as can other people that are present (e.g., co-workers or friends) and the environment in which the interaction takes place. As the ISO definition of usability states we can only assess the level of usability of a specific product, for a specified goal, when used by specified users, in a specified context of use. In other words: *the* usability of a product does not exist; usability is situated[2].

Usability can be judged by measuring or observing the effectiveness and efficiency of the interaction, as well as how people experience that interaction (their satisfaction about use); two 'perspectives' that Bevan and MacLeod (1994) refer to as user performance and user-perceived quality. There is no one-to-one relationship between the user performance and user-perceived quality. If two users have identical performances when interacting with a product, someone that previously had a mobile phone with a poor level of usability may be quite satisfied, while someone who previously had a phone with excellent usability will most likely be dissatisfied by interacting with the mediocre phone.

1.1.2 Manifestations and effects of usability

The usability of a product can be said to manifest itself in human-product interaction and in how people experience the interaction, see Figure 2.

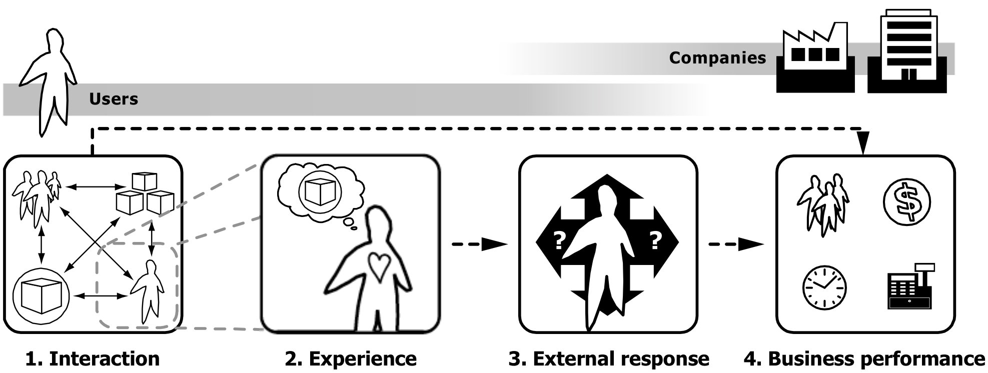


Figure 2: The manifestations and effects of usability in the user and the company domain. (1) human-product interaction can provoke (2) a user experience, which in turn may prompt (3) an external response (e.g., product returns, complaints, lower purchase intention). In the end this may result in consequences for (4) the business performance of companies making or owning these products.

---

[2] In contradiction to this, in this thesis I will refer to i.e. '*the* level usability of a product', because otherwise this thesis would become somewhat unreadable. It should be noted though, that when I refer to 'the level of usability' or 'the usability' of a product it is implied that usability is situated.

A high level of usability has been argued to lead to increased productivity (quantity and quality of it), increased safety, and reduced effort for operation (Cushman and Rosenberg, 1991; Mayhew, 1999; Donahue, 2001; ISO, 2006), see Figure 3. How usability manifests itself in the interaction can in turn have consequences for the business performance of companies (see Figure 2 and the example in Figure 4). For example, if a railway company has ticket machines that are hard to use, in order to allow all customers to buy tickets within a reasonable amount of time, the company will have to buy more machines, or replace them with a model that allows for a more efficient interaction.

Apart from manifesting itself in terms of performance (quality and quantity of results, and required effort), the interaction can also result in 'an experience'. Forlizzi and Battarbee (2004) describe experience as the "constant assessment of our goals relative to the people, products, and environments that surround us". When our goals are met, we tend to have a positive experience. The absence of usability problems, which allows us to reach our goals, is considered to be closely linked to satisfaction about use (Frøkjaer *et al.*, 2000; Rooden, 2001, p.2; Lindgaard and Dudek, 2003) and to how pleasurable people consider the product (Jordan, 1998a; Demir *et al.*, 2009) (see Figure 3).

As a reaction to the interaction and experience, people may exhibit an 'external response' (see nr. 3 in Figure 2), which is not directed at the product, but, for example, at the company who made it or sold it to them, or at their friends. If a product has a poor level of usability, users might ask the company that sold or made the product for assistance (see Figure 5 and Figure 6) or return the product if they are dissatisfied about the interaction (Den Ouden, 2006, p.66). Another type of external response is that people warn family and friends about the product or its seller (negative word-of-mouth), and stop buying the product or brand or to boycott the seller (Park *et al.*, 1992; Reichheld, 2003; Otker *et al.*, 2005). On the other hand, positive experiences with a product have been argued to result in a stronger brand position and (re)purchase intent among consumers (Park *et al.*, 1992; Reichheld, 2003).

Finally, the quality of the interaction, the user experience, and external response can have consequences for the business performance of product development companies, for whom the consequences of the level of usability might be an increase in the required resources (time, staff, budget) to deal with customer support and complaints (see Figure 2). But an external response can also mean product returns (Donahue, 2001), and influence sales numbers through of word-of-mouth, repurchase intent and brand image (Park *et al.*, 1992; Reichheld, 2003). How usability manifests itself in the interaction and the user experience, and how it can affect the external response and business performance is discussed in more detail in Chapter 2.

In addition to the above economical approach Jordan (1998b, p.16) observes that: "*Products such as these are intended for people's convenience and enjoyment – if they are difficult to use they cause annoyance and defeat their intended purpose.*"

Figure 3: When introduced in 2009, the Dutch public transport chip card system caused confusion among its users, leading to complaints, negative publicity, and a negative image (photo courtesy of Hilderik71/Flickr)

> www.uselog.com/2010/01/dutch-public-transport-chip-card-system.html

Figure 4: In this hotel remote control the pay-per-view button has the appearance (red) and position (upper left) that is usually reserved for the on-off button, thus prioritizing sales over adhering to user interface conventions.

> www.uselog.com/2009/03/sales-outweighs-usability-in-remote.html

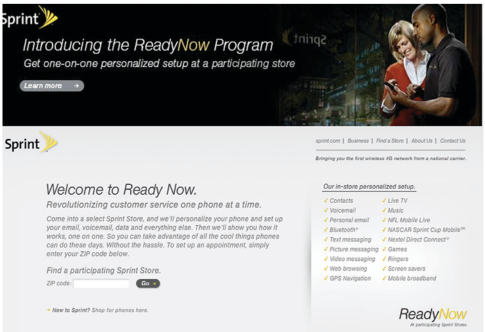


Figure 5: US telecom provider Sprint offers free, in-store training, because 21% of the smartphone buyers came back to return the phone or to seek help in setting it up and learning to use it.

> www.uselog.com/2008/10/sprint-launches-training-for-smartphone.html

Figure 6: Redesigning an ADSL installation kit caused a 30% reduction in helpdesk calls, resulting in a seven-fold return on the investment required to redesign the kit for Dutch telecom provider KPN (Photo by Marsel Loermans, Den Haag; courtesy Flex / THE INNOVATIONLAB)

> www.uselog.com/2008/04/30-fewer-help-desk-calls-because-of.html

1.2 Usability of electronic consumer products under pressure

This study aims to identify factors that contribute to or obstruct the usability of electronic consumer products. The focus is on electronic consumer products specifically because the usability of these products is pressured due to a number of their properties and because of how they are developed. I define electronic consumer products[3] as products that are purchased by consumers for personal use (as opposed to business-to-business), with a physical presence, and with integrated information technology that enables them to interact with the user. Examples are mobile phones, MP3-players and microwaves.

1.2.1 Signals from product development practice

As pointed out previously, the level of usability of products can have serious consequences, for users as well as businesses. The next question is: how much of a problem is usability in the field of electronic consumer products? Recently signals have come from product development practice that indicate that the usability of electronic consumer products is under pressure.

In the past product returns and complaints were largely due to technical failures (quality or reliability issues). Over time companies became better and better at managing product quality and until the late nineties the number of product returns was decreasing (Den Ouden, 2006, p.3). However, from that time on the number of product returns has been on the rise (Brombacher, 2005). In a study by Den Ouden (2006, p.825) in 48% of products that were returned by consumers no technical fault could be detected. Consultancy firm Accenture puts the percentage for this 'no-fault-found' category for returned electronic consumer products in 2007 in the US at 68%. The company estimates the overall cost for product returns for the US market alone in 2007 to be $13.8 billion (Steger *et al.*, 2007).

Products being returned even though technically they are not broken is partly attributed to people not understanding how to use a product properly and thinking it is not working, as well as to consumers being dissatisfied with the product because it did not meet their expectations (Den Ouden *et al.*, 2006). Improving the usability of products is seen as one of the strategies that can be applied to deal with the rise in returns (Steger *et al.*, 2007).

A number of studies have been reported in the popular press that provide further indications that the usability of electronic consumer products is under pressure. When performing the consumer research that led to its new brand position 'Sense & Simplicity' the Dutch electronics firm Philips found that: "Around 30% of home-networking products (…) are returned because people can't get them to work. And 48% of people have put off buying a

---

[3] I do not use the term 'consumer electronics' as in industry this is most commonly used to describe audio and video products, but is applied less to describe personal communication devices (mobile phones) and domestic appliances (washing machines), product categories that I do study.

digital camera because they see them as too complicated" (Philips, 2005). In a questionnaire by the Pew Research Center nearly half (48%) of adult respondents who use the Internet or have a cell phone indicated they usually need someone else to set up a new device or learn how to use it (Horrigan and Jones, 2008). In a survey by the IT-support department of British Telecom over 50% of the participants indicated that they had unused 'gadgets' lying around the house, because they didn't know how to use them properly (www.webuser.co.uk, 2008).

1.2.2 Potential causes

As mentioned before, human-product interaction is a resultant of the properties of the user(s), the product, other people, symbiotic products, and the environment in which the interaction takes place (Figure 1). Below I discuss how each of these elements of human-product interaction is a potential cause for usability problems. In addition I discuss a number of trends in product development considered to complicate the development of usable products.

Users

Developers of electronic consumer products sell to buyers in many different countries, who may differ hugely in needs, preferences and customs (van Eijk, 2006) and developing products that fit a wide variety of users can be a challenge (Wilson, 2000). Secondly, Den Ouden (2006, p.85) suggests that the increasing amount of customer complaints and product returns may be due to a decreasing tolerance among consumers for quality problems, which include usability.

Products

In addition to their physical manifestation, electronic consumer products rely on microelectronics or information technology to offer functionality. As a consequence, their appearance does not have a one-to-one relationship with the functions they offer, and though "*devices may look simple in their system parameters concerning the physical layout, they are difficult to operate as a consequence of the complexity of the underlying system*" (Standaert, 2004, p.2-3). In comparison to non-electronic products, electronic consumer products contain less visual clues as to what the products are for and how to operate them (Jordan, 1994; den Buurman, 1997; Norman, 2002, p.8) (see Figure 7).

The number of functions in electronic consumer products has been increasing for a number of years (Lindholm *et al.*, 2003, p.12; Den Ouden, 2006, p.85; Norman, 2007b), which is attributed both to advancements in technological possibilities (Norman, 2002, p.30; Koca *et al.*, 2008) and the commercial advantage of offering more and new functions (Thölke *et al.*, 2001). Meanwhile the size of electronic consumer products has been decreasing (Lindholm *et al.*, 2003, p.12). Products with more elaborate functionality generally are harder to use than the ones with a limited amount of functions (Rust *et al.*, 2006; Keijzers *et al.*, 2008).

This may become even more of a problem if this large amount of functions has to be accessed through a small user interface (Keinonen, 1998).

Figure 7: An increase in functionality, a decrease in dimensions, and an increase in being networked, result in a decrease in the 'guessability' of music players.

Symbiotic products

Electronic consumer products increasingly function as a part of a network of products and services (Buxton, 2007; De Visser, 2008, p.12; Law *et al.*, 2009). For example a television can be part of a 'network' with a home cinema set, a hard-disk recorder and a satellite decoder. Even if the usability of the individual products is at an acceptable level, this does not guarantee that the system as a whole is usable.

Dynamic environments

The technological development of microelectronics has enabled electronic consumer products to become smaller, and thus more mobile. With an increase of the amount of environments a product is to be used in, the challenge of designing a product that is usable in all situations becomes bigger (van der Bijl-Brouwer and van der Voort, 2009).

Product development

Along with the increase in functionality the technological complexity of electronic consumer products has been increasing (Den Ouden *et al.*, 2006). De Visser (2008, p.1) points out an example of an electronic consumer product in which the number of lines of software programming code increased tenfold every five years.

Products are getting more complex, but simultaneously there is an increase in the pressure on time to market (Brombacher *et al.*, 2005), because 1) the sooner a products is on the market, the sooner a company starts gaining profit from it, and 2) the adoption cycles for products (the time it takes for a product from first introduction to become subsequently accepted, normal and outdated) are increasingly shorter and thus companies only have a limited amount of time to get a return on investment for a certain product category (Minderhoud and Fraser, 2005). The fast development cycles put pressure on product development activities: there is less time to perform usability tests and the recommendations that are the outcome of these tests cannot always be implemented (Minderhoud and Fraser, 2005). In addition, implementing market feedback about a previous product can be troublesome, because the development of a model starts directly after a previous product design has been finalized. So by the time the team starts working on the new product, the predecessor often still has to be introduced on the market (Brombacher, 2005).

Due to the increasing complexity of products, current new product development often requires the collaboration of multidisciplinary teams (Kleinsmann, 2006, p.20). Increasingly product development teams are distributed across the planet (Ketola, 2002, p.28; Minderhoud and Fraser, 2005) which complicates team communication (Song *et al.*, 1997). Product development groups are observed to increasingly utilise local subcontractors or outsource development activities which is considered detrimental for product quality (Den Ouden, 2006, p.85).

Finally, in a part of the electronic consumer products sector, namely consumer electronics (audio and video), development budgets are pressured, as this product category is showing signs of being a commoditized market, characterized by low margins, intense competition and low importance of brands, in which in order to make a profit, producers need to sell in high volumes (Wever, 2009, p.52).

1.3 The gap between usability in theory and practice

In the previous paragraph I argued that the usability of electronic consumer products is under pressure, and pointed out a number of potential causes in human-product interaction and product development. The combination of these causes makes usability an urgent issue in the electronic consumer products market. In this subparagraph I discuss the gap between on the one hand theories and methods for creating usable products, and on the other hand product development practice.

1.3.1 Methods for creating usable products

Along with the conceptualization of usability, a large number of theories and methods have been developed that provide product developers with guidance on how to involve the user in the different phases of product development (Nielsen and Mack, 1994; Stanton and Young, 1998; Bevan, 2003). Two of the most prominent methodologies for creating usable products are Usability Engineering (Nielsen, 1992b) and User-Centred Design (ISO, 1999; Preece *et al.*, 2002; Vredenburg *et al.*, 2002a). Guiding principles in both approaches are taking the user into account in all phases of product development, testing early and often, and performing iterative design cycles.

Apart from the development of these methodologies, a considerable amount of research has been performed in order to optimise methods that can be used in the user-centred design process, for example by comparing the effectiveness of methods for uncovering usability problems (Jeffries *et al.*, 1991; Karat *et al.*, 1992), and on conducting research on how to learn about user needs, preferences and behaviours (Jääskö and Mattelmäki, 2003; Garmer *et al.*, 2004; Sleeswijk Visser *et al.*, 2005; Gyi *et al.*, 2006).

1.3.2 The problem may lie in practice

However, even though there is a considerable amount of knowledge of and methods for usability, products with poor usability still come onto the market. Hence it may be argued that there are factors in product development practice that obstruct the development of usable electronic consumer products. In a case study on human-centred design (HCD) in the development of ICT systems Steen (2008, p.1) observed that human-centred design practice is very different from HCD principles and theory. Wixon (2003) and Norman (1996) also underline the contrast between usability in research and in practice: real, day-to-day product development is messy (at best) and the effectiveness of usability testing methods should not only be considered from a theoretical perspective (how good are they at uncovering usability problems in a controlled situation), but also from a more pragmatic standpoint: how effective these methods are when applied in product development practice. Wixon (2003, p.32) puts forward the notion that to improve usability, product development practice should be studied:

> *"…a case study approach is both the only practical way to produce a body of knowledge for applied usability, and the most effective. (….) Second, the development of real products is the only context sufficiently rich to produce the kind of nuanced examples that are needed to develop a differentiated and contextualized understanding of methods and techniques needed by practitioners. An accumulation of case studies might even permit meta-analyses to be conducted that would help in suggesting patterns that can be generalized across cases."*

In 1991, in an article in which he identified obstacles for user involvement in software product development, Grudin (1991, p.435-436) pointed out that his observations were mostly based on personal experience, as "*reliable, industry-wide data are difficult to find*". Gulliksen *et al.* (2006, p.570-571) point out the importance of investigating the practical concerns of the usability professional involved in designing and creating systems or products – a 'shop floor' perspective on usability:

> *"Integration on this level is about getting into the team, getting action space (that is, establishing a role and a position within the team and creating the conditions that are required for performing the desired/necessary activities), and creating leverage for usability within the project (that is, obtaining attention and support as well as the required resources for usability work)."*

This is to be the focus of this research: providing a 'shop floor' perspective on usability in the development of electronic consumer products.

1.3.3 Existing research on usability in product development practice

Before setting up studies to investigate the phenomenon described above I first reviewed existing research on usability in product development practice. Though there is a considerable number of reports on the practice of usability in product development (e.g., Wiklund, 1994; Jordan *et al.*, 1996a; Lauesen, 1997; Väänänen-Vainio-Mattila and Ruuska, 2000; Bouwmeester and Stompff, 2006; Lee and Pan, 2007), a large number consists of descriptions of usability departments and development projects based on self-reports by participating observers, often usability specialists or designers employed by the company being described. Additionally, most of the reports are not anonymized, which and the author is usually employed by the company s/he reports about. These are factors that may have lead to what Steen (2008, p.56) calls somewhat less critical descriptions in most insider accounts of human/user-centred design practice. Lindholm *et al.* (2003, p.vii), working at Nokia, point out that they find this type of reports somewhat positive: *"Reading such material from a Nokia point of view (…) creates ambivalence. How can they keep the whole thing on track so well?"* Finally, though the reports do provide insight, they often do not report how data collection and interpretation was conducted and thus no assessment can be made of their trustworthiness (Graneheim and Lundman, 2004; Shenton, 2004).

In the analysis of existing research on usability in practice (Chapter 2), I only included studies that were conducted (at least partly) by an external researcher. Studies conducted in various sectors (software, IT systems, electronic consumer products, and diversified) were included, because there were only a few studies targeting electronic consumer products specifically. The selected studies consist of questionnaires targeting (mostly) usability professionals at a large amount of companies (Rauch and Wilson, 1995; Vredenburg *et al.*, 2002b; Venturi and Troost, 2004; Ji and Yun, 2006), or interviews within a more limited number of companies (Bekker, 1995; Borgholm and Madsen, 1999; Boivie *et* *al.*, 2003; Boivie *et al.*, 2006; Bruno and Dick, 2007). In some cases a combination of methods was used (Rosenbaum *et al.*, 2000; Gulliksen *et al.*, 2006). Most qualitative (interview-based) studies were conducted in software and IT systems development environments. The questionnaire-based studies usually included usability specialists across a variety of industries and did not focus on electronic consumer product specifically.

In most studies the informants were usability specialists and interaction designers, and the focus was not so much on the product development process and the team that executed it, but on usability-related activities and usability departments even though several authors of these studies (Rauch and Wilson, 1995; Gulliksen *et al.*, 2006) conclude that to achieve high usability, many disciplines must be involved.

A returning topic of interest in existing literature on usability in practice is what methods for user-centred design are applied, why, and when. There does not seem to be a lack of knowledge of user-centred design methods among practitioners, but organizational factors are reported to limit their application. Apart from methodological issues, most studies point out factors related to teamwork and communication, and to how the company and usability department are organized. A final topic that surfaced throughout the studies is how to create support for and understanding of usability within an organization.

It can be concluded that existing research on usability in product development practice does not take an integrated approach (including 'all' disciplines and phases). Secondly, very few studies are available that study electronic consumer products specifically, even though in that sector usability problems are increasingly becoming a problem. A considerable number of studies employs questionnaires targeting user-centred design professionals, which requires the researchers to a priori identify the relevant variables and in most studies it is not made clear based on what assumptions the researchers have selected these variables. Finally, most qualitative studies only involve a very limited number of cases – often a single one – which limits the possibility to conduct cross-case analyses.

1.4 Research design

In this section the previous observations are synthesized into a problem statement, from which a research goal is derived. Next the research questions are introduced and finally the research design and thesis outline are presented.

1.4.1 Research goal

Problem statement

Despite the development of theories on usability as well as methods and methodologies for creating usable products, the usability of electronic consumer products leaves much room for improvement. There is insufficient insight into product development practice of electronic consumer products to explain why product development companies may fail at delivering usable products.

Aim
The goal of this research is to obtain insight into the current practice of product development of electronic consumer products, and to identify what factors in product development influence the usability of these products.

Research questions
This leads to the following research questions:

- How is usability dealt with in the current practice of product development of electronic consumer products?
- What variables in product development practice contribute to or obstruct the usability of electronic consumer products and how are these variables related?

1.4.2 Research approach

Below, four important aspects of the overall research design are discussed: why the research takes an integrated approach (i.e., includes all relevant product development disciplines and phases), why the studies focused on product development practice, why the research questions called for a qualitative approach, and finally how the case studies executed as part of this research relate to each other.

Integrated

Most usability-related research has been performed on usability evaluation methods with the goal of increasing the accuracy of these test methods. Less attention has been paid to how product developers deal with usability issues in actual product development; in essence more attention is paid to detecting usability issues than to fixing them. Also, the follow-up to a usability test (whether the recommendations test produces get implemented) is often left out of the scope of studies that investigate usability evaluation methods. The research approach underlying this thesis is based on the premise that if the goal is to study usability in practice, one cannot focus only on usability testing; the whole product development process, as well as the context in which this is performed has to be taken into account. As a consequence of the focus on the entire development process, this research has to take a multi-actor approach, which means including other members of the product development team besides the usability specialist, such as product managers, development engineers, interaction designers and market intelligence experts.

Practice-oriented

This study aims at studying 'real life' product development in order to identify what variables in product development influence the usability of electronic consumer products. This seems to call for a practice-oriented research approach. In a discussion of research in the medial sciences Malterud (2001a) argues that in addition to controlled experiments, with their focus on questions and phenomena that can be controlled, measured and counted, the knowledge of experienced practitioners should be studied, because that could offer a broader understanding of a phenomenon. The same goes for product development. It should not only be studied whether design and development methods work when they are applied in a controlled setting, but also what happens when they are used in that fast-paced, hectic process of developing electronic consumer products. In addition, because experienced product developers have been immersed in product development on a daily basis, they can possess a wealth of knowledge on what does and does not work for usability in product development practice. This research is set up to tap into that knowledge.

Apart from product development practice being the focus of this research, I adopt what one could label a 'practitioner-centred' research approach. While exploring the topic, in parallel with studying the literature, I conduct interviews with usability practitioners and experts. Throughout the studies product development practitioners are treated as informants, not as the subject of study. In addition to this, throughout the case studies I verify whether informants find my interpretations and conclusions accurate and comprehensive: each of the case studies includes a feedback workshop or workshops in which the results and conclusions are presented and discussed. And finally, the recommendations for industry are 'user tested' by presenting them on my weblog.

Qualitative

Because of the limited amount of research conducted on usability in the development of electronic consumer products it is not known what variables in product development practice influence usability. This limits the possibility of conducting studies in controlled environments or quantitative approaches such as questionnaires. The problem at hand seems to call for a qualitative research approach. According to Miles and Huberman (1994, p.10) qualitative research can provide a "*strong handle on what 'real life' is like*" and "*has often been advocated as the best strategy for discovery, exploring a new area, developing hypotheses*". The primary research method applied is the case study; a suitable method for explanatory studies into "*a contemporary set of events over which the investigator has little or no control*" (Yin, 2009, p.13).

Three case studies, three angles

The same phenomenon – how product development groups deal with usability – is studied in three case studies, and each of the studies takes a different perspective. The first study investigates how product development groups in four different markets, adjacent to electronic consumer products, deal with usability. The second study investigates five development groups of electronic consumer products, and in the final study three product development projects in one development group are the focus. This stepwise approach provides the possibility to focus each subsequent case study a little more on aspects that were previously unclear or unstudied. Secondly the level of detail increases with each of the studies: from four different markets, to five different companies (within one market), to three different projects (in one company).

1.4.3 Research context: the Design for Usability project

This research is a part of the Design for Usability project, funded by the Dutch government's IOP research programme and four companies. The goal of this project is to reduce usability problems with electronic products by developing a coherent design methodology to anticipate expectations and needs of users on the one hand, and the influence of products on product usage on the other. The research project is a collaboration of three Dutch universities and the companies Philips, Océ, Thales and Indes. The project is divided into five sub-projects (of which this research is one):

- Use problems: how to estimate the risk of usability problems in the field during a new product development process?
- User characteristics: which user characteristics are deeply involved in user-product interactions that lead to satisfactory or dissatisfactory usability?
- Product impact: how can the influence of products on the behaviour and attitudes of users be taken into consideration in the design process?
- Company processes (this thesis): What are barriers and enablers in product development practice for the usability of electronic consumer products?
- Development methodology: what should a design method, which is at least applicable to the development of electronic products, look like in order to minimize usability problems?

1.4.4 uselog.com | the product usability weblog

While conducting this research I kept a weblog on www.uselog.com entitled 'the product usability weblog'. Twice a week I wrote a post about the usability of electronic consumer products. The goal was to attract an audience of product managers, interaction designers and usability specialists by generating constant flow of news, research (by other authors as well as by me), and opinions and examples relating to consumer product usability. Having this audience provided the opportunity to disseminate my research to the product development and human-product interaction community.

Secondly, it turned out that a weblog can be a two-way street: apart from being a way to disseminate my publications, uselog.com also became a platform for a dialogue with practitioners, who started commenting on the posts I wrote or contacted me via email. Having established a dialogue with practitioners through the weblog provided a possibility to 'user test' the recommendations for industry by publishing them on my weblog.

Finally, writing about consumer product on a regular basis meant that I was continuously confronted with the phenomenon I was studying, was continuously testing my ideas against empirical evidence, and collected a great collection of examples and anecdotes about the benefits of usability, how usability is used in marketing, what simplicity is, and usability problems in consumer electronics.

At the time of writing uselog.com had almost 10.000 hits per month, an estimated 1400 followers via RSS, 143 followers on Twitter, and 71 subscribers to the email newsletter. For a more in-depth description of how uselog.com was developed and used, and of its audience, see Appendix A.

1.5 Thesis outline

This section outlines how the individual parts of this research are related, and how these are documented in the chapters in this thesis (see Figure 8).

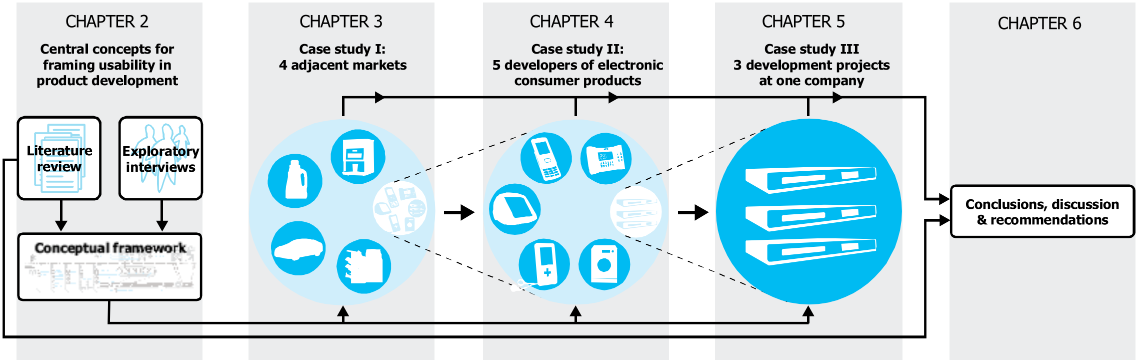


Figure 8: Visualization of the thesis outline.

In Chapter 2 the primary concepts for studying usability in product development practice are identified by reviewing existing research on usability in product development practice, as well as through exploratory interviews with experts on usability from academia and industry. Based on these sources I synthesized a conceptual framework that provides an overview of concepts that may influence user-centred product development and usability, as well as the (expected) relations between them.

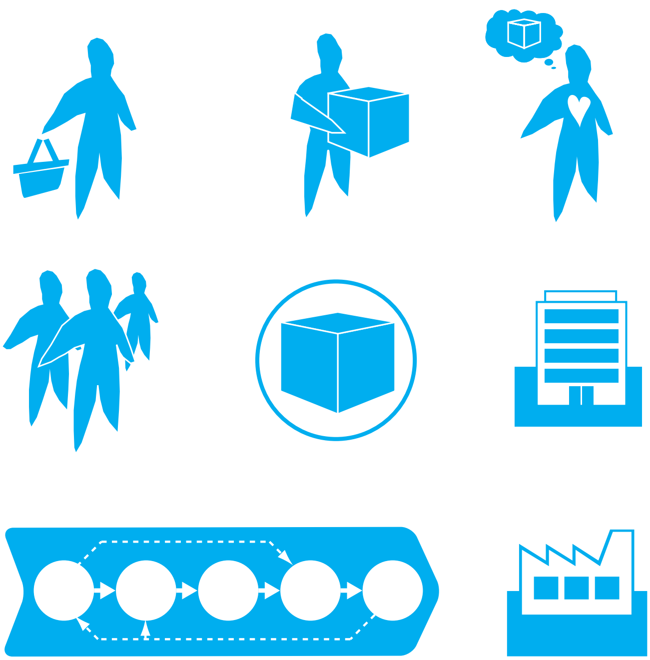
Chapter 3 contains an interview-based case study, set up to explore how usability is dealt with in four sectors adjacent to the electronic consumer products market: high-end automotive, professional printers and copiers, office coffee makers and fast moving consumer goods. This study has a pilot-like character and serves as an opportunity to test and refine the research method.

Chapter four describes an interview-based case study in the electronic consumer products sector at five major international product development groups of personal audio and video, personal navigation devices, mobile phones, home controls and laundry care. This study provides insight into how usability is dealt with by product development groups in the electronic consumer products market. As a result, barriers and enablers for usability in the following main categories are identified: (1) process (2) knowledge, (3) team, (4) project, (5) company and (6) market. In addition, the development is described of an interactive software tool for analysis of the data and communication of the results to the participating companies.

The third and final case study, described in Chapter 5, investigates the development history of three electronic consumer products within one product development group. Based on usability tests and after sales feedback usability issues are identified per product, and subsequently discussed with the product development teams that created the products. This provides a more detailed look at the development process, which results in a detailed description of how the product development group dealt with usability and in two causal models of usability in product development practice. The first model - the usability issue lifecycle model - aims to explain how usability is dealt with throughout the product development process and the second model shows what variables play a role in the generation of shared knowledge on usability issues.

In Chapter 6 the final conclusions of this thesis are drawn. In the discussion section, the conclusions are related to existing literature and the implications of the findings for existing usability theories and methods are discussed. In addition I reflect on the methods used during this research, and provide recommendations for future research. Finally an overview is provided of recommendations for industry - the full version of which are published in a separate card set alongside this thesis - in which I describe how I would organize a company if its goal is to make usable products.

Chapter 2 | Central concepts for framing usability in product development



Chapter 2

Central concepts for framing usability in product development

In the previous chapter it became evident that the usability of electronic consumer products is under pressure, and that there is a need for performing studies on how usability is dealt with in product development practice. As this research takes a practice-oriented, multi-disciplinary approach to studying usability in product development, its scope is considerable, and a large number of concepts may play a role. Therefore, in this chapter the goal is to define the scope of the research by identifying relevant concepts, explore these concepts, and integrate them into a conceptual framework.

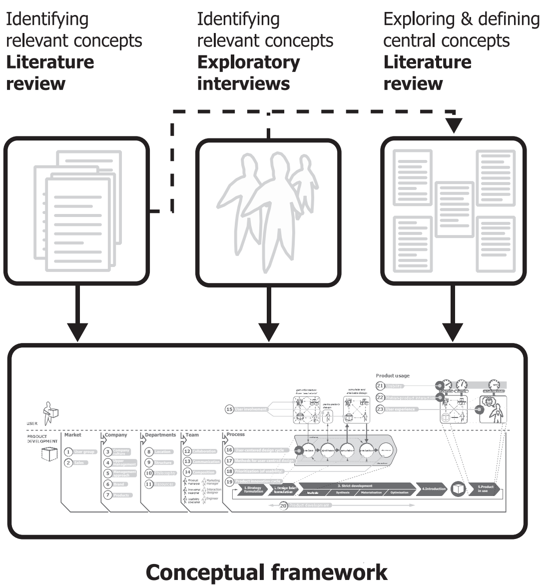


Figure 9: A visualization of the structure of this chapter. Central concepts were identified by reviewing existing research (upper left) and interviewing experts (upper centre). These concepts were studied more in-depth through a literature review (upper right). All three sources were synthesized into a conceptual framework.

The approach followed is visualized in Figure 9. Relevant concepts for framing usability in product development were identified by reviewing existing research and by interviewing experts (paragraph 2.1). Next, a number of the identified central concepts are explored in-depth and defined, namely human-product interaction and user experience, usability, product development (process and team), and methodologies and methods for creating usable products (paragraphs 2.2 to 2.5). Finally, the information from both literature reviews and exploratory interviews are integrated into a conceptual framework for usability in product development, which outlines the main subjects to be studied in the case studies, and how these are related (paragraph 2.6).

2.1 Identifying central concepts

This paragraph describes a review of existing literature on usability in product development practice, and exploratory interviews with experts on usability in practice. Both were used to identify what concepts are relevant when studying usability in product development practice.

2.1.1 Review of existing research on usability in practice

A review of existing studies on usability in product development practice was conducted (the setup of the review is described in Chapter 1, page 12). The literature review led to the identification of the following potentially relevant concepts for studying usability in product development practice:

- User involvement;
- Methods for user involvement (and considerations to apply these methods);
- Product development process;
- Product development team;
- Presence and position of usability specialists;
- Organizational support for usability, and
- Prioritization of usability in projects.

User involvement

User involvement - seeking information (directly) from users to be able to create or evaluate a design - starting in an early stage and continuing all throughout the development process is widely reported to positively influence usability (Rauch and Wilson, 1995; Clegg *et al.*, 1997; Borgholm and Madsen, 1999; Boivie *et al.*, 2003; Gulliksen *et al.*, 2006; Bruno and Dick, 2007). In a large number of studies the degree of user involvement is described as limited (Rauch and Wilson, 1995; Clegg *et al.*, 1997; Vredenburg *et al.*, 2002b; Boivie *et al.*, 2003). In the study by Venturi and Troost (2004) about 50% of the respondents indicated they applied methods for user involvement throughout the process in a 'representative' project (Venturi and Troost, 2004). Conducting user involvement only in a late stage (e.g., a user test of a nearly-finished product) of product development is reported be a barrier for implementing the feedback (Rauch and Wilson, 1995).

Steen (2008: p.163) describes a fundamental issue related to user involvement: product development practitioners tend to represent users and talk about them instead of having them participate directly in discussions and decision making.

Methods for user involvement

What methods for user involvement a company applies is considered to influence the level of usability (Vredenburg *et al.*, 2002b; Boivie *et al.*, 2003; Ji and Yun, 2006). Clegg *et al.* (1997) identify the lack of established methods for user participation as a barrier for user involvement. Besides evaluating designs, establishing an understanding of the user (needs and usage context), is pointed out as an important issue (Bekker, 1995; Clegg *et al.*, 1997; Boivie *et al.*, 2006). Though there is considerable variation in what methods are reported as being applied in practice (Vredenburg *et al.*, 2002b), the most commonly applied methods seem to be user testing methods (Rosenbaum *et al.*, 2000) and usability inspection methods (Bekker, 1995; Rauch and Wilson, 1995; Borgholm and Madsen, 1999; Rosenbaum *et al.*, 2000; Venturi and Troost, 2004).

From the selected studies emerged the following considerations for choosing to apply a particular method for user involvement:

- Required time to execute a method, as time pressure in development projects is often high (Bekker, 1995; Clegg et al., 1997; Rosenbaum et al., 2000; Vredenburg et al., 2002b; Boivie et al., 2003; Boivie et al., 2006; Gulliksen et al., 2006; Ji and Yun, 2006; Bruno and Dick, 2007);
- Required financial costs to execute a method (Bekker, 1995; Rauch and Wilson, 1995; Clegg et al., 1997; Vredenburg et al., 2002b; Ji and Yun, 2006; Bruno and Dick, 2007);
- Required knowledge and experience to apply a method; whether there is staff with the required knowledge and experience (Rauch and Wilson, 1995; Clegg et al., 1997; Ji and Yun, 2006; Bruno and Dick, 2007);
- Required equipment/facilities required for applying a method (Bekker, 1995; Venturi and Troost, 2004);
- Availability of prototypes (in the case of evaluations) (Bekker, 1995; Vredenburg et al., 2002b; Boivie et al., 2006)
- Whether the results will be available in time to be applied within the current project (Rosenbaum et al., 2000; Vredenburg et al., 2002b);
- The information a method produces (Rosenbaum et al., 2000; Vredenburg et al., 2002b). Whether the results require much interpretation and are (thus) perceived as 'objective' or 'subjective' by the audience, and whether the results are actionable and specific (Rosenbaum et al., 2000).
- How the results of the study can be communicated. Whether the study can be observed by the development team (Rosenbaum et al., 2000; Vredenburg et al., 2002b) and how convincing the results are, e.g., due to sample sizes and/or the availability of video images.

Overall, pragmatic considerations, such as required resources and ease of execution, seem to outweigh the effectiveness or suitability of methods for user involvement. This explains the reported low adoption of methods that were ranked high on practical importance but costly, such as field studies, versus the high adoption rate of easy and less costly methods, such as heuristic evaluations (Vredenburg *et al.*, 2002b).

Development process

Whether user involvement methods can be applied is also influenced to a large extent by whether the development process allows for user involvement and an iterative approach throughout the process (Clegg *et al.*, 1997; Boivie *et al.*, 2003; Boivie *et al.*, 2006; Gulliksen *et al.*, 2006; Ji and Yun, 2006; Bruno and Dick, 2007). A second factor to influence whether user involvement occurs is whether a company formally and explicitly includes user involvement (methods) in its development process (Clegg *et al.*, 1997; Boivie *et al.*, 2006), though there is a concern that this may lead to development teams only conducting user involvement because they are required to (Clegg *et al.*, 1997; Boivie *et al.*, 2006). Boivie *et al.* (2003) report that usability benefits from a development process that includes an explicit design phase, an issue that seems somewhat specific to the software development industry where design and implement often coincide (Buxton, 2007, p.72). Finally, in several studies practitioners indicated that working on a complex product and in a complex development project (large team size, long duration) makes it harder to manage the process, design a usable product and to complete the project (Bekker, 1995; Boivie *et al.*, 2003; Gulliksen *et al.*, 2006).

Product development team

Whether and to what extent a product development team features members with user-centred design expertise was widely identified to have an impact on usability (Clegg *et al.*, 1997; Vredenburg *et al.*, 2002b; Boivie *et al.*, 2003; Venturi and Troost, 2004; Gulliksen *et al.*, 2006). Most product developers believe that a multidisciplinary approach is essential for effective user-centred design, as individual disciplines do not have the required expertise to analyse, design, implement and evaluate complex systems (Clegg *et al.*, 1997; Vredenburg *et al.*, 2002b; Boivie *et al.*, 2006; Gulliksen *et al.*, 2006). Additionally, Bekker (1995) and Gulliksen *et al.* (2006) indicate that domain knowledge (knowledge of the product category one is working on) positively influences usability. However, building up this knowledge may take several years (Gulliksen *et al.*, 2006).

Bekker (1995) found that user interface designers wanted support for communicating and discussing their designs or ideas with other team members. In a study by Venturi and Troost (2004) most respondents reported that within their companies they had developed a common terminology, templates and tools for communication between the different disciplines. Bovie *et al.* (2006) pointed out that communication with a development team, and between a team and users is facilitated by having prototypes, sharing offices with users[4], having smaller development teams (or sub-teams). Steen (2008: p.155) pointed out a number of complications due to the multidisciplinarity of human-centred design practice, such as aligning activities, the conducting of 'redundant' of user research activities, and identifying problems based on the collected user research.

---

[4] Boivie et al. conducted their study in IT systems development, in which (highly) customized information systems are developed for a specific client.

Presence and position of usability specialists

Borgholm and Madsen (1999) found that the presence of usability or UCD specialists, and to what extent they are integrated in the development team (i.e., whether they are a part of the team throughout the development process), influences usability. They found that the presence and position of usability specialists in the team depends on the education and background of the usability specialists, whether they are distributed across the organization and project teams or work in centralized departments, and on what methods they apply for user involvement and the communication of user involvement.

Whether a usability specialist can work effectively is also reported to depend on whether usability specialist is a recognized role within the company, whether the team regards her/him as the 'user expert', whether the team can be described as technology or user-centred, on whether the usability specialist has authority within the development team, and whether the usability specialist is able to properly communicate to the rest of the team what her/his plans are (Gulliksen *et al.*, 2006).

Several studies investigated the organizational arrangement of usability specialists, whether they worked in a centralized group or distributed over development teams (Rauch and Wilson, 1995; Borgholm and Madsen, 1999; Vredenburg *et al.*, 2002b). Vredenburg *et al.* (2002b) found that a centralized usability department was a predictor of high perceived effectiveness of the department, while in contrast, Borgholm and Madsen (1999) and Rauch and Wilson (1995) found that usability specialists who worked integrated in development teams were more closely involved in the early stages of product development. Additionally, Rauch and Wilson (1995) found that many companies did not feature a formal usability group or roles to provide UCD-support.

Rauch and Wilson (1995) reported that in many companies, late involvement of involvement of usability specialists product development inhibits their effectiveness. Informal relationships between managers of a usability group and of the product development team are said to influence in what stages of product development UCD-specialists are involved (Borgholm and Madsen, 1999).

Organizational support for usability

In existing research awareness of and support for usability within an organization is reported as a very important factor to influence whether a company can effectively conduct user-centred design (Bekker, 1995; Rauch and Wilson, 1995; Rosenbaum *et al.*, 2000; Venturi and Troost, 2004; Boivie *et al.*, 2006). Support for usability can manifest itself on different levels. First of all there is the question of whether usability is part of a company culture; whether the attitude in a company is best described as technology, marketing or user-driven. Secondly there is the attitude of individual development team members towards usability (Bekker, 1995; Boivie *et al.*, 2003; Boivie *et al.*, 2006; Bruno and Dick, 2007). Finally, a very important issue is whether upper management sees the value of usability and user-centred design, and prioritizes and supports it (Bekker, 1995; Rauch and Wilson, 1995; Venturi and Troost, 2004; Boivie *et al.*, 2006).

Product development practitioners often consider usability an ungraspable, fuzzy concept (Clegg *et al.*, 1997; Gulliksen *et al.*, 2006), and in order to create support for usability among colleagues, 'educating other disciplines' about what usability and user-centred design is and explaining the value of usability, is a common strategy (Clegg *et al.*, 1997; Borgholm and Madsen, 1999; Rosenbaum *et al.*, 2000; Venturi and Troost, 2004; Gulliksen *et al.*, 2006; Bruno and Dick, 2007), even though this is considered a less effective strategy by some (Rosenbaum *et al.*, 2000). It is argued that in order to 'sell' usability, usability specialists should learn to communicate the value of usability to their peers, in particular development engineers and upper management, in the language of the audience (Rosenbaum *et al.*, 2000; Gulliksen *et al.*, 2006). Other reported approaches to improve support for usability is to distribute findings of usability activities throughout organizations (Rauch and Wilson, 1995; Rosenbaum *et al.*, 2000), the development and application of practical methods and tools to improve human-computer interface design (Clegg *et al.*, 1997), usability specialists being involved in high profile projects (Rosenbaum *et al.*, 2000), and communicating success stories and reference cases about the impact of usability efforts (Boivie *et al.*, 2006).

Upper management supporting and understanding usability and user-centred design is mentioned in a large number of publications as an essential factor, both for creating a user-centred company culture as well as for creating the appropriate infrastructure in a company for conducting user-centred design (Clegg *et al.*, 1997; Borgholm and Madsen, 1999; Rosenbaum *et al.*, 2000; Vredenburg *et al.*, 2002b; Venturi and Troost, 2004; Gulliksen *et al.*, 2006; Ji and Yun, 2006). From many studies the image arises that usability is not yet what Borgholm and Madsen (1999) refer to as 'established': many usability specialists still had to convince upper management of the added value of their work. Clegg *et al.* (1997) offer the suggestion that (project) managers may shy away from user involvement out of fear to expose weaknesses of their project.

In addition to support from upper management, reasons for a company to engage in user-centred design are to increase customer satisfaction and an anticipated positive effect on sales/profits, and anticipated savings in development time and costs (Ji and Yun, 2006).

Prioritization of usability in projects

Boivie *et al.* (2003) point out that during product development a very large number of decisions has to be taken, and that it matters significantly whether the user perspective is taken into account when making the necessary compromises. However, in development projects, usability is just one of many considerations contending for priority (Boivie *et al.*, 2006) and because usability is a complex, less-tangible concept and its future advantages seem uncertain, development teams are more likely compromise usability than concrete, measurable goals such as deadlines and deliverables (Gulliksen *et al.*, 2006). Gulliksen *et al.* (2006) point out that for usability to be prioritized in a project, support from the project manager is crucial.

Even though setting goals for the level of usability is identified by many practitioners as facilitating usability (Clegg *et al.*, 1997; Bruno and Dick, 2007), most authors found that the level of usability was not included in the project goals nor being monitored (Rauch and Wilson, 1995; Vredenburg *et al.*, 2002b; Venturi and Troost, 2004; Gulliksen *et al.*, 2006). Gulliksen *et al.* (2006) suggest that this is due to the perceived fuzziness of the concept of usability.

2.1.2 Exploratory interviews with experts on usability in practice

In parallel to the literature review described in the previous subparagraph, I conducted exploratory interviews with experts on usability in practice from academia and industry. The goal of the interviews was to get insight to what concepts are relevant to include when studying usability in product development practice.

Setup

The interviews had an open and exploratory character. The interviewees were asked about their views on the biggest obstacles and stimulants for usability in practice. The interviews took 1,5 to 2 hours and were captured by taking notes during the sessions. Following the interviews a write-up was made. The interviewees had the following profiles:

- Founding partner of a human-centred design consultancy;
- Senior handset manager at a major telecommunications provider;
- User experience architect at an internal consultancy of a company that developed professional and electronic consumer products, and
- Academic researcher on the topic of ergonomics and business administration.

Results

An analysis of the interviewee comments resulted in an extensive overview of obstacles and stimulants for usability during product development, which then were clustered into relevant concepts for usability in product development (Table 1).

2.1.3 Selected concepts

The concepts identified through the literature review and exploratory interviews (Table 2) suggest that research of usability in practice should go beyond just studying the usability department and its activities. The product development organization as well as the process should be investigated, as contextual, management and organizational issues are reported to influence a company's ability to conduct user-centred product development. From Table 2 it becomes evident that the exploratory interviews produced more concepts with regard to the product development context (i.e., company and department organization, product portfolio, market) than the literature review.

Table 1: Relevant concepts for studying usability in product development practice, identified through exploratory interviews with experts on usability in practice.

Concept	Covers:
Product development process	• Structure of the product development process. • Whether the development process facilitates the execution of user involvement and implementation of the outcome of these activities. • Whether the product development process includes systematic evaluation of the properties of products under development. • Whether project goals include statements about usability.
User involvement	• When and to what extent input from users is sought during product development. • To what extent the execution of methods for user-centred design is formalized.
Methods for user involvem.	• The portfolio user-centred design methods that the company applies. • How development teams select the appropriate method.
Product development team	• The disciplines that make up the product development team, and the background (experience and education) of the individuals fulfilling these roles. • Whether the actors work in integrated teams. • The team members' understanding of and attitudes towards usability.
Company structure and organization	• Type of organization (e.g., by product category, discipline, matrix organization). • Whether and to what extent individual departments cooperate. • Whether a specific department is (or feels) responsible for contact with users. • Whether product development is conducted in-house or outsourced.
Company culture	• Decision-making style (e.g., gut feeling versus evidence-based). • To what extent there is a focus on quality management and formal processes. • Whether usability is a part of a company's 'DNA': whether all team members know what usability is, believe it is important, and act accordingly.
Management approach	• To what extent upper management is committed to usability. • To what extent usability is part of the planning and control cycle of the company (e.g., whether usability-related dimensions are performance indicators). • How management defines success (financial, customer satisfaction, sales).
Usability department	• How mature or 'established' the usability department is. • Whether the usability department is in-house, an internal consultant (brought in per project on a contract basis) or an external consultant. • Whether usability specialists work in project teams or in the usability department (centralized versus decentralized). • The way the usability department looks upon usability; whether its primary concern is, e.g., scientific rigor, developing guidelines, or the uniqueness of each new product. • The background (education and experience) of the usability specialists.
Product portfolio	• The type of products a company sells (e.g., consumer electronics, bathroom furniture, office equipment). • The amount of products and diversity of products in a company's product portfolio. • Whether a company's products are evolutionary or revolutionary.
Market	• The target group in terms of demographics (and the variation thereof), business-to-business or business-to-consumer, end-users or purchasers. • Whether the target group considers usability important during purchase • Whether the company has a brand image that may cause consumers to have expectations with regard to usability.

Table 2: Comparison of similarities and differences in the relevant concepts identified through the literature review and exploratory interviews.

	Product development process	User involvement	Methods for user involvement	Product development team	Company structure & organization	Position of usability specialists / usability department	Organizational support for usability / company culture	Management approach	Prioritization of usability in projects	Product portfolio	Market
Literature review	•	•	•	•		•	•		•		
Exploratory interviews	•	•	•	•	•	•	•	•		•	•

In the following paragraphs a number of these concepts will be explored in-depth. Usability is a construct originally developed to evaluate human-computer interaction and how people experience this. Therefore the first central concepts to be explored are human-product interaction and user experience (paragraph 2.2). Paragraph 2.3 discusses definitions of usability and their implications, experienced and expected usability, and the potential consequences of usability. Also attention is paid to ways of evaluating products that go 'beyond usability'. Finally, a working definition for usability as applied in this thesis is provided.

It is also explored how products are created. The focus of the case studies (Chapter 3 to 5) will be on the product development process and the team that executes it. Therefore paragraph 2.4 investigates relevant properties of the product development process and of working in multidisciplinary teams. Next, paragraph 2.5 outlines methodologies for creating usable products (like user-centred design and usability engineering) and provides an overview of methods for user-centred design.

2.2 Human-product interaction and user experience

In the ISO standard 9241-11 usability is defined as the efficiency and effectiveness of human-product interaction, and how satisfied people are about (using) the product (ISO, 1998). Because usability is a construct meant to evaluate human-product interaction, I first take a look at what constitutes human-product interaction. To begin with the different 'roles' are examined that humans have in the purchase and usage of products, namely being consumers, buyers, and users. Secondly, an overview is provided of the principal components of human-product interaction and what properties of these components can influence human-product interaction.

Clients, consumers, buyers, and users

The focus of this thesis is on electronic consumer products, in which the word 'consumer' is primarily present to set it apart from professional electronics, such as office copiers and medical equipment. Professional electronics are sold in business-to-business markets, where one organisation sells products to another organisation whereas consumer products are sold in a business-to-consumer market, in which organisations (companies) sell to individuals (Figure 10).

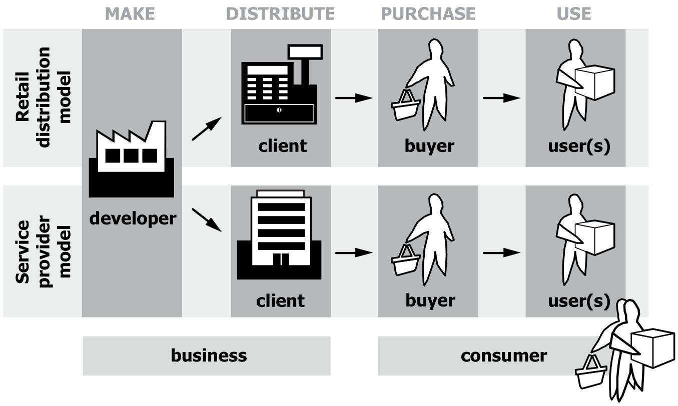


Figure 10: A representation of how product development companies distribute their products to consumers. The left side represents a business-to-business market, in which product developers sell to their clients, which in the electronic consumer products sector is usually a retailer (upper part) or a service provider (lower part). Consumers buy their products from retailers (e.g., for an MP3-player), or they have a contract with a service provider who supplies them with the product in order to provide them access to the service (e.g., cable decoder or mobile phones). A distinction is made between buyers (who buy a product) and users (who interact with a product).

A person who buys a product is not necessarily the person that uses the product. For example, a TV set may be purchased by one member of the family, but used by the entire family. Secondly, there are indications that people set very different priorities when purchasing a product than when using it (Rust *et al.*, 2006; van Kuijk *et al.*, 2009). The distinction between who buys and who uses the product is an important one to make in this thesis. Following Howard (1994, p.1), I define the consumer as a person (not an organisation) who buys and consumes a product or a service[5], while a *buyer* is a person that *buys* a product or service from an organisation. The user is a person who interacts with a product with the aim of attaining a certain goal. This can be the end-user, but also, for example, service engineers.

2.2.1 Framework for human-system interaction

The ISO 20282 standard on usability of everyday products (ISO, 2007a) describes interaction as bi-directional information exchange between users and equipment, in which information exchange may include physical actions, resulting in sensory feedback. Hekkert and Desmet (2007) distinguish three types of human-product interaction: (1) instrumental interaction, such as using, operating and managing products, (2) non-instrumental interaction, which does not have the purpose of operating a product, such as playing with or caressing a product, and (3) non-physical interaction, which refers to only fantasising about, remembering, or anticipating usage[6]. In this thesis the focus is on instrumental interaction, in which people engage with products because they have a goal.

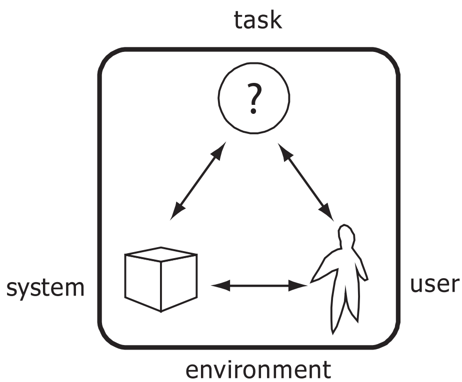


Figure 11: Shackel's (1984) principal components of a human-machine system

Though human-product interaction can be described from different perspectives, such as information processing, ecological psychology and activity theory, which all have a different take on how human-product interaction takes place (Rooden, 2001, p.9). However, all theories do contain what Shackel (1984, p.54) calls the principal components of a system situation: the user, her/his task, the tool s/he uses and the environment in which the interaction takes place, see Figure 11. In the next sections Shackel's principal components of a human-machine system are used as a basis to discuss variables that constitute human-product interaction.

The user

The user is the person who is at that time operating the system (Shackel, 1984). It should be taken into account that the characteristics of users can vary greatly from one person to the next; there is no such thing as *the* user. For example, for a coffee vending machine the

---

5 The original edition of Howard's book was called 'Consumer behavior in marketing strategy', which was changed to 'Buyer behavior in marketing strategy' in following editions.

6 Note that instrumental and non-instrumental interaction both include non-physical (cognitive, sensorial) aspects, but are not exclusively non-phyiscal.

users are the ‘end-users’ (who buy coffee), service-people (who refill the coffee), and maintenance staff (who install and maintain the product) (Nielsen, 1992b). All ‘types’ of users – with all the variation within and between them – make up the user group. I use the term user group here as complementary to ‘target group’. Whereas the user group is the aggregation of people that that use the product, the target group is whom a company is primarily aiming its marketing and sales efforts at.

The characteristics of the user (group) influence how the human-product interaction will take place. Physical, cognitive and sensory capabilities (Rooden, 2001) play a role, though Kanis (1998) points out that people’s *capabilities,* the characteristics of the individual, may only be loosely related to the user *activities* (what the user actually does during usage). For example, a person’s hand size can be a poor predictor for how this person will turn a button. The influence of user characteristics can be moderated by the user’s ‘current state’ (Rooden and Kanis, 2000), for example, tiredness, mood, and motivation to use the product (Shackel, 1984, p.59), but also his/her physical condition (clammy hands, feeling cold). Also the user’s attitude towards the product can influence how the user approaches the product (Shackel, 1984, p.58).

Users have expectations about how a product works and should be operated (Norman, 2002, p16; Standaert, 2004, p.160), which are (among others) influenced by the extent to which the user has experience with similar products or with different products from which experiences can be ‘transferred’ (Standaert, 2004, p.133). The experience a user has with a particular type of product is referred to as his/her ‘expertise’ (Doane *et al.*, 1990; Sauer *et al.*, 2000; Ziefle, 2002).

The tool: electronic consumer products

In Shackel’s framework, the tool is what the user applies to achieve a task. In Shackel’s case the tool is a system or visual display terminal, however in this thesis the focus lies on electronic consumer products. A product is a material system, made by people for the purpose of its properties, which allow the product to fulfil a function, which in turn fulfils a need (Roozenburg and Eekels, 1991, p.52).

I define electronic consumer products as products that are purchased by consumers for personal use (as opposed to business-to-business), with a physical presence (as opposed to software), and that feature a certain amount of integrated information technology that enables them to interact with the user (as opposed to, e.g., chairs and vases). Examples are mobile phones, MP3-players and microwaves. Electronic consumer products generally consist of a similar set of components. The system as a whole consists of (1) the core product: the product that the user primarily interacts with (2) the extended product: those parts that facilitate the use of the core product and finally (3) the ecosystem (Buxton, 2007, p.50): the system of symbiotic products, software, services and content that allows the core product to function (Figure 12).

The goals that a product can help the user achieve, such as cleaning clothes or playing music, are referred to as its functionality or utility (Shackel, 1984, p.54; Grudin, 1992).

Though often used interchangeably, functions and features are not the same. Features are the identifiable aspects of a total product offering that a critical reference group perceives and evaluates as an 'extra' to a known standard among comparable products (Thölke *et al.*, 2001). In practice though, what is featured about a product often are its functions (e.g., 'sleep timer', 'high-speed dubbing', 'shuffle').

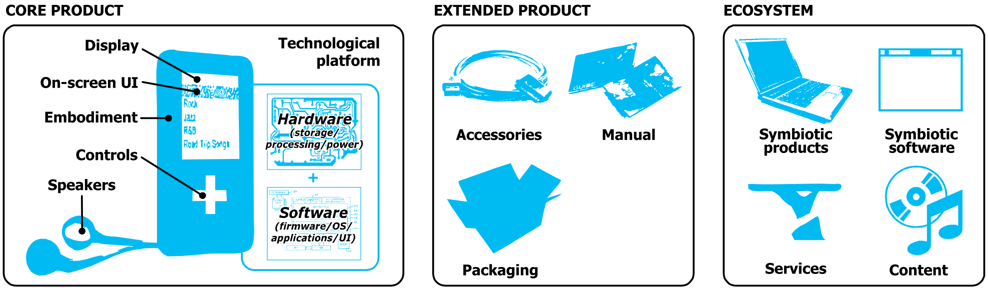


Figure 12: Visualization of the primary components of electronic consumer products, clustered by the core product, extended product and its ecosystem.

The user interface consists of those elements of a product used to control it and receive information about its status and the interaction. The part of the product that enables the user to use it for its intended purpose (ISO, 2007a). The user interface allows the user to provide the product with 'input', from which the product derives what actions to take or information to process, or that the product processes as content (for example in the case a user talking to another user on a mobile phone). In addition, the product can generate 'output', which can be feedback (how the product conveys its current state, a required user action, etc) or content (a letter, music, etc). The embodiment of a product may also be considered a part of the user interface, as users may also attribute a certain meaning to the appearance of the product, for example what product category it falls into and how it (thus) should be operated (Boess and Kanis, 2008), and because the embodiment influences how the product can be interacted with physically and the physical (dis)comfort users experience (Vink, 2005)

Goal and task

Shackel defines the task as what a user is trying to accomplish, which is a "*very complex combinatorial iterations of a basic sequence: input-decision-output*", which can range from a total job, down to the smallest detailed subtask (Shackel, 1984, p.63). The ISO 9241-11 definition of usability distinguishes between goals and tasks: a goal refers to the intended outcome and a task is an activity required to reach the goal (ISO, 1998).

The ISO 20282 definition of usability for everyday products adds the concept of 'main goals': the most frequent or important outcome(s) that all or a large majority of users want to achieve when using a product (ISO, 2007a). Norman (2005) suggests that the process of reaching higher-level goals can be labelled as 'activities': a coordinated, integrated set of reaching tasks (sub-goals). To listen to music a user has to, for example, (1) acquire MP3 files, (2) connect the MP3-player to a computer, (3) transfer files to the MP3-player, (4) switch on the MP3 player, (5) select the file to play, (6) possibly connect the headphones, and then (7) play the selected file (see Table 3).

Hassenzahl (2003) suggests that in some cases the goal of interacting with a product is the activity itself. In his view, goal-mode is for productivity (the user wants to achieve an end result), while action-mode (the user wants to be engaged in an activity) is for fun. In comparison to professionals, consumers have been argued to have a less clear picture of what they want to accomplish with a product; their goals can be quite vague, explorative and creative (Kaikkonen *et al.*, 2005).

In this thesis I apply the notion that each goal can be divided into sub-goals (Table 3). Sub-goals are achievements that the user does not wish to reach in itself, but that are necessary intermediary steps required to reach the goal. The process of reaching a goal is referred to as an activity, while reaching a sub-goal is called a task.

Table 3: Hierarchy of activities, tasks and subtasks, leading to goals and sub-goals.

Process	**Achievement**	**Example**
Activity	Goal	• Listening to music on the go
Task *Sub-task*	Sub-goal Sub-sub-goal etc....	• Acquiring mp3-files • Transferring music to an mp3-player • Connecting mp-3 player to computer • Transferring music files • Disconnecting mp3-player • Switching mp3-player on • Put earplugs in ears • Playing the desired song

Environment

The environment is the physical, psychological and social context in which interaction takes place (Shackel, 1984; Rooden and Kanis, 2000). Physical aspects include the layout and spatial attributes of the environment in which the product is used, but also environmental factors such as lighting conditions, noise, and temperature. Psychological and social aspects include the presence of other people, the social context (e.g., work versus relaxing), but also societal attitudes. Kanis and Rooden (2000) point out the output or side effects of the product change the environment, which in turn influence the user, but also other people that are present in the environment (e.g., someone hearing the music of an mp3-player another person is listening to).

BOX TEXT

The ambiguity of simplicity

The terms simplicity and complexity have been used to signify various product properties as well as the consumer's perception of those: the amount of functions a product offers, how hard it may be to use it, but also the amount of components and to what extent these are intertwined. Below I explore what meanings are associated with simplicity and propose a working definition for use in this paper.

Rogers (1995) defines complexity as the degree to which an innovation is perceived as relatively difficult to understand and use, which in the Human-Computer Interaction (HCI) domain would be described as expected usability (Keinonen, 1997; van Kuijk *et al.*, 2009). In 2005 Philips presented its new slogan 'Sense and Simplicity' in which 'Sense' refers to products that offer something consumers want, and 'Simplicity' to products that are "*easy to experience*" (Philips, 2005). Maeda (2006) explored the notion of simplicity from varying angles: visual clarity, ease of use and basic functionality. Furthermore, simplicity (or complexity) has been used to refer to user interface structure (Ziefle, 2002) and to the degree of sophistication of the technological platform (De Visser, 2008). Though Maeda (2006) argues that simplicity is to be desired over complexity, Norman (2007a; 2008) pointed out buyers might prefer products with extensive functionality, and that simplicity is not synonymous with usability.

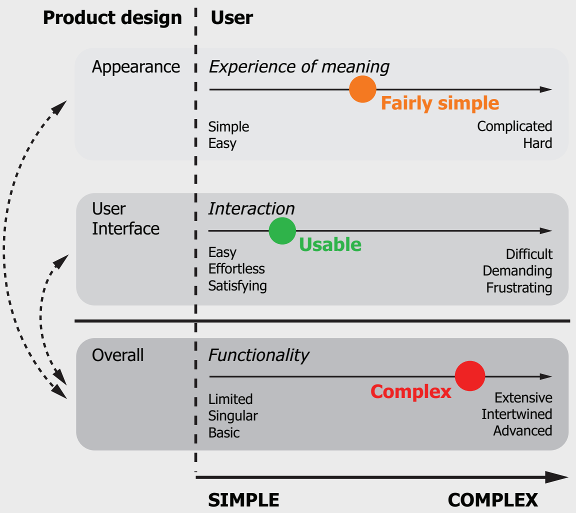


Figure 13 The simplicity-complexity diagram. Product characteristics (left) are interpreted by the user when s/he observes or interacts with them (right). Based on its functionality (bottom) a product may be classified as complex, but when mediated by design advanced functionality does not need to result in a complex interaction (middle) and experienced meaning (top).

Instead of considering simplicity (or complexity) a product property, it can also be viewed as a dimension that manifests itself when the user observes or interacts with the product, see Figure 13. The desired functionality of a product (lower right) results in an overall product design (lower left), a spatial and physical-chemical arrangement for the product and all of its parts (Roozenburg and Eekels, 1991: p.52). Based on the functionality that a product offers, people may classify the product as simple or complex; for example a 'basic phone' versus a 'smart phone'. The design of the user interface (middle, left) (ISO, 2006: p.4) strongly but not exclusively influences how the user experiences interacting with the product, e.g., 'usable' or 'complicated' (Bevan and Macleod, 1994; Tractinsky *et al.*, 2000; van Kuijk *et al.*, 2009). Product appearance (upper left) influences the meaning the user attributes to the product (Hekkert and Desmet, 2007), the expectations with regard to a product's usability (Keinonen, 1997; Creusen and Schoormans, 2005; van Kuijk *et al.*, 2009), and how it should be interacted with (Boess and Kanis, 2008). Also a relation has been shown to exist between product appearance and how the interaction is experienced (Tractinsky *et al.*, 2000).

When looking at it this way, simplicity on the level of functionality would mean a product that offers a limited amount of functions, whereas simplicity on the level of interaction is usability, the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO, 1998, p.2). Finally, simplicity on the level of experience of meaning implies that a product is perceived as a having a simple spatial arrangement or is expected to be easy to use.

Limited functionality is likely to lead to a more straightforward interaction, of which the Muji CD-player designed by IDEO may considered an example. However, when mediated by design (den Buurman, 1997; Norman, 2007b) it is possible to create products with extensive functionality but with an interaction that is experienced as simple (usable); an often touted example of this is the Apple iPhone (Mossberg and Boehret, 2007).

2.2.2 Human-product interaction for electronic consumer products

The framework for human-machine system interaction (Figure 11) was developed with 'visual display terminals' (computer workstations) in mind. To fit the domain of electronic consumer products I modified the framework to reflect that today's products are often product-service combinations, function in networks with other products, and that – more often than not – other people (not the user) will be involved in or affected by their usage. In the resulting framework for human-product interaction for electronic consumer products (Figure 14), 'system' became 'product-service combination' because many electronic consumer products are combined with a service that influences the product significantly., and the following elements were added:

- 'Other people', because other people can be affected by the usage of a product, or a user can use a product to communicate with other users. In Shackel's model 'other people' were a part of the environment or social context.

- 'Symbiotic products', to stress that electronic consumer products increasingly function in networks with other products.

In personal use people do not get tasks, but define their own goals. Therefore the task or goal, which was a part of Shackel's original framework, is not included in the new framework as a separate element, but considered to be a property of the user.

Usage and interaction

An important distinction to make is between usage (or use) and interaction. For the purposes of this thesis usage is defined as applying a product in order to reach a goal, while interaction is bi-directional information exchange between users and equipment (ISO, 2007a). Besides the 'using' phase the product usage cycle (see Figure 15) includes other phases that are required and/or relevant for usage. Before someone actually owns a product s/he can be exposed to advertisements, other people's opinions, visual representations of the product, other people using the product, or the product itself (exposure only, no interaction). Next, possibly, the product is acquired (most likely through a purchase situation) and has to be set up properly. In all phases, except during 'exposure', interaction can occur. The focus in this thesis lies on the setup, usage, and maintenance phases. In the 'using' phase three alternating states are distinguished (See Figure 15): 'interaction' (e.g., choosing a TV channel, putting flowers in a vase, 'exposure' (e.g., watching TV, seeing a vase) and 'system only' (e.g., hard disk recorder recording a TV program, the vase holding water and flowers).

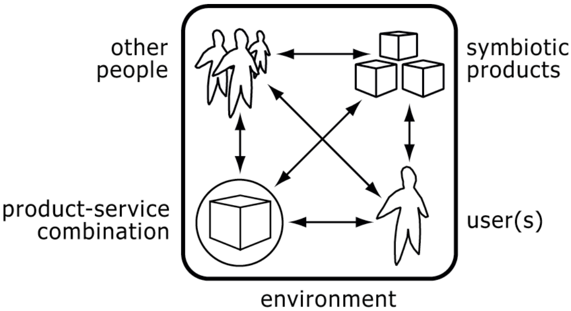


Figure 14: Framework for human-computer interaction for electronic consumer products, featuring the product as a product-service combination, and including 'symbiotic products' and 'other people'.

Human-product interaction is dynamic

The properties of the components of human-product interaction can vary considerably, and as a consequence human-product interaction is not something static (Shackel, 1984); large intra and inter- individual variation in user activities can occur when people interact with the same product (Weegels, 1996; Kanis, 1998). An important factor to influence intra-individual variation in human-product interaction is that in the different stages of the product usage cycle (e.g., setup, first use, extended use, servicing) (Roozenburg and Eekels, 1991, p.136; Jordan, 1994; Bouwmeester and Bosma, 2006)) a user's goals may vary.

The environment, and this is especially the case for portable electronic consumer products such as mobile phones, may vary strongly in terms of for example lighting conditions, but also social contexts (a ringtone that is great when cycling outdoors might not be appropriate during an office meeting). Brouwer-van der Bijl and Van der Voort (2009) use the term 'dynamic use situations' to describe situations in which a product is used by various people, with varying goals in varying contexts of use.

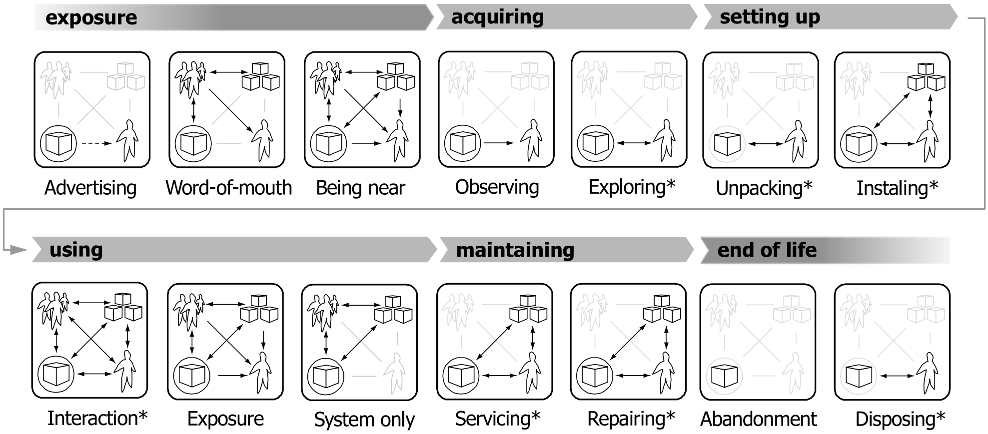


Figure 15: The product usage cycle: an illustration of how human-product interaction can vary per phase. In the diagram the states that include interaction (bi-directional information exchange (ISO, 2007a)) takes place are marked with an asterisk.

2.2.3 User experience

The term 'user experience' has been widely used to describe what using a product 'does' to the user. It is often been billed as the 'next step beyond usability'; products should be usable, but they should also appeal to people's sense of aesthetics, provide pleasure, etc… Secondly, usability has been argued to include both user performance (effectiveness and efficiency) and user perceived quality of use (satisfaction about use) (Bevan and Macleod, 1994), the latter of which seems strongly related to user experience. Therefore, in the following section I will discuss a number of definitions of (user) experience and their implications.

Definitions

Forlizzi and Battarbee (2004, p.263) describe experience as: "*the constant stream of 'self-talk' that happens while we are conscious. Experience is how we constantly assess our goals relative to the people, products, and environments that surround us at any given time*." The draft ISO standard 9241-210 on human-centred design for interactive systems defines user experience as "*a person's perceptions and responses that result from the use or anticipated use of a product, system or service*" (ISO, 2008). Finally, Hekkert and Desmet (2007, p.58) use the term 'product experience' to refer to all possible affective experiences involved in human-product interaction, in which the term affect refers to "*all types of subjective experiences that are valenced, that is, experiences that involve a perceived goodness or badness, pleasantness or unpleasantness*". As Hekkert and Desmet consider anticipated usage a form of human-product interaction (see page 30), an implication of their definition is that a product can be experienced when the user is not (yet) interacting with it, which is opposed by the ISO definition, which considers user experience a consequence of interaction.

Implications

As Hekkert and Desmet (2007) point out, part of the user experience is an evaluation of the human-product interaction, which makes it related to the notion of satisfaction: whether a product lives up the expectations that people have about a product (Matzler *et al.*, 1996; Reichheld, 2003). This implies that user experience can be influenced by factors that are not a part of human-product interaction as expectations can be influenced by advertising, word-of mouth or product appearance (Wood and Moreau, 2006; Karapanos *et al.*, 2009). However, as someone is at that time not yet actually using the product, it seems somewhat inappropriate to label experiences as a consequence of exposure as *user* experience.

As the user experience is a resultant of the properties of the user, product, and context in which the interaction takes place (Forlizzi and Ford, 2000), user experience is dynamic and context-dependent. Finally, as the user experience is an individual's perception of the interaction, it is personal; it can differ from one person to the next how an interaction is experienced (Karapanos *et al.*, 2009; Law *et al.*, 2009).

Working defintion

I consider user experience to be an experience that arises as a consequence of instrumental human-product interaction. However, based on the preceding distinction between exposure, usage and interaction (see Figure 15) it should be noted that prior to usage exposure to a product can already cause an experience (e.g., seeing the product or seeing someone use the product), which can cause the prospective user to have expectations about how the product should be used and how the experience of interacting with the product will be.

Modifying Forlizzi's and Battarbee's definition (2004, p.263) the working definition of user experience for this thesis reads: "The constant stream of 'self-talk' that happens as a consequence of being exposed, applying and interacting with products; how we constantly assess our goals relative to the products we observe and use."

Given the definitions above it can be argued that, contrary to the often-held position, user experience should not be considered the 'next step, beyond usability', but refers to how people interpret human-product interaction. If human-product interaction refers to 'what happens' the user-experience is how someone feels about this, as visualized in Figure 16.

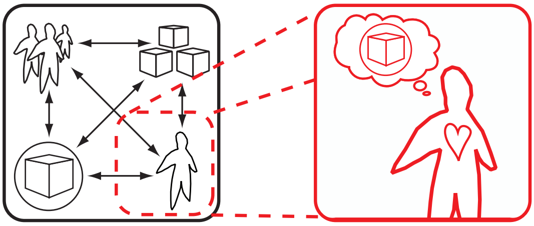


Figure 16: Visualization of the relation between human-product interaction (black, left) and the user experience (right, red). The user experience is the user's affective response to the interaction, which can iteratively influence the interaction.

As a user's current state can influence human-product interaction (Rooden and Kanis, 2000), and how a user experiences the interaction can be said to influence his/her current state, it can be argued that the user experience is not just a result of human-product interaction, but has an iterative relationship with it (see Figure 16). For example, if a user experiences setting up a product as surprisingly easy, his/her expectations may different for the remainder of the interaction than they were when s/he started interacting with the product.

2.3 Usability

In this paragraph the concept of usability is discussed as well as its potential manifestations and effects.

2.3.1 Defining usability

In this section first a number of definitions of usability are reviewed, and it is discussed why some authors have argued to broaden the definition. Subsequently it is explored how usability should be defined in the context of electronic consumer products, and the concepts of experienced and expected usability are introduced. Finally a working definition for usability in this thesis is provided.

Intrinsic and pay-off measures

Usability is a construct to evaluate the 'ease of use' of a product. It can be viewed from a number of perspectives (Bevan *et al.*, 1991). A first distinction to be made is between evaluating the usability of a product by assessing product features or by assessing the outcome of the interaction. Gray and Salzman (1998) call this the 'intrinsic measures' and 'pay-off measures' of usability. They cite Scriven (1977), who illustrates this distinction by referring to the evaluation of an axe:

> *If you want to evaluate a tool … say an axe, you might study the design of the bit, the weight distribution, the steel alloy used, the grade of hickory in the handle, etc., or you*

might just study the kind and speed of the cuts it makes in the hands of a good axe man.

To assess the usability of a product it is most common to evaluate the outcome of the interaction, to which end one would need measures.

Three definitions of usability

Three authors who have contributed to the operationalisation of the concept of usability - Brian Shackel, Jakob Nielsen and the ISO organisation - are discussed below.

Shackel

Shackel was one of the first to fully discuss and define the concept of usability (Keinonen, 1998; Maguire, 2001). At the time (mid 80s) 'ease of use' and 'user friendly' were popular terms, but undefined and unoperationalised (Bevan *et al.*, 1991). Shackel conceptually defined usability as the "*the capability to be used by humans easily and effectively*" (Shackel, 1984, p.54). But he felt that in order to evaluate ease of use, one should be able to evaluate it on particular dimensions, be it quantitative or qualitative. Shackel proposed an operational definition including the dimensions effectiveness, learnability, flexibility and attitude (Shackel, 1991). Effectiveness refers to the performance of users with a task, learnability to how fast performance improves, flexibility to whether the product can only be used for a narrowly defined task or whether it can also be applied for other tasks, and finally attitude, which Shackel defined as the levels of human cost in terms of tiredness, discomfort, frustration and personal effort.

Nielsen

Nielsen (1994) refers to Grudin (1992) for a conceptual definition of usability: usability is how well users can use the functionality of a product. Based on this he provides an operational definition consisting of five dimensions of usability: learnability, efficiency of use, memorability, few and non-catastrophic errors, and subjective satisfaction.

The ISO organization

The ISO 9241-11 standard defines usability as "*the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*" (ISO, 1998, p.2). In this definition effectiveness refers to the "*accuracy and completeness with which users achieve specified goals*", efficiency to "*resources expended in relation to the accuracy towards the use of the product*", and satisfaction to "*freedom from discomfort, and positive attitudes towards the use of the product.*" Context of use is defined by the "*users, tasks, equipment (hardware, software, and materials), and the physical and social environments in which a product is used.*" The ISO 9241-11 definition is considered the most widely accepted definition of usability (Jordan, 1998b; Jokela *et al.*, 2003).

When comparing the ISO definition to the one by Shackel it becomes apparent that the ISO definition adheres to the important notion that usability is context-dependent that Shackel proposed. Learnability and memorability, dimensions used by Shackel and Nielsen, are excluded from the definition, which seems logical as these concepts can be considered a resultant of the usability over time, and are therefore not part of the definition itself. Jordan stresses that in different phases of product use (Figure 15), different 'types' of usability can be important, e.g., learning speed or maximum performance (Jordan, 1994; Jordan, 1998b).

The ISO definition presents a framework for setting up an evaluation of the usability of a product, but essential in this process is on which aspects of the framework one places the most weight (effectiveness, efficiency, satisfaction), what measures one chooses, and for which of the phases of product use one wants to evaluate the usability (Bevan and Macleod, 1994). For each specific case the evaluator should assign appropriate measurements to the dimensions of the definition.

Implications

All definitions above include the notion that usability includes both user performance and user experience dimensions, but differ on whether the functionality a product offers influences its usability.

Both user performance and user experience

Definitions by all three authors include what Shackel (1984, p.53) calls "*subjective assessments of ease of use*" as well as "*objective performance measures*", which Bevan (1991) refers to as the user-oriented view and the user-performance view. Studies have shown that objective (user) performance measures and subjective assessments of ease of use are not necessarily related to each other (Frøkjær *et al.*, 2000; Hornbaek and Law, 2007). Because satisfaction is influenced by expectations (Lindgaard and Dudek, 2003) it could be the case that a mediocre level of effectiveness and efficiency is completely satisfying to a person who has had previous experiences with particularly unusable products, whereas the same level of efficiency and effectiveness is completely unacceptable to a person who is used to a (much) higher standard. One could say that two of the dimensions of usability (effectiveness and efficiency) relate to human-product interaction, whereas satisfaction about use is about how users experience that interaction (Figure 17).

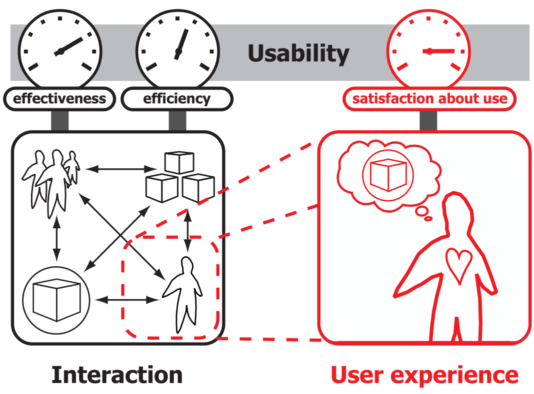


Figure 17: The relation between human-product interaction, user experience and the ISO definition of usability. Two out of three dimensions of usability (effectiveness and efficiency) relate to human-product interaction. The third (satisfaction) is about how users experience that interaction (user experience).

Usability and functionality

While Shackel and Nielsen conceptually define usability as to what extent users can apply the functionality the product has to offer, the ISO 9241-11 definition describes usability as to what extent the user can apply the product to reach the goals s/he has in mind. This implies that according to the ISO definition, when evaluating usability one should take into account whether the product is offering the right functionality.

For example if an in-car CD-player does not offer a fast-forward button, the usability of the remaining functions may be fine, but the usability of the product, for the goal of listening to music is compromised. Another example is the usability of E-books versus the usability of conventional books, as illustrated by this quote of a director of a chain of bookstores in The Netherlands.

> *"Electronic books are sort of convenient. Especially if you're going on a trip. We're selling these things ourselves and it's starting to generate a considerable turnover. (....) The real book can never be beat because of its superior usability. It's so often that you just want to go back a few pages, to reread what a character said. Try doing that with an E-book" (Haighton, 2009).*

For the goal of quickly looking up a page and scanning the content conventional books can be considered more efficient, whereas for the goal of being able to read during your whole holiday an eBook may be a more effective and efficient solution.

By stating that usability is to what extent can achieve specified goals, instead of saying defining it as to what extent users can execute tasks, the ISO definition has effectively incorporated functionality. This aligns with statements from various authors that to create a product that is useful to the user, the functions it offers should align with the needs and preferences of the user (den Buurman, 1997; Mathieson and Keil, 1998; Bruseberg and McDonagh-Philip, 2001). This also implies that for consumer electronics it is important to correctly communicate to buyers what functionality the product offers, because otherwise the buyer may select a product that does not align with his/her (latent or explicit) goals, and thus be considered unusable; a mobile phone is not a suitable choice if you want to write a letter.

When taking this view into account, the often-argued point that limiting the amount of functions is beneficial for the usability of a product (Lindholm *et al.*, 2003; Maeda, 2006; Keijzers *et al.*, 2008) can be countered by arguing that a product that offers more functionality can assist the user in reaching more goals in more situations, and thus is more effective, and thus overall should be considered more usable. A product that has more functionality is bound to be more flexible (it can be used in more situations (Shackel, 1991)). This can be described as the backpacker's dilemma. When going on a trip, to limit the required effort (efficiency) to haul around his/her luggage a backpacker needs to minimize the amount of items s/he brings. However, to have the appropriate garments for different types of weather (effectiveness) s/he should pack a variety of clothes. Similarly, integrating a camera, calendar, and MP3 player into a mobile phone is likely to make the function that allows you to simply make a call harder to use. However, in comparison to having to carry around a digital camera, PDA, MP3-player and a mobile phone, for the goal of carrying around equipment, a product with all these functions is more usable.

Beyond usability, or not?

For a number of years the HCI and design community have been expanding their horizon beyond usability, and explored concepts such as pleasure and hedonics (Jordan, 1995; Kim and Moon, 1998; Hassenzahl *et al.*, 2000). The basis of this development seems to be the notion that having a product that people *are able to* use is no guarantee at all that people will use it, will enjoy it, and will buy it. Some authors (Han *et al.*, 2001; Helander and Tham, 2003) argue that the definition of usability should be expanded to accommodate, for example, the hedonic aspects of products or the user's appraisal of the appearance of a product. However, usability specifically addresses the question whether people are *able* to use a product and to what extent they experience the product sufficiently usability. Other concepts, such as acceptance, consumer appeal, customer satisfaction or pleasure relate to whether people will use, buy, be satisfied with, or enjoy a product.

Nielsen stresses that usability is just one of the properties that determines 'system acceptability', or "*whether the system is good enough to satisfy all the needs and requirements of the users and other potential stakeholders*" (Nielsen, 1994, p.24). Jordan (2000) argues that though usability is vital, it is not the whole story. That a product has a high level of usability does not guarantee that users will buy it, fall in love with it, or love its appearance. It does however reduce the chance of frustrating users.

Finally, per product category it may differ how important usability is to users in comparison to other product properties. For example, in a study by Russo *et al.* (forthcoming) the authors describe women that keep wearing shoes that make their feet hurt, because the pleasure of wearing them does not originate from their comfort, but from how the shoes look or how they think the shoes make them look.

Electronic consumer product usability

According to Jordan *et al.* (1996b) the concept of usability was mainly developed in the human-computer interaction (HCI) domain, which is illustrated by the fact that the usability definitions by Shackel and the ISO organization were originally written to be applied to visual display terminals (Shackel, 1984; ISO, 1998) and Nielsen's book on usability engineering focused mainly on software development (Nielsen, 1994). However, this research is about the usability of electronic consumer products, and these products differs substantially from software in a number of ways. In contrast to computers, electronic consumer products do not have a (near) standard physical user interface, which means that the physical interface needs to be included in the evaluation. During a usability evaluation of software not much attention is likely to be paid to the interaction with the mouse and keyboard, as software developers have very little influence over these components. The ISO 9241-11 definition of usability is formulated in such a way that it evaluates the outcome of the interaction and how users experience this interaction. It does not specify which components should be included in the evaluation. So even though physical components come into play when evaluating electronic consumer products, the definition of usability does not need to be fundamentally altered to be applied to this product category.

As the definition of usability was developed with the productivity of office workers in mind the 'effectiveness' and 'efficiency' dimensions were considered very important. Consumer products, however, are used voluntarily with the aim facilitating tasks or bringing enjoyment, which causes Jordan *et al.* (1996b) and Han *et al.* (2001) to argue that a less performance-oriented approach is appropriate when evaluating the usability of consumer products, and that thus the satisfaction dimension is most important.

The ISO 20282 standard for the 'ease of operation of everyday products' (ISO, 2006, p.1) applies the ISO 9241-11 standard to everyday products, which are defined as "*mechanical and/or electrical products with an interface that a user can operate directly or remotely to gain access to the functions provided*", which includes "*consumer products intended to be acquired and used by an individual for personal rather than professional use (e.g. alarm clocks, electric kettles, telephones, electric drills).*" In contrast with the aforementioned argument by Jordan and Han, that for electronic consumer products the satisfaction dimension is most important, in the ISO 20282 standard, effectiveness is considered the most critical usability measure: can users complete the main goal that the product was intended for. The ISO 20282 standard distinguishes between the installation and operation of consumer products, where ease of operation is the "*usability of the user interface of an everyday product when used by the intended users to achieve the main goal(s) supported by the product*" and ease of installation is the ease of operation for the goal of first installing a product (ISO, 2006, p.2).

Expected and experienced usability

Just having seen (or heard about) a product can cause people to have expectations about its usage. In a study by Keinonen (1997), participants primarily used brand, display size and the number of buttons as indicators of a product's usability. Kurosu and Kashimura (1995) and Tractinsky (1997) found a strong relation between a positive evaluation of the appearance of a user interface and expectations about its usability. A study by Van Kuijk *et al.* (2009) suggests that expected usability - expectations that people have about a product's usability without having actually used that particular product - is influenced by several factors, most of which are not necessarily related to a product's actual usability. Examples of these are brand, price, styling, and functional form (i.e., number/shape of buttons, screen size) (Figure 18).

It has been argued that the brand proposition of a company may cause users to have certain expectations about a product's usability (Wood and Moreau, 2006). More general, price is considered a factor that influences the perception of overall product quality (Antonides *et al.*, 1999), and thus can be assumed to also affect expected usability. As mentioned above, usability can be assessed in terms of user performance (effectiveness, efficiency) as well as user experience (satisfaction about use). Only taking into account the subjective measures would result in an indication of the 'experienced usability': an individual assessment of how usable someone considers a product to be after having used it (van Kuijk *et al.*, 2009).

Tractinsky *et al.* (2000) found that a positive evaluation of the appearance of a user interface not only influences expectations about usability, but also to what extent participants experienced the interface as usable after having used it. However, Van Kuijk *et al.* (2009) found that if the usability of a product is below a certain level, a beautiful appearance can no longer compensate for this. The latter study also indicated that the appearance (i.e., styling and functional form) of a product can be a misleading indicator for the experienced usability of a product.

2.3.2 Working definition of usability in this thesis

In this thesis I apply the definition of usability from the ISO 9241-11 standard as a working definition. I choose to follow the ISO standard as this definition is formulated in great detail, is sufficiently generic to be applied in all phases of product usage, and is considered the most commonly applied definition. I adhere to the notions that the ISO 9241-11 standard implies that usability is situated and that when evaluating usability it should be taken into account whether a product has the right functionality. I choose not to broaden the definition as there are other concepts that can be applied to evaluate products on other aspects, such as pleasure, acceptance, and customer satisfaction. In addition, I consider usability to apply to what Hekkert and Desmet (2007) call 'instrumental interaction', and the satisfaction dimension of the ISO definition to refer to satisfaction about use, and not to satisfaction about the product in general (including for example the appearance), or about owning the product. I subscribe to the notion that usability has both user performance and user experience dimensions, but would not argue that for electronic consumer products either of these is more important. The consumer market is indeed less performance driven than the

Figure 18: The alarm clocks used in the study on experienced and expected usability by Van Kuijk et. al (2009). For the 'playful' alarm clock in the middle, the expected usability was high, which the participants seem to base in part upon the styling, which also prompted keywords such as 'playful' and 'fun'. In contrast, after usage the product was described as very hard to use.

(office) software sector, so satisfaction about use is important, but even if people are satisfied about use, there still may be possibilities to improve the interaction, which can be identified by studying user performance.

2.3.3 Manifestations and effects of usability

In Chapter 1 it was shortly discussed how usability can manifest itself and the consequences it can have. This section provides a more in-depth discussion. The effects of usability can be viewed from two perspectives: the user perspective and the company perspective. In Figure 19 the user perspective starts on the left, the company perspective on the right (represented by the icons in the upper left and right of the illustration). Usability can manifest itself in (1) the interaction, as well as in (2) how the user experiences the interaction[7]. Depending on the user experience the user may take action that goes beyond interacting with the product: (3) the external response (e.g., file a complaint, call the helpdesk, discuss with friends). This is where the user and company perspective overlap. The quality of the interaction (1) can have consequences for the (4) business performance of companies owning a product (clients), while the (3) external response can affect the (4) business performance of companies that develop and sell products (developers).

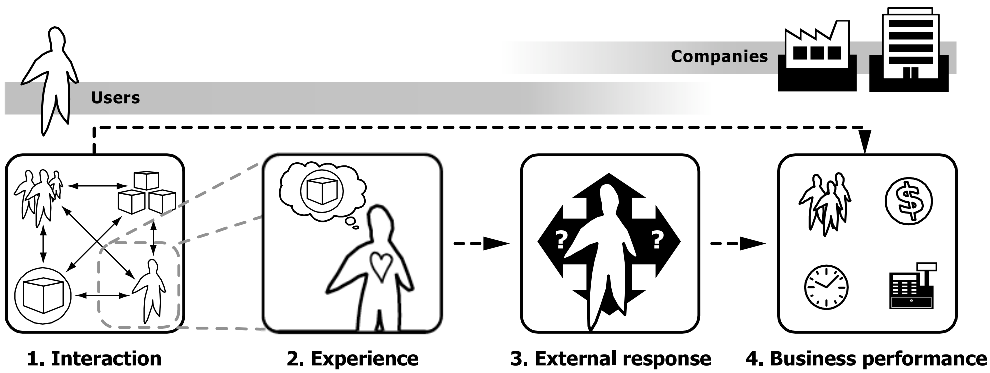


Figure 19: Possible manifestations and effects of usability. (1) human-product interaction can provoke (2) a user experience, which in turn may prompt (3) an external response (e.g., product returns, customer complaints, lower purchase intention). This may have consequences for (4) the business performance of companies making or owning these products.

---

[7] As usability is measured in dimensions that are part of human-product interaction and the user experience domain, it would a circulatory line of reasoning to say that usability has an effect on or has consequences for human-product interaction and user experience. Therefor I choose to say that usability *manifests* itself in the interaction and user experience, which in turn can have an *effect on* or *consequences for* the external response and business performance.

Manifestations in human-product interaction

If a product has poor usability, this can manifest itself in reduced output (quantity and quality) and/or an increase in the effort required from users of the product. Systems with a high level of usability have been argued to lead to higher productivity, increased safety, and less effort to be operated (Cushman and Rosenberg, 1991; Mayhew, 1999; Donahue, 2001; Norman, 2002; ISO, 2006). In addition, users may react to poor system design by compensating (putting in extra effort), changing their task, limiting their use of the system, or may even stop using the system or product completely (Shackel, 1991, p.49).

Manifestations in the user experience

Shackel argued that if professional software systems are too hard to use, and actions by the users to mitigate this are inadequate this can lead to frustration and apathy among users (Shackel, 1991, p.49). For electronic consumer products, the user performance dimensions of usability are relevant if they in turn affect the user experience, which is likely to happen if users are unable to achieve their goals, or if they consider the effort they have to invest too high. Studies suggest that for consumer electronics usability is a major influence on how pleasurable users consider products to be (Jordan, 1998a; Demir *et al.*, 2009).

Effects on the external response

The level of user satisfaction may cause people to take either private action or public action (Donoghue, 2006). Private action is, for example, to warn family and friends about a product or its seller (word-of-mouth) or to stop buying the product or brand or to boycott the seller (Park *et al.*, 1992; Reichheld, 2003; Otker *et al.*, 2005). Public action is, for example, to seek compensation (i.e., repairs, reimbursement, replacement) (Den Ouden *et al.*, 2006; Steger *et al.*, 2007), to file a complaint with a company or a consumer protection agency, or to take legal action against a retailer. Whether consumers will actually complain depends on the degree of (mis)match between expected and actual product performance, to what or whom the problem is attributed (i.e., to oneself or to the product?) the importance of the purchase, the consumer's personality, and the expected response time to get an answer (Cho *et al.*, 2002; Donoghue, 2006).

Effects on business performance

Usability can affect business performance in two ways: it can affect the business performance of a company using a product (e.g., office copiers, IT systems), and secondly it can affect the business performance of companies that develop and sell products. The following section focuses on the latter.

A high level of usability is seen as a way to prevent customer complaints and product returns and thus as a tool for cost prevention. In today's markets the responsibility of a product development company does not end at the warehouse exit or store counter; a company is expected (or required by law) to provide its customers with support, take back faulty products, and give consumers the opportunity to trade in a product if they are disappointed by it. Both customer support activities and product returns can incur huge costs (Brombacher, 2005; Den Ouden, 2006; Steger *et al.*, 2007). Steger and Sprague put the costs for 2007 for the return and repair of consumer electronics by US consumers alone to be $ 13.8 billion, and attribute this in part to the low level of usability of these products. On the other hand, products with good usability have been argued to prevent costs due to a reduction in consumer complaints and requests for assistance (Donahue, 2001).

In the current market the high degree of technological sophistication worldwide has made it hard for companies to compete on technology, because technological innovations can be imitated very fast. Under such circumstances, the quality of the interaction has been argued and shown to be a strategic differentiator (Green and Jordan, 1999; Dul and Neumann, 2009). Some authors claim that a high level of (expected) usability positively influences consumer preference (Dumas and Redish, 1999; Venkatesh, 2000). While some of these authors have been enthusiastically cited[8], others point out that there seems to be a weak relation between a high level of usability and good sales numbers. This is attributed to the fact that one only experiences the usability of a product after purchasing it (Keinonen, 1998; Jokela, 2004; Nielsen, 2004; Creusen and Schoormans, 2005) and that expectations about usability hardly influence consumer preference for a product (Keinonen, 1997, p.183; Creusen and Schoormans, 2005).

Though the impact usability has on buyer preference *before* purchase is debatable, there is evidence that usability does influence customer satisfaction (after people have actually used the product) (Cooper, 1999; Rust *et al.*, 2006). Positive experiences with a product can result in a stronger brand position and (re)purchase intent among consumers (Park *et al.*, 1992; Reichheld, 2003). Considering the above it can be argued that though usability may not be of direct influence on consumer preference and thus sales, through its impact on consumer preference, and thus on brand perception, repeat sales and cross-sales (purchases in other product categories), usability can be a competitive advantage, be it a long-term one.

2.4 Product development

The previous paragraphs discussed the concepts of human-product interaction, user experience and usability, and how these can be applied to electronic consumer products. So now there should be a clearer picture of what this research aims up to improve: the usability of electronic consumer products.

---

[8] In the case of Dumas and Redish (1999) the product is PC software, and as evidence for the commercial importance of usability they present the results of a questionnaire-based survey by a PC magazine in which the participants indicated they found usability the second most important property (after functionality) with regard to consumer software.

As mentioned before, the usability of an electronic consumer product is determined by the properties of the user, other people, symbiotic products, the environment in which the product is used, and by the product itself. The product is the element of human-product interaction over which product developers have most influence. The properties of the product are a result of a product development process performed by a product development team within a product development company. To ensure that the resulting product is be usable one can take a user-centred product development approach, which is generally described as actively involving users in order to get a clear understanding of user and task requirements, performing iterative design and evaluation cycles, and taking a multi-disciplinary approach.

The following subparagraphs discuss the distinction between product innovation development and design, the Delft Innovation model as a reference model for product development in this thesis, how companies manage portfolios of product development projects, and finally the intricacies of working in multi-disciplinary development teams.

2.4.1 The product development process

Product development processes are representations of how companies structure product development, and can be used both in a descriptive (documenting/communicating) and a prescriptive (guiding) manner. Davenport (1993, p.5) defines a (business) process as:

> *"A structured, measured set of activities designed to produce a specific output for a particular customer or market. It implies a strong emphasis on how work is done within an organization, in contrast to a product focus's emphasis on what. A process is thus a specific ordering of work activities across time and space, with a beginning and an end, and clearly defined inputs and outputs: a structure for action."*

There are several models of product development and innovation processes (Cross and Roozenburg, 1993; Brown and Eisenhardt, 1995; Smith and Morrow, 1999). However, I will limit myself to comparing three models of product innovation, two of which are commonly applied in design research (Roozenburg and Eekels, 1991, p.14; Ulrich and Eppinger, 2004), and one that is used as a basis for teaching and studying product development at the Faculty of Industrial Design Engineering at TU Delft (Buijs and Valkenburg, 2005).

Innovation, development and design

This section explores the distinction between product innovation, product development and design, as these terms are often used in close connection or interchangeably.

Product innovation

Product innovation refers to the repeating cycle of conceiving a company strategy, generating product ideas based on that strategy, creating designs, and producing, distributing and selling products, as well as collecting feedback once the products are in use, and then (possibly) starting the whole process from the start (Roozenburg and Eekels, 1991, p.14; Buijs and Valkenburg, 2005, p.167).

Product development

Product development can be defined as the activities that start with the perception of a market opportunity and ending in the production, sales and delivery of a product (Ulrich and Eppinger, 2004) or as conceiving, developing, and market introduction of a product (Buijs and Valkenburg, 2005). A distinction should be made between product development and 'strict development' (Roozenburg and Eekels, 1991; Buijs and Valkenburg, 2005): the activities in product innovation that start with the assignment or design brief and end with a production-ready design.

Design

Roozenburg and Eekels define designing as 'reasoning from function to form': finding a suitable spatial and physical-chemical arrangement for the product and all of its parts so that the desired function is fulfilled (Roozenburg and Eekels, 1991, p.52). The starting point for design are the desired functions (that were determined through product planning), based on which a set of desired product properties is determined. These are in turn translated into form (spatial and physical-chemical arrangement).

In Buijs and Valkenburg's model of product innovation the product design is created in a sub-phase of strict development. Strict development starts with an analysis phase, in which the design brief is analysed and translated into requirements. In the subsequent synthesis phase the actual design is made. This step, synthesizing specifications of form (spatial and physical-chemical arrangement) and behaviour in varying level of detail, with the goal of fulfilling certain requirements (desired product properties), is how I define designing in this thesis, following the definition of design by Luckman (1984). Figure 20 visualizes the relations between product innovation, product development and design as I have defined them for the purpose of this thesis.

The Delft Innovation Model

I have chosen to use the Delft Innovation Model (Buijs and Valkenburg, 2005) (Figure 21, page 52) as a reference model for product innovation and development in this thesis because it (1) stresses the generation-wise (circular) approach to product development that is common in the electronic consumer products industry, (2) explicitly includes the phase when the product is in use, and (3) explicitly includes evaluations and iterations, which are important principles of usability engineering and user-centred design (Nielsen, 1992b; ISO, 1999; Vredenburg *et al.*, 2002a).

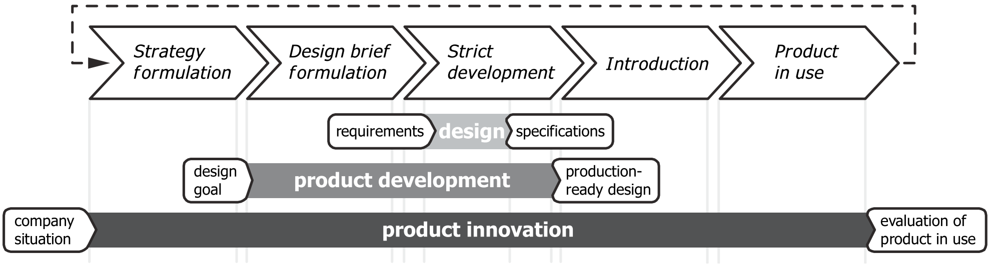


Figure 20: Visualization of the relation between product innovation (as defined by Buijs & Valkenburg (2005)), product development, and design, as applied in this thesis.

The Delft Innovation Model (DIM) is divided into five phases:

1. Strategy formulation: analysis of internal strengths and external opportunities lead to a 'search area';
2. Design brief formulation: analysis of internal limitations and external needs lead to a design brief, which is the assignment for the product development department and contains the most important notions underlying the product that is to be designed;
3. Strict development: the design brief is developed into a production-ready design. This phase is in turn divided into four sub-phases: (3-1) analysis, (3-2) synthesis, (3-3) materialisation and (3-4) optimisation. During analysis, based on a technology analysis, function analysis, and market-and consumer research, the design brief is refined further and this culminates in a problem statement and a list of requirements. During the synthesis phase, based on the problem statement and list of requirements, and by means of an exploration of technological possibilities and user tests, concepts are developed. During materialisation these concepts are developed into working prototypes, which are then tested, and subsequently detailed and engineered during the optimisation phase;
4. Introduction: production, distribution, marketing and sales of the product, and
5. Product in use: the product is being used, and the company evaluates product use, and conducts an internal evaluation of the product.

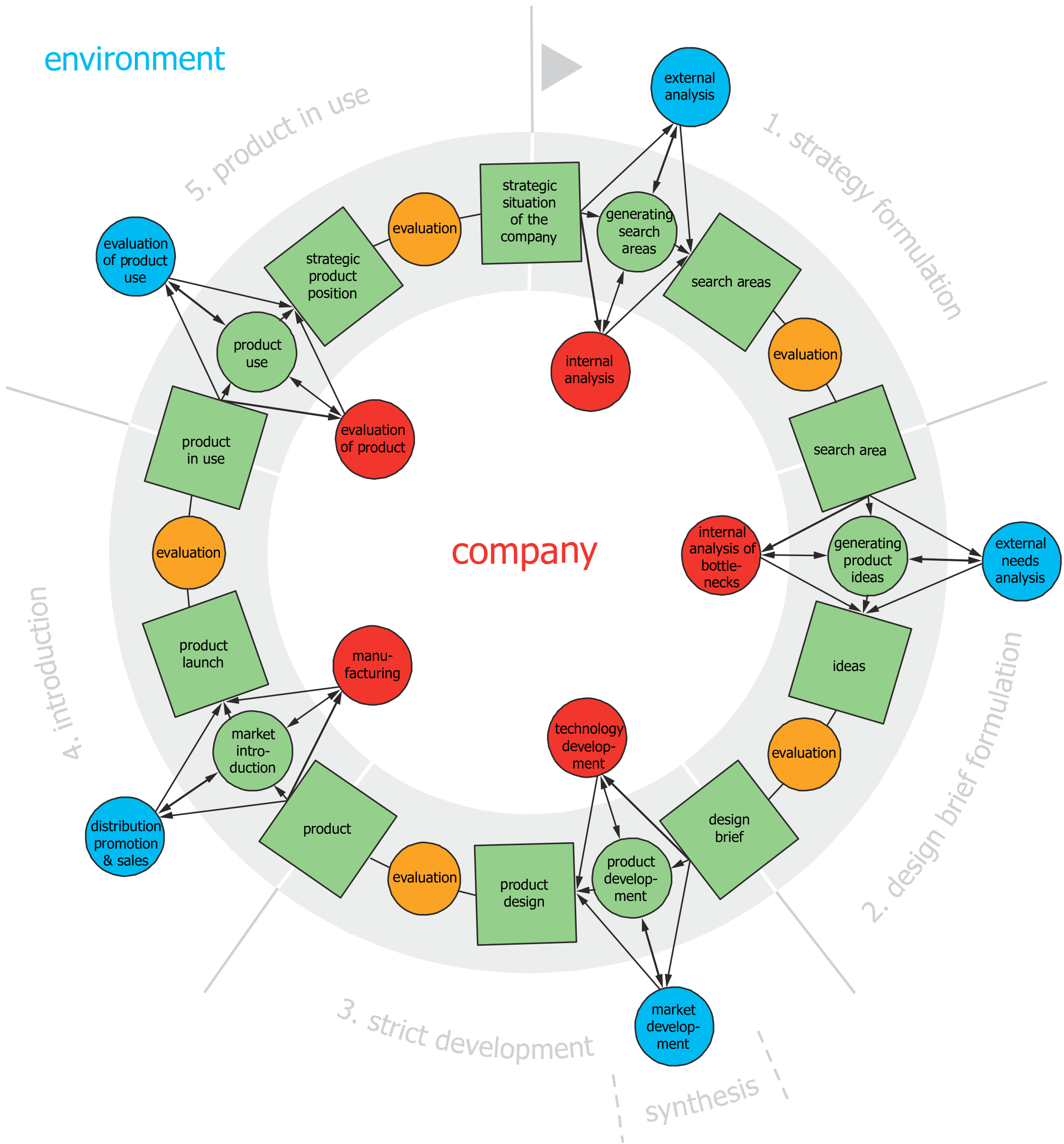


Figure 21: The Delft Innovation Model adapted from Buijs and Valkenburg (2005). Circles refer to activities, boxes to results. Activities inside of the ring (light grey circles) refer to internal analyses within the company, the boxes and circles on the grey ring represent product development activities and results and evaluations, while the dark grey circles on the outside refer to external analyses of the company's environment.

Structure, phases and gates

The Delft Innovation model is a product innovation model of the stage-gate™ variety, which is a common way to divide a product development process into phases, each with a specific goal or deliverable (Cooper, 1990; Ulrich and Eppinger, 2004; Buijs and Valkenburg, 2005). In the initial version of Cooper's stage-gate™ development process a project only proceeded to the next phase once the goal of the current phase had been met, which does not align well with the concurrent and iterative nature of product development (Ketola, 2002, p.36), potentially causing delays in the development process. In a later version of the stage-gate™ model Cooper therefore replaced the 'hard gates' by 'soft gates', allowing for a certain degree of parallel work and iteration between phases (Cooper, 1994).

A series of problem-solving cycles

In every phase of the product innovation process alternatives are generated and choices have to be made. The process of generating alternatives is called diverging: the number of possible solutions expands. Selecting, on the other hand, is convergent process of converging: the number of alternatives is reduced. Thus the innovation process as a whole can be represented as a sequence of divergent and convergent sub-phases (Roozenburg and Eekels, 1991, p.12) or a as going through a series of problem solving cycles (Cross and Roozenburg, 1993). Roozenburg and Eekels (1991, p.79) have adapted the basic problem solving cycle so it represents a specific kind of problem solving: designing. The basic design cycle (Figure 22) consists of an analysis phase in which the designer tries to understand the problem at hand and the aspects that play a role, a synthesis phase in which solutions are generated, during simulation solutions are simulated, and subsequently evaluated (matched with the criteria from the analysis). At the end of the cycle the design is chosen or the cycle iterates back to earlier phases to evaluate whether the analysis and synthesis were done properly. Note that the basic design cycle does not contain an iterative path back to simulation and evaluation, which implies that if the evaluation results in the conclusion that the synthesized solution does not match the desired criteria (decision) it is not reassessed whether the simulation and evaluation were properly conducted.

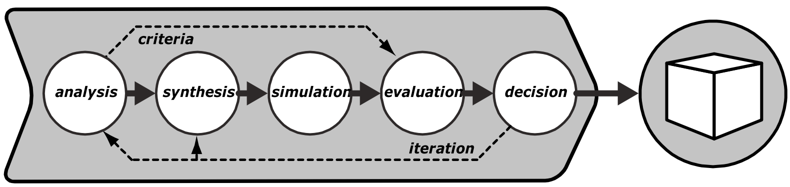


Figure 22: The basic design cycle (adapted from Roozenburg and Eekels, 1991).

2.4.2 Development projects

A project is a set of activities in the development process for a particular product (Ulrich and Eppinger, 2004, p.25). Even if the process followed is identical, development projects may differ in terms of goals and available resources. This section discusses two properties of projects: how companies manage portfolios of development projects and, secondly, to what extent a project is innovative or not. These topics are discussed because portfolio management and platform-based development are important properties of the development of electronic consumer products, and the degree of innovation is one of the most important ways to distinct projects as this is considered to be related to the risk of failure and (thus) of the resources required.

Portfolios, platforms and generations

Companies hardly ever rely on one single product for their survival; they usually have a product portfolio or family. Reasons for companies to expand their product lines are to target unexploited opportunities in the market, and in addition, an extensive product portfolio has been reported to have a positive effect on the perceived reliability of a brand, product quality, market share and a negative effect per unit production cost (Person *et al.*, 2008).

On the one hand, companies strive to reduce the complexity of developing and managing their products, and on the other hand want to offer its buyers an optimal variety of products so each buyer can find the product s/he likes (Jiao *et al.*, 2007). To manage the cost of product variety and to reduce complexity of product development, companies resort to developing products based on platforms: components and subsystems shared across a family of products (Sawhney, 1998; Sundgren, 1999; Krishnan and Gupta, 2001). Other benefits of platform-based product development include a reduction in development risks and system complexity, an improved ability to upgrade products, and enhanced flexibility and responsiveness of manufacturing processes (Sawhney, 1998).

A specific version of a product-platform is the user interface style, which is defined as a design framework describing interaction style and objects, including appearance (look) and behaviour (feel) (Hartson and Hix, 1989) or a combination of user interface conventions, audiovisual-tactile appearance, and user interface hardware (Lindholm *et al.*, 2003, p.20). A UI style can be shared across a number of models and inherited and adapted over generations. Because of the connotation of style with styling, in this thesis I will use the term 'UI paradigm'.

In addition to sharing a platform with multiple products it also common practice to develop multiple generations of a product, improving the product with each new generation (Buxton, 2007, p. 56-57).

Revolution and evolution

An important way to distinct product development projects is to what extent the end product is innovative (new to the company or market). Ulrich and Eppinger (2004, p.35) distinct (1) new product platforms, (2) derivates of existing product platforms, (3) incremental improvements to existing products and (4) fundamentally new products. The last category have a high risk and are difficult for companies to execute, because it typically involves targeting new markets, the consumer needs are unknown or dormant, and the projects may go beyond the capabilities of a product development organization, but on the other hand, these projects can create significant opportunities and may be essential to the long-term success of a company (Song and Montoya-Weiss, 1998; Ulrich and Eppinger, 2004, p.36).

2.4.3 Multidisciplinary product development teams

The previous section discussed the difference between product innovation, development and design, presented the Delft Innovation Model as a reference model for product development, and outlined how product development companies manage their product portfolios and distinct between evolutionary and revolutionary product development projects. The aforementioned subjects all deal with structuring product development through processes, projects, phases, methods. Who are not present in the previous section are the people. Every project, every phase, every decision is executed by people. This is especially relevant for this research, as one of the principles of user-centred design is a multidisciplinary approach (ISO, 1999; Vredenburg *et al.*, 2002a). This section discusses the intricacies of developing products in multidisciplinary product development teams.

The level of complexity of electronic consumer products means that a single individual cannot develop them; they are developed by teams that composed of all the required disciplines. Even to only address the human aspects of a design requires a variety of disciplines (ISO, 1999). This section discusses which roles can be expected to influence usability in product development. A role describes "*what the holder of it will do in the process, what responsibilities s/he has, what skills and expertise are required, what the other project members can expect from him/her, etc. The description is independent of the individual role holder*" (Gulliksen *et al.*, 2006, p.581). Secondly, this section outlines what communication issues can arise in multidisciplinary teams, especially with regard to usability.

Team composition

A product development team is formed by the collection of individuals developing a product (Ulrich and Eppinger, 2004, p.3). The core team coordinates the efforts of the extended team, and includes representatives from all departments or disciplines involved, while remaining small enough to conduct effective meetings. Figure 23 visualizes product development team composition for an electromechanical product of modest complexity (from Ulrich and Eppinger, 2004, p.4).

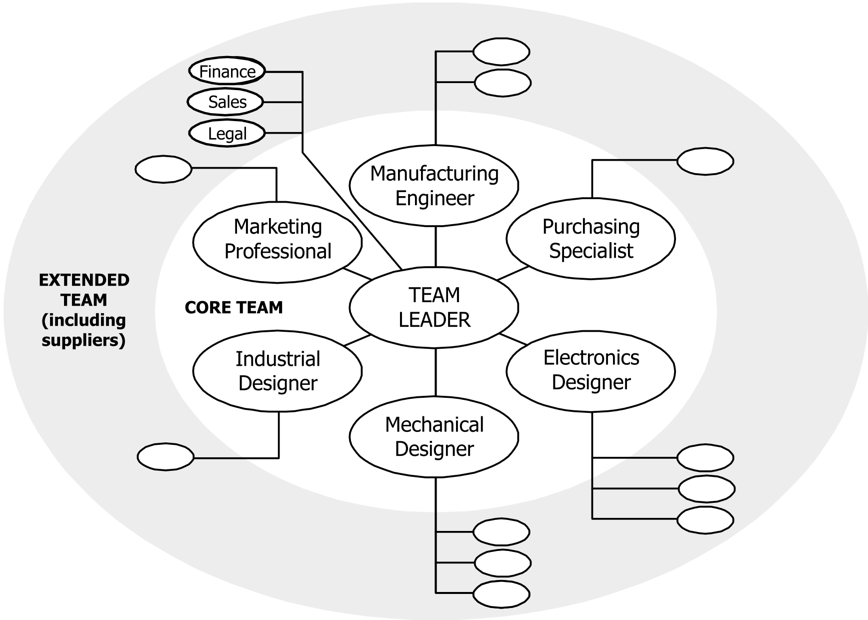


Figure 23: Product development team composition for an electromechanical product of modest complexity. The core team (central white area) coordinates the activities of the extended team, which includes external suppliers (Illustration from 'Product Design and Development' © 2004 Ulrich And Eppinger. Reproduced with permission from the McGraw-Hill Companies).

For the user-centred design activities a specific set of actors is relevant. The ISO standard for human-centred design (ISO, 1999) states that, apart from clients and users, the following product development roles should be involved in a human-centred design project:

- Application domain specialist, business analyst;
- Systems analyst, systems engineer, programmer;
- Marketer, salesperson;
- User interface designer, visual designer;
- Human factors and ergonomics expert, HCI specialist;
- Technical author, trainer and support personnel.

As in this thesis the focus is on electronic consumer products and not on large systems (as is the case in the aforementioned ISO standard) the roles of application domain specialist and business analyst are less relevant. By combining the team composition of Ulrich and Eppinger from Figure 23 with the roles mentioned in the ISO standard I arrived upon six roles to focus upon in my case studies. These roles are depicted in Figure 24 and specified in further detail in Table 4.

Figure 24: Acting out the six roles in the development of electronic consumer products that this thesis focuses on: the product manager, marketing specialist, industrial designer, interaction designer, usability specialist, and development engineer.

Table 4: Development team roles identified as relevant for studying usability in product development.

Job title	Role description	Also known as (aliases)
Product manager	Coordinates product development, sets the priorities for the product	Project manager, customer-marketing manager
Marketing specialist	Collects market information, defines marketing strategies	Marketing manager, market intelligence manager, marketer, sales manager
Industrial designer	Designs the physical appearance of the product	Product designer
Interaction designer	Designs the user interface of the product	User interface designer, user experience designer, visual designer
Usability specialist	Collects user information, evaluates the usability of products	Usability tester, user experience specialist
Development engineer	Responsible for technological and production aspects	Mechanical engineer, software engineer, production engineer, electronics engineer

In the development of electronic consumer products the role of team leader is often fulfilled by a product manager, who sets the product requirements and constraints in an early phase, and can define to a large extent how the product should turn out. It can also be that managing the product and the project are separate responsibilities, in which case the team has both a product and a project manager. Gulliksen *et al.* (2006) claim having a project manager that prioritizes usability is crucial; s/he can set priorities that ensure usability, and support the usability specialist when usability conflicts with other concerns. The marketing specialist can be involved in front-end marketing (collecting market information, helping set the product proposition) and/or in developing the market introduction strategy. The usability specialist evaluates the usability of designs and products, but often also generates or helps with setting the user requirements for the product (Borgholm and Madsen, 1999). In addition to an industrial designer, who mostly focuses on designing the appearance of the product, there is the interaction designer (Preece et al., 2007, p.8) or user interface designer[9] (Bekker, 1995). Since my focus is on the roles that perform usability-related activities, I put less emphasis on the engineering roles from Figure 23, and integrate these into one role (the 'development engineer').

Cooperation and communication

Working in multi-disciplinary teams is an important principle of user-centred design (ISO, 1999; Vredenburg *et al.*, 2002a), which makes team collaboration a relevant issue for this research. Team communication is an essential part of collaboration, especially because product developers often consider usability an ungraspable, fuzzy concept (Clegg *et al.*, 1997; Gulliksen *et al.*, 2006).

The relationships in a product development project can be very complex and the degree of integration of disciplines can have significant effect on a product's success or failure (Veryzer and Mozota, 2005). Thus it is essential that the team members communicate and cooperate. Kleinsmann (2006) points out the difference between cooperation and collaboration. Cooperation in product development can be defined as the interdependency and information sharing between various organisational units (Song *et al.*, 1997). Collaborative product development, on the other hand, is the process in which actors from different disciplines share their knowledge about both the design process and the design content, which they do in order to create shared understanding on both aspects, to be able to integrate and explore their knowledge and to achieve the larger common objective: the new product to be designed (Kleinsmann, 2006, p.38). Song *et al.* (1997) identified five potential barriers for cross-functional cooperation: (1) personality differences between functions (especially between technical and marketing people), (2) cultural differences or thought-worlds, (3) language or jargon unique to each area, (4) organizational

---

[9] Often a distinction is made between interaction design and user interface design. Preece *et al.* (2007) define interaction design as "designing interactive products to support the way people communicate and interact in their everyday and working lives", whereas user interface design can be said to have a more narrow focus, and concern itself mostly with designing the (on-screen) user interface.

responsibilities and reward systems, and (5) physical distance, such as physical distance between departments.

Guldbrandsen (2006) found that the challenge of creating shared understanding becomes even bigger if the development team has to communicate about non-quantifiable product qualities. These are are (usually non-technical) product qualities that are hard to measure, such as styling or usability. With regard to user-interface design practice, Bekker (1995) found that user-interface designers have to discuss potential design solutions with many people involved in the design process, in order to, for example, elicit extra information, explain the design, or decide how to proceed. However, the communication is often hindered by, among others, difficulties in understanding other team members' representations (e.g., documents, drawings, or prototypes), and because team members use different terminology.

With regard to the communication of usability and user-related information Kanis *et al.* (1999) conclude that quantitative information is uninformative to designers when communicating the results of user tests. Similarly, Sleeswijk Visser (2009, p.224) points out that findings from user research are best communicated in a rich, qualitative manner. Kahman and Henze (1999) stress that communicating results of usability tests to other disciplines in the product development team is a critical step, and point out the benefits of conducting a workshop in which the results are presented and discussed as an ideal tool for efficient communication. This aligns with a recommendation by Sleeswijk Visser (2009, p.236): to give the receiving party an active part in the communication of user research.

2.5 Creating usable products

The previous paragraph discussed the product development process is organized and who performs it. This paragraph will explore methodologies applied to increase the usability of products and the user-centred design cycle. The first section discusses two common methodologies for creating usable products: User-Centred Design (UCD) and Usability Engineering (UE). In the second section, Roozenburg and Eekel's basic design cycle (Roozenburg and Eekels, 1991, p.79) is modified to create the user-centred design cycle. In the final section an overview is given of methods for user involvement and representation.

2.5.1 Methodologies for creating usable products

The following section features the two most prominent methodologies for creating usable products: User-Centred Design (UCD) and Usability Engineering (UE).

User-Centred Design

Several authors claim that the quality of human-product interaction can be improved by following a user or human-centred design process (ISO, 1999; Preece *et al.*, 2002;

Vredenburg *et al.*, 2002a). Gould and Lewis (1985) proposed four principles that can be seen as having formed the basis for user-centred design:

- Know who the user group is;
- Incorporate current knowledge of users in the early stage of design;
- Evaluate: confront users repeatedly with early prototypes for evaluation purposes;
- Iteration: re-design as often as necessary.

These principles have found their way into the ISO 13407 standard for human-centred design processes for interactive systems (ISO, 1999), which adds multi-disciplinary design to the list. Vredenburg *et al.* (2002b) describe user-centred design as the active involvement of users for a clear understanding of user and task requirements, iterative design and evaluation, and a multi-disciplinary approach. Instead of focusing on technological possibilities and quality measurement in terms of components, solutions that fit the user should be taken as a starting point and product quality should be measured from a user point of view, taking into account needs, wishes, characteristics and abilities of the projected user group (Vredenburg *et al.*, 2002a).

Usability Engineering

Usability engineering is described as a process with the aim of improving usability of user interfaces, involving user testing, prototyping and iterative design as the key elements (Nielsen, 1992b) and as providing "*systematic methods and tools for the complex task of designing user interfaces that can be readily comprehended, quickly learned, and reliably operated*" (Butler, 1996, p.59). Nielsen introduced the usability engineering lifecycle (Nielsen, 1992b) which he calls a modified and extended version of Gould and Lewis' (1985) 'golden rules', and that consists of the steps listed in Table 5.

Table 5: The steps of the Usability Engineering lifecycle as proposed by Nielsen (1992b).

0. Consider the larger context; 1. Know the user (characteristics, task, function analysis, evolution of the user); 2. Competitive analysis; 3. Setting usability goals; 4. Participatory design;	5. Coordinated design of the total interface (standards, product identity); 6. Guidelines and heuristics analysis; 7. Prototyping; 8. Empirical testing; 9. Iterative design, and 10. Collect feedback from field use.

In essence Nielsen proposed a user-centred product (or software) development process with a focus on usability. A remarkable property of the Usability Engineering life cycle, is the explicit inclusion of a guidelines and heuristics analysis (before building prototypes and conducting empirical testing), and the capturing of feedback from field use, something that is not featured in most models of user-centred design.

2.5.2 The user-centred design cycle

On page 53 (Figure 22) the basic design cycle was discussed, a special version of the problem solving cycle that represents how designers analyze problems, and then create and evaluate solutions. When designing a new diesel engine, one could perform an analysis of the problem, design a new engine and evaluate its performance without including users in the process. However, if the goal is, for example, to create an engine for which one of the criteria is that users should really like the performance characteristics or sound, it would be appropriate to take a user-centred design approach, in which users can be involved in each of the steps. This is visualized in the user-centred design cycle (Figure 25), which integrates the basic design cycle (Roozenburg and Eekels, 1991, p.79) with user involvement (Grudin, 1991; Lauesen, 1997).

User involvement and representation

Grudin (1991) used the term 'user involvement' to refer to collecting information – directly from users, not through an intermediary – about users and their work environments. Following Lauesen (1997) in this thesis I define 'user involvement' as input by users in all steps of the basic design cycle. In some cases, conducting a simulation with actual users is not possible, but product developers still need to anticipate product usage, in which case they might resort to so-called inspection methods (Rooden, 2001, p.3), such as an expert evaluation or a method that methodically simulates product usage. I refer to methods are used to anticipate usage but that do not include users as 'user representation'.

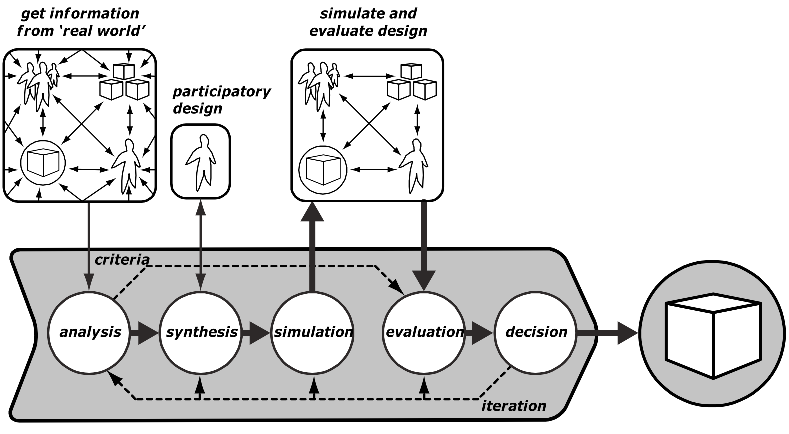


Figure 25: The user-centred design cycle, which is a combination of the framework for human-product interaction with the basic design cycle by Roozenburg and Eekels (1991).

Combining the basic design cycle with user involvement and representation results in a problem solving cycle that starts with gathering of information from the 'real world', and then continues with the - possible - participation of users in synthesizing solutions (i.e., participatory design). Next a simulation of human-product interaction is performed, which includes simulating the future product (by means of a prototype), the users (e.g., by means of participants), and the context of use (physical environment, other people, symbiotic products). The simulation is then evaluated by applying a specific evaluation method. Based on the evaluation it is decided whether the result is acceptable, or that iteration should be performed to 1) reassess the criteria, 2) rework the design, or assess whether the 3) simulation and 4) evaluation were appropriate. Roozenburg and Eekels' (1991) representation of the basic design cycle does not include iterations back to the simulation and evaluation steps. Because of the attention paid in HCI literature to the influence of simulation and evaluation methods on the outcomes of the evaluation (Hertzum, 1999; Hertzum and Jacobsen, 2001; Molich *et al.*, 2004; Kaikkonen *et al.*, 2005; Vermeeren, 2009) I decided to include these iterations in the representation of the user-centred design cycle.

Not a development process

The user-centred design cycle does not represent the process of developing a product or creating a design, but is a representation of user-centred problem solving that can be applied throughout the phases of product development, as suggested by Den Buurman (1997) and it is similar to Maver's model of the architectural design process (Cross and Roozenburg, 1993). This model suggests that the architectural development process consists of a number of phases, each with a specific deliverable, to arrive at which one goes through a problem solving cycle for each phase[10]. The basic design cycle can be considered a building block for the user-centred product development process.

Methods for user-centred design

Over the years a great number of methods for user-centred design have been developed that can be applied in the different steps of the basic design cycle. Efforts have been made to provide an overview of these methods, either online (e.g., Bevan, 2003; Battle *et al.*, 2004; Leurs *et al.*, 2009; HHS, undated) or through (text) books (e.g., Nielsen, 1994; Nielsen and Mack, 1994; Jordan, 1998b; Preece *et al.*, 2007), while others have focused on comparing and improving these methods, and on how to apply them (e.g., Karat *et al.*, 1992; Lavery *et al.*, 1997; Molich *et al.*, 2004; Kaikkonen *et al.*, 2005; Vermeeren, 2009).

[10] For example, during design brief formulation, a team could perform home visits and analyse help-desk calls (analysis), based on which they could formulate product concepts in the form of scenarios (synthesis), which in turn can be discussed in a focus group (evaluation), the outcome of which helps the team to decide which concept to select, or to, for example, perform more user research or generate new concepts (iteration). In a later phase, such as strict development, the design team could observe people using products in the streets (analysis), create a number of user interface designs (synthesis), create simulations of these on computer with a touch-screen (simulation) and have users interact with these simulations (evaluation).

Below, for each of the steps of the user-centred design cycle important issues for applying user-centred design methods in that step are discussed, and a number of methods that are commonly applied in that step are discussed.

Analysis

During analysis a designer does not only explore the technological possibilities and business aspects of a product, but also investigates relevant properties of the 'real world' that s/he expects to have an influence on human-product interaction. This means that s/he studies the properties of the user group (e.g., needs, behaviour, preferences, anthropometrics), the environment they will use the product in (e.g., at home, on the go, lighting conditions, temperatures), what symbiotic products the new product should be able to interact with (e.g., television set, wireless network router), and finally in what kind of social context the product can be expected to be used (e.g., what other people are present, what will their role be). Methods for what is often called 'user research' are, for example, user observation, interviews, focus groups (Bevan, 2003, p.492-495; Preece *et al.*, 2007), context mapping (Sleeswijk Visser *et al.*, 2005), and contextual inquiry (Holtzblatt and Jones, 1993).

In some cases users are invited to create solutions or objects with the goal of eliciting needs, desires and concerns (Gyi *et al.*, 2006; Sanders and Stappers, 2008). Although in these cases something is created I consider this an analysis activity, as the goal of the activity is to elicit information. Similarly, user testing (of an existing product) can be used as a means to elicit requirements (Garmer *et al.*, 2004).

Sleeswijk Visser *et al.* (2005) argue that the method that is used to conduct user research influences the type of information that is found. They argue that interviews are more likely to produce information on what the user group says or thinks, observations will lead to information on what people do and use, and what they call 'generative sessions' will lead to uncovering more tacit and latent knowledge, about what the user group knows, feels and dreams.

Synthesis

Gulliksen *et al.* (2006, p.592) point out that it is remarkable that most usability-related activities focus on analysis and evaluation as: "*you can only design your way into usability.*" The synthesis activity is where the 'magic' happens. Or should happen. As Green (1999) points out, to many usability specialist the making of the design is still a black box on which they have limited influence.

Synthesis techniques

Though indeed the actual creation of a solution may remain somewhat of a mystery, interaction designers (can) use a set of techniques for designing a product's behaviour, such as scenarios (Carroll, 2000), task analysis (Preece *et al.*, 2007, p.515), and use cases (Jacobson *et al.*, 1992). Buxton (2007, p.114) points out that these 'sketches' of the product or interface both visualize what the designer has 'in mind' as well as 'talk back' to the designer and thus offer the possibility for reflection or for iteratively inspiring new ideas.

Synthesis-context techniques
Apart from using these synthesizing techniques, one can also influence synthesis activities through the context in which this is done, and the person by whom this is done. I refer to this as synthesis-facilitation. Techniques for synthesis-facilitation are for example guidelines and heuristics to ensure consistency and the application of proven solutions and existing knowlege (Lauesen, 1997; Bachman et al., 2003), providing designers with theories of human behaviour so they can anticipate future use of their design (Cushman and Rosenberg, 1991), exposing designers to personas to remind them of who they are designing for (Hoefnagels, 2009), and the active participation of users in the synthesis step, an approach that is labelled participatory design (Nielsen, 1992b; Muller and Kuhn, 1993; Buur and Boedker, 2000).

Simulation

Simulation refers to a representation that is made of human-product interaction in order to evaluate it. Simulation and evaluation of human-product interaction cannot be viewed as completely separate activities, as the simulation of the interaction (for example, the kind of prototype or whether the interaction takes place in the lab or in the field) determines the type of evaluation that can and will be conducted. And vice-versa the type of evaluation puts demands on the simulation.

Representativeness
Four factors determine to what extent a simulation is expected to represent the future usage situation[11] (also referred to as 'contextual fidelity'): the representativeness of (1) user characteristics, (2) task scenarios, (3) system prototype, and (4) testing environment (Bevan and Macleod, 1994; Sauer *et al.*, 2000). It has been reported that results can differ if the same prototype is tested in different environments (e.g., laboratory versus in the field) (Hertzum, 1999; Kaikkonen *et al.*, 2005), or by users that vary on certain properties, such as expertise (Bont and Schoormans, 1995; Sauer *et al.*, 2000; Ziefle, 2002). Whether or not participants conduct the same tasks or are given the same goals can also affect what usability problems are (not) found (Molich *et al.*, 2004).

Prototype fidelity
A prototype can be defined as an approximation of the product along one or more dimensions of interest (Ulrich and Eppinger, 2004, p.247). Buchenau and Fulton Suri (2000, p.424) use the term 'experience prototyping' to describe the "*form of prototyping that enables design team members, users and clients to gain first-hand appreciation of existing or future conditions through active engagement with prototypes.*" Virzi *et al.*

---

[11] Note that those who set up a simulation may strive for representativeness of usage, but achieving complete representativeness is unlikely. For example, the simulation may involve participants that are representative of the anticipated user group, and an environment that is believed to reflect the actual usage environment, but this makes the simluation representative of what the development at that time anticipates future usage to look like. The team is unlikely to have a complete or completely accurate image of future usage, which – at the time of simulation – makes it hard to claim that a simulation is representative.

(1996) propose four dimensions along which prototype fidelity[12] – the degree to which a prototype varies from the final product – can vary:

1. Breadth of functionality[13]: the number of functions the prototype supports;
2. Degree of functionality: the extent to which the details (per function) are complete;
3. Similarity of interaction: how participants communicate with the product, and
4. Aesthetic refinement: to what extent the appearance of the product is in line with the final product.

Examples of different kinds of simulations are (1) scenarios or storyboards: illustrated stories communicating product usage (Fulton Suri and Marsh, 2000), (2) paper prototypes: rough, non-interactive visualizations of user-interfaces or sequences of screenshots (Sauer et al., 2000), (3) mock-ups: physical, non-interactive 3D representations of the product (Sauer et al., 2000), (4) fully interactive physical prototypes (Sauer et al., 2000), and (5) virtual prototypes: interactive 2D or 3D simulations (Kuutti et al., 2001).

Evaluation

Not every evaluation is a usability evaluation. In the earlier phases of a project, the focus is more on determining the right product proposition or concept, and in this stage it is hard to evaluate a product's usability (Greenberg and Buxton, 2008). This does not mean, however, that the early phases don not impact a product's usability. As I argued earlier, the functionality of a product (which is determined in the early phases) can determine to a large extent whether a product will help a user to reach his goals or not. To paraphrase Buxton: in the early phases the emphasis is more on making the right product, whereas in the later phases there is more focus on getting the product right (Buxton, 2007). Secondly, when applying overly strict usability criteria to early concepts one may dismiss concepts with high potential, simply because they are immature at that time (Greenberg and Buxton, 2008).

In response to studies that investigate the reproducibility of (usability) evaluation activities Wixon (2003) argues that the goal of conducting usability evaluations is not to be consistent, but to make products more usable. In that sense, the number of problems identified is an inappropriate measure.

Important distinctions to make with regard to evaluation methods are (1) whether they are conducted with the help of users (empirical) or without (analytical) and (2) what their goal is: to learn what aspects of the design can be improved (formative) or to assess the level of

---

[12] The use of the term 'fidelity' is debatable, because whether a product simulation can be considered an approximation of the future product depends on the goal of the evaluation. For example, a physical mock-up can be considered 'low fidelity' when it comes to evaluating an on-screen menu, but 'high fidelity' when it comes to evaluating physical interaction, such as how it is to hold the product or whether it fits into one's pocket jacket.

[13] Virzi *et. al* actually refer to 'breadth of features'. However, as explained earlier, I consider features (what you put 'in the spotlight' in order to sell a product) not to necessarily overlap with functionality of a product (the goals or tasks it helps you to achieve).

usability (summative). Two other important issues are 'representativeness' and the influence of the researcher that conducts the evaluation.

Empirical methods and inspection methods

In empirical methods participants use a product or a prototype and a researcher tries to measure or observe the interaction and draws conclusions from there. In analytical evaluations product developers try to anticipate user behaviour without involving users, for example by using guidelines, heuristics, or a specific method for mimicking human-product interaction (Nielsen and Mack, 1994; John and Marks, 1997; Lavery *et al.*, 1997; Connell, 1998). The advantages of inspection methods are described as being more time and cost efficient, as they don't require the involvement of users, and can already be used when the design is less mature (and thus much earlier in the process, when there is more possibility to change the design). Examples of empirical usability evaluation methods are usage observation (Kanis, 1998), group-wise interviews (focus groups) (Garmer *et al.*, 2004), thinking-out-loud (Hertzum and Jacobsen, 2001), pair-wise user testing (Jordan, 1998b), questionnaires (Hartevelt and Vianen, 1994). Examples of inspection methods are heuristic analysis (Nielsen, 1992a), GOMS (John and Kieras, 1996), cognitive walkthrough (Karat *et al.*, 1992), and usecue evaluation (Boess and Kanis, 2008).

Formative and summative methods

A second important distinction is between formative and summative evaluation methods. Summative usability activities have the aim of determining how good a particular product is in terms of usability compared with a previous version or competing products, whereas formative usability activities have the aim of finding out what problems are occurring in product use, what the underlying causes are, and to suggest possible solutions (Gray and Salzman, 1998; Preece *et al.*, 2002; Redish *et al.*, 2002). The goal of an evaluation determines how the evaluation will be conducted. For example, in summative tests researchers are less free to intervene and probe participants for comments, as this will affect the measures taken (e.g., errors, deviations from optimal path, time taken per task) and make the circumstances differ per participant (Tamler, 1998).

Evaluator effects

Not just the contextual fidelity of the simulation of human-product interaction during evaluation can affect the results; who conducts the evaluation can also influence the outcome. When conducting evaluations of the same system, using the same usability evaluation method, Hertzum and Jacobsen (2001) found inter-evaluator agreement rates on identified usability problems to range from 5 to 65%. This is in line with earlier findings that whether a heuristic analysis is conducted by an expert or not, and by how many experts, has a considerable impact on the amount of usability problems that are identified (Nielsen, 1992a). Molich *et al* (2004) found that a user test of the same website by different usability laboratories produced very different results. Even if the same tasks had been conducted during the user test, as much as 70% of the problems identified per test were unique. In a study in which usability evaluators evaluated the same user test (on video) they still came to different conclusions on what the source of a usability problem was (Vermeeren, 2009).

2.5.3 If we know all this, what is going wrong?

When going through the above overview of methodologies and methods for user-centred design, one could get the impression that creating usable electronic consumer products is a piece of cake. There is a wealth of methodologies and methods for creating usable products, as well as theories on human-product interaction, user experience and usability. However, as shown in Chapter 1, the usability of electronic consumer products is under pressure. So *something* must be going wrong. Perhaps the methodologies and methods for user-centred design do not actually work in the way their authors claim they do? Can it be that the methods are not known in the electronic consumer products industry, as they have been developed in the HCI community? Or maybe the methods are not applied in practice because they don't take into account the context in which product development teams have to work? The above overview of methodologies and methods for creating usable products should not be considered a description of what *is* happening in product development practice. It is an overview of proposals and best practices brought forward by practitioners and researchers.

In the case studies in the following chapters I investigate the gap between usability in theory and practice. In order to do this it should be defined what these case studies should focus on. A case study researcher cannot just walk out there and note everything that s/he encounters. That would be too much to note, analyse and comprehend. Before conducting a case study an assessment should be made of subjects that may be relevant to include. This is why the following paragraph describes the development of a conceptual framework that captures and communicates what concepts should be the focus of the case studies.

2.6 Conceptual framework for usability in product development

In the previous paragraphs, through a literature review of research on usability in product development practice and through interviews with experts on usability in practice relevant concepts were identified for studying usability in product development practice. In paragraphs 2.2 to 2.5 these concepts were explored and defined further, based on literature about human-computer interaction, product development and user-centred design. In this paragraph these preceding three analyses are integrated into a conceptual framework for usability in product development.

A conceptual framework is an explanation, either graphically or textually, of what the (qualitative) researcher beliefs to be the main things to be studied – the key factors, constructs, or variables – and the presumed relationships among them (Miles and Huberman, 1994, p.18). The goal of creating a conceptual framework for usability in product development (see Figure 26) is to outline the scope of the case study, as well as to make its propositions explicit (Yin, 2009, p.28). As such it also serves as a basis for selecting interviewees and setting up the topics guide for the interviews in the case studies (see for example the topics guide in case study II, Chapter 4). Secondly, visualizing the conceptual framework, as opposed to just having it in textual form, made the relations between the selected concepts explicit, instead of just clustering them.

Build-up of the framework and implications

The framework (Figure 26) is divided into a user domain (above the dashed line) and the product development domain (below the dashed line). The user domain is where consumers 'live', where the product is used, and from where participants are recruited to represent the user in the product development domain. The product development domain is divided into six main categories (from left to right), namely market, company, departments, team, process, and product usage, which are explained further in Table 6.

Together, the main categories market, company and departments form the product development context in which the team can execute the process. As visualized in the framework I assume there is an outside-in influence; e.g., that the properties of a company's market influence how a company is organized, that the philosophy of a department influences the attitude of team members, and that the development team influences how the process is executed.

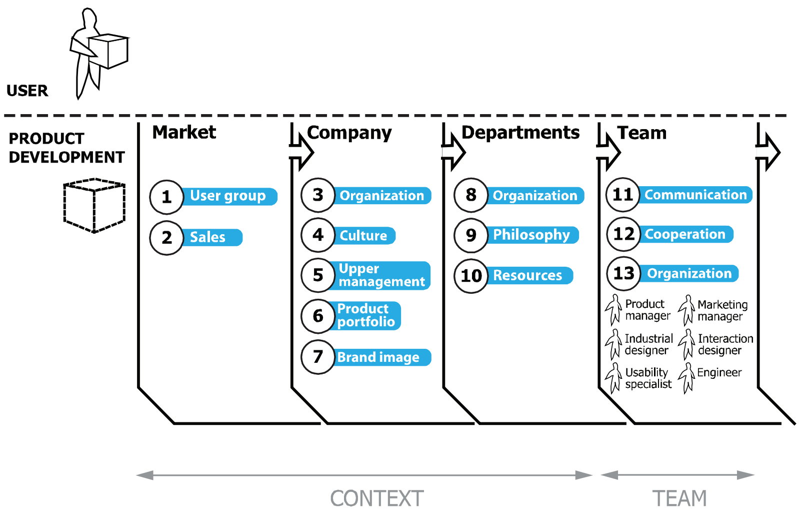
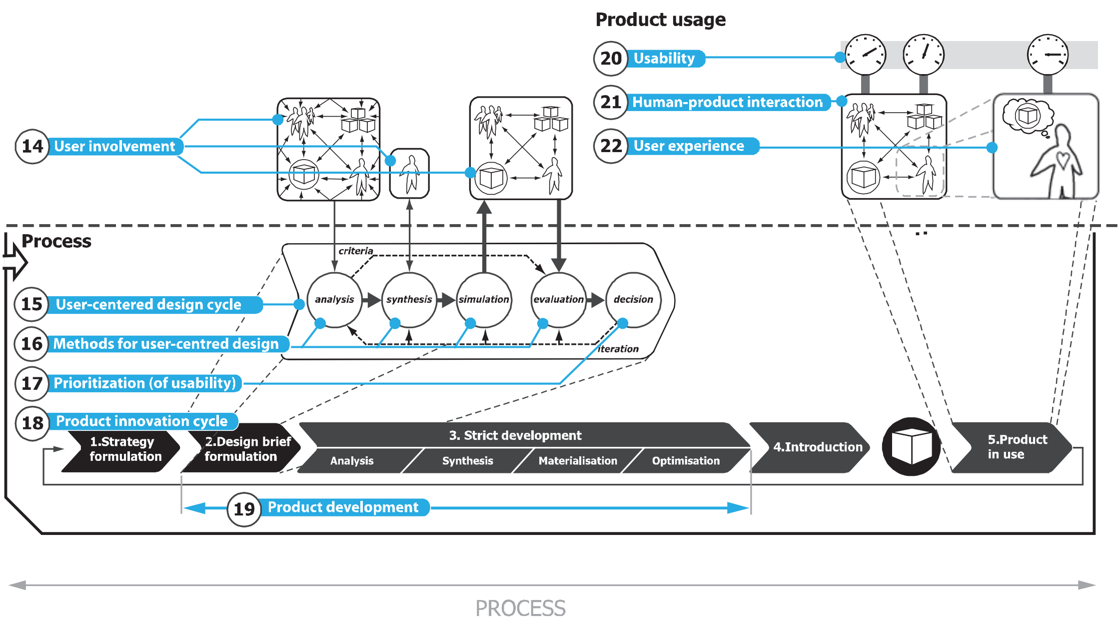


Figure 26: The conceptual framework for usability in product development (figure continues on the right page). The numbers in the framework refer to the definitions in Table 7 on page 71.

Table 6: The six main categories of the conceptual framework.

Main category	Details
Market	A particular area, country or section of the population that might buy goods.
Company	How a product development group and/or its parent company are organized. A product development group is the part of a company that concerns itself with a particular type or line of products.
Departments	How a product development group is subdivided and organized; usually according to discipline, product category or both.
Team	The collection of individuals developing a product (Ulrich and Eppinger, 2004, p.3).
Process	A process is thus a specific ordering of work activities across time and space, with a beginning and an end, and clearly defined inputs and outputs: a structure for action (Davenport, 1993).
Product usage	Where human-product interaction occurs ('Product in use' phase of the DIM).

Within the process the focus is on the phases that constitute product development (design brief formulation and strict development), which means that, though included, less attention is paid to the phases of company strategy and design brief formulation. However, the 'product in use' phase is included, as this is when users interact with the product, and when a company may provide a service through the product, and feedback and business consequences are generated. After the product in use phase, the product innovation



process starts over to illustrate that I consider product innovation to be a continuous, cyclic activity. In Figure 26 it can also be seen that I consider the product innovation cycle to be made up out of user-centred design cycles. In each phase analysis, synthesis, evaluation, etc, activities can be identified.

As product development is a multidisciplinary activity, in the main category 'team' it can be seen that the informants to be involved go beyond just usability specialists and interaction designers, but also include, for example, marketing specialists and development engineers.

The concepts that underlie the six main categories can be found Table 7 (next page), which also includes how these concepts were identified as being relevant (through the literature review of existing research on usability in practice or the exploratory interviews), an explanation of the concept, and references to the parts of this chapter in which this concept is discussed. For the concepts usability, human-product interaction and user experience it is not indicated where they were identified, as these are the concepts that are (related to) the dependent variable of this research, namely usability, so these concepts were an inherent part of the framework.

Table 7: The central concepts of the conceptual framework. The numbers and concepts in the first column refer to the labels in Figure 26. The next two columns indicate how the concepts were identified, and the final column indicates in which parts of this chapter the concept is discussed in-depth. As the final three concepts (usability, interaction, and user experience) are the dependent variables of this study, they were not probed for nor did they surface in the literature review and exploratory interviews.

CONCEPT	**Literature review**	**Exploratory interviews**	**EXPLANATION**	**DISCUSSED IN:**
Market				
1. User group		•	The group of end users that is expected to interact with a particular product, often defined by age, gender, geography and socio-economic grouping.	Central concepts (p.30): the user
2. Sales channels		•	The type of distribution channels (shops, internet) that a company uses to market and sell its products.	Central concepts (p.29): clients, consumers, buyers and users, (p.44): expected and experienced usability
Company				
3. Company organization		•	How the product development group or company is subdivided into organizational units, how these units are related, and how responsibilities are divided.	
4. Company culture	•	•	The attitudes, experiences, beliefs and values of an organization. E.g., user-focused or technology-driven and whether usability is understood and prioritized.	Literature review (p.24): organizational support for usability
5. Upper management	•	•	The general management of a company or product development group, concerned with running the company.	Literature review (p.24): organizational support for usability
6. Product portfolio		•	The range of products that a product development group develops and markets, as well as the properties of individual products.	Central concepts: (p.31) the tool: electronic consumer products, (p.54) product development projects
7. Brand image		•	A consumer's total understanding of a brand (Howard, 1994).	Central concepts (p.44): expected and experienced usability
Department				
8. Department organization	•	•	How a department is subdivided, how its organizational units are related, and how responsibilities are divided.	Central concepts (p.58): cooperation and communication
9. Department philosophy		•	A set of beliefs or an attitude that guides a department's actions.	
10. Department resources	•	•	What an organization can apply to reach its goals. Includes staff, equipment & facilities, and budget.	Literature review (p.21): methods for user-centred design
Team				
11. Team communication	•		Actors from different disciplines share their knowledge about both the design process and the design content, which they do in order to create shared understanding on both aspects (Kleinsmann, 2006, p.38).	Literature review (p.23): product development team, Central concepts: (p.58): cooperation and communication

CONCEPT	Literature review	Exploratory interviews	EXPLANATION	DISCUSSED IN:
12. Team cooperation	•	•	Different roles in the organization integrating and exploring their knowledge to achieve the larger common objective: the new product to be designed (Kleinsmann, 2006, p.38).	Literature review (p.23): product development team, Central concepts (p.58): cooperation and communication
13. Team organization	•	•	The roles that make up the product development team, the backgrounds of the people that fulfil the roles, as well as subdivisions that exist in the team and how the roles relate to each other.	Literature review (p.24): presence and position of usability specialists, Central concepts (p.55): team composition
Process				
14. User involvement	•	•	In what stages of the product development process and to what extent product developers collect input by users.	Literature review (p.21): user involvement, Central concepts (p.59): methodologies for creating usable products
15. User-centred design cycle			An adaption of the basic design cycle by including user involvement and representation (Roozenburg and Eekels, 1991, p.79). Divides user-centred problem solving behaviour into analysis, synthesis, simulation, evaluation, decision, iteration.	Central concepts (p.61): the user-centred design cycle.
16. Methods for user-centred design	•	•	Handling processes in which structural elements are arranged time-related in respect to each other (Roozenburg and Eekels, 1991), for use in each of the steps of the user-centred design cycle.	Literature review (p.21): methods for user involvement, Central concepts (p.61): user-centred design cycle
17. Prioritization of usability in projects		•	How important team members consider usability to be, also in relation to other product considerations.	Literature review (p.25): prioritization of usability in projects
18. Product innovation cycle	•	•	Description of product innovation based on the Delft Innovation Model (DIM) (Buijs and Valkenburg, 2005). Each of the phases of is a (user-centred) design cycle.	Central concepts (p.50): the Delft Innovation Model
19. Product development	•	•	Conceiving, developing, and market introduction of a new product (Buijs and Valkenburg, 2005).	Central concepts (p.50): product development
Product usage				
20. Usability			The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (ISO, 1998, p.2).	Central concepts (p.39): Usability
21. Human-product interaction			Bi-directional information exchange between users and equipment, in which information exchange may include physical actions, resulting in sensory feedback (ISO, 2007a).	Central concepts (p.30): framework for human-system interaction, (p.35), human-product interaction for electronic consumer products
22. User experience			Constant stream of 'self-talk' that happens while and after interacting with a product (Forlizzi and Battarbee, 2004, p.263).	Central concepts (p.37): user experience

Chapter 3 | **Case study I**

Exploring usability in product development practice in four adjacent markets

Chapter 3: Case study I

Exploring usability in product development practice in four adjacent markets

In the previous chapter central concepts, synthesized into a conceptual framework, were described that could serve as a guide for setting up case studies. This chapter describes the first - exploratory - case study. In order to explore usability in product development practice, as well as to gain experience with the case study method, interviews were conducted with nineteen product development professionals in product development groups operating in four differing markets. The development groups were active in high-end automotive, fast-moving consumer goods, office coffee machines, and professional printers and copiers. The goal of this first case study is to assess the suitability of the method for studying usability in practice as well as to improve the method. As such, this study has a pilot-like character. Secondly, studying adjacent markets provides a possibility to compare the findings from the subsequent case studies in the electronic consumer products market, and thus provides the possibility to assess the generalizability of the subsequent case studies.

The goal of this study is to identify how companies deal with usability in their product development activities. Based on this, the following research questions were formulated:

1. How is usability dealt with in product development practice?
2. What variables in product development practice contribute to or obstruct the usability of the products that are developed?

To limit the scope of the study, the focus was put on three of the concepts identified in the previous chapter, which are (1) the product development process that a company employs (including user involvement), (2) the composition of and cooperation within the product development team, and (3) the attitude towards and prioritization of usability. In Chapter 2 the first two concepts - development process and team - were defined as being the focus of the case studies, and the attitude towards and prioritization of usability surfaced as an influential factor in both the literature review and the exploratory interviews.

Paragraph 3.1 discusses the research design and method. In paragraphs 3.5 to 3.2 the findings at the four cases are described, outlining the case context description as well as the barriers and enablers for usability per company. In the cross-case analysis (3.6) a comparison is made between the product development groups of the case context descriptions and barriers and enablers, in order to explore differences and similarities. In paragraph 3.7 the results of a feedback workshop with the participating companies are described. Finally, in paragraph 3.8 the conclusions are presented and in paragraph 3.9 I reflect on the implications of this case study for the setup of the subsequent case study that focuses solely on companies in the electronic consumer products industry (Chapter 4).

3.1 Research design

This case study has a multiple case design with each case being a holistic case (Yin, 2009, p.59), and uses interviews as the primary source of information. Apart from being a relatively time-efficient data source, interviews have the benefit of being very insightful as the interviewees provide their perceived causal inferences (Yin, 2009, p.102). The unit of analysis (Patton, 2002, p.228-229; Yin, 2009, p.29) of this study are product development groups of large product development organizations, with the product development process as the focus.

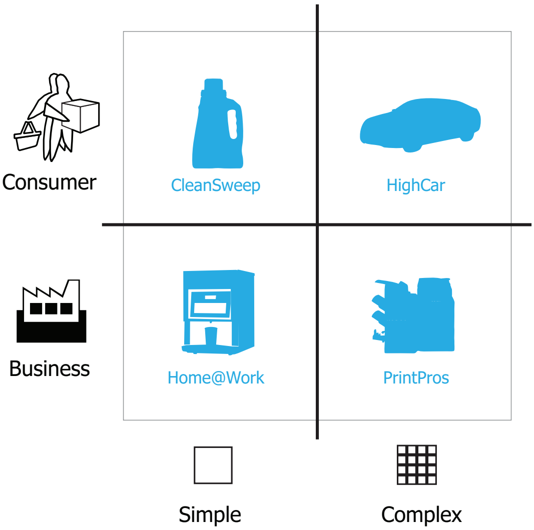


Figure 27: Distribution of the cases across markets (business versus consumer) and degree of product complexity (simple versus complex). CleanSweep was the household care division of a multinational making fast-moving consumer goods, HightCar developed sophisticated cars, Home@Work in-office coffee vending machines, and PrintPros professional printing and documentation systems.

Case selection

A maximum variation case sampling strategy was employed, the purpose of which is to explore variations and identify important common patterns (Miles and Huberman, 1994, p.28). The primary differentiators of the cases (see Figure 27) were whether they were targeting businesses or consumers (Chapter 2, p.29) and the degree of product complexity (Chapter 2, p.34).

Large-scale multinational companies in Western-European countries participated in the study. As the aim was to study how usability was dealt with in multidisciplinary product development teams large-scale companies were contacted, as these are more likely to feature multidisciplinary teams with specialized roles.

Researchers

This case study was conducted by two researchers and supervised by two experienced researchers. Table 8 describes the researchers involved in setting up and executing this case study, their backgrounds, and which parts of the study they conducted or supervised.

Table 8: The researchers who setup, executed and supervised the study.

Researcher	Background	Tasks
Primary researcher	Graduate student at the Design for Interaction Master's program at the Faculty of Industrial Design Engineering of Delft University of Technology. Previously obtained a Master's degree in cognitive psychology.	Set up and conduct interviews Per-case analysis Cross-case analysis Organize feedback workshop Write/review final case description
Secondary researcher	PhD candidate, author of this thesis	• Set up research design • Supervise graduate student • Cross-case analysis • Take part in feedback workshop • Write/review final case description
Supervisor A	Experienced user-centred design professional, researcher and supervisor of PhD candidate	• Supervise graduate student
Supervisor B	Experienced researcher in the area of new product development	• Supervise graduate student

Interview setup

The interviews took place in a private setting, either a closed-off office or a conference room and were recorded on a digital audio recorder. Each interview took between one and one-and-a-half hours. Overall nineteen interviewees were selected based on two criteria: (1) s/he was closely involved in the product development process; and (2) s/he fulfilled a role that allowed him/her to provide a perspective on the practice of product development and usability. Based on the analysis of development team compositions made in Chapter 2 the following roles were selected as interviewees:

- Product/project manager: coordinates product development, determines priorities;
- Marketing manager: collects market information, defines marketing strategies;
- Designer: transforms product requirements into specifications;
- Usability specialist: evaluates and improves the usability of products;
- Development engineer: responsible for technological and production aspects.

The primary researcher was introduced to the interviewees as studying design processes in practice. The term usability was not mentioned in order to prevent response bias. The purpose of the interview set-up was to provide the opportunity for the interviewee to share as much as possible, but to also touch upon pre-defined subjects. The actual wording of questions was not determined in advance, but the research did use an interview topics guide (Patton, 2002, p.343), containing the following subjects:

- Personal data and background information;
- Introduction (goal and setup of interview, anonymization, interviewee background);
- Description of product development (process, team) at development group;
- Description of interviewee role in product development;
- Interviewee's description of usability;
- Usability-related activities in product development at company;
- Personal involvement of interviewee with usability-related activities;
- State of usability at company and possibilities for improvement;
- Interviewee attitude towards usability;
- Success factors for usability.

Data analysis

The segments of the interview that the researchers interpreted as relevant were transcribed literally. The resulting documents were sent to the interviewees for verification before analysis commenced. All descriptions were identified that contained properties, situations or conditions that were obstructing for or contributing to usability, which were labelled barriers and enablers (Kleinsmann, 2006, p.74). For each company the identified factors (both barriers and enablers) were categorized according the three pre-defined subjects: (1) product development process (including methods for user-centred design), (2) working in a multidisciplinary team, (3) attitude towards usability. In addition there was a category for 'remaining issues'; for capturing relevant issues that did not fit the pre-defined categories. The analysis of each company, consisting of a context description as well as of an overview of barriers and enablers, was verified by a representative from the company it referred to. Finally, a cross-case analysis was conducted in which we[14] analysed the similarities and differences between the companies (Yin, 2009, p.156).

Paragraphs 3.5 to 3.2 provide an analysis of each company, including a company description company and an overview of the main barriers and enablers for usability. For each of the companies a description[15] is provided of its (1) product development process (including methods for user-centred design), (2) team composition, and (3) attitude towards usability. Subsequently for these three topics the barriers and enablers for usability are outlined.

---

[14] In this chapter 'we' is used to describe activities in which both researchers were involved, 'the primary researcher' to describe activities undertaken solely by the graduate student, and 'I' to describe activities and decisions by the secondary researcher (the PhD candidate).

[15] I chose to report context descriptions in past tense, as they are descriptions of a situation that existed at a certain point in time. Though the descriptions were 'true' then, and the described situation actually occurred, I do not make claims that this situation remains or is always the case; there is no general truth to the description.

3.2 CleanSweep | fast-moving consumer goods

CleanSweep was a product development group in the household care division of a multinational developer and manufacturer of fast-moving consumer goods with over 100.000 employees worldwide. The division developed products for cleaning and maintaining homes, which should be based on a thorough understanding of consumer needs and habits. With regard to human-product interaction, the packaging of CleanSweep's products played an important role as it (1) enabled the use of the product, e.g., a broom for floor wipes, and (2) kept the contents (powder, wipes, etc.) together, e.g., in the case of bottles and tubes.

3.2.1 Context description

Development process

Within CleanSweep there were two types of product development processes (Figure 28): one focused on improving existing products, while the second, innovation projects, encompassed the development of new products. A project took about one to three years, depending on the type of project. In innovation projects, in-depth interviews with consumers were organized to identify opportunities. Once such an idea had been formulated, brainstorm sessions were organized leading to a so-called idea board: a sketch of the idea complemented by a few sentences to explain the concept. Idea boards were subsequently evaluated with consumers in order to narrow down the amount of ideas.

The most promising idea was then described in a concept board, consisting of three parts: (1) the insight on which the concept is initially based, (2) the benefits of the concept to the consumer, (3) the reason for the consumer to believe that the concept would answer to the promises it makes. The concept was then brought into a quantitative consumer evaluation (concept & use test) involving about 250 consumers per country, to assess whether the product would be a success or not; whether there is a need for the product. If this was assessed to be the case, the next stage was to establish a project. Subsequently the products were prototyped in foam or plastic and evaluated with consumers in appropriate contexts, which was usually in the homes of consumers.

With all qualitative feedback gathered, optimization was started: many cycles of improving and evaluating with consumers. After that the project team started developing the necessities for the production line. A first sample of the product was used to conduct a second concept & use test: the product was sent to consumers to be used at home for a couple of weeks. If the results were good, the concept was presented to upper management in order to receive project commitment so that the required investments could be made and production could be initiated.

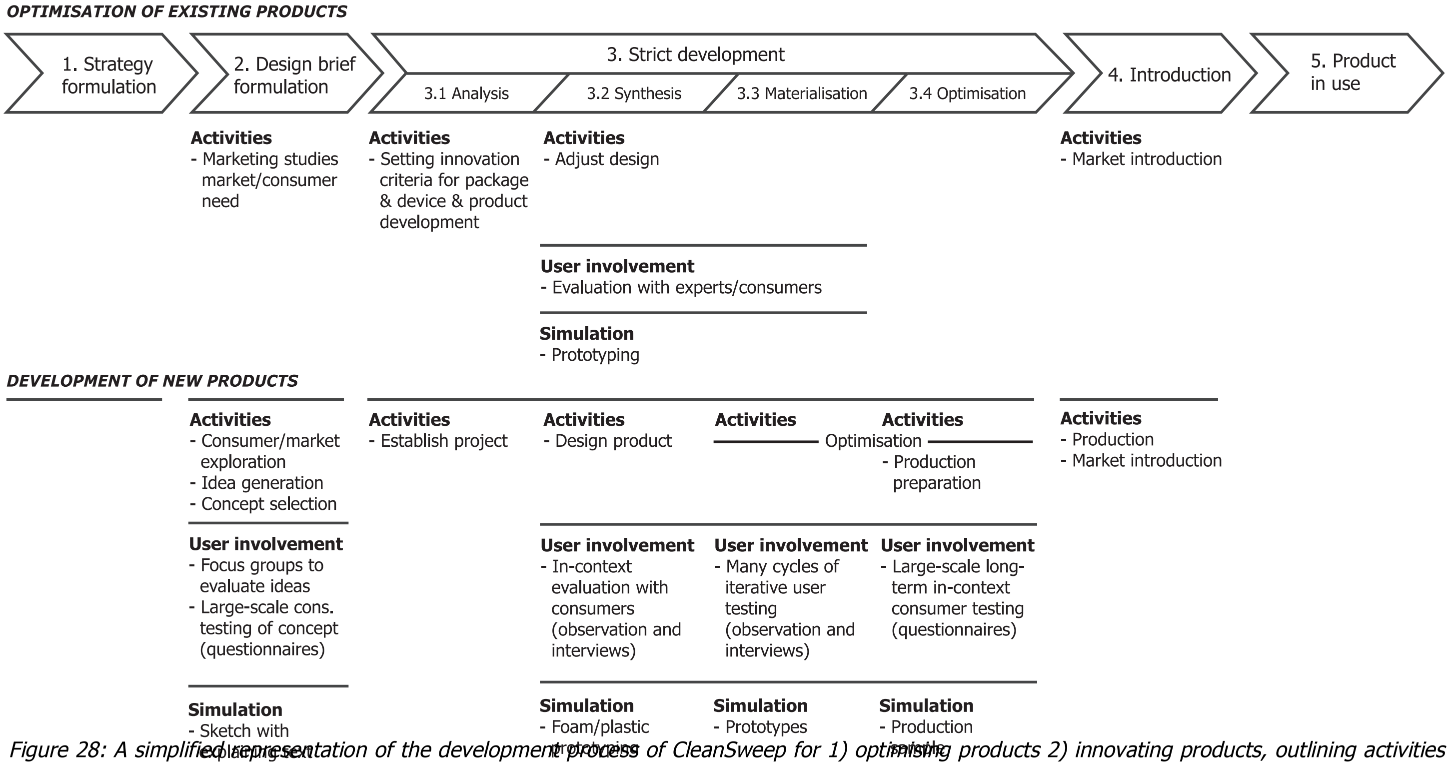


Figure 28: A simplified representation of the development process of CleanSweep for 1) optimising products 2) innovating products, outlining activities per phase, as well as methods for user involvement and simulation mapped on a linear representation of the Delft Innovation Model (Buijs and Valkenburg, 2005) (see Figure 21).

Multidisciplinary teamwork

Typically, someone from product research or marketing would head the product development team. Team composition changed per phase of the project, and featured representatives from marketing, consumer market knowledge (sets up meetings with customers), product development (makes the powders, wipes, fluids, etc.), package & device development, design, manufacturing engineering, regulations officers, finance, and external relations.

Product research was the department responsible for the research of all consumer-related research, including usability-related aspects, conducting interviews, qualitative evaluation sessions with idea boards and quantitative concept & use tests.

Project teams held weekly meetings, either involving solely R&D or a broader group. About every two months project progression was reported to upper management in steering committee meetings.

Attitude towards usability

Usability was generally seen as an aspect contributing to the success of a product: if a product is inconvenient to interact with, it will not be bought again and a more convenient packaging may even compensate for less effective contents (e.g., in the case of cleaning solvents).

Previously, CleanSweep had been mostly focused on creating products that would answer customers' demands and expectations, but recently there was also more attention for whether the products appealed to buyers in the stores. With regard to making products that satisfy customers, the convenience and performance of the product itself (e.g. powder, cleaning solution, etc.) had always been a major point of focus and also the usability of the parts of products that facilitate usage (e.g., a broom for floor cleaner pads) received attention. The company was increasingly investigating the user-product interaction with containers (e.g., bottles and boxes).

Besides those of the end-user, CleanSweep also took into account the demands of its clients (retail companies) on who the company relied to sell its products. The company had no explicit, shared definition of usability (see interviewee definitions and descriptions of usability in Appendix B).

3.2.2 Barriers and enablers for usability

Development process

Enablers

- During product development, CleanSweep aimed at choosing the appropriate method to reach the goals that were set, rather than sticking to a set of methods.
- Interviews were often performed in the homes of consumers, which was considered to lead to a higher 'reliability' of information.

- In case a project team had created a concept but a prototype was not yet available, concept boards were found to be a practical substitute for evaluating the concept with consumers.
- The previously mentioned context and concept boards were found to help to obtain rich information from consumers, which in turn facilitates the creation of a good product proposition.
- Competitor products were used as a benchmark to assess whether a product is an improvement even though it is completely new to CleanSweep's portfolio.
- There was a desire to take usability into account already during design phases, as there is more opportunity to change the design in this stage.

Barriers

- In case no user problems emerged during a concept & use test, no further examination was conducted into any other usage-related aspects, of for example the packaging, because further user testing was not a standardized activity in the development process. As a consequence it was hardly ever revealed *why* a consumer might like (or dislike) a bottle or a box.
- Evaluating a product's usability was done in a rather late stage, at which point there is minimal opportunity to change a design.
- Even if consumer evaluations pointed out that a particular concept really appeals to consumers in multiple ways, there might be limited possibilities to actually make the necessary changes to production lines required to produce the product.

Multidisciplinary teamwork

Enablers

- Having talented drawers and prototype builders on the project team was considered beneficial as, for instance, a designer with good drawing skills can be helpful during consumer sessions with idea boards: in case a consumer gives an inspiring comment, the designer can react to that by instantly adapting an idea board and verify the new visualization with the consumer.
- To translate consumer feedback successfully into product features, product researchers organized and ranked information: this helped the designers to interpret the feedback and creating suitable concepts.

Barriers

- There was a tendency to perceive quantitative results as a better starting point for creating new concepts and to dismiss qualitative studies/evaluations as being unreliable.

Attitude towards usability

Enabler

- To receive project commitment (investment of capital) from upper management, the team was obliged to have collected consumer feedback concerning the concept at least once.

Remaining issues

Enabler

- A desire was expressed for increasing knowledge about user-related aspects by building, maintaining and using a knowledge database. This was considered a systematic and 'scientific' way to integrate usability in the design process. Being able to review previous user tests would make it possible to make an assessment of an idea in the early stages of a project.

Barriers

- Because the concept & use tests were quantitative in nature, they usually involved a large amount of data. As a consequence, product researchers often found it quite complex to understand all the data, and to detect patterns, which made concept & use tests very time-consuming.

3.3 HighCar | high-end automotive

HighCar was a Western-European developer and manufacturer of high-end cars, with more than 50.000 employees. The HighCar brand was considered to stand for advanced technology, progressive design and sustainability.

3.3.1 Context description

Development process

A product development process at HighCar (Figure 29) took about five years. At the start information was gathered on trends, ideas, customers, new technologies, etc. Then a product planning team was compiled, which started to create the overall concept for the new car. Based on the first ideas and information a 'dimension concept' was created, which, in combination with interior components and the engine/wheel/axis base, was conceptualized into a 'package model' and a dimension plan (list of requirements). Based on the requirements the design department first defined the outward appearance of the car, after which work would start on the interior design. Interviewees stressed that at HighCar the exterior design had priority over the interior design. After the sketching-phase, models were made, in the computer as well as in clay.

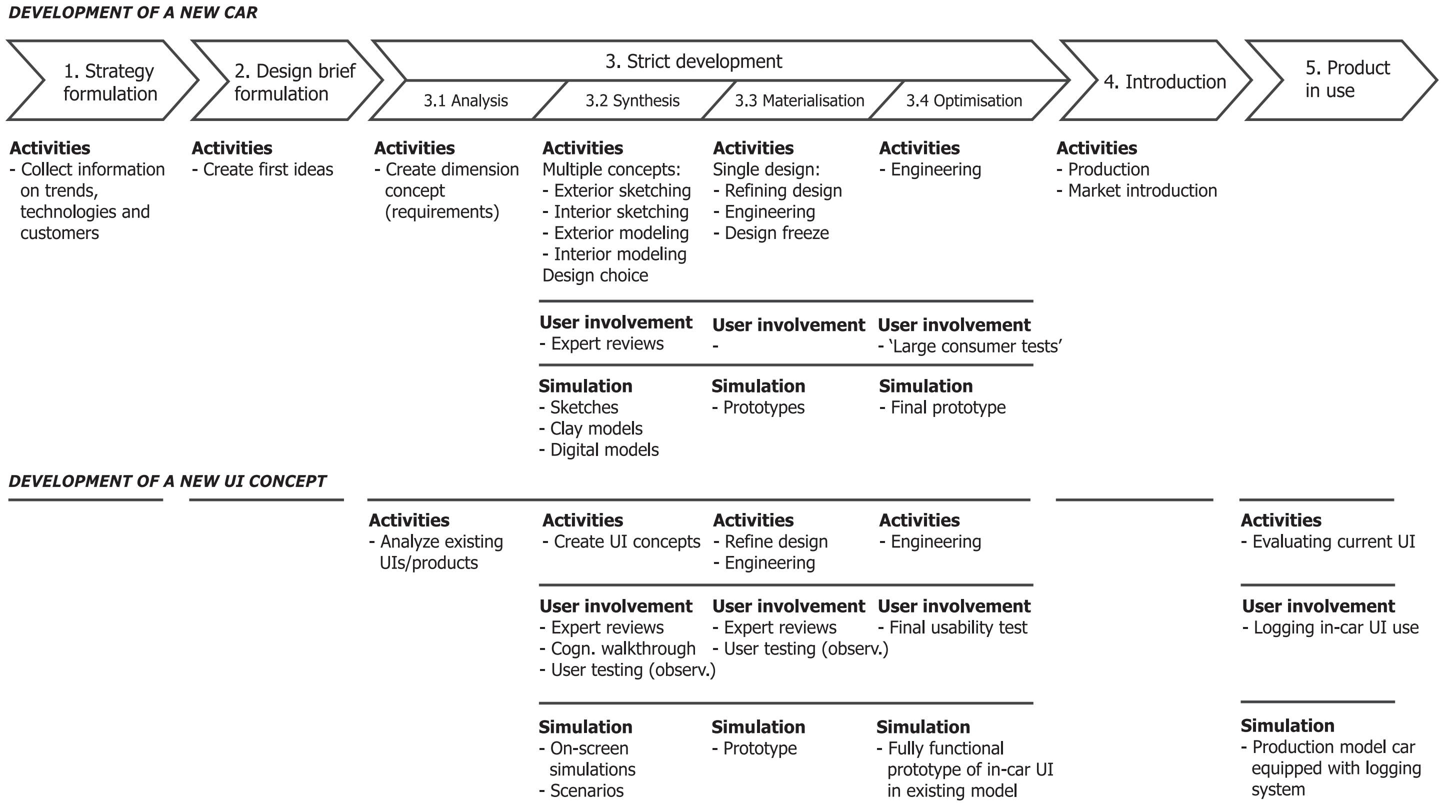


Figure 29: A simplified representation of the product development process of new cars (upper part) and new UI concepts (lower part) at HighCar, outlining activities per phase, as well as methods for user involvement and simulation mapped on a linear representation of the Delft Innovation Model (Buijs and Valkenburg, 2005) (Figure 21).

Out of multiple competing exterior and interior models, one exterior model and subsequently the most suitable interior model were chosen. At this point the development departments started implementing the design. About two years later the product development project was finished and production could start. The development of a new user interface, which can be applied across models, was considered a separate product development project.

In the early stages, usage of existing machines or products of any kind was analyzed, in order to translate existing solutions to user issues in a car, and expert reviews were conducted. During the development process prototypes and simulations of the car concept were built and usability tests were conducted, using techniques such as observational research, interviews and checklists. In the final stages of development usability was once more evaluated, through a final usability test. In some cases a car equipped with a logging system could be used for collecting data about all user interaction.

Multidisciplinary teamwork

A representative from Technical Development led the early stages of product development, but all departments had representatives in the product planning team. The director of the board had the final responsibility for the products and was very influential in decision-making. HighCar had a design department with separate divisions for interior and exterior design. For the development of user interfaces, a team was assembled wit representatives from Design, Ergonomics and Electronics. When usability test results were discussed, psychologists and usability test experts would assist the team. Recently a department for UI concept development had been established, which was concerned with every switch, knob and display with which the driver interacts. When doing large-scale consumer or usability tests HighCar would at times work together with research institutes, universities or market research firms.

Attitude towards usability

Interviewees indicated that buyers mainly purchased HighCar's cars because of their styling and performance; practical usage aspects (i.e., usability) were believed to be less important. However, long-term (production) quality and usability were mentioned as important purchase considerations. Usability was considered hard to measure, and therefore it was hard to assess its contribution product success. The company had no explicit, shared definition of usability (see interviewee definitions descriptions of usability in Appendix B).

3.3.2 Barriers and enablers for usability

Product development process

Enablers

- At the start of a project, to derive learnings that could be applied to the design of a car, the team studied the usage of a wide variety of products, from other types of vehicles to computer games.
- User tests of user interfaces were preferably conducted with more than one concept, which allows for the comparison, and thus for a more grounded choice.

Barriers

- Modelling digitally might be helpful in early development stages; however, it does not provide the sensation of a real model, which was considered essential for an evaluation of the car concept (both exterior and interior).
- It was difficult to evaluate cognitive ergonomic aspects in the early phases of UI development, as in this phase no functional prototype was available yet, which is a prerequisite for a user test.
- HighCar did not apply a standard user test format, but customized the setup of the evaluation depending on the question at hand. However, it was considered not efficient and rather discouraging to completely set-up a usability evaluation test time and time again.

Multidisciplinary teamwork

Enablers

- When developing interfaces three departments were continuously collaborating: (interior) design, ergonomics and electronics. Especially a good cooperation between ergonomics and design was seen as a contributor to making usable user interface designs.
- A good network between departments was considered essential for sharing information and changing a design to improve usability, as the latter requires multiple disciplines to work together.
- With regard to convincing decision makers, the experience was that showing alternative concepts of, e.g., an interface, contributed to understanding and therefore persuasion. Being able to provide precise information about a concept's advantages and disadvantages, preferably in the form of models or mock-ups, was considered a powerful communication tool between developers and the board.

Barriers

- A user interface in a car is intertwined with the overall interior of a car and does not have its own inherent shape or design. For successful communication to other team members or decision makers an operating concepts developer was dependent

on the availability and visualization skills of a designer that would visualize the concept.
- It was indicated that HighCar would do better in terms of usability if there would be a larger group of people working solely on the topic of usability testing, and when if there would be a usability lab.

Attitude towards usability

Enablers

- HighCar staff had the attitude that a product is never finished: there is always room for improvement.
- At the time human-machine interaction was a relatively unexplored area in the automotive industry. This provided the company with the opportunity to pioneer the field, which increased motivation to pay attention to interaction aspects.

Barriers

- Design was perceived as a very important role in product development. Yet, their main responsibility was styling and the designers were not encouraged to take usability into account.
- The opinion of upper management about an idea or concept had a very high impact. The highest manager considered himself to be one of the most ideal test persons concerning any aspect of HighCar-cars, which might not actually have been the case.
- The automotive sector was described as a conservative industry that was somewhat reluctant to innovate, also on the level of human-product interaction.
- Automotive design was described as focused mostly on the exterior aspects of the car, such as performance and styling. Subsequently, user interfaces and usability issues were considered to never be a designer's most important considerations.

3.4 Home@Work | in-office coffee machines

Home@Work developed coffee concepts for the out-of-home market (mostly offices environments). Next to coffee and tea, it aspired to deliver the best coffee equipment as well as technical services. The company had formulated the ambition to continuously overwhelm its consumers with the enjoyment and richness offered by its coffee and tea serving products and concepts. Though its end users were people who drink the beverages, such as office workers, Home@Work's clients were office managers, and thus Home@Work operated in a business-to-business market.

3.4.1 Context description

Development process

Home@Work developed products according to its own standardized New Product Development (NPD) process (Figure 30). After an opportunity or a problem in the market had been identified, idea generation and concept definition took place. This was followed by a feasibility and specification phase, and in turn by development, which consisted of three sub-phases: basic design (which also might be done during feasibility), detail design/engineering, and prototyping. In the subsequent market test stage about forty coffee machines would be distributed among clients for a test period of roughly four months. In crucial projects a smaller, internal 'market-test' was conducted before the actual market test. When the product passed the market test, market introduction was prepared.

Additionally, preceding this NPD process there was an innovation process during which idea generation was supported by insights gained through sessions with clients and consumers.

Previously, involving end-users had been done on a rather ad hoc basis, but at the time of research the company was heading towards more user involvement. Usability tests, with external test users, were conducted once there was a prototype of the machine, which was halfway the development phase. Occasionally usability was tested in an earlier stage, using so-called low-fidelity (see page 64) prototypes (e.g., drawings) to represent the different states of a display. Home@Work's own operators and service engineers usually evaluated a first production sample on operator friendliness. Incidentally, information about usage of a machine was gathered by video recording user interactions with a former version of a coffee machine.

Multidisciplinary teamwork

The core team during product development consisted of an overall project manager, a technical project manager, a number of technical specialists, a manager technical support (responsible for maintenance aspects of the machine), and a marketing product manager. Early in the process, during idea generation and concept definition, a concept developer was essentially the only person involved, sometimes in cooperation with a marketing manager. After concept definition, the concept developer left the team, which was then expanded with technical developers, distribution representatives, a marketing person and a project manager. Designers were usually involved from the feasibility phase onwards; occasionally they were engaged already at the end of the concept definition. User tests were either carried out by Home@Work or by an external human-centred design consultancy.

Within Home@Work brainstorm session and meetings (which were often described as being time-consuming) were common in every phase of the project. Idea generation and concept definition were executed with a smaller group of people, because otherwise decision-making efficiency would decrease.

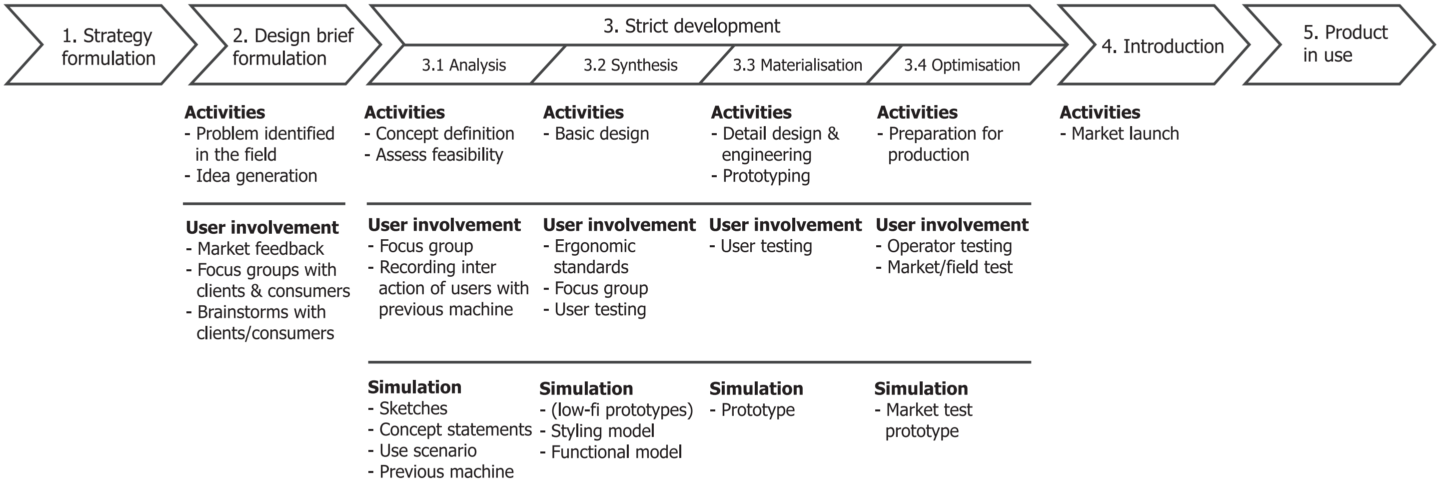


Figure 30: A simplified representation of the product development processes of office coffee vending machines at Home@Work, outlining activities per phase, as well as methods for user involvement and simulation mapped on a linear representation of the Delft Innovation Model (Buijs and Valkenburg, 2005) (Figure 21).

Attitude towards usability

At Home@Work the most important product aspect was the quality of the coffee. There was also a strong focus on maintaining the brand identity, which incorporated style, solidness, usefulness, high ergonomic standards and hygiene. Other key aims were ergonomic standards for service engineers and operators, who are respectively responsible for maintenance and refilling the coffee in the machine. Home@Work considered its products to be advanced in terms of usability, in comparison to their competitors. Additionally, the company perceived coffee machines as fairly simple products (compared to e.g. mobile telephones), which are thus "inherently easy to use". Usability was seen as a potentially product differentiator, but was not regarded particularly exciting. The client (who buys the device) and the consumer (who drinks the coffee) were the main stakeholders of Home@Work's product development teams. Also consideration was given to the interaction of operators with the machines. The company had no explicit, shared definition of usability (see interviewee definitions and descriptions of usability in Appendix B).

3.4.2 Barriers and enablers for usability

Product development process

Enablers

- To optimize the execution of user evaluations in the concept phase, during these evaluations it was monitored whether the concept presentation (concept statement, visualization and/or use scenario) was understandable to a client or consumer. If not, the presentation was changed.
- At Home@Work there was a belief that the quality of a product is related to the number of tests to which it is subjected, which includes usability tests. This stimulated the execution of usability tests.
- Design guidelines were seen as a contributor to creating a more usable design.
- Development of the UI was at times a separate process from that of the coffee machine itself. In a user test of the interface it was considered important that the simulation provided a similar experience as a real machine, which was done by fitting an existing product with redesigned components.
- It was considered crucial to identify, before conducting usability-related activities, exactly what information the product development team needed, and for what purpose.

Barriers

- Within Home@Work the results of formative user tests were not considered very convincing, due to their qualitative character and small number of participants.

- It was not unusual that, during (late-stage) market test a lot of usability problems were revealed, even though the machine was evaluated on usability at an earlier stage in the project. This was attributed to the fact that in the market test, users had to operate the machine on their own, whereas in the earlier usability test, the user would was continuously accompanied by a test leader.
- Home@Work found it difficult to uncover which functions (especially of their high-end machines) were actually being used.
- As Home@Work's products were used in a wide variety of usage contexts it was difficult to define the context of usage for a product (i.e., a coffee machine).

Multidisciplinary teamwork

Enablers

- To convince management of a selected concept, it was considered helpful to show videos of concept evaluations with clients/consumers, in order to reinforce the selection considerations with the more 'emotional' impact of the videos.
- When a product was tested on usability aspects, it was considered important that the development team attended one of the tests, which makes it easier for the team to interpret - and subsequently implement - test results.
- For a usability problem to be dealt with, it needs to be understood and acknowledged by all team members involved in the product development process.
- The external human-centred design consultants considered it a benefit that they were not involved in design activities, because then they would not be able to provide an objective evaluation of the design.

Barriers

- The coffee machines that Home@Work developed had very dissimilar designs. It was argued that there was a need for an overall design manager to ensure that the concept of a new coffee machine aligned with existing product concepts, especially with regard to the user interfaces.
- The involvement of usability or interaction specialists in product development was prompted by a team identifying a human-product interaction issue. Usability and interaction specialists were not pro-actively involved in product development.

Attitude towards usability

Enablers

- Home@Work had the ambition of conducting more user involvement; to evaluate early product *ideas* with clients/consumers in a structural way, instead of ad hoc.
- There was a belief that even though making a product usable may not increase profits right away, it will result in more loyal customers, which in turn contributes to the success of the company.

Barriers

- At Home@Work the notion existed that the (end-)user interface of a coffee machine is not at all complicated, so the chances that something goes wrong during usage are minimal. This reduced the priority of usability.
- User testing was not considered very 'exciting' by some product development team members and thus not worth spending a lot of resources (time and money) on.
- Within Home@Work there was a tendency to think that there was sufficient know-how on how to design usable products inside the company and that thus user testing was not (always) necessary.
- Upper management was mostly focused on selling coffee and did not have a very thorough understanding of how to conduct product development. As a consequence development time was limited, and, with that, the available time for evaluating concepts on, for example, usability.

3.5 PrintPros | professional copiers & printers

PrintPros was a developer of printing equipment and digital document solutions for the professional domain. Its goal was to assist office workers or printing professionals in producing, distributing, presenting and archiving (digital) documents by offering a combination of ICT applications and productive and usable equipment. PrintPros operated in a business-to-business market, serving mainly offices and professional printing studios.

3.5.1 Context description

Development process

Each development project started with a project definition, based on an exploration of markets and technologies (Figure 31). After the approval of the project definition the actual development process started. The process consisted of several phases, and overall could be divided into two distinct parts: (1) translating the project definition into requirements and next into a technically feasible product concept, and (2) refining the concept further into an actual product. After market introduction the product was monitored to learn about 'child diseases' and acquire buyer/customer feedback.

At the start of a project usability engineers would conduct user research and communicate this information to the team, for example, through personas. A usability test was usually set up in such a way that people of the project team could attend the test so they could see users interacting with the product. Or afterwards they could watch a video compilation. Analysing user test results, as well as recommending design changes, was usually done by a usability engineer in cooperation with an interaction designer. The team believed that every usability-related research question demands a specific approach and thus methods.

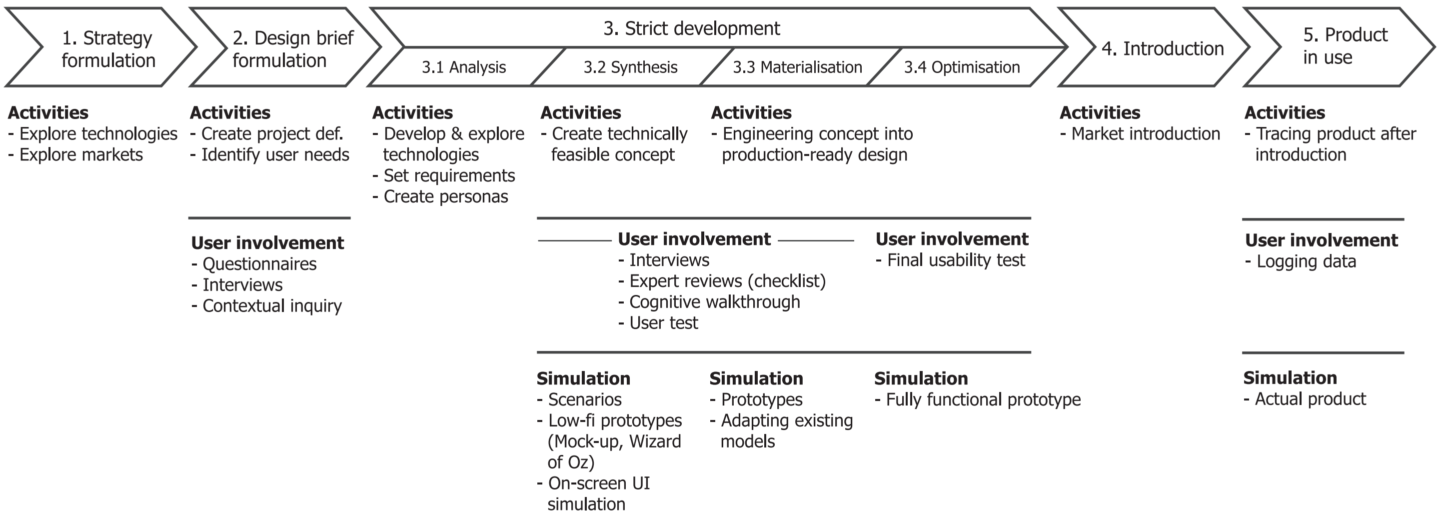


Figure 31: A simplified representation of the product development processes of professional printing products at PrintPros, outlining activities per phase, as well as methods for user involvement and simulation mapped on a linear representation of the Delft Innovation Model (Buijs and Valkenburg, 2005) (Figure 21).

Multidisciplinary teamwork

Over the course of a project a team worked in sub-teams that, each under supervision of a sub project leader, were responsible for a different aspect of the machine. One of these sub-teams was responsible for the user interface and consisted of all disciplines needed for realising a UI concept (i.e., software, construction, product design, graphical design, interaction design and usability engineering). Often there was also a group of people responsible for the interaction with the product as a whole, beyond the user interface, formed by designers, software and hardware engineers, and often the project leader.

Sub-teams of a project, including the sub project leader, were usually located together in a single workspace, which was said to facilitate cooperation in the team. Brainstorms and discussions with multidisciplinary groups were organized frequently. The organisation featured two usability engineers, working from within the industrial design department, who were mainly engaged in setting up and conducting usability tests and analyzing test results. The usability engineers were usually involved as experts in one main project, but were involved in parallel in setting up user tests for other projects.

Attitude towards usability

Usability was one of the focus points of product development, as PrintPros perceived usability as something that set its product apart from the competition. Usability was not considered to directly influence sales numbers, but to improve customer loyalty. Other important considerations were productivity, reliability, quality and costs. Interviewees indicated that because some managers, who did not consider usability a very exciting subject, were at times inclined to pay less attention to it. Among the usability experts there was an attitude of never being satisfied with the result of a product development project: there is always an opportunity to improve the product.

Within PrintPros there was no explicit, shared definition of usability (see interviewee definitions and descriptions of usability in Appendix B). Team members were conscious that their products had to appeal to purchasers, as well as satisfy end-users. In the past the concept of usability had been mostly applied to evaluate human-product interaction, but the company had recently started to apply it to evaluate how products fit operator workflows.

3.5.2 Barriers and enablers for usability

Development process

Enablers

- When developing a completely new product, usability issues were considered from the start.
- Usability-related findings from previous projects were consulted.
- Even after product launch user feedback sessions were organized to acquire information about usability issues in the final product.

- Many iterations of smaller-scale tests and redesigns were preferred over a single, but extensive design-test cycle. Many iterations were believed to lead to a higher number of identified and fixed usability issues.
- During user tests the tasks the participants had to perform were formulated as a desired outcome (goal), which should prevent participants being (mis)guided by the instructions.
- PrintPros made use of personas to put the user front and centre already at the start of a project, which results in more consistent early design decisions.

Barriers

- Identifying a product's (core) functionality was considered hard (even for products that had been on the market for a while), as users find it hard to formulate what functionality they would like in a product.
- Test results can vary considerably, depending on whether it is conducted with internal or external participants.
- Stimulus material influences outcomes: user testing with only a user interface was believed to cause a different user experience than testing with a complete product.
- Early testing usually involved immature stimulus material and was conducted with internal participants. Both aspects were considered to possibly influence the 'external validity' of the test results, and thus the appropriateness of resulting design decisions.
- The transfer of information from user tests from one project to the next is complicated by the fact that it may not be clear what information is needed in the new project.
- The lack of a knowledge database made the retrieval of past user test results dependent on recollection by and communication between team members.
- Users did not have a channel to share their thoughts, complaints and questions with the R&D department.

Multidisciplinary teamwork

Enablers

- The design department was involved from the start of a project, which reduced the focus on purely technical aspects and made the project more user-focused from the beginning.
- When sharing user test results with the development team, the presence of usability engineers and interaction designers was considered to improve the translation of results into design specifications.

Barriers

- Not having an interaction designer in the product development team limits the team's ability to follow up on user test results, because the team then finds it hard to translate the findings into a redesign.

- There was a concern that when a usability specialist would not only evaluate a product, but also contribute to its development, his or her objectivity and critical view might be lost.

Attitude towards usability

Enablers

- Usability was perceived as an opportunity to differentiate products.
- PrintPros aimed at installing a product at its clients with default settings that were adapted to the needs of the user within that particular context.

Barriers

- User tests were conducted rather ad hoc, and were not a formal part of the development process.
- Among upper management, usability was at times perceived as not exciting enough to give attention to it. This influenced priorities that were set in projects.

3.6 Cross-case analysis

The following section offers a comparison of the four product development groups dealt with usability for each of the three research topics: 1) product development process and user involvement, 2) usability in multi-disciplinary teams, and 3) attitude towards usability.

3.6.1 Development process and user involvement

All four companies reported to precede the actual product development process by exploring consumer/user needs, desires and wishes. At PrintPros even after market launch products were monitored for usability issues. At CleanSweep already during the concept phase concepts and ideas were carefully evaluated with consumers and both quantitative and qualitative user evaluations were conducted. PrintPros, HighCar and Home@Work reported that they conducted user evaluations mostly once there was a - high or low-fidelity - prototype. Usability seemed to be mostly in focus in user evaluations with high-fidelity prototypes. Methods used to evaluate usability across cases are summarized in Table 9.

From the overview CleanSweep seems to have a high degree of user involvement throughout the product development process. The goal of this mostly was to identify the right product proposition, more than uncovering usability issues. PrintPros emphasized there were differences in test results when testing with external or internal participants. However, both Home@Work and HighCar mainly tested internally. At HighCar the most important reason to mainly test internally was confidentiality.

Table 9: Usability evaluation methods per product development group, organized by moment of application during the product development process (top = more likely to occur early in the development process, bottom = more likely to occur in the later stages of product development).

Timing	Method	CleanSweep	HighCar	Home@Work	PrintPros
Later stages ← → Early stages	*Focus groups*	●		●	
	Interviews	●		●	●
	Participatory design	●			
	Conjoint analysis of reqs.	●			
	Personas			●	●
	Cognitive walkthrough		●	●	●
	Expert review	●	●	●	●
	Eye-tracking	●			
	Questionnaire	●		●	●
	Observational study	●	●	●	●
	Formative user testing	●	●	●	●
	Summative user testing	●	●	●	
	Logging usage data		●		●

A final important aspect of user involvement was how ideas, concepts and products were communicated to participants (see Table 10). A story or description refers to a product concept presented briefly through a few lines of text; a scenario extends this by informing about a timeline related to user-product interaction; visualizations may guide a concept or story but may also merely emphasize the aesthetic qualities of a concept; mock-ups or simple prototypes make a concept three-dimensional; simulations present mostly the interaction concept of a product; and high-fidelity prototyping refers to providing users with an initial working model of the product.

Table 10: Presentation modes of product ideas or concepts when evaluating with consumers, arranged according to presentation mode maturity, from 'low-fidelity' to 'high-fidelity'.

'Fidelity'	Presentation modes	CleanSweep	HighCar	Home@Work	PrintPros
High ← → Low	*Story/description*	●		●	
	Scenario	●		●	
	Visualization	●	●	●	
	Mock-up/lo-fi prototype	●		●	●
	UI simulation		●		
	Hi-fi prototype	●	●	●	●
	Adapt existing product		●	●	●

3.6.2 Usability in multi-disciplinary teams

PrintPros had its own usability engineers who in the organizational sense were a part of the industrial design department, but on a day-to-day basis worked in product development projects, each of which had a sub-team completely devoted to developing human-product interaction concepts.

At HighCar, there was also a team for human-product interaction concepts, but this operated rather independent of the product development projects. Both CleanSweep and Home@Work did not have dedicated in-house departments for usability. Home@Work employed a human-centred design consultancy for conducting usability evaluations when considered necessary, whereas CleanSweep, mainly relied on the expertise of their product researchers for studying usability-related aspects, as well as on the interest taken in usability issues by other roles involved, e.g., packaging developers.

At PrintPros a strong cooperation was reported between usability engineers and interaction designers, which was experienced as beneficial for the translation of user test results into design specifications. This also was the case at HighCar, where design, ergonomics and electronics collaboratively generated and evaluated designs. Contrary to this, the consultancy responsible for usability tests at Home@Work intentionally did not get involved with design activities such as translating the test results into a design; they emphasized the importance of independency of a usability specialist in relation to design activities, in order to remain unbiased towards the design. The consultancy believed that because they did not evaluate their own design they had a more critical view.

Another important issue was the communication of the results of usability evaluations. Whether this was a critical issue or not seemed to depend, among others, on the degree of cooperation between the team members: if teams cooperated closely, as for example at PrintPros, less attention seemed to be given (and required) to the communication of usability test results. Table 11 shows the various media used to communicate the results of usability evaluations. At HighCar mock-ups and prototypes were used for presenting the outcomes of user tests, which had already been translated into solutions. Finally, in none of the participating companies we encountered an explicit, shared definition of usability.

Table 11: 'Vehicles' for communication usability-related test results to team members/management

'Vehicles' for user test communication	**CleanSweep**	**HighCar**	(HCD consultant) **Home@Work**	**PrintPros**
Visualizations		●		
Mock-ups/prototypes		●		
Video compilations	●		●	●
Written report	●		●	●
Discussion	●	●	●	●
Workshop			●	

3.6.3 Attitude towards usability

All product development groups reported to have people responsible for usability within their product development aims, though there were differences regarding the priority of usability. At PrintPros usability was a relatively high priority. Home@Work also rated it as important, though formulated as 'ergonomics' and as part of their brand identity. HighCar mainly prioritized aesthetics and performance. At CleanSweep the importance of usability depended on the type of packaging: whether it was a usage device (e.g., a brush) or merely a container (e.g., a bottle). At CleanSweep, usability was reportedly becoming more important, because of the success of previous usability efforts and the awareness of the growing importance of usability due to an aging population.

PrintPros, Home@Work and CleanSweep considered usability as a product quality that contributes to product success, and perceived usability as a way to differentiate their products in the marketplace. Additionally, PrintPros and CleanSweep believed usability would become even more crucial for product success in the future, because of respectively an expanding area in which it is relevant (social contexts, workflow) and the previously mentioned aging population. Home@Work considered the usability of its machines superior to that of competitors, and did not expect to increase its attention for usability.

At PrintPros, Home@Work, and CleanSweep, it was indicated by subsequently two project managers and a design manager that usability was perceived as not to excite consumers enough to continuously pay a substantial amount of attention to. HighCar did not see usability as a quality that contributed to product success. Aspects as styling and power are considered more important. However, the accomplishments of the successful new user interface system had given usability an improved status. In Table 12 an overview is given of product characteristics that emerged as determinants for the prioritization of usability in the four product development groups.

Table 12: Product and company characteristics linked to the prioritization of usability during product development (one dot = low/small, two dots = medium, three dots = high/large), namely what type of product category the company is active in, whether it is a business to consumer (B2C) or business to business (B2C) market, the complexity of the product, the diversity of the user group, and how many 'units' were produced of a product. The final row indicates to what extent the company indicated it used usability to set its products apart from its competitors'.

Case characteristics	**CleanSweep**	**HighCar**	**Home@Work**	**PrintPros**
Core product	Household care	High-end cars	Coffee	Prof.printers
B2C or B2B market	B2C	B2C	B2B	B2B
Product complexity	●	● ● ●	● ●	● ● ●
Diversity of user group	● ● ●	●	● ●	● ●
Production batch size	● ● ●	● ●	●	● ●
Usability as competitive advantage	● ●	● ●	●	● ● ●

3.7 Feedback workshop

A workshop was organized to share the cross-case analysis with the participating companies, verify the findings with the participants (Yin, 2009, p.182), and to explore a number of topics that had emerged during analysis.

3.7.1 Setup

Table 13: Overview of the workshop participants

Company	Role
CleanSweep	Industrial designer
HighCar	Interior designer
Home@Work	Manager technical development
	Human-centred design consultant
PrintShop	Usability specialist

The workshop took place at the faculty of Industrial Design Engineering of Delft University of Technology. Each company that participated in the study was represented during the workshop (Table 13).

Apart from discussing the cross-case analysis, during the feedback workshop three subjects were introduced for a follow-up discussion: (1) whether or not to formalize the inclusion of usability evaluations, (2) whether the 'external validity' of (early) user tests was a concern, and (3) how the participants felt about conducting usability evaluations in which the usability of multiple designs or products (for example, comparing your own product with a competitor product) were compared. During the workshop a discussion arose on (4) the possibility of using after-sales feedback as a source of information on usability.

3.7.2 Results

Formalizing the inclusion of usability evaluations (or not)

The first topic of discussion in the workshop was whether user involvement should be a formal, mandatory step in product development processes or whether the decision to involve users should be left up to the team. Additionally the question was raised whether a company should use a fixed set of methods or select a method depending on the problem at hand.

Both PrintPros and Home@Work did not formalize when and how user involvement was to be conducted in their product development processes. At CleanSweep user research and testing was a formal part of the process, but mainly had the goal of creating an appealing product proposition. As of yet there was no formalized process for creating usable packages and devices. At HighCar, during the five years a car is being developed, practically every day was accounted for in the project planning and every project milestone had its own predefined tests.

PrintPros and Home@Work believed it should be assessed per development phase what information is required and whether user involvement is required. The representative from PrintPros felt that usability testing should only be conducted if there also was a chance of acting on the results. She thought that by formalizing usability testing one might risk that it would become 'checklist activity', something that teams only do because they have to. Both representatives from PrintPros and Home@Work believed that with regard to standardizing user involvement a distinction had to be made between innovative and evolutionary projects: if an existing product is redeveloped it might not be necessary to perform all the user research and evaluations that are done in an innovative project, also keeping in mind the costs that are associated with performing user tests. As a response, the human-centred design consultant argued that even though a certain concept may be familiar, a small change might still cause a major influence on the usability of the product as a whole. Testing every detail repeatedly may be impractical time and money-wise, however it does need to be checked whether the design is usable. The representative from CleanSweep pointed out that to what extent user tests are conducted also depends on the project manager; whether this is a marketing person or a product researcher. At PrintPros a usability evaluation could be triggered by a question an interaction designer might have, concerning specific interaction features of a design.

'External validity' of usability tests

During the original interviews, testing a part of a product was seen as convenient when there is a wish to test early in the development process. It was discussed to what extent evaluating a part of the whole threatens what was referred to as the 'external validity'[16] of usability test results?

The PrintPros representative argued that even though using 'lo-fi' prototypes in user tests does introduce a risk of basing a (re)design on incorrect information, testing with parts of a product is useful: otherwise one has to wait until the product is almost done and by that time the product can hardly be changed anymore. Both the PrintPros representative and the HCD consultant argued that a part of the UI should be tested as much as possible as a part of the complete design, possibly by providing the participants with the impression of the remainder of the product by simulating it. The HighCar's representative indicated that in its products the functions were so tightly linked that the whole product was needed to be able to test of a part of it. In case a single function needed to be verified quickly, experts were consulted to provide relevant insights. Testing a new part or concept by building it into an older version of the product was also experienced as a good way of testing it as realistically as possible.

[16] The interviewees used the term 'external validity' to refer to the extent that findings from user testing could be considered to occur when the final product was used in the real world.

Comparing products on usability

From the initial interviews a desire surfaced to assess the usability of a product in a more measurable way by comparing a new design in a user test with a similar model, competitor product or a previous version of the product.

At all companies the developed products were compared to competitors' products. PrintPros explained that they wanted to know how they performed in comparison to their competitors: "To what extent is it necessary to improve; to what extent are we better than the competitor?" The CleanSweep representative supported this notion, by pointing out that such a comparison might not be possible until the product is sufficiently mature. Home@Work did not study the usability of competitor vending machines, but did compare the quality of the coffee.

After sales feedback

During the workshop the participants brought up the subject of after sales feedback: gathering or receiving information after a product has been launched.

At PrintPros clients were invited to receive a trial version of a product. Based on their feedback the final details were improved. PrintPros' usability engineer would like to monitor the product as it is on the market. But because the project is finished by then and there is no clear question-owner, such monitoring was usually not performed. PrintPros did aim to collect after sales feedback through its customer service organization. The PrintPros representative indicated that there was a lot of useful knowledge stored at service divisions, trainers, helpdesks and sales departments, but that it was very difficult to access that knowledge; only the most urgent problems were communicated to the usability engineers. Additionally, there was the issue that feedback usually consisted of a short summary, while the usability engineers would prefer more detailed information.

The representative from Home@Work agreed with PrintPros regarding the availability of relevant information from the market. However, he found that the difficulty lay rather in finding the relevant data in the huge amount of information coming in. On the other hand it may be difficult to arrive at a complete overview of user-issues related to the product in the market, because of missing information. He considered interviewing service-people too time-consuming.

A network of car dealers provided information about the cars of HighCar once they were on the market: the dealers knew a lot about user issues. Furthermore, it was indicated there was an independent car-usability standard that was used to score each car brand on usability, making comparisons available to the whole sector.

At CleanSweep, the designers usually did not receive after sales feedback about the products they worked on. The HCD-consultant pointed out that most after sales feedback information entered the company through marketing. However, collaboration between Marketing and Research & Development (R&D) is often difficult, which limits the ability of R&D to collect information from the real world. The representative from PrintPros countered that at PrintPros designers were able to request the user-related information collected by instructors that gave courses at clients.

3.8 Conclusions

The research questions to be answered through this case study were:

1. How is usability dealt with in product development practice?
2. What variables in product development practice contribute to or obstruct the usability of the products under development?

Through individual analyses per company insight was gained into how companies in four different markets, namely professional printing (PrintPros), high-end automotive (HighCar), office coffee machines (Home@Work), and fast-moving consumer goods (CleanSweep), deal with usability, and what properties of the product development groups were indicated to be barriers and enablers for usability. Additionally a cross-case analysis was conducted and a feedback workshop were hosted in which the cross-case analysis was verified and discussed.

This section discusses the conclusions that were drawn from this case study. Because this study compares companies that develop quite varying products in four different markets, one of the most important conclusions of this study relate to how the type of product a company makes and market it is active in can affect what usability means to a company and how it prioritizes usability. Secondly, the prioritization of usability and the type of products that a development group made was observed to affect the applied methods for user-centred design as well as team composition. Thirdly, the communication of user involvement was identified as a critical activity in multidisciplinary teams. Finally, conclusions are drawn about how the focus areas of this study, the product development process, multidisciplinary teamwork, and attitude towards usability, relate to each other.

Different products, different attitudes to usability

The concept of usability (ISO, 1998) - the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in particular environments - has quite a different meaning for a high-end car (HighCar) than for a floor cleaning device (CleanSweep). The type of products the companies developed, and the market they were in, seemed to have a large influence on the urgency to deal with usability. For example, professional printing products (PrintPros) are so advanced that if no attention would be paid to their human-product interaction, the products would become utterly inoperable. On the other hand, fast-moving consumer goods (CleanSweep) are much less complex, and were considered less likely to become hard to use. For CleanSweep the challenge in user-centred design lay more in the upfront part, in figuring out what people wanted to have.

In three out of four cases interviewees pointed out that there was a distinction between who buys and who uses the product. The two business-to-business companies, developing office coffee machines and professional printing equipment, made a distinction between corporate purchasers and end-users. In the two business-to-consumer companies (fast-moving consumer goods and automotive) the people that purchased the product would usually be the user as well, though the fast moving consumer goods company also took into account the demands of the retailers, through whom the products were distributed. Though selling to different stakeholders than to the actual end-users, the manufacturer of professional printing equipment did give a high priority to usability, because it considered usability something that evoked customer loyalty. On the other hand, the developer of high-end cars, for whom the buyer was the end-user, did not give quite such a high priority to usability. The companies making high-end cars and office coffee machines indicated that for their target group usability was not an important purchase consideration, and therefore it was not as high on their list of priorities.

The prioritization of usability within a company seems to depend on the complexity of the products that are developed, and on whether the company perceives usability as an important purchase consideration among buyers. The latter is in turn dependent on how and by whom the product is purchased: are products purchased repeatedly or only incidentally, and is the buyer the same person as the user?

Variation in user involvement methods and team composition

The four companies in this study differed in the methods they applied to deal with usability during product development, how teams were composed, how they communicated about usability, and their attitude towards usability.

A high prioritization of usability seemed to trigger a company to start looking for possible ways to deal with usability in its product development, both in terms of user involvement methods as well as team composition. PrintPros, where usability was a very important product quality featured an in-house usability group, usability engineers were an integral part of the product development teams, and user involvement occurred throughout the product development process. CleanSweep had been increasing the amount of attention given to usability and indicated that they were now looking for suitable usability-related methods. At HighCar the development of an in-car user interface had been a success, and, reportedly as consequence, usability got more attention during product development and the user-interface group started expanding.

The type of product that a company developed seemed to influence the type of methods for user-centred design that were used, as developing these products evoked the need for a particular type of information, or because the type of product allowed, or did not allow, for a certain type of simulation. For example, the companies that developed the most complex products to interact with, namely professional printing and high-end cars, applied the cognitive walkthrough method, whereas the companies with products featuring a more basic interaction (office coffee machines, fast-moving consumer goods) did not apply this method, which is mostly suited for finding cognitive issues. Because of the properties of the technological platform of their products, HighCar and PrintPros were able to log the usage of their products in prototypes and actual products.

Multidisciplinarity makes communication of user involvement critical

Creating and implementing a design is (or should be) a highly multidisciplinary activity, involving a variety of disciplines, such as designers, engineers, and project managers. However, *evaluating* that design is much less multidisciplinary: a usability evaluation is usually carried out by one single role: the usability specialist. But to follow-up on any of the issues that were identified in the usability evaluation, once again the involvement of all or many disciplines is required. Because most of the team is not involved in usability evaluations and because they are not experts in this field, the communication of usability evaluations becomes a critical issue.

Determinants for methods for user-centred design and team composition

As a result of the cross-case analysis we would like to propose a number of relations between the product/market combination, attitude towards usability and methods for user-centred. The product-market combination that a company targets seems to influence the attitude of a company towards usability, and on the methods for user centred-design that are applied. The attitude towards usability influences the integration of user involvement methods in the product development process, and the presence and integration of user-centred design specialists (usability specialist, interaction designers) in the product development team. Methods for user centred-design as well as team composition affect the usability of the product. The proposed relations are visualized in Figure 32.

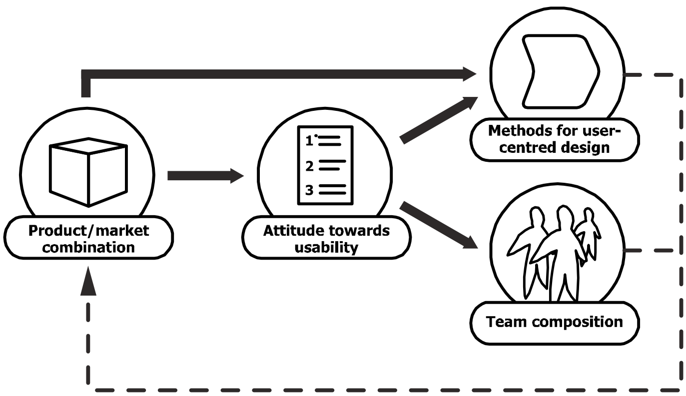


Figure 32: Visualization of the proposed relations between the product, attitude towards usability, user-centred design methods and team composition.

3.9 Implications for the subsequent study

Prevent a linear representation of the development process

The interviewees gave remarkably linear descriptions of the product development process of their companies, almost without any parallel activities or iterations. This may be caused by the fact that they were asked to describe the product development process orally, which offers less of an opportunity for structuring activities in parallel than by, for example, drawing the process.

Consider after sales feedback as user involvement

During the feedback workshop it became evident that participants found after-sales feedback, from for example sales and customer service departments, to be a potential source of information about usability issues, though the information can sometimes be hard to obtain and analyse. In the subsequent study after-sales feedback is included as one of the topics to be studied.

Include the communication of user involvement

It became evident that in user-centred design it is important not only to conduct the user involvement activities (e.g., focus groups, home visits, usability tests), but also to communicate the findings from these activities in an effective way. So when studying user involvement in companies, one should not only study what methods are applied and how, but also how the results of user involvement are communicated.

Focus on companies that make complex products

In this case study usability issues seemed more urgent if the products that were developed featured extensive functionality. For the subsequent case studies, if the goal is to find innovative ways of dealing with usability and to identify barriers and enablers for usability, it seems likely that more data will be found in companies that develop complex products than in companies that offer simpler products.

Focus on companies that exhibit an effort to create usable products

In this study the prioritization of usability, which seemed to influence the presence of usability specialists and activities, differed from company to company. When conducting a case study on how companies deal with usability, it may be recommendable to focus on companies that exhibit an effort to create usable products. An effort to create usable products seems to manifest itself in the presence of usability specialists in the company and in usability evaluations being conducted.

More detailed definition of what is a barrier and enabler

We did not define in detail when something was to be considered a barrier or enabler for usability. During the analysis of the interviews something was labelled a barrier or enabler when the participants pointed out they were, and we also relied on comparing the findings with best practices described in literature. However, there are many ways in which the usability of a product can be influenced. In the following studies it should be defined in more detail when something can be considered a barrier or enabler.

Chapter 4 | **Case study II**

Barriers and enablers for usability in five development groups of electronic consumer products

Chapter 4: Case study II

Barriers and enablers for usability in five development groups of electronic consumer products

In Chapters 1 and 2 it became evident that the usability of electronic consumer products is under pressure, even though theories on usability and methods for user-centred design are available. In the previous chapter a first exploratory case study was reported, to investigate how usability was dealt with in four markets adjacent to electronic consumer products. In the case study described in this chapter the aim is to explore the differences and similarities in dealing with usability between product development groups, all active in the electronic consumer products market. The setup of this case is similar to the previous one: a multi-actor, interview-based case study of product development groups. By interviewing 31 product development and user-centred design professionals I identified what barriers and enablers for usability they experienced in product development practice. The companies involved were active in the domains of personal media players, personal navigation, laundry care, home controls (climate control, etc.) and mobile phones.

The goal of this study is twofold: it has a descriptive as well as an evaluative component. The descriptive goal is to obtain insight into how major electronic consumer products companies, which have the ambition of improving the usability of their products, deal with usability in the current practice of product development. The second – evaluative – aim of the study is to assess what factors in product development of electronic consumer products influence the usability of the products either positively or negatively, and how these barriers and enablers are related. The study aimed to answer the following research questions:

1. How is usability dealt with in the current practice of product development of electronic consumer products?
2. What variables in product development practice contribute to or obstruct the usability of electronic consumer products and how are these factors related[17]?

Paragraph 4.1 provides an overview of the research design and 4.2 elaborates on the method that was followed to collect and analyze the data. In paragraph 4.3 context

---

[17] I use the term 'factors' to refer to variables in product development that have an influence on usability. Barriers are factors with a negative influence on usability, enablers are factors with a positive influence on usability.

descriptions are provided of each product development group in order to provide a description of how each product development group operates and is organized. In paragraph 4.4 the results are presented in a cross-case analysis, in which the mechanisms of barriers and enablers found in the individual cases are compared and an overview is provided of the distribution of barriers and enablers over different categories. The results of the evaluation workshop to verify the findings and discuss the conclusions are presented in paragraph 4.5. Finally, in paragraph 4.6 I draw overall conclusions and in the discussion section (4.7) I reflect on the findings and the method applied and implications for the subsequent study are provided.

4.1 Research design

The following paragraph describes the overall design of the case study, its unit of analysis, the criteria for selecting the product development group and an overview of the five product development groups that I studied.

Multiple case design

I decided to study multiple product development groups, because this reduces the risk of studying a particular product development project or company, which produces results that may turn out not to be generalizable to other projects or groups (Yin, 2009: p.61). In addition, a case study with several cases is often considered more compelling, and more robust (Yin, 2009, p.53) quoting (Herriott and Firestone, 1983). They offer researchers a deeper understanding of the outcomes of and of causal relationships in a case, because by comparing the results from several cases it can be observed whether and under what circumstances a certain phenomenon will occur (Miles and Huberman, 1994, p.26, p.29).

Unit of analysis

The unit of analysis (Patton, 2002; Graneheim and Lundman, 2004; Yin, 2009, p.29) of this study are product development groups of major electronic consumer products manufacturers. The unit of analysis defines what the 'case' is about; what the focus of the study is. In a unit of analysis, a distinction can be made between the focus and the context of the study (Miles and Huberman, 1994, p.25). In this case, the focus is on the product development process (structure, activities, and characteristics), and the context consists of the development team, project characteristics, company properties, and market situation.

Case selection

Because the study features multiple cases which each have a single unit of analysis makes this a study with a multiple case design with holistic cases (Yin, 2009, p.46). The cases were selected based on a comparable case sampling strategy, which means that the intention was to select product development groups that have similar relevant characteristics (Miles and Huberman, 1994, p.28). To enhance the selection of similar development groups selection criteria were established (see Table 14), based on the research questions and the conceptual framework from Chapter 2 (page 67).

Table 14: The case selection criteria.

Selection criteria	Details
Complex products for personal use	Develop electronic consumer products (as defined in the introduction).
Product development group exhibits efforts to improve the usability of its products.	Feature usability-related activities or roles in the product development process.
Large scale product development companies.	Have a division of tasks among the development team members.
In-house product development.	Not purchasing products from suppliers 'as is'.

I wanted to study companies that exhibited an effort to make usable products. If this effort is not made, it can hardly be called surprising if the products it makes turn out unusable and secondly companies that do try to develop usable products are a potential source of best practices. That a company exhibited an effort to make usable products was defined having usability related roles and activities in the organization. The study focused on large scale product development companies, because I assumed that in these organizations there would be a segmentation of roles in the product development team, such as usability specialist, product designer or engineer, which causes group dynamics typical for multidisciplinary or collaborative design to occur (see Chapter 2).

Based on these criteria five development groups in Asia and Europe were selected to participate in the study (Table 15). The development groups are described anonymously, the promise of which ensured their willingness to also share negative observations and agree to publication of the results.

Table 15: The five participating product development groups

Name	Product category	Location
AV2go	Portable audio and video	Asia
D-phone	Mobile phones	Europe
EnRoute	Personal navigation systems	Europe
HomeControl	Home heating, ventilation, security	Europe
WashCare	Washing machines and tumble dryers	Europe

Researchers

The primary researcher was the author of this thesis. He was supported and supervised by three researchers from the section of Applied Ergonomics and Design of the Faculty of Industrial Design Engineering of TU Delft, one of which was active in the field of observational research, the expertise of the second researcher lay in analysing (user-centred) design processes, and the third supervisor was an experienced user-centred design professional and researcher in the area of new product development.

4.2 Method

This section describes how and with whom I collected and analyzed the data. It is explored further when something can be labelled barrier or enabler, and then overview is provided of how, based on the interviews, I arrived at barriers and enablers for usability. Next, a categorization scheme for barriers and enablers in product development is introduced, and it is shown how this categorization was used as a basis for an interactive software tool for mapping the barriers and enablers. Finally, a description is provided of how I collected feedback on the findings of the study from the participating companies.

4.2.1 Data collection: interviews with product developers

This section outlines the data sources that were used for this study, among which interviews were the most important source of information. Next I describe how the interviewees were selected and how the interviews were set up and captured.

Sources

Interviews were used as the primary data source, supplemented with information from direct observation during site visits (e.g., office layout, atmosphere, communication style), physical artefacts (the products that the development groups made), and public documents (reviews of products, descriptions of the company). Apart from being a relatively time-efficient data source, interviews have the benefit of being very insightful as the interviewees provide their perceived causal inferences (Yin, 2009, p.102).

This study focuses on uncovering what barriers and enablers product development professionals perceive in product development practice, and as such the interviewees were treated more as informants than as respondents (Yin, 2009, p.107). Experienced product development professionals are in a unique position to observe usability in product development practice up close and over the years, and are quite knowledgeable on the subject. On the other hand, because of their experience, informants can also grow 'blind' towards certain issues or develop certain hang-ups, something that can be compensated for by interviewing people that view the same phenomenon from different perspectives (Eisenhardt and Graebner, 2007).

The interviewees were not working on one project or team, but were a sample from the development group. The criterion for selecting interview participants, or sampling parameter (Miles and Huberman, 1994, p.30), was their role in the product development process. If possible, in each company at least one person fulfilling each role included in the conceptual framework was interviewed. In practice, actors were found under different names, or a single person would perform several roles. The working definitions of the roles (see Chapter 2) were used to discuss with the primary contacts within each company who should be interviewed.

Interview setup

The interviews were performed using a general interview guide to ensure that with all interviewees the same basic lines of inquiry are explored, but within each of the subject areas the researcher "*is free to explore, probe and ask questions that will elucidate and illuminate that particular subject*" (Patton, 1990, p.343). The interview guide consisted of the following main subjects:

- Product development process (structure, activities, role of the interviewee, team organization, communication & documentation);
- Product development context (company culture, department organization & philosophy);
- Interviewee definition of, and attitude towards, usability;
- Role-specific questions: activities, responsibilities and concerns;
- Critical incidents regarding usability (products that had good or poor usability, probing for underlying causes);
- Barriers and enablers for usability in product development (what are properties, situations or conditions that positively or negatively influence usability);
- Personal data and background.

In addition, the interviewees were asked to sketch and describe their product development process and to indicate where they were involved (Figure 33). This strategy was chosen because in the first case study (Chapter 3) only talking about the development process provided remarkably (or overly) linear descriptions of the product development process.

Data recording

The interviews were recorded using digital audio recording equipment. Directly after an interview a write-up was made, capturing the salient notions from the interview. In addition, during the site visits field notes were taken to capture informal conversation and on-site observations.

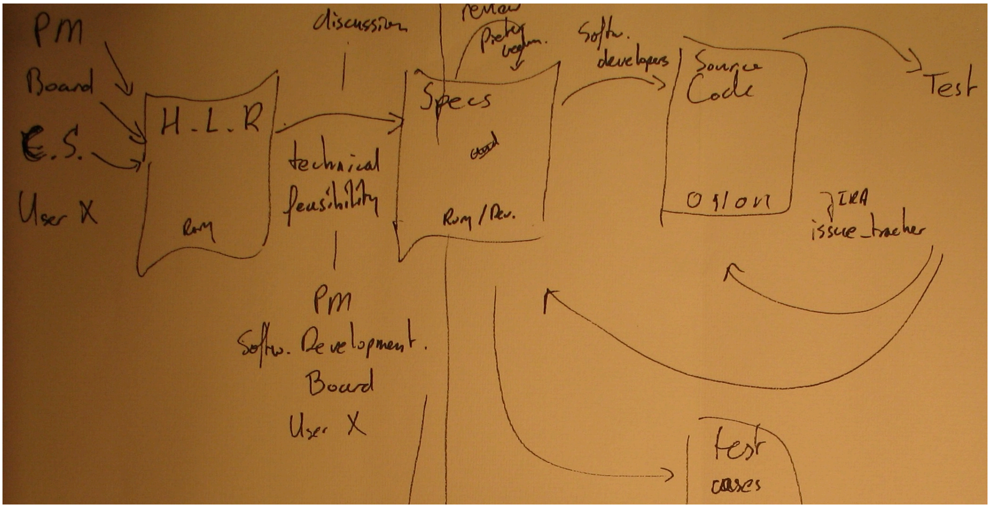


Figure 33: Example of a drawing by an interviewee of the development process that his/her product development group follows, including the roles that are involved (e.g., 'PM', 'Board', 'CS' (on the left)) and the deliverables (e.g.,'source code') and actions taken (e.g., 'specs') during the process.

4.2.2 Data analysis: from interviews to barriers and enablers

This section describes how the barriers and enablers for usability and context descriptions of the product development groups were derived from the interview data.

Creating jointly told tales

The interviews were transcribed literally and in full and analyzed using the qualitative data analysis program Atlas.ti. As a first step I identified meaning units, which are the words, sentences or paragraphs containing aspects related to each other through their content and context (Graneheim and Lundman, 2004). As some of the meaning units were quite elaborate, or contained proprietary terminology, each of the meaning units was shortened, while preserving its core, into 'condensed meaning units' (Graneheim and Lundman, 2004). The combinations of meaning units and condensed meaning units are analogous to Van Maanen's (1988, p.95) '*jointly told tales'*. These communicate both the viewpoint of the informant as well as the interpretation of the informant's statement by the researcher (Roth and Kleiner, 2000, p.190) (Table 16, left and middle column).

The next step was to derive barriers and enablers from the condensed meaning unit (Table 16, right column). Analogous to Kleinsmann's concept of barriers and enablers (Kleinsmann, 2006, p.74), a barrier is a property, situation or condition in the product development process, team or context that negatively influences the usability of a product. An enabler is the positive equivalent of this. I chose to use the polarizing concept of barriers and enablers because ultimately I was looking for handles to improve how usability was dealt with in product development. By using the concept of barriers and enablers it would not only be marked *that* something had an effect, but also whether this effect was positive or negative for usability.

Table 16: An example of a 'jointly told tale' by the interviewee (left) and the researcher (middle, and right), in this case about information coming from customer service. On the left the original fragment from the transcript (the meaning unit) accompanied by the interpretation by a researcher (middle, condensed meaning unit) and the barriers that were identified (right).

Meaning unit	Condensed meaning unit	Barrier/enabler
"We'll as I said, I think there is a delay, it is slow, and certainly it's just too massive data and the […] the data can be analyzed with more, I say more clear, you know, findings."	The customer service department communicates the after sales feedback to the usability specialist with a considerable delay and the data are is raw, massive, and unanalyzed, without clear findings.	B: Poor analysis of customer service logs. B: Slow communication of customer service logs. B: Development team not knowing what product aspects customers complain about.

Identifying barriers and enablers: is there influence?

Whether a condition was labelled a barrier or enabler was based on indications by the interviewees and on counterfactual reasoning. Barriers and enablers are variables in product development that have influence on the usability of products. They are factors: things that are thought to have an effect. This suggests the presence of causal or explanatory relationships. I labelled a condition as a barrier or enabler if interviewees indicated that a situation, condition or property had a positive or negative influence on usability, i.e., by explicitly saying something had an effect on usability, or more implicitly, by saying that it should not be done like that anymore (or done more often).

A second method I applied to determine whether there was influence was counterfactual reasoning (Mackie, 1974; Goodman, 1991). When applying counterfactual reasoning one uses existing knowledge, for example, from literature and experience, to argue how the end result of a situation would have been changed by hypothetically removing a condition from the situation (Weegels, 1996, p.68). I considered a situation or condition a barrier or enabler if by hypothetically removing or altering it the usability of a product would have been influenced. Influence means that more or less of one 'variable' changes to some extent the rating of another (Miles and Huberman, 1994, p.156).

Determining the kind of influence: positive or negative?

To determine whether a factor should be captured positively or negatively I looked at the original wording by the interviewee. For example, "*we should do more user testing*" would lead to a classification of 'user testing' as an enabler. "*We did not have time to do user testing*" would lead to the indication of 'time pressure' as a barrier, which in turn lead to the barrier 'not doing user testing'. As these examples demonstrate, a large number of barriers in a case does not mean that in this company everything was going wrong. It merely points out that the interviewees phrased the influence negatively.

Determining the direction of the influence

As shown earlier barriers and enablers often exert their influence through a chain of events or conditions. I refer to a chain of barriers or enablers that influence each other as a 'mechanism'. In addition to the property that makes the barrier or enabler exert influence, the direction of that influence should be indicated. Some barriers or enablers influence usability in a fairly direct way, as in the following example:

Example mechanism 1:

Adding a lot of features to a product → Poor usability

However, in quite a number of cases, barriers and enablers exert their final influence on the usability of products through a chain of events:

Example mechanism 2:

User testing →
Communicating user test results →
Knowledge of a potential usability issue → Improving a design → Better usability

---

Explanation: *User testing does not influence the usability of the product if the results are not communicated and if no action is taken.*

Also, multiple barriers and enablers that individually seem not to influence usability can together produce an effect on usability:

Example mechanism 3:

Selling products worldwide →
Centralized product development department →
Limited knowledge about the user group → poor design → poor usability

---

Explanation: *If either the development group would have had a global network of local design departments, or the group would have only produced products for its local market (with which the designer is familiar) the knowledge of the designers about the user group would have been more elaborate.*

The reverse situation, where one barrier/enabler influenced multiple others is also possible. What is a barrier in one 'chain' can turn into an enabler in the next. The 'centralized product development department' from the example above is actually quite beneficial for the communication of usability test results. This means that the barriers and enablers should be seen in their context.

I distinguish two types of relationships between barriers (–) and enablers (+): conditional and mitigating relationships. A barrier or enabler can act as a cause for another barrier or enabler (a condition) or it can reinforce or reduce another barrier or enabler (a mitigating relationship). Apart from whether a relation is conditional or mitigating, there are relations between enablers only (+ → +), between barriers only (– → –), and between barriers and enablers (– → + , + → –). Relationships between only barriers or only enablers have reinforcing nature. If a barrier is related to an enabler (– → +) it means that this barrier can prevent or negatively influence the occurrence of the enabler. If an enabler influences a barrier (+ → –) this means that something positive is mitigating or even neutralizing a negative circumstance.

Eliminating multiple instances per interviewee

To prevent multiple instances of an identical barrier or enabler that was mentioned multiple times by one interviewee, identical barriers and enablers were merged. They were considered to be the same if they referred to the same situation, property or condition. In order not to lose the information that the barrier or enabler had been mentioned multiple times the number of mentions was marked in brackets behind the title of the barrier/enabler. If, e.g., user testing was mentioned three times by a single interviewee, the jointly told tales were merged and labelled with a single enabler description, as in "*User testing (3x)*".

4.2.3 Categorizing and visualizing barriers and enablers

The previously described steps resulted in the identification of over 1700 barriers and enablers[18]. Because of the sheer amount of data I had to create a digestible overview, and secondly the interrelated nature of barriers and enablers pushed me to find a way to explore the relations between the barriers and enablers while maintaining a connection with the original data.

Structuring the data: product development categorization scheme

In order to facilitate further analysis of the large amount of barriers and enablers, I wanted to categorize them, as grouping and then conceptualizing objects with similar patterns and characteristics allows for better understanding of a phenomenon (Miles and Huberman, 1994, p.249). Faust (1982) argues that humans are not very well equipped to deal with large numbers of data in a purely textual or tabular form. Large amounts of data require

[18] Overlapping barriers and enablers from different interviewees were counted als multiple barriers and enablers, so the 1700 barriers and enablers are not describing 1700 different ways in which usability can be influenced.

structuring and reduction. To provide qualitative researchers with a structured overview Miles and Huberman (1994) advocate the use of data displays, which are "*organized, compressed assemblies of information that permits conclusion drawing and action*". In addition, according to Meyer (1991) in multidimensional information processing graphical feedback leads to faster and more complete learning than numerical feedback and graphical displays improve decision makers' performances when detecting and comparing trends, or discovering relationships among variables and categories.

I started with an initial coding scheme that was based on the conceptual framework (Chapter 2), which I then modified through open coding (Malterud, 2001b quoting Strauss & Corbin, 1999). This resulted in a rather detailed coding scheme of about 250 codes which I then categorized and merged into a final categorization scheme (Graneheim and Lundman, 2004) that bears similarity to a conceptually clustered matrix data display (Miles and Huberman, 1994, p.127). The resulting categorization scheme, which is visualized in Figure 34, consists of six main categories, from left to right: process (matrix in the left square area), knowledge (single column in the middle), team, project, company and market (grouped in the area on the right).

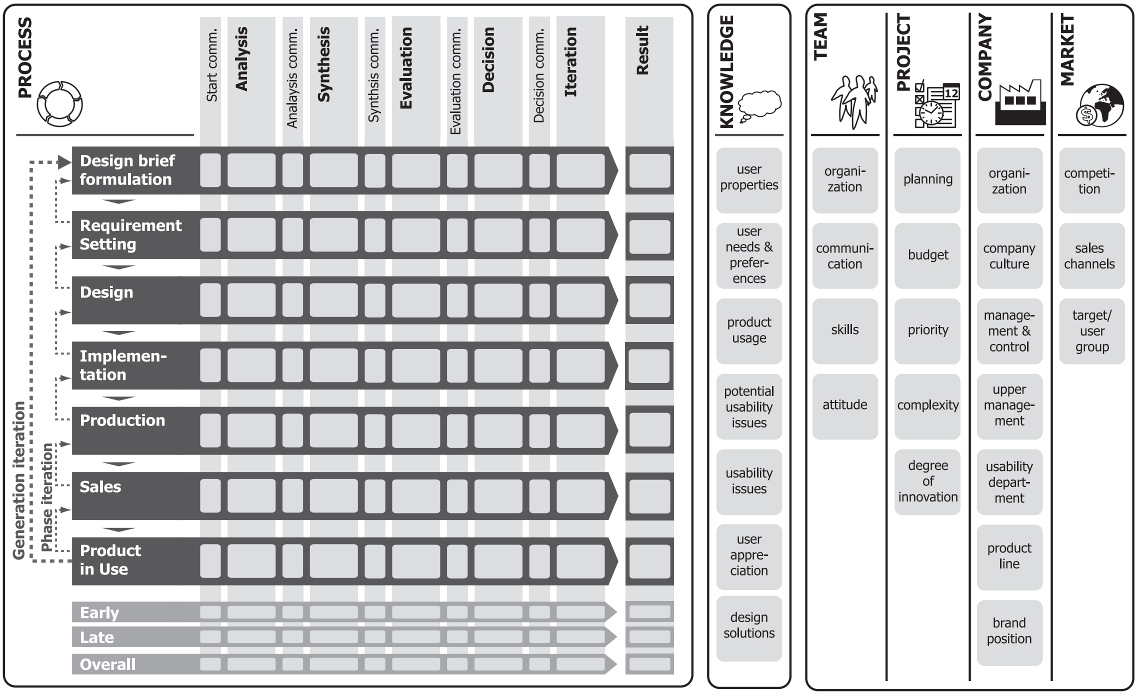


Figure 34: The categorization scheme for clustering the barriers and enablers, containing from left to right the main categories process, knowledge, team, project, company, and market.

The matrix that forms the process category in consists of phases of the product development process - adapted from Buijs and Valkenburg (2005, p.181), see Table 17 - on the vertical axis, while the horizontal axis is based on the activities of the basic design cycle (Roozenburg and Eekels, 1991, p.79), see Table 18. Between the steps of the basic design cycle I added a 'communication' subcategory (the narrow columns), for the transfer of information between the activities of the basic design cycle.

The resulting process matrix shows that I assume that the activities of basic design cycle (can) take place in each phase of product development. Some activities (such as studying users) result in knowledge, while in other activities (such as creating a design) knowledge is used. In the categorization scheme the main category 'Team' contains barriers and enablers that refer to properties of people that conduct the activities that form the process, and 'Project' refers to properties of a product development project, such as planning and budget, that influence usability. 'Company' contains barriers and enablers that refer to properties of a product development group or its parent company, while 'Market' contains references to the area, country or section of the population that the development group is targeting.

Table 17: The vertical axis of the process matrix in the categorization scheme (Figure 34) is based to the phases of the Delft Innovation Model (DIM) (Buijs and Valkenburg, 2005, p.181). The codes for the product development phases as used in the categorization scheme (middle column) were generated through open coding. Each of these phases is related to the DIM (left column) and a working definition is provided (right column).

DIM	Categorization scheme	Working definition
2. Design brief formulation	Design brief formulation	Determining what product will be developed and when
3. Strict development	Requirement setting	Defining the design goal in depth, the target group, user needs, and requirements
	Design	Generating (conceptual) designs that offer a solution to user needs and requirements
	Implementation	Developing concepts/designs into working prototypes or product samples
4. Introduction	Production	Manufacturing the product
	Sales	Providing customers with the opportunity to purchase the product
5. Product in Use	Product in Use	Product is being used by the customer/users. Company provides support and services.
-	Early, late, overall	Rough indication of phase
-	Phase iteration	Returning to a previous phase in the product development process in order to improve the results of an evaluation
-	Generation iteration	Changing a part of a product or development process based on information from a predecessor product/project.

Table 18: The horizontal axis of the process matrix in the categorization scheme (Figure 34) is based on the activities of the basic design cycle (Roozenburg and Eekels, 1991, p.79), which in the table below are listed in the left column. In the categories of the categorization scheme (which are listed in the middle column) simulation and evaluation have been merged into a single 'evaluation' category, because in the data the two categories were very hard to separate. An additional 'communication' category is added to indicate activities that involve communicating the results from one activity to the next (e.g., a workshop to communicate user research (analysis communication) or a sketch to communicate a design (synthesis communication)).

In basic design cycle	In categorization scheme	Working definition
Analysis	Analysis	Forming an image of possibilities, limitations and formulating criteria for what needs to be created.
Synthesis	Synthesis	The generative moment of the design cycle; when a 'solution' is conceived.
Simulation	Evaluation	Assessing the value or quality of the design/concept. Requires the use of a simulation, prototype, or product.
Evaluation		
Decision	Decision	Deciding whether to improve the requirements, design or evaluation by going back to the analysis, synthesis or evaluation phase or to proceed to the next phase in the product development process.
Iteration	Iteration	Repeating (a part of) the basic design cycle in order to improve the results of the evaluation. Can involve the acquisition of more information, or generating better requirements, a better design or a better simulation.
-	Communication	Between all steps in the basic design cycle, e.g. analysis communication is communication of user research, synthesis communication can be a prototype.

Enabling exploration and transparency: developing the Trace tool

By categorizing the barriers and enablers and visualizing their position in the categorization scheme I obtained a kind of 'heat map' of barriers and enablers. However, manually creating the visualizations was quite cumbersome and did not produce particularly readable representations, and in the qualitative data analysis program that I employed (Atlas.ti) it was not possible to create the desired visualization. Additionally, as pointed out earlier, barriers and enablers are often interrelated, and when these relations were added to the categorization visualization that produced a dense, unreadable network of arrows between barriers and enablers.

I wanted to limit the data reduction that would occur by categorizing and visualizing the barriers and enablers. As Eisenhardt and Greabner (2007) point out, in case studies that involve multiple cases a rich insightful description often has to be sacrificed for less-detailed reporting that provides a better overview. However, 'transparency' or 'traceability' is also an important quality in qualitative research: to the reader it should be clear what interpretations were made, and how the conclusions relate to the original data (Miles and Huberman, 1994; Malterud, 2001a, p.280; Eisenhardt and Graebner, 2007).

Additionally, I wanted to facilitate a constant alternation between the global overview provided by the categorization scheme and a detailed view of the data; what Ragin (1987) calls the 'dialogue' between ideas and data, a process that Malterud refers to as 'decontextualisation and recontextualisation' (Malterud, 2001b). The categorization provides an indication of *when and where* something happens, the more detailed view provides insight into what happens, and why.

The solution to the issues mentioned above was found by developing a software tool with the ability to visualize the database of barriers and enablers. The tool consists of an Adobe Flash application that, based on the categorization scheme in Figure 34, provides a categorized, interactive, browsable overview of the barriers and enablers (Figure 35, Figure 36). The software application, called Trace, allows users (i.e., design researchers) to view the distribution of barriers and enablers across different categories, to explore the relations between categories of barriers and enablers, and look at a listing of barriers and enablers within a category. Barriers and enablers can be viewed per company or per type of role (e.g., interaction designers, product managers). By clicking a certain category the researcher gets an overview of the barriers and enablers in that category and gets access to the complete 'jointly told tale' underlying each of the barriers or enablers, thus allowing a constant iteration between the very concrete detailed level of the original interviews as well as the abstract high-level view of the categorization of barriers and enablers.

Trace also allowed for the interactive exploration of the relations between categories of barriers and enablers. Visualizing the relations was only possible because Trace provided an interactive environment. Mapping all relations on a static version of the categorization scheme filled with more than 1700 barriers and enablers, would have led to an unreadable representation. See Appendix C for a more in-depth explanation of how the Trace tool works. Because the software application was made in Flash it could be placed online (in a secure environment), which allowed me to share the data with fellow researchers, supervisors, reviewers, and representatives from the participating companies.

Analysis of barriers and enablers per company

Using the Trace tool I analysed the barriers and enablers and the relations between them for each of the companies. For each case I identified (mechanisms of) barriers and enablers that were mentioned by multiple interviewees, as this indicated agreement, but also unique barriers and enablers, as I considered these to be possible sources of new insights. For each company an analysis was written that guides the reader through the barriers and enablers in the Trace tool. These descriptions are too elaborate to include all of them in this thesis, but below an example is given of a mechanism of barriers enablers, illustrated with a visualization from the Trace tool. Figure 35 provides an overview of a mechanism of barriers and enablers regarding seasonal sales peaks and its influence on time pressure, as identified in the AV2go case. The bracketed items in the caption refer to categories in Trace.

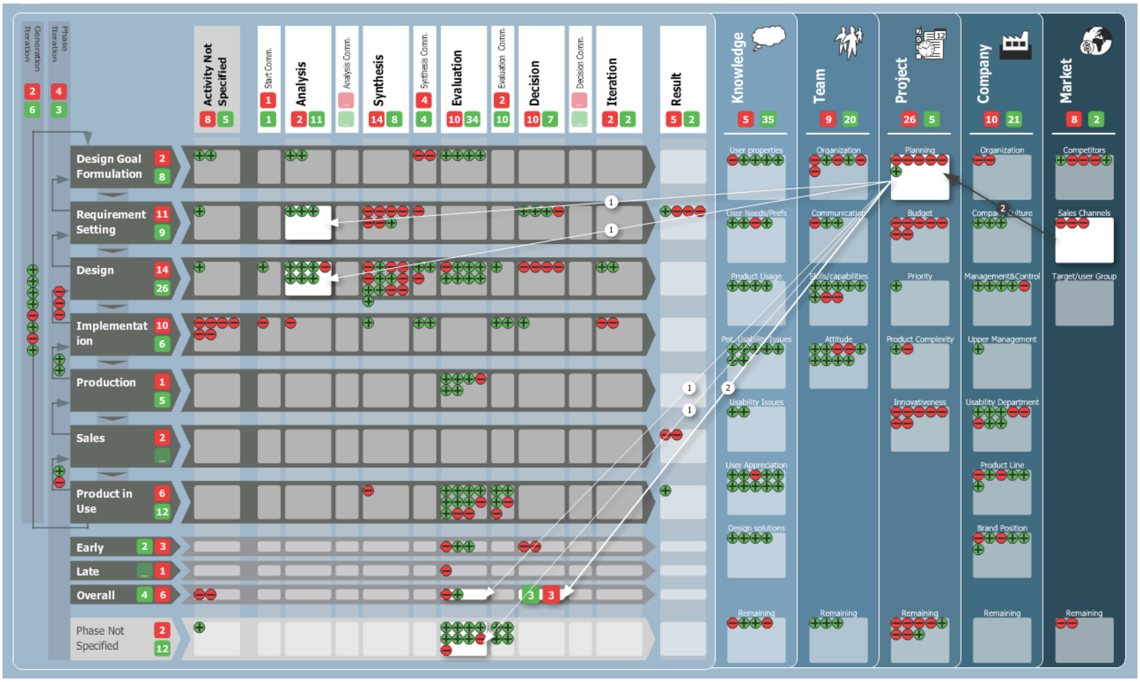


Figure 35: Visualization of a mechanism of barriers enablers related to project planning in the AV2go case. Explanation: There was considerable time pressure on product development [project/planning] because of strict deadlines for delivery to retail channels and because of seasonal sales peaks [market/sales channels]. This was suggested to negatively influence the effort that could be put into analysis [requirements/analysis, design/analysis] and evaluation activities [overall/evaluation; not specified/evaluation], and to lead compromising the original concept/design [overall/decision].

4.2.4 Creating the context descriptions

In addition to the mechanisms of barriers and enablers, for each of the development groups I wrote a context description, which outlines how the group was organized, conducted product development, communicated, etc. The context descriptions facilitated explaining of the presence of barriers and enablers as well as conducting the cross-case comparison discussed in the next paragraph. Additionally, it is important to provide the reader with an in-depth insight into the study site and its context (Malterud, 2001b), as this provides other case study researchers with the possibility to judge whether the cases they are studying are comparable.

Similar to the procedure followed to arrive at the barriers and enablers, first meaning units were identified, which were then condensed and coded using a coding scheme that was initially based on the conceptual framework in Chapter 2, and was then refined while coding the interviews. Per interviewee, this produced a collection of jointly told tales that described a number of relevant properties of the product development groups (see Table 19). Subsequently the jointly told tales of the various interviewees were merged into a context description, allowing for comparison of interviewee descriptions. Informal interviews with the primary contact and on-site observations were used as supplementary sources of information.

Table 19: The categories of the context description. The categories are similar to the relevant concepts identified through the review of existing literature and exploratory interviews (see Table 2). Some concepts were renamed (e.g., 'company structure and organization' became 'development group organization) while other concepts were merged into one category (e.g. 'usability department' under 'development group organization'). The sequence of the concepts was changed to result in a top-down description so the reader would first be familiarized with the organization as a whole (context) and only then with the description of the product development activities.

Category	Explanation
Development group organization	What departments does the group have, and how are they organized and located?
Company culture	What is the company's 'way of doing things': the atmosphere, attitude, and way of working?
Management approach	What measures and incentives are in place to control the direction and quality of the company's activities?
Product portfolio	What are important product and product line characteristics?
Brand strategy and product positioning	What is the company's brand strategy, how is it perceived, and how is the product line positioned?
Market	What are the properties of the market the company is operating in? What are the primary sales channels, competitors and target group properties?
Product development	What are the defining characteristics of product development such as in-house versus outsourced, formalized versus informal and the pace and degree of time pressure? What are the primary steps in the product development process, what are the goals and who are involved?
Product development team	What are the roles within the product development team and what responsibilities are there per role? What modes and style of communication do members of development teams use during development?
User involvement and representation	What methods are used to collect user-related information, or simulate product usage, when are they used, and by whom?

4.2.5 Cross-case analysis

By comparing the analyses of barriers and enablers and context descriptions across the development groups, a cross-case analysis was performed. The goal was to compare what mechanisms of barriers and enablers occurred in which groups, and if possible to offer an explanation why. As with the individual analyses of the cases, the goal was to identify both common as well as unique mechanisms.

By loading the data of all cases in the Trace tool the categories, product development phases and types of activities with the highest density of barriers and enablers became evident (Figure 36) and could subsequently be explored in depth. Secondly, in a clustering (Tassoul and Buijs, 2007) exercise the mechanisms described in the individual reading guides were grouped to identify shared mechanisms.

This dual approach allowed for both identifying unique instances as well as the most common, dominant mechanisms of barriers and enablers. These mechanisms were then captured in a description, structured according to the categorization scheme of the barriers and enablers. In the description it was indicated in which of the development groups a certain mechanism occurred or not.

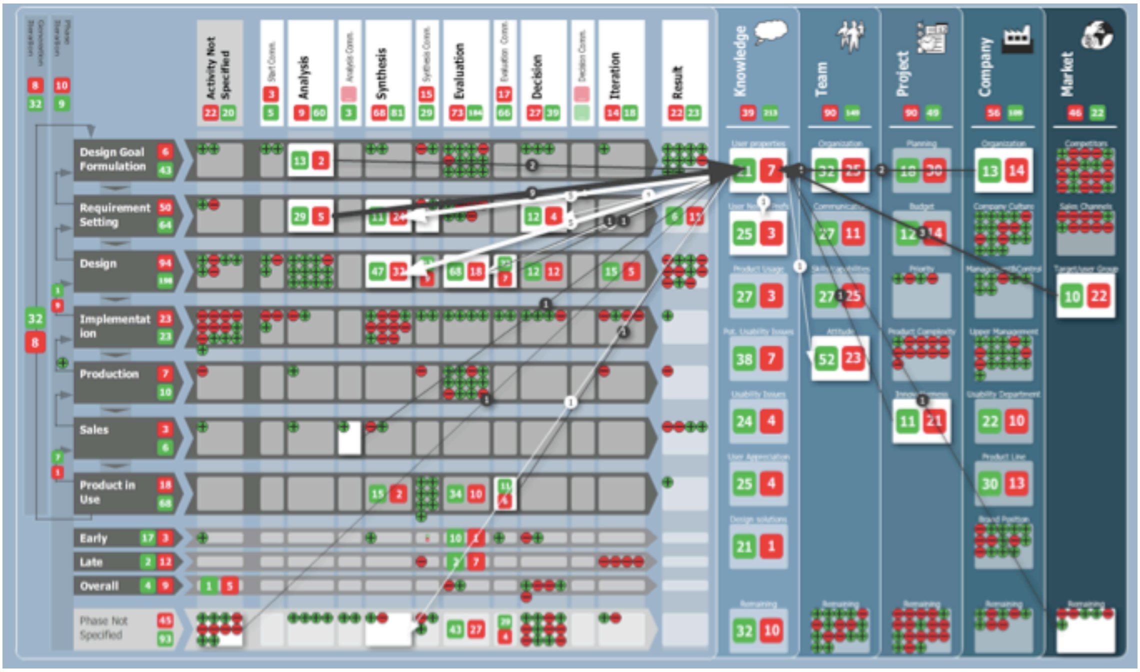


Figure 36: A screenshot of the Trace tool filled with the data from all five cases and while exploring the relations of the 'knowledge/user properties' category.

4.2.6 Verification strategies

This study contained two verification mechanisms. During data analysis a second researcher reviewed interpretations, and secondly, by the end of the study a workshop was held in which the primary contacts of four of the participating companies reviewed the findings per company and overall conclusions.

During data analysis of the first two development groups, the second researcher read all jointly told tales and noted unclear wording or questions regarding interpretations that the first researcher made. The researchers then discussed unclear issues and differences they had in interpretation, arriving at a consensus. This process allowed the first researcher to improve his way of working. For the third case the first researcher only discussed jointly told tales he felt might contain problematic interpretations with the second researcher. The first researcher researched the last two cases independently.

To verify the development group descriptions and the mechanisms of barriers and enablers identified at the individual development groups, as well as to get feedback on the cross-case analysis, a feedback workshop was held which was attended by the primary contacts of four of the companies. The feedback from the fifth company was obtained on an individual basis through telephone and videoconferences. The setup of the workshop is described in more detail in sub-paragraph 4.2.6.

4.3 Context descriptions: the product development groups

4.3.1 AV2go | personal media players

Development group organization

AV2go (Audio-Visual-to-go) was an Asia-based development group of portable media players for music and video. The group was part of a large European multinational electronics company with 120,000 employees worldwide. Within the offices in the Asian capital there were about 50 people dedicated to working on personal media players. AV2go had its own product strategy and management, and market intelligence groups, while development engineering (developed technological platforms for new products or coordinated external parties that did technological development and manufacturing) quality management and design were shared with other product categories (Figure 37).

The design department was independent from the AV2go development group and the designers had a consultant-like role in product development teams. The department consisted of about 80 to 90 people, working in disciplines such as product, interaction, visual interface, and graphic design. AV2go also had a research department in Europe that developed or selected new technologies and suppliers. Customer service was outsourced to a third party company and was executed in a different location.

Two years prior the research AV2go had setup a consumer/user testing centre, which was responsible for the setup, coordination and execution of user/consumer tests, and consisted of a manager and an assistant. The centre was understaffed and the testing facilities could be more suitable for the type of products it was testing. The department did all the tests in-house, but - because it was understaffed - hired free lancers to execute some of the tests.

Except for technology research and customer service all departments were housed in the same building. The design department was in a different part of the building than the rest of the group.

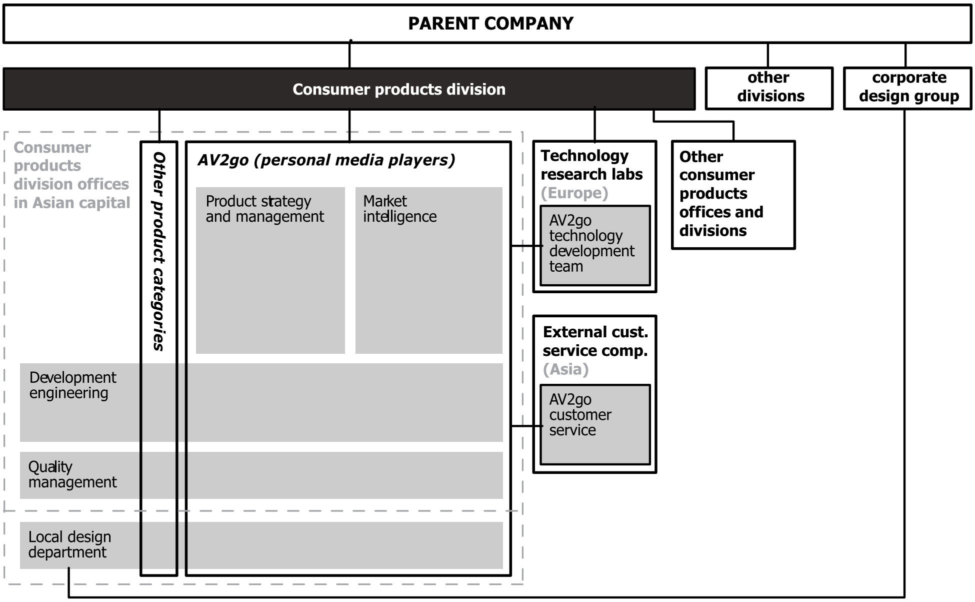


Figure 37: Organizational structure of AV2go.

Company culture

The multinational that AV2go was a part of was a very big and complex organization, with a lot of distributed decision-making, and formally documented processes. The way of working at AV2go was described as very analytical, methodical, and democratic, with a lot of stakeholders involved in each decision. Decisions seemed to be based on a lot of input, such as concept testing, consumer research, market trends analyses and competitor analyses. Decision-making at AV2go was described as quite a slow process, due to the involvement of many stakeholders and so much input being used.

Management and control

The most important key performance indicators within AV2go were time-to-market and sales numbers, and to a smaller extent the amount of customer complaints and returned products. Design and engineering awards were also considered somewhat important. The goals that set for a product development project did not explicitly include usability. However, AV2go had recently introduced consumer experience tests, in which products were tested on usability measurements just before they would be launched. AV2go had a well-established quality management system.

Branding strategy and product positioning

AV2go thought its brand was perceived by consumers not as hip or innovative, but as reliable, knowledgeable and down to earth. The products were considered 'value for money': good quality, at a reasonable price, from a fairly well known brand. About a year prior to the interviews AV2go repositioned its brand to communicate that its products were easy to use.

Products

AV2go developed four types of products: solid-state music players, hard-disk music players, and micro-music systems. Recently the development group started moving into the video-player domain as well. For each product category about five to ten models were developed per generation. Most products in the sector shared the same technological platform that the different brands purchase from third party suppliers. The interviewees characterized the usability of AV2go's current range of products from 'poor' to 'reasonable'.

Market

The personal media player market was described as a very competitive, fast-changing market: the available technologies changed rapidly, there was a huge amount of competitors, and new products were released frequently. There was one dominant competitor with an extremely large market share: Apple. All the other - smaller - players on the market were competing to be number two. Personal media players were mostly bought through retail stores or online shops. For the cheaper MP3-players, consumers made ad-hoc in-store purchase decisions. For more expensive music-players consumers turned to the Internet and shop floor assistants to inform themselves. The sector had a sales peak at Christmas-time.

The informants considered price and memory capacity (for storing music files) to be the most important product purchase considerations. Other potential purchase considerations were product appearance, quality, brand, and (maybe) the UI. Usability was not considered an important purchase consideration among buyers, but a post-purchase (dis)satisfier.

Product development

AV2go had roughly three different types of development projects:

- Third party products: a completely finished product was purchased from a third party supplier, it was rebranded as an AV2go product, and put out on the market as fast as possible.

- Third party platform: hardware/software platform was purchased from suppliers, and AV2go designed an AV2go 'skin' for the product.
- In-house product development: AV2go develops both the product architecture and the product design (UI and industrial) internally.

Recently AV2go had been switching more to the third party products and platform approach.

AV2go followed a stage-gate type product development methodology that was used throughout the parent company. It was well documented and featured a large amount of mandatory process steps and deliverables, which could be adjusted slightly per project. At the end of each phase a milestone meeting was held in which the project was presented to and reviewed by colleagues and upper management. The phases from product concept to market launch were very structured and ran on a strict schedule. Pre-development (developing the product concept) was less formal and more explorative. AV2go released new product lines at least every year, if not every 6 months. The total development time from the beginning (identification of user needs) to end (market launch) was about one year. There was constant, fierce time pressure to make the release deadline agreed upon with the retailers.

A large amount of meetings was held to take and align decisions about the product. PowerPoint documents were used to share and document information. Informal communication (other than in meetings) was somewhat limited because the team members were not seated by project but by discipline. There was no explicit definition of usability at AV2go and shared understanding of the concept seemed limited. It was rarely discussed what usability really means. Higher management was said to have a very limited understanding of usability.

Development team

For each of the phases in the development process a team with a specific skill set was assembled.

- Pre-Development Team: Created design brief and requirements. Consisted of a product planner, mechanical and software engineers, a UI specialist, and interaction and product designers.
- Product Development Team: Created the product design. Consisted of a product manager, project manager, designers, and architects for the mechanical, electrical and software design.
- Implementation Team: Implemented the design that was made by the product development team. Consisted of people from third party suppliers, including software engineers and mechanical engineers.

Many of the interviewees indicate that they are not sure how their colleagues define usability and some of the interviewees state explicitly that there is no shared understanding of usability at AV2go.

User involvement and representation

AV2go employed a wide range of user involvement and representation methods, mostly focused on evaluation (Table 20). In the design brief formulation phase most of the methods were intended to support the creation of the right product concept and were mostly performed by market intelligence. The most commonly performed tests (customer experience development and validation tests) were performed relatively late in the process, when the product had already been designed, implemented, and – in the case of the validation test – produced. Beta testing was a relatively new activity for AV2go. The group employed a considerable amount of information sources to monitor usability issues and customer appreciation of products once they were on the market, some of which were pro-active (such as a customer satisfaction survey and focus group discussions), which enabled the company to also detect issues that people did not find serious enough to complain about.

Table 20: User involvement and representation throughout the product development process at AV2go.

Phase	Analysis methods	Evaluation methods
Design brief formulation	• Market trend data • Voice of the customer • Home visits	• Qualitative concept testing • Quantitative concept testing • Review by sales organization
Requirement setting		
Design	• Reading online product reviews	• Designers mimicking product use • Colleagues trying out product/prototype • Expert review of UI • User test of early prototypes • Comparison test of UI (choosing from multiple concepts, or comparing with competitors)
Implementation		• Consumer experience development test • Field test of prototype
Production		• Beta testing • Consumer experience validation test • Translation validation
Sales		
Product in use		• Focus group discussion • Analyzing product returns • Analyzing customer support data • Customer satisfaction survey • Monitoring product review websites • Collecting professional reviews

4.3.2 EnRoute | personal navigation

Development group organization

EnRoute ('on the road') developed personal navigation devices, primarily for in-car use. The company had originally been a software company, but started to make its own hardware a number of years prior to this study. In recent years the company had grown very rapidly from about 50 to roughly 450 employees and was still growing, which had resulted in a lot of organizational changes. Product innovation activities were distributed over three locations. The main offices were located in a major European city and most members of the product development team were located here, such as product management, software development and customer service. Hardware development was located in another European city. Hardware engineering and production took place in Asia by third party contractors.

The task of the recently established user experience group was to 'defend the user' in development of the software and UI. The group did this by making UI designs, reviewing designs, and performing user tests. The group was very much pressed for time, as it was understaffed and the number of projects within EnRoute was continuously increasing. There was a lack of office space in the EnRoute building, preventing the members of the user experience group from being seated together and the group did not have a dedicated test lab; tests were usually conducted in conference rooms.

The user experience group and a number of software developers acted as UI designers (there was no dedicated design department). A semi-external industrial design agency, in the same city as the hardware development group, was the company's hardware design group. The board of directors was very influential and very much involved in product development. One of the directors was a big and influential advocate of usability within the company, and he had a strong vision on how to develop easy to use products.

Company culture

EnRoute focused on one specific product category and wanted to be innovative and deliver high-quality products. The company's staff was relatively young, and the atmosphere was described as eager, non-hierarchical, informal and open. The way of working was fast-paced. EnRoute did not make extensive reports, documents or risk analyses to support decision-making. There was what one of the interviewees described as a 'small business mentality': think of something new, bring it to the market quickly, and see more opportunities than obstacles.

Making usable products was an important part of the values of EnRoute. The previously mentioned director had instilled a widespread notion among the staff that usability was an essential contributor to the success of the company. The usability of EnRoute's products was considered something that set the company's products apart from their competitors.

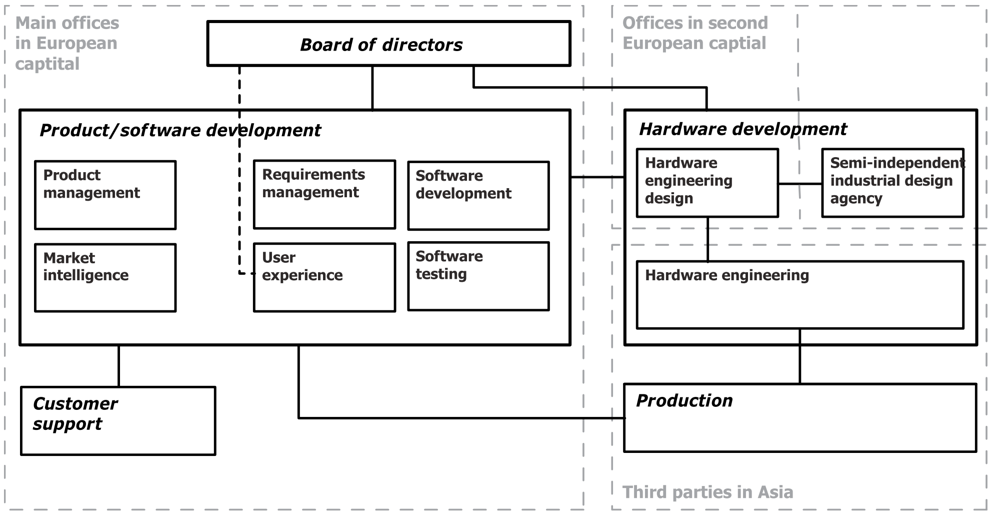


Figure 38: The product innovation organization of EnRoute

Within EnRoute the most important reasons to consider a product successful were commercial, such as revenues and sales numbers, others were related to product quality and customer satisfaction, such as customer feedback (complaints and product returns), positive-word-to-mouth among consumers, and reviews by journalists and on Internet forums, and the reliability of the product.

Management and control

The development group did not have a systematic bonus/reward system and had not implemented a formal quality management system.

Products

All EnRoute products shared the same navigation software platform, which could be customized slightly if the functionality and hardware of a particular model required it. The products could be connected to a computer and communicated with using a software suite, allowing users to update the device software and content (maps). At the time of the study EnRoute had just started to offer online services in combination with their products, such as traffic information. Some of the products featured Bluetooth connectivity to connect them to a mobile phone, thus enabling hands-free calling and Internet access (which was required to use the online services). Previously EnRoute had had a limited product portfolio, but was now expanding and diversifying the product range. The usability of EnRoute's products was generally considered very good. Through customer service EnRoute received relatively few complaints about the usability and in customer surveys the products were rated very high on usability. In addition, journalists and motorist organizations were also very positive about the usability of the products.

Brand strategy and product positioning

EnRoute had been the first to the market with an easy to use, stand-alone, affordable navigation system and the interviewees pointed out that as a consequence, to some buyers, the company's brand name had become almost synonymous to personal navigation. The company promoted its products as technologically advanced and easy to use. EnRoute targeted a high-end, high-quality product position.

Market

The market for personal navigation was relatively new, but had grown very fast over the previous years, and still continued to grow. At the time of the study, the first replacement buys were taking place, users started being interested in advanced functionality, and the number of competitors was increasing. There were two dominant players in the personal navigation market, one of which was EnRoute. The prices of navigation products were dropping very fast and there was fierce competition to be the first with new features. Though EnRoute aimed to reach a broad target group, not just the technology-savvy, its buyers at the time could best be described as the 'early majority' market segment. The most important retail channels were electronics retail shops and Internet was a popular alternative. When buying a personal navigation device the interviewees indicated that many buyers would collect information on the Internet, and in the stores would rely on the advice of the sales people to great extent. Furthermore information from friends, family and colleagues was considered to play a significant role. When buying personal navigation products consumers primarily looked at the form factor and brand image. There was a peak in sales before the summer and Christmas holidays.

Product development

The development group did not have a formally documented product development methodology and throughout the company varying terminology was used to refer to the same phases or documents. However, there was a common understanding of how product development was performed, which was communicated informally. Because of the fast growth of the company, its way of working was under pressure, and EnRoute was starting to formalize and document its product development process.

EnRoute defined and designed its product in-house. Ideas for new products or features were conceived by upper management and the very next step was then for the industrial design group to create a visualization of what that proposition could look like. Next a feasibility study was conducted. If deemed possible, the project started by defining high-level requirements. Next, hardware and software were developed in parallel. Extensive software (reliability) testing was an important part of the development process. Once the product was on the market, the development team stayed responsible for the product, processing feedback, implementing improvements in new product releases and distributing new software releases on the Internet for consumers to be able to update their products.

Software design and development, and hardware design was performed in-house, but development of hardware and production of the product was performed by third party companies. Map data were licensed from third party suppliers.

There was considerable time pressure on product development, as the sooner a product was on the market, the bigger the chance it would be the first with a certain feature. The market sales peaks around Christmas and summer vacation also resulted in tight deadlines and planning.

Development team

Product development was led by a multidisciplinary core team, with representatives from each department. The team included a product manager, people from software development, hardware development, logistics, sales, customer support, and marketing & communications. There seemed to be quite a lot of (informal) communication between the different disciplines within the company. Within the headquarters, the different departments were not very segmented. The fact that headquarters and software development were in a different location than hardware development did seem to complicate communication between these two parts of the company. During software development, the team used an issue tracking system to monitor and prioritize issues. Within EnRoute there was no explicit, shared definition of usability. Many of the interviewees were uncertain what views their colleagues held of usability or indicated that there were quite varying views of the concept within the company.

User involvement and representation

The type of research the user experience group did (see Table 21) was largely qualitative in nature, and included relatively small numbers of participants: the main goal was to find the major usability problems. EnRoute tried to perform user tests regularly, but the tests were so time-consuming that the team could not always do that. Expert reviews were done quite regularly because the user experience group was understaffed, even though the UX manager thought of expert reviews as a last resort. The product manager was the most important audience for after sales feedback, because he had to coordinate the efforts to fix the causes of the problems. Other members of the product development team (including the user experience manager) did not receive after sales feedback on a structural basis.

Table 21: User involvement and representation throughout the product development process at EnRoute.

Phase	Analysis	Evaluation
Design brief formulation	• Sales numbers analysis • Market trends monitoring • Field studies on product category usage	• User interface concept testing
Requirement setting	• Competitor product evaluation • Interviews/focus groups	
Design		• Designers and colleagues evaluating early prototypes • Remarks from colleagues • Audio quality testing
Implementation		• Informal testing with friends/family • Expert reviews of UI
Production		• Beta testing • Out-of-the-box test of (near) final product
Sales		• Feedback from trade marketing colleagues
Product in use		• Customer survey (bi-)yearly • Monitoring service use • Long term field study of current product • Monitoring Internet forums • Monitoring reviews in the press

4.3.3 WashCare | washing machines and tumble dryers

Development group organization

WashCare was a product development group of a European multinational that made home appliances, with more than 15.000 employees worldwide. The company was a matrix organization (Figure 39): people were organized in departments by discipline (i.e., marketing, design), and each department worked for all of the various product divisions (i.e., vacuum cleaners, kitchen appliances). The company had a very low personnel fluctuation and thus the staff had a lot of experience and domain knowledge.

The company had a combined industrial/interaction design department of roughly 35 people. User testing for all product development groups was done by the recently established user testing group in the market research department, at the time consisting of one person, which was not sufficient to deal with the rising requests for user tests. There was a dedicated user-testing lab, equipped with video recording and editing equipment. Part of the user testing – especially abroad – was outsourced to third party research institutes.

The directors of the company had been in charge for a long time and were well respected within the company. They were well informed about and involved with how the company as a whole was run as well as with product development.

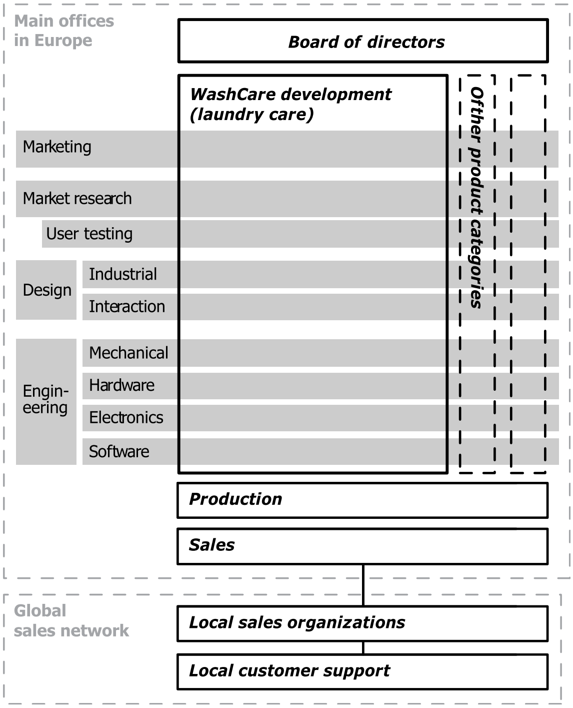


Figure 39: Organizational structure of the WashCare development group. Each department does not only work for WashCare, but also for other product development groups within the parent company.

Company culture

WashCare was described as a traditional company, focused on quality and customer satisfaction. Traditionally the company had always had the ambition to make technologically advanced products, though over past the years it had also become to some extent marketing-driven and more and more attention was being paid to design. The company had a serious, polite company culture and the way of working was described as precise and careful. Within the company consumer trusts was its most important asset. A lot of attention was paid to improving details in the products and processes.

Within WashCare products were considered successful if they made a profit (healthy margin, and high sales volume). Also, customer satisfaction was considered very important, because word-to-mouth advertising was an important marketing strategy. This required the products to perform very well and be extremely durable. WashCare's employees considered usability important, as washing machines should be no-worry products, but usability was not considered more important than, for example, aesthetics or functionality.

Management and control

WashCare used a quality management system focused on monitoring the manufacturing quality of the machines. Usability was not included in the measurements. During the interviews bonus or key performance indicators were not mentioned.

Products

WashCare developed two types of products: washing machines and tumble dryers. Other product development groups in the parent company offered a wide range of household appliances, from dishwashers to ovens, coffee machines, and vacuum cleaners. WashCare's products were very expensive, but of high quality. The product development group offered a limited product line per country, but did diversify its product lines between countries in terms of the basic architecture of the machine and the functionality that the product offered. In addition the UI was always in the local language. Different models were built on the same technological platform, of which the performance qualities (such as spin) could be adjusted to fit the marketing proposition of a specific model.

Recently, WashCare had introduced menu-based user interfaces in high-end products, and tried to make them consistent between similar products but also across product categories (aligning laundry care products with i.e., kitchen appliances), and therefore was developing interface elements and interaction methods to define a consistent corporate design vocabulary for their products. Low and mid-end products still had different UIs. Product appearance was described as understated, modern but not trendy, and with 'honest' materials. In general, the usability of WashCare products with traditional user interfaces was rather good, but the newer, high-end models, provided more extensive functionality, which was accessed through a menu-based UI, which considered more complex.

Brand strategy and image

WashCare offered high quality products. In its marketing the company stressed the technological superiority of its products as well as user benefits. The company wanted to be honest towards its customers and was careful not to claim that its machines could do more than they actually could. In terms of design the company described itself as modern, but not trendy. Consumers viewed WashCare as one of the trustworthiest brands worldwide.

Market

WashCare sold its products nearly worldwide. Between market situations could differ considerably. The European market, a primary market of WashCare, was described as a stable, saturated market, mostly consisting of repurchasing customers. No big new companies had entered the market and in the last 3 to 4 years few technological innovations were introduced. In the previous five to ten years most competitors had started to compete more on price and some competitors were moving production to low-cost countries. A large number of companies were starting to introduce machines with menu-based user interfaces. The company's product line differed per country, because how people wash their clothes differs significantly between countries. Customer trust in the WashCare brand was considered an important purchase consideration. Retailers were the most important sales channels for WashCare's products. The company paid a lot of attention to the relationships with its retailers, making sure that they would accept and understand new product lines as well as collecting feedback from them.

Product development

WashCare designed, developed and produced its products completely in-house. A distinction was made between technology projects and product development projects. Technology development projects were relatively informal, relatively informal projects in which ideas for new technological, interface or marketing concepts could be explored. However, most product development projects built on predecessors; only once every 10 years or so did WashCare develop a completely new washing machine. Product development projects, which lasted about 3 to 4 years, had a stage-gate structure, and were divided into pre-development, in which the feasibility of a product idea is explored and the product was defined in more detail, and series development, in which the product definition was implemented. Product development – especially series development – had a more formal character and very strict planning. Once a launch date was set it was preferably not changed, because all the marketing and sales preparations had already been made.

Development team

WashCare developed its products by generations. What products were to be developed in a generation was based upon strategic development roadmaps. The individual development project assignments were conceived by the board of directors and the upper management of the various departments and factories, in cooperation with others like marketing, engineering, electronics components, buying department and design. Further definition of a product was done by marketing, engineering, electronics, and design management in cooperation with purchasing, quality control, etc. For strict development a core team was formed of representatives from all departments, to coordinate the efforts of their departments for the project. That team included people from marketing, electronics engineering, mechanical engineering, industrial and interaction design, and the usability group. A representative from marketing served as product manager, and the project manager was usually from the engineering department. It was customary for the development team to remain intact during the first three months after launch, to fix issues that surfaced in after sales feedback. The core team met on a regular basis (i.e., once or twice a week), and communicated through telephone, e-mail and face-to-face contact. Within WashCare there was no explicit, shared definition of the concept usability.

User involvement and representation

There was no standardized way for conducting user involvement in the product development process. Whether user testing was performed was dependent on whether, for example, the user interface was very well known, or, in some cases, time pressure. However, the design department had thoroughly incorporated informal user testing with the use of mock-ups and simulations in their way of working. Recently an extensive field had been performed to learn about the customs, needs and context of use of users in an unfamiliar region, which was experienced as very positive. The development group invested a significant amount of time and effort in a thorough round of beta testing by WashCare employees and selected test households. An overview of user involvement and representation methods applied at WashCare can be found in Table 22.

Table 22: User involvement and representation at WashCare.

Phase	Analysis	Evaluation
Design brief formulation	• Market trends analysis (per country). • Competitor analysis (per country). • Field study (home visits).	
Requirement setting	• Focus group to identify user needs. • Analysis of the (physical) context of use. • Analysis of product use scenarios.	• Evaluating product ideas in a focus group.
Design		• Discussing early sketches with designers and marketers. • Evaluating early product designs in focus groups. • Designers personally trying out mock-ups. • User testing by the design department (mock-ups/paper prototypes/simulations, non-design colleagues/local participants).
Implementation		• User testing by market research (prototypes/early samples, local participants). • User testing by third party test institutes (global participants). • Locally verifying translations (implemented in a functional control panel).
Production		• Home use of products (by WashCare employees and test households).
Sales		
Product in use		• Launching a product in a test market and collecting feedback. • Feedback from sales departments about complaints and questions (sales representatives meeting). • Feedback from the customer service department (limited). • User tests of the current product line (and user interfaces) by external test institutes. • Third party brand perception surveys.

4.3.4 D-phone | mobile phones

Development group organization

D-phone was a Europe-based product development group of mobile phones, which at the time had between 5000 and 10.000 employees. Commercially it was quite successful and the organization was growing and organizational changes were frequent. The product innovation organization was divided into two large units (Figure 40), supplemented by a global sales and marketing network. Product & Application Development created and implemented new products and applications, and the marketing organization collected market information and marketed and distributed the products. The whole product development organization was located in one city, but not all in the same building. The global corporate offices, as well as the marketing and sales organization were located in different European country. Software development was performed in a matrix organization:

the departments contributed team members to teams that focused on a particular application within the user interface, such as messaging, calling or photos.

The design department had about 50 employees, working in the areas of industrial design, colour and material, graphics, and packaging design. The department concerned itself mostly with the appearance of the products, which included the physical controls and the appearance of the UI. In the interaction design department (30 people), interaction designers and usability specialists cooperated closely on the development of user interfaces. The interaction department had been established several years prior, and was well established within the company, and they had what they considered a well-equipped usability lab and sufficient staff. The department had recently been reorganized and now had has four sections, focusing on 1) user interface paradigms/fundamentals, 2) application design, 3) project coordination and 4) localization (customizing interfaces for different countries). Upper management was not directly involved in product development decisions and mostly had an engineering background.

Company culture

D-phone was a young, innovative company that, though it paid considerable attention to the consumer and user perspective, still also was very technology-driven. The employees were described as relatively young, eager and ambitious. D-phone employees considered both consumer appeal, as well as the user satisfaction of a product important. Product appearance and the appropriate functionality was considered very important for consumer appeal. Usability was considered an important contributor to a good user experience, which in turn was considered to make customers loyal to the brand. Within D-phone usability was considered to go beyond the on-screen UI; one should consider the usability of the whole product, in all its phases of use.

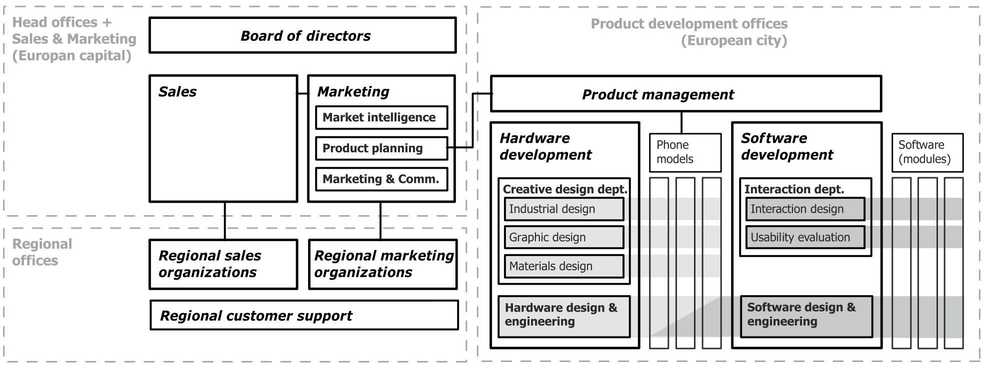


Figure 40: Structure of D-phone's product innovation organisation.

Management and control

Key performance indicators of the team members included sales numbers, profitability, brand recognition, time to market and reliability. Usability was usually not mentioned in the project goals, and if so only in vague terms.

Brand strategy and product positioning

D-phone was a premium brand making advanced products. D-phone had too big a portfolio to communicate a proposition for each phone. Therefore, in addition to the D-phone brand, D-phone had developed marketing segments, which were marketing propositions for a particular type of phones. The marketing approach differed per product line.

Products

D-phone had a very extensive product portfolio, and products would usually have extensive functionality, and were often multi-functional (they included music players, calendars, cameras). Recently D-phone had been extending its low-end range. D-phone based its products on a limited number of technical platforms. Often it first introduced a high-end model, based on a new platform, and then derived the lower end products from this. The company based user interfaces for individual products on a UI paradigm, of which there were several versions (high, mid, low-end). Changes in the hard and software between generations were limited. The interviews considered the usability of D-phone's product relatively good, given the extensive functionality of D-phone's products.

Market

The mobile phone market was described as very dynamic, with new technologies and functionality being introduced continuously. As a consequence the demands that D-phone's target groups placed on the products were continuously changing. There were a number of well-established competitors. In Europe, US and also Asia most purchases were replacement buys, and phones were getting more advanced. In less-developed countries, where people were looking for basic phones, a new target group was emerging. D-phone had gained some market share in the previous four years. In the high-end, advanced segment the company was one of the market leaders. In the low-end segment it performed a bit less.

D-phone mostly did not sell directly to consumers, but to network operators and retail companies who then sold the products to consumers. The retail channels and network operators were D-phone's clients, and could demand that the phones would have specific properties.

When buying a phone, consumers would to find it more important what phone they were getting than what operator they were with. Because the phones were usually sold in low-quality retail store environments where users could not use the products the most important ways to make the products stand out were features, price and appearance. A number of 'hygiene factors' were performance measures like battery life, talk time, etc. The interviews thought that to buyers usability was not the most important purchase consideration.

Product development

D-phone defined, designed and implemented its products in-house, and produced its phones partly in-house and partly through third party manufacturers. Most product development projects lasted about one to one-and-a-half years. The early phase of product development, in which new designs, UI concepts and technologies were explored, had a more iterative character, whereas the rest of the development process was a very strict stage-gate process, which as defined in much detail, and should be followed in every project.

All product development projects were derived from the product portfolio that had been defined for that year by product planning and product marketing. The product concept that was determined on a strategic level did not have a form factor yet, but described the basic design of the phone, such as 'clamshell', its functionality (i.e., Bluetooth), the products it should compete with, the user groups it should target, and through which channels (such as magazines) the product would be marketed.

Design and implementation of the hardware and embodiment on the one hand, and of the software on the other were performed independently. The industrial design department was involved early, in the concept phase. By the time the interaction design department got involved the physical design of the product, including the controls, had already been specified.

Development team

Within the organization there were two types of teams: teams that developed products, and teams that were responsible for functions that were implemented across products, such as messaging, music, etc. Within product development teams the product planner was responsible for the product definition and for the concept being implemented. The project manager was responsible for the planning, budget and coordination of the project and his or her biggest contribution was in the early phases of the project, but he or she remained involved throughout.

Because they were located in different cities, people from the marketing and the product development organization did not meet face to face that often. During product definition the product-marketing manager would visit the product development group to provide input and participate in discussions. Though the departments of the product development organization were not located in the same building, face-to-face meetings occurred regularly. In addition, within D-phone a lot of communication took place via the documents that formed the deliverables of the development process. D-phone had an issues management system where team members can enter issues, but it was primarily used for beta testers and operators to report bugs. The interviewees indicated that within D-phone there was no explicit, shared definition of usability.

User involvement and representation

The usability group within the interaction department could perform tests in all phases of the development process, and for a large range of purposes (hardware keys, call quality, evaluating applications). The interaction designers could 'order' tests from the usability lab. Tests were mostly done during design and most of the user tests were for the interaction designers and focused on the on-screen UI. There was less cooperation with industrial designers. Table 23 provides an overview of user involvement and representation methods applied at D-phone.

Table 23: User involvement and representation throughout the product development process at D-phone.

Phase	Analysis	Evaluation
Design brief formulation	• Interviews with consumers • Interviews from the regional sales organisation • Third party user research	• Design guidelines
Requirement setting	• Comparative user test of (competitor) products	
Design	• User observation in the field	• Industrial designers evaluating physical ergonomics of a design (mock-ups) • Expert evaluation of (on-screen) UI design by usability specialist • (Groupwise) cognitive jog/walkthrough • Lab-based user testing (paper/simulations/prototypes, external participants)
Implementation		• Verification of translation of UI texts/labels • Lab-based user testing (prototypes, external participants) • Field studies (functional prototypes, external participants)
Production		• Beta testing • Questionnaire about use to beta testers
Sales		
Product in use		• Customer satisfaction survey • Analysis of customer questions/complaints logs • Listening in on customer service calls • Competitive intelligence reports: sales numbers • Feedback from network operators • Press reviews

4.3.5 HomeControl | thermostats

Development group organization

HomeControl was a Europe-based product development group of controls for home automation systems[19]. It was part of a division that develops components for home and office automation systems (i.e., security, heating, hot water, air, etc.), which in turn was a subsidiary of a large-scale multinational (100.000+ employees) that developed controls for high-tech business-to-business markets.

The development group was relatively small, with about 15 people working on the development, marketing and sales of home-control products. The product management and sales department were located in the division's

main offices. The engineering department was a semi-independent unit of that division and was located in another city than the main HomeControl offices. The department works for HomeControl, the division of which HomeControl is a part, as well as for other clients. The development group did not include an industrial design and usability department, but worked with an external design consultancy and a human-centred design agency.

User interfaces were usually copied from predecessor products, and adapted by the product manager in cooperation with the consultants. HomeControl had a customer service department in the same location as the product marketing & sales group and a quality management department that monitored whether product development projects were performed according to the formal process.

The user-centred design consultancy specialized in user testing of consumer and professional products, and consisted of three senior experienced user centred design specialists. The company did not have its own user test lab, but had video equipment for on-site testing, and if needed rented a user testing lab. The industrial design consultancy was a medium-sized industrial design agency in which industrial designers, graphic designers, engineers and prototyping specialists cooperated.

Company culture

HomeControl's parent organization was a very large organization, described as technologically advanced, though also was fairly marketing-driven. It was a public company, and was therefore under pressure from shareholders to perform well financially, making the company somewhat risk averse: quality management and risk control were very important. Some interviewees described HomeControl as very hierarchical, with a lot of management layers, where short-term financial results were very important and in which takeovers and reorganisations were common. However, it was also an organization where one had the opportunity to take initiative and for example launch new product proposals.

---

[19] In the interviews for this case the focus was on a specific development project, which was the development of a new type of thermostat in which an external industrial design agency and human-centred design consultant were involved.

Within HomeControl the most important reason to consider a product successful were revenues (sales numbers and margins). In addition, customer satisfaction was considered very important, and usability in turn was considered a contributor to customer satisfaction. Thus user testing was considered an important tool for customer satisfaction.

Management and control

HomeControl's parent company had a very structured product development process, with specified deliverables and in which important decisions had to be presented and agreed upon by senior people in the organization. The company also had multiple quality monitoring and management systems.

Brand strategy and product positioning

The primary selling argument used by HomeControl was a home climate that is always comfortable. For some products, the marketing contained explicit claims that the products were easy to use. The group's marketing strategy was also to build brand loyalty through a good user experience.

Products

HomeControl's product portfolio consisted of roughly ten models of thermostats for home use, ranging from a simple knob for a single radiator to advanced touch-screen devices to control the temperature in the whole house. The products were mostly based on predecessors from the US market. The range did not share a common technological or UI platform. User test results, informal feedback, and letters from customers suggested that people generally found HomeControl products easy to use.

Market

Most potential customers already had home-automation control products (mostly thermostats) in their homes, which they were not likely to replace frequently. HomeControl targeted the European market, in which it was market leader. The products were sold primarily through business-to-business channels: installers, property development companies or housing associations. A smaller number of products were sold via retail channels, mostly via Do-It-Yourself stores. To consumers the products were of low interest products. A model would stay on the market for a relatively long time in comparison to, e.g., mobile phones.

Product development

The product development process at HomeControl was a stage-gate type process, which had been in place for about four years. During product development quality management tools were used to prioritize product properties and monitor process and production quality. Projects that required a certain level of investment had to be performed according to the standardized new product development process. Smaller projects, such as product updates, did not need to follow this extensive methodology.

On a European level the division strategy was defined yearly, which in turn was the basis for the product portfolio plan that outlined which products would be developed. For each initial product idea a 'market request' document had to be written that outlined how big the market potential was, and which competitors there were. If the market request was approved, a project could be setup, which consisted of five phases: 1) customer needs identification, 2) concept generation, 3) implementation, 4) market introduction and 5) project close.

First customer needs requirements were identified, and at the end of that phase, the resulting product idea was reviewed on market data, proposed pricing, required investments etc. Next, during the concept phase, the customer requirements were translated into product requirement specifications. A product concept consisted of the product requirement specifications, production planning, and investment overview. During implementation the software, hardware and embodiment were designed, implemented and tested (on reliability). Before the product was launched, internally Sales was briefed about the product, and external marketing efforts started. After market introduction, product management remained responsible for dealing with (product return) issues that arose with the product.

Development team

New product ideas were usually developed by the marketing & sales department and the division director. During concept design, people from marketing & sales, the engineering department, and the design and usability consultants were involved. During implementation the engineering department becomes more involved, as well as representatives from the future production location. The sales department coordinated the national sales organizations. The product manager coordinated the whole product development process and the market introduction of the product and a project manager (from the engineering department) coordinated engineering and production.

In the HomeControl main offices, between the people in the sales and marketing department, there was a lot of informal communication and face-to-face meetings. At the end of every product development phase project leaders gave a presentation to senior management about the status of the project. During implementation a lot of communication took place via e-mail. In addition there were weekly teleconferences, and incidentally meetings were held.

HomeControl did not seem to have en explicitly defined shared definition of the concept of usability, however, a number of criteria relating to usability (can be used of a manual, no key-combinations, 1on1 key mapping) were a part of the idea selection criteria, and well-known among the team members.

User involvement and representation

Information about user group needs was mostly collected through the sales organization and through clients or resellers of the product. Because most of HomeControl's products were based on existing products for the US market, these existing products could serve as stimulus material in a user test to evaluate a product proposition. Another method used by HomeControl that stood out was the use of a conjoint analysis to prioritize product requirements. However, most of the user involvement at HomeControl (Table 24) seemed to take place through user testing, of for example predecessor products and simulations.

Table 24: User involvement/representation throughout the product development process at HomeControl.

Phase	Analysis	Evaluation
Design brief formulation	• Input from local sales departments • Input from clients/resellers	• Evaluating existing US products on their fit with the European market.
Requirement setting	• Input from local sales departments • Input from clients/resellers	• Conjoint analysis of product requirements.
Design		• Adherence to UI design principles • Designers (and their colleagues) evaluating physical ergonomics with (foam) models • Colleagues (non-team members) evaluating a simulation of the UI • User test of a PC-based simulation of the UI and mock-up the product • User test to compare two potential UI design concepts • Failure Mode and Effect Analysis for assessing potential product failure due to human error during installation
Implementation		
Production		
Sales		• Customer service department collecting after sales feedback and communicating to product management
Product in use		• Customer service department tracking what questions people have.

4.4 Cross-case analysis: mechanisms of barriers and enablers

For each of the product development groups a description was created of the mechanisms of barriers and enablers that were identified in that case. Mechanisms are chains or systems of barriers and enablers that influence each other (a sample of a mechanism-description can be found on page 121). Using those descriptions per case as a basis, I conducted a cross-case analysis and identified at mechanisms of barriers and enablers that were either occurring across the cases, or mechanisms that were unique and therefore were a source of new insights. The cross-case analysis was based on the analysis of barriers and enablers per product development group. The description is structured according to the main categories of the product development categorization scheme (Figure 34 page 117), namely:

- Process (per phase and activity);
- Knowledge;
- Team;
- Project;
- Company, and
- Market

The process barriers and enablers found in one phase (e.g., design brief formulation, product in use) are often discussed per type of activity (e.g., analysis, synthesis, evaluation). In the text it is indicated in which of the product development groups the mechanism was found. To keep the text as readable as possible while still being able to indicate the origin of the findings I use bracketed numbers to refer to the cases. At the bottom of each page of the cross-case analysis a legend is provided, that links the numbers to the cases. At the end of this paragraph, in subparagraph 4.4.7, an indication is given of the distribution of barriers and enablers over the main categories.

4.4.1 Process

Below, the mechanisms found in the process category are described. The main categories of the process-related mechanisms are the phases of the product development process (see Figure 34, page 117). These categories are:

- Design brief formulation;
- Requirement setting;
- Design;
- Implementation;
- Production;
- Sales;
- Product in Use, and
- Early/Late/Overall

Next, per phase, there is a subdivision per activity of the basic design cycle by Roozenburg and Eekels (1991: p.79) (i.e., analysis, analysis communication, synthesis, synthesis communication, etc. see Figure 34 page 117). As the cross-case analysis only lists the activities within a phase in which mechanisms were detected, not every activity of the basic design cycle is listed per phase.

Phase: Design brief formulation

Activity: across activities

In regular product development projects there usually is no time and budget to explore new possibilities [2] (NOTE: the bracketed numbers refer to the legend below). If exploration and evaluation of radical or innovative products and UI concepts are to be conducted [2,4], this phase seems to be most suitable, as in this phase of development usually no launch date has been set yet which reduces time pressure. It was also suggested that a dedicated UI innovation group might be beneficial [4].

Activity: analysis

When defining a new product it is essential to have early [4] knowledge on what user needs a product could target [1,2,4,5]. However, techniques that could produce this information, such as field studies [2,4], are indicated to be time consuming and expensive [2]. A concern with regard to consumers self-reporting their needs (as in interviews and surveys) is that people might not be experts of their own needs: they may overestimate the possibilities of future technologies or what they really want in a product [4].

If an analysis is made of the risk of usability issues at the start of a project, action can be taken to prevent them, such as more user testing [1,4,5]. The risk of usability issues in a project increases if the product to be developed is complex [1,4,5] and innovative [1,4,5].

Activity: evaluation

User needs and product ideas can be evaluated by getting feedback from sales and marketing departments [4], and by conducting focus groups [2] or conducting concept evaluations with participants [1,2,3,4,5], which requires the presence of suitable stimulus material [1,2] and in which the representativeness of participants can be a concern [3].

Results

Usability being a part of the project goals or primary product requirement is considered an important enabler [1,2,3,4,5]. Whether the team does this can depend on whether or not usability issues are anticipated in a project [5], whether usability or user-centeredness is a part of the company culture [4,5], whether the usability department has an advisory or a requirement-setting role [4], and on whether previous products that were very usable were successful [2,5] or on usability being seen as a barrier for sales in a previous product [2]. Having usability as a project goal may influence whether usability is be prioritized in decision

Legend: 1=AV2go, 2=EnRoute, 3=WashCare, 4=D-phone, 5=HomeControl

making throughout the development process [4] but it can also go as far as a company completely changing its organization to align with the identified need for usability and becoming a product development instead of a software development company [2].

Phase: Requirement setting

Activity: analysis

In the analysis phase user research activities are performed with the goal of gaining knowledge about user group properties [2,3,4,5], their needs and preferences [1,2,3,4,5], product usage [2,3,4,5] and potential usability issues [5]. Additionally, competitor products can be analyzed to learn about existing design solutions [1,2].

Asking users about requirements for the product is considered potentially dangerous as users may find it hard to mention what they want in a new product [2,5]. Poor management of focus groups was also mentioned as a concern [2], as was the representativeness of the participants [3] and input from colleagues [3].

Activity: synthesis

Adding too much functionality [1,2,3,4,5] and not offering the appropriate functionality [1,2,3,4,5] was considered a major barrier for usability, because products with a lot of functionality are believed to be harder for users to interact with. In addition, products with extensive functionality are harder to design [2], simulate [2] and test. Finally it was suggested that when a lot of new functionality has to be implemented all attention may go to new functions and much less to the existing ones (that might need improvement) [2].

Requiring a product to have elaborate and non-user-centred functionality is influenced by selling to a global user group and thus targeting a diverse set of needs [5], a desire to keep up with the functionality in competitor products [1,2,4], retail channels demanding non-user centred requirements [4], team members (especially from marketing and sales) believing that products with more functionality will sell better [2,3,4,5], and by team members not being able to think from the user-perspective [1,2,3,5]. Setting user-centred requirements is positively influenced by having knowledge about the user group [1,2,3,4,5], its needs [4] and potential usability issues [4].

When setting requirements it is considered beneficial to consider the whole usage cycle of a product [1], for all users (from end-users to maintenance people [5]).

Activity: evaluation/decision

Methods used for the evaluation of requirements were few, and included user tests of concepts [2,5], which could be subject to poor execution (especially with regard to questioning) [2], conducting a conjoint analysis of user requirements [5], and an expert review of the requirements with the user group description in mind [2,4]. Knowing how often a function is used enables a team to prioritize and select the right functionality [2].

Legend: 1=AV2go, 2=EnRoute, 3=WashCare, 4=D-phone, 5=HomeControl

Results

Putting explicit statements about the level of usability in the requirements [4,5] is considered an enabler. Product requirements should be prioritized [1,5] because that stimulates user-centred decision-making in the design phase [5] and enables development engineers to focus their efforts on the most important functionality in the product [1].

For the communication of user requirements to development engineers it is beneficial to write them in the form of use cases [4]. For UI designers it is very hard to create a design if there are too many requirements [2] and if they are actually specifications (and thus limitations) and not requirements [2].

Phase: Design

Activity: start communication

To ensure a thorough understanding of the requirements by the members of the design and development team who had not been involved in conceiving the concept, one company started the design phase by having a workshop in which the background of the requirements was explained to the design and development team [1].

Activity: analysis

Analyzing competitor products can increase designers' knowledge about possible UI designs [1,2,3,4]. By studying the context of use designers can learn how a product will be used [3].

Activity: synthesis

Because of the long lead-times for the development and production the technological platform (hardware and firmware) was often selected or designed without communication with the interaction designer or usability specialist, and before the (user) requirements are available [1,3,4]. One company, which was developing its whole product line on a similar hardware and software platform, encountered less of these issues [2]. To prevent problems during the implementation phase, interaction designers should be (made) conscious of the limitations of the technological platform [1].

When creating a usable UI design, it is beneficial not to have to start from scratch [2,4] as this takes too much time and effort [4]. It is preferable to base a UI design on a predecessor or UI paradigm [1,2,3,4,5]. The creation of a usable UI design can be hindered if designers are confronted with limited design freedom [1,2,3,4]. Causes for limited design freedom can be that the interaction designers may only design the on-screen UI and not the physical controls [1,2,4], and the limitations of the technological platform [1,2,3,4], which in turn may due to the use third party supplier platforms [1] or components [2] and the early and isolated design of the technological platform [1,3,4].

Designs should not be based on the designers' own preferences or gut feeling [2,4] or, but be based on knowledge about the user group [2,4,5]. The presence of design guidelines

Legend: 1=AV2go, 2=EnRoute, 3=WashCare, 4=D-phone, 5=HomeControl

may stimulate making a usable design [2,4].

The UI is less likely to be usable if styling is prioritized over usability [1,2,3,4], because competitors have a UI that makes the products look modern [3] or because of a desire to make a product look clean, and thus reduce the amount of buttons [1,3].

Getting the design right the first time was suggested to be important, because an existing design or function is not likely to receive attention as soon as it is implemented, because of the time pressure on future products and resistance to change in the team [2]. It was also suggested that a UI with a consistent behaviour is not only easier for the user to understand, but also easier for designers to create and for software engineers to implement [2].

Activity: evaluation

The most-used methods to evaluate the usability of a design were reviews by the designer, colleagues, or a specialist [1,2,3,4,5], and user testing with external participants or colleagues [1,2,3,4,5]. Only in a single case were methodological usability inspection methods mentioned [4], and early user testing of UIs with for example paper prototypes were only mentioned limitedly [3].

Activity: evaluation communication

When communicating user test results it was considered important that the development team members are exposed to rich information [1,3,4,5,5] of 'real' people [5] using their design, which can be achieved by showing them video clips of user tests [1,3,4,5] or by having the product development team visit user tests [1,3,4,5] or team members conducting user tests themselves [3]. Whether the development team is present at the user test depends on how valuable the team considers user testing to be [1,3,4,5] (which in turn depends on whether they have seen user testing before [3]), and on the location [4] and duration of the user test [4]. For using video clips to communicate user test results having video recording and editing equipment [3,5] is a condition.

However, the danger of having development team members present at a user test is that people may jump to (the wrong) conclusions [4,5] due to their lack of skills to interpret what happened during the user test [4,5] or because they only see a few participants [4,5]. Especially if the representativeness of usage during the test is low (as is the case in lab tests, with simulations and participants), some interpretation by experts is required [4,5]. If the stimulus material is considered unrepresentative by the development team, they may not accept the results of a user test [3].

To arrive at conclusions about user tests that are supported by the usability specialists and the development team it is good to hold a workshop in which the results are discussed and prioritized, and possible solutions are discussed [4,5].

Legend: 1=AV2go, 2=EnRoute, 3=WashCare, 4=D-phone, 5=HomeControl

Phase: Implementation

Activity: start communication

It is important to supply the development engineers with a complete specification of the product right from the start [1,2,3], because otherwise the specifications will keep getting updated throughout implementation, which is bad for the stability of the product [1], and the engineers will have to implement according to their own preferences [2,3,4]. For the engineers' understanding of the design it is beneficial to communicate product specifications in the form of use cases and screenshots instead of just text [2,4].

Activity: across activities

During implementation often iterations have to be made back to the design phase [1,2], because specifications were incorrect or incomplete [1,2,4]. It can also become clear that it is not possible to implement the original design [1,2,3,4] due to system limitations [1,3,4,5], components not being available [1], insufficient staff to implement a design [2], time pressure [1,4], budget limitations [4], or engineers resisting changes [2,4]. The usability of a product may increase if a usability specialist or interaction designer is available during implementation for the development engineers to answer details of the design that are not clear, or deal with usability issues that emerge during implementation [2,4].

Phase: Production

Activity: evaluation

To assess the reliability of a product the first production samples can be submitted to a beta test [1,2,3], in which participants or testers may also experience usability issues. However, the reported issues may require some interpretation, because the representativeness of the participants is not necessarily high as they can be an internal test team [2], third party testers [1], or recruited participants [3].

Phase: Sales

Activity: across phases

The way a company communicates about a product in its marketing material may influence the expectations that consumers have, perhaps even set them too high [2].

Results

If a company previously had commercial success with products with a high level of usability, the attitude of the development team towards usability may be influenced positively [2,5].

Legend: 1=AV2go, 2=EnRoute, 3=WashCare, 4=D-phone, 5=HomeControl

Phase: Product in use

Activity: synthesis/evaluation

When the product is on the market quite some information on usability issues [1,2,3,4,5], product usage [1,2,4] and user appreciation [1,2,3,4] can be collected. This information is considered valuable as it originates from real-world users [1,4]. However, the resolution of the information can be quite low [1] and it is not always properly analysed [1], which can make it hard to draw conclusions about the cause of the issue [1]. Secondly, information coming from customer service is usually self-reported by customers [4], which can make it unreliable and additionally there might be a threshold for customers to complain [2,4,5]; if no complaints or questions are received it does not mean that there are no usability issues in the product, only that customers do not wish to complain or ask questions about it. It was indicated that after sales feedback can be collected from:

- Customer service (questions/complaints) [1,2,3,4,5]
- Customer satisfaction questionnaire [1,2,4]
- Monitoring forums and consumer review websites [2]
- Monitoring press reviews [1,2,4]
- Monitoring service and/or product use [2]
- Feedback from colleagues in the department [4]
- Feedback from marketing/sales organizations [3,5]
- Longitudinal user test in the field [4]
- Evaluation communication

After sales feedback is mostly communicated to the project or product manager who then decides how to deal with the information [2,3,4], even though distributing this information among the whole development team (including designers, usability specialists and engineers) is considered beneficial [1,2,3,4] as this allows people to learn.

Whether or not information from the customer service department finds its way back to the product development team seems to be influenced by the organization of the customer service department; whether this is an internal [2,5] or external group [1] and whether it is in the same building [2,5] or not [4]. If a company has an in-house department this seems to facilitate fast informal communication of usability issues [2].

Activity: iteration

Some companies make changes to a product while it is still on the market [2,3]. For one company this made sense because it could send updates to its products, as users would connect these to the Internet [2]. Another company that implemented changes in products while they were on the market had products that were on the market for quite a long time [3], so for this company it made sense to adjust the design and implement the changes in a new production batch, which did require the development team to stay intact after product launch [3]. A company with products that are on the market for a shorter time did not consider it beneficial to update its products while they were on the market [1]. When not improving products while on the market, improving the next generation of products was considered an important alternative [1,2,3,4,5].

Phase: Early/Late/Overall

Activity: evaluation

Early usability evaluation is considered very important [1,2,4], because in the early phases of the product development process it is still possible to improve the product [1], whereas when late testing is conducted [1,2,4] implementation of changes that would improve usability is less likely [1,2,4], as late iteration requires a lot of time and effort. However, evaluating a design and especially user testing requires stimulus material [1,2,4], such as mock-ups or simulations, prototypes or samples, which are often not available in the early stages of product development [1,4].

Whether and how user testing is conducted depends on whether time is available [1,2,3,4,5], and on availability of budget [1,3,4,5] and staff [1,2,3,5]. With regard to the setup of user testing the primary concerns seem to be the representativeness of the test participants [1,3,4,5] and of the stimulus material [1,3,4]. Quality of execution of user testing [1,3,5] was also considered to be influenced by the properties of the user testing facility [1,2,5], the method being used [1,2,5], the evaluator's user testing skills and experience [1,3,5], knowledge about the product [1,4].

Overall (across phases and activities)

Separation between hardware and software development

In a number of companies the development processes of hard- and software were quite separated [2,3,4,5], even to the point where the software and hardware department were located in different cities [2]. This separation seems to be one of the causes for the limited communication about limitations of the technological platform [1], or the usability department not being able or allowed to comment about the usability of for example the controls of the product [2,4]. In one company the product concept was thought up by one team and was implemented by another, which was considered one of the causes of product concepts rarely being implemented as planned [1].In all of the companies the (product) design department was quite a separate organizational unit, which seemed a source communication and cooperation issues between the designers and the rest of the product development team [1,2,3,4,5]. Product designers and interaction designers were in some cases only cooperating to a limited extent [2,3,4]. Usability experts were generally mostly cooperating with the interaction designers and software developers and had limited influence on the physical design of the product, such as controls and peripherals [2,4].

Legend: 1=AV2go, 2=EnRoute, 3=WashCare, 4=D-phone, 5=HomeControl

4.4.2 Knowledge

While analyzing and categorizing the barriers and enablers, knowledge, which I had previously considered a team property, emerged as a very elaborate and impactful category, and therefore was 'upgraded' to a main category. Knowledge was found to act as an intermediary between the different activities of the basic design cycle. Generally, analysis and evaluation activities produced knowledge that would form the input for synthesis, decision and iteration type of activities. Seven main categories of knowledge emerged that seem to play a role during user-centred design:

- User properties: the properties and capabilities of the target group, such as demographics, anthropometrics, cognitive skills, previous experiences, etc.
- User needs and preferences: *what* that the user group would like the product to do (functionality, needs, goals), and *how* (preferences).
- Product usage: a description or prediction of how (potential) users interact with a design or product (category) and in what kind of environment (physically and network) the product will be used.
- Potential usability issues[20]: predictions about instances in which users that interact with a product cannot reach their goals or fulfil tasks with effectiveness, efficiency and satisfaction (about use).
- Usability issues: knowledge about instances in which users that interact with a product cannot reach their goals or fulfil tasks with effectiveness, efficiency and satisfaction (about use).
- User appreciation: knowing whether people (will) evaluate a concept, design or product positively or negatively.
- Design solutions: knowledge of usable designs and alternative designs.

A more elaborate analysis of the mechanisms in the knowledge category, including the content that each subcategory holds, how it is generated and what other categories it influences can be found in Appendix D.

4.4.3 Team

Team: Skills-capabilities

The most important skill that a team needs to create usable products can best be described as 'seeing the user perspective': the ability to understand what is important to users and anticipate how they will use the product [1,2,3]. However, a certain degree of 'home blindness' (not seeing the particularities of a design because one is so familiar with it) [2,3,4] can occur, because the team members have too much knowledge of their product [2,4]. Other reasons for not being able to design from the user perspective are that product

---

[20] Potential usability issues are usability issues that are identified by means of a simulation and evaluation and that might not occur in the actual product. For the latter the term 'usability issues' used.

development team members are often more advanced users than the average user [3,4], which may be due to their technological background [2,3], or because they have 'fallen in love with their design' [1,2,3].

Having experienced team members was considered to make it easier to create usable products [1,2,3,5] as experienced people have a lot domain knowledge and carry with them knowledge from previous projects. Having experienced team members is more likely to occur in a company with low personnel rotation [3,5] than with high personnel rotation [1].

Team: Attitude

Team members' attitude towards and prioritization of usability has considerable influence, especially in the synthesis [2,3,4,5], evaluation [2,4,5] and decision [1,2,3,4,5] activities of the requirements [3,5], design [1,2,4,5] and implementation phase [1].

Attitude towards and prioritization of usability seems dependent on the perceived benefits of usability (i.e., that usability is important to the target group, that it improves sales [2,4,5], and prevents costs [1,4]), on the company's brand position or strategy [1,2,5], and the company culture [2,4,5]. If the company has usability as a brand value [1,2] or a unique selling point [2,5], this communicates to the product development team members that it is a priority to the company. On the other hand if a company has the ambition to be perceived as modern [3] or advanced [4] this might lead to products with a less-usable but 'clean' design [3] and elaborate feature sets [4].

Usability seems more likely to become a part of the company culture or philosophy [1,2] if upper management [2] or another 'usability champion' [4] promotes usability, and if it the brand position includes usability-related claims [1,2]. The degree to which team members are exposed to users (i.e., through field studies or user testing) is also seen as a contributor to a more user-centred attitude [2,3,4,5].

The attitude towards usability also seems to depend on the role that people have [1,2,4]. Product designers may prioritize styling over usability [1,2,4], and engineers may prioritize system stability [1,4], as these product properties are their primary responsibility. Development engineers are often mentioned as not having a user-centred attitude [2,4,5] and not being able to see the user-perspective [2,4], because of their technological background [2,4,5], but also because their limited contact with users (they hardly ever see user tests or market feedback) [2,4].

Team: Organization

Whether a team as a whole has a user-centred attitude and the skill to see the user perspective seems to depend on the presence of usability and interaction design specialists in the team [2,3,4,5], who often only join the team in later stages and/or for a limited period of time [1,2,3,4,5].

Legend: 1=AV2go, 2=EnRoute, 3=WashCare, 4=D-phone, 5=HomeControl

4.4.4 Project

Project: Planning

Time pressure on a project, which is related to project planning, has a large impact throughout the product development process [4,5]. It influences how user research is conducted [1,2], the creation of designs [1,2,3,4], whether and how user testing is conducted [1,2,3,4,5], the evaluation, designs being compromised or not [1,3,4], and whether or not a design and changes that improve usability can be implemented [1,2,3,4].

Companies that have short product development cycles [1,2] and have very distinct seasonal sales peaks, such as the Christmas and summer holidays [1,2], seem to be suffering from higher time pressure than companies with longer cycles [3,5] and less strict deadlines [5].

Formally including user research, interaction design and usability evaluation activities seems to increase the chances of these activities actually being executed, because then they are included in the project plan [3,4,5].

Project: Budget

Similar to planning, budgetary concerns have a large effect throughout the product development process: on conducting more expensive activities such as field studies [1,2,4,5], on the freedom during UI, product and platform design [1,3], whether the design can be implemented as intended [1], what kind of simulations can be made [1,3,4,5], and on how concept and design evaluations are conducted [1,3,4,5].

The available budget is influenced by how important a project is to the development group [4], and by the product positioning of the company [1,3]. If a company sells high-end products [3] the budget is likely to be higher, when selling high-volume low-margin products [1] the budget is likely to be lower.

Project: Degree of innovation

Introducing a new product, platform, UI or content heightens the risk of usability issues [1,2,4,5], because it decreases the knowledge of design solutions [1,2] and of potential usability issues [1,4]. Creating and implementing a new design costs a lot of time and effort [4] with the risk of not being able to implement the design as planned [2]. Additionally, when introducing a product that is totally new to the company the knowledge of the user group [2] and its needs [2], and of product usage [4] are limited. When introducing a product that is new to the market there are also no competitor products for the product developers to learn from and users are not familiar to the product or UI yet [4].

Developing a product over generations [2,3,4,5] and/or having a UI paradigm [2,3,4] are

Legend: 1=AV2go, 2=EnRoute, 3=WashCare, 4=D-phone, 5=HomeControl

ways to prevent having to create a (UI) design from scratch for each product [2,4] and it makes it easier for users to use a company's products, because they know the UI from other or predecessor products [3]. When developing products over generations the design of a product is based on that of a predecessor, which requires between generation consistency (similarity between the different generations of a product) [4,5]. A UI paradigm is a UI concept that is implemented across a product line, and (slightly) tailored per product. Feedback from each individual product can then be used to improve the shared UI paradigm. In addition to between generation consistency having and implementing a UI paradigm requires within-generation consistency [3,4]: the product line of one generation should be similar enough to share a UI concept, as forcing an unsuitable UI paradigm on a product category leads to less usable products [3]. Finally, one of the pitfalls of having UI paradigm is that if the usability of the UI paradigm is not good, a whole generation of products will have poor usability [4].

4.4.5 Company

Company: Organization

A big, complex organization [1] tends to have more steps and stakeholders in the product development process, which may lead to product concepts being compromised [1], whereas in smaller, less complex organizations [2] less people are involved.

When a company conducts its product development activities in a centralized location but sells its products worldwide [3,4] team members have less contact with the user group (as they don't live among them) [3,4] and it is harder for them to visit user tests (if these are conducted in the target market) [3,4] or the user tests have to be conducted with unrepresentative participants [3]. This results in reduced knowledge of the user group properties [3,4], needs and preferences [3], product usage [4] and usability issues [3].

Company: Management & control

In one case it was suggested that usability should be a part of product development team member's key performance indicators (or balanced score cards or bonus sheet) [1], perhaps indirectly by including customer satisfaction as a performance indicator, because that influences their attitude towards usability. Several companies wanted to measure or quantify the usability of a product [1,4], seemingly under the influence of usability being a part of the brand proposition [1]. Measuring usability requires the presence of a (shared) definition of usability in a company [4].

Company: Upper management

If upper management is knowledgeable about usability it can exert a positive influence by

Legend: 1=AV2go, 2=EnRoute, 3=WashCare, 4=D-phone, 5=HomeControl

monitoring decisions that affect usability in development projects, and by influencing the priority that team members give to usability [2]. Having a so-called 'usability champion' in the organisation can make usability a part of the company culture and affect the attitude team members have towards usability [2]. Finally, if upper management is actively involved in decision making for product development projects it has the power to intervene and force the implementation of a design that improves usability [2,3,4]. It was suggested that upper management might be less user-centred if it has an engineering background [4].

Company: Usability department

In several development groups the usability department was understaffed [1,2,3] or not present [5] even though usability was considered important within the company [1,2,5] and a part of the brand proposition [1,2] or a unique selling point [5]. The lack of staff negatively influenceed the involvement of usability specialists in product development projects [2], the ability of the usability specialists to learn about and explore new methods [1], and the time it took for the usability department to provide product development teams about their products [3]. The shortage of staff was compensated for by hiring freelancers [1] or consultants [5].

Other important properties of usability departments were the presence and quality of a user testing lab [1,2,3,4,5], participant recruitment database [3] or agency [1,5], and documentation of methods [5].

Company: Product line

Having control of the ecosystem (network of products and services in which a product functions) was considered beneficial in many of the development groups [1,2,4], because it enables a company to design the whole usage cycle [1,2,4]. Only one company went out of its way to control the whole ecosystem [2], even to the extent that it would purchase and integrate suppliers of components [2].

4.4.6 Market

Market: Competitors

Competitor products act as a double-edged sword. On the one hand competitor products can have a negative influence on the usability of a product because development teams can feel pressured to compete with the functionality that competitor products offer and blindly copy the functionality [1,2,4] or UI [3] they offer. On the other hand competitor products can act as an important source of inspiration for coming up with valuable functions and especially UI designs [1,2,3,4].

Competitor products [4] and a company's own products [3] influence the expectations and

Legend: 1=AV2go, 2=EnRoute, 3=WashCare, 4=D-phone, 5=HomeControl

preferences that the user group has with regard to product functionality and human-product interaction styles.

Market: Sales channels

When a company is reliant on third party sales channels (i.e., retailers and service providers) to get its products out on the market, sales channels may pressure the user-centredness of product requirements, because the retailer's or service provider's interests are in conflict with the most usable solution [4]. Local sales departments may play a similar role [3]: they are very concerned with having an appealing product proposition, and therefore may demand requirements negatively influencing usability.

If a company has products that are very usable, it was considered advisable to sell through a retail environment in which customers can experience the product before buying it [4].

Market: Remaining

In a fast-moving market (i.e., a sector in which new models and technologies are introduced often) knowledge about the user group needs and preferences outdates quickly [2]. However, because of the short development cycles, companies in such markets also have the opportunity to refine a product over generations, provided that it employs a generation-wise development strategy [4]. However, a fast-moving market can also lead to big changes between product generations [1] preventing generation-wise product development.

4.4.7 Distribution of barriers and enablers

Overall more than 1700 barriers and enablers were identified across the five product development groups. The goal of the following section is to provide an indication of the distribution of the barriers and enablers in the data set. The distribution is compared across companies and actors, and across the main categories of the categorization scheme.

Per actor

In Figure 41 an overview is given of the number of barriers or enablers that were mentioned by the interviewees, clustered per development group. Overall I identified 1735 barriers or enablers, within which overlap occurred, as similar barriers and enablers that were mentioned by multiple interviewees were counted as multiple instances. In all cases except that of WashCare the usability (testing) specialist mentioned the largest number of barriers and enablers, while - perhaps not surprisingly - engineers tend to mention fewer barriers and enablers. Figure 41 also provides an indication of the ratio between the number of barriers and number of enablers mentioned. In all development groups the total number of enablers identified was higher than the total number of barriers, with D-phone and especially HomeControl having a remarkably positive profile. For the marketing and market

Legend: 1=AV2go, 2=EnRoute, 3=WashCare, 4=D-phone, 5=HomeControl

intelligence managers the amount of barriers and enablers they mention varied from under average (within that case) for EnRoute’s market intelligence manager to the over average number mentioned by D-phone’s product-marketing manager.

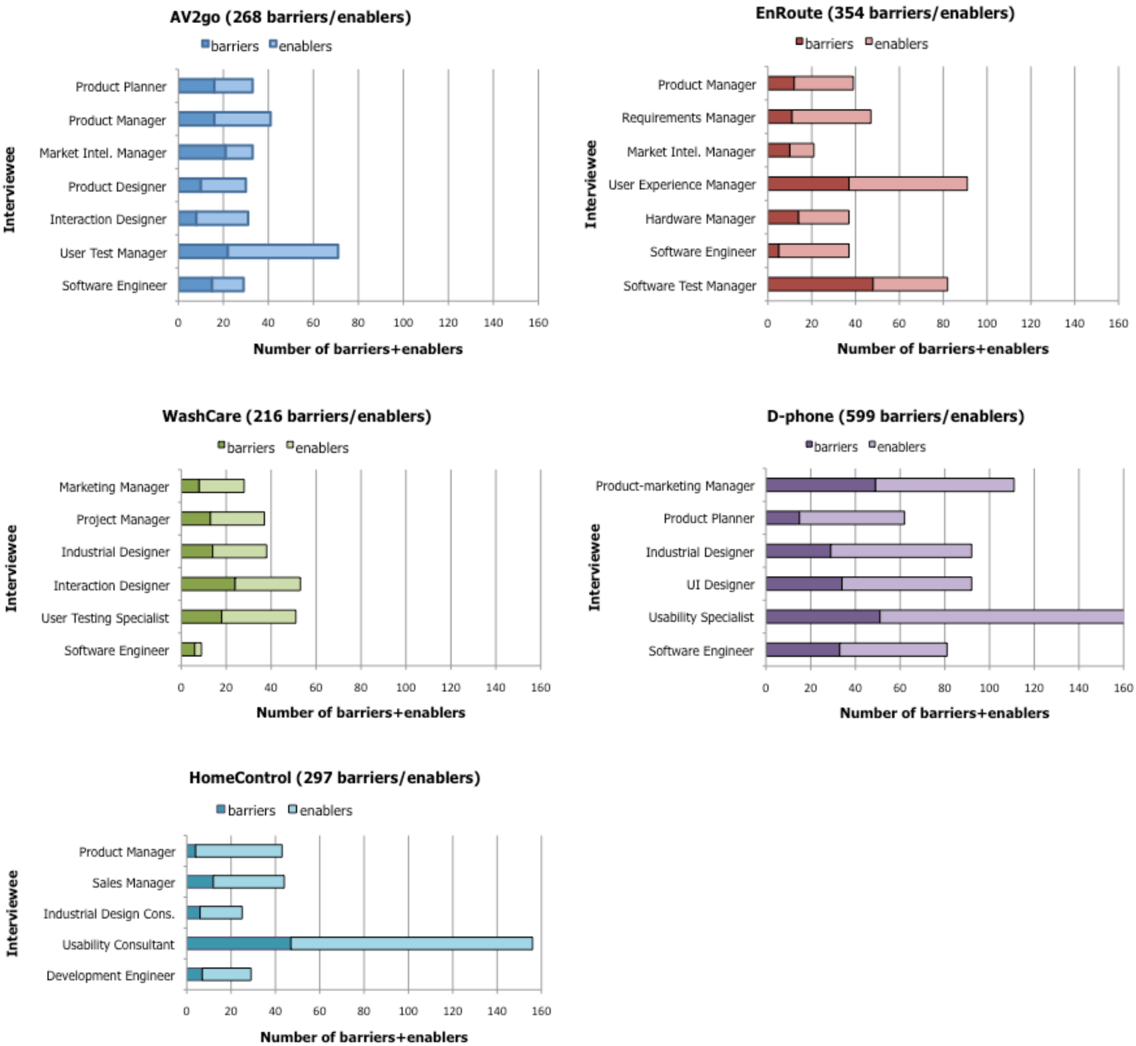


Figure 41: The number of barriers (left part of bar) and enablers (right part of bar) per interviewee for each of the product development groups.

Per main category

Figure 42 gives an overview of the percentage of the total number of evaluative remarks (barriers plus enablers) within a case, per main category of the product development categorization scheme (Figure 34). The majority of the barriers and enablers (around half) are found in the product development process. Distribution of the barriers and enablers over the main categories is fairly consistent between cases.

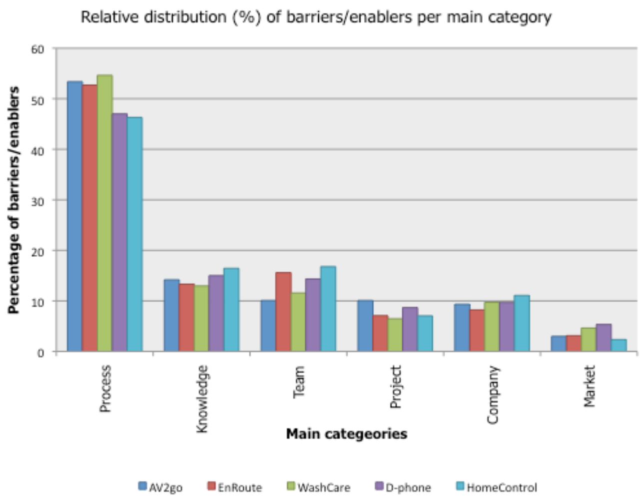


Figure 42: Percentage of evaluative remarks (relative to the total number of evaluative remarks mentioned in a development group) for each product development group over the main categories.

Process barriers and enablers per phase and per activity

Figure 43 visualizes what percentage of barriers and enablers in the process category was found in which type of activity of the basic design cycle, across all phases of the product development process. Most remarks were made about evaluation activities (such as user testing), with synthesis activities coming in second place, and analysis, evaluation communication and decision activities coming after that. The relative distribution of process barriers and enablers over activities is fairly similar across product development groups. In Figure 44 it is shown what percentage of barriers and enablers were found in which phase of the product development process. The highest scoring phase is design, though with considerable differences between the product development groups. Requirement setting and product in use are also phases with a relatively dense distribution, followed by design brief formulation and implementation. In comparison the distribution per type of activity is less similar than per product development phase.

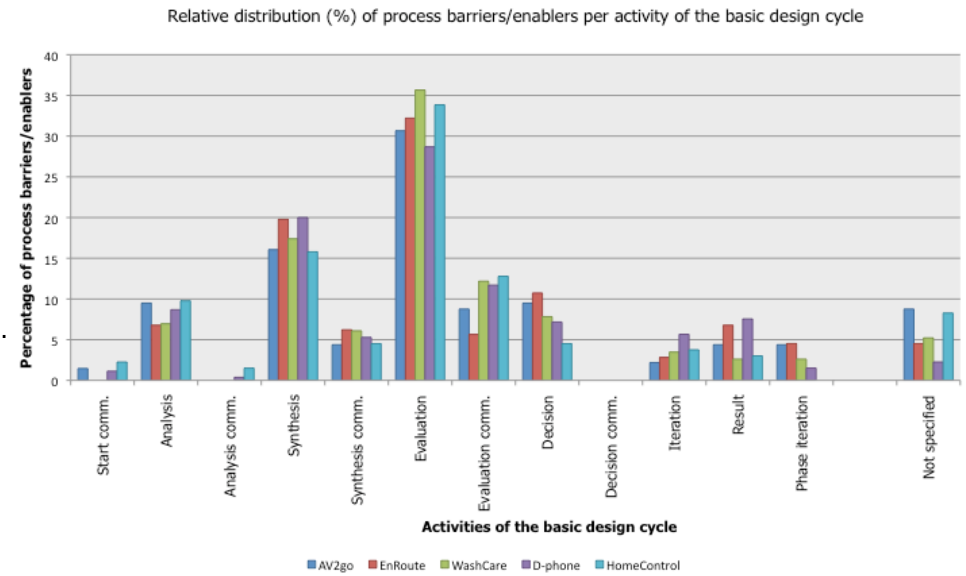


Figure 43: Percentage of process barriers/enablers per company in each of the activities as defined in the basic design cycle.

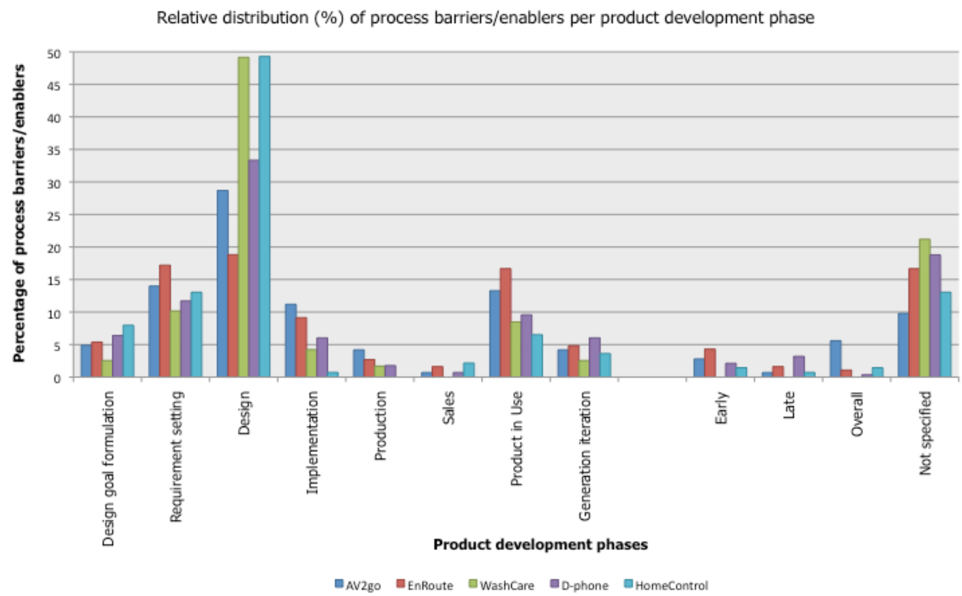


Figure 44: Percentage of process barriers/enablers per company in each of the phases of the product development process.

4.5 Feedback workshop

In the feedback workshop the primary contacts from four out of five product development groups provided feedback on the accuracy of the mechanisms of barriers and enablers for the individual groups, on the cross-case analysis and on working with the Trace tool.

4.5.1 Setup

Between the conducting the interviews and presenting the overall conclusions in the feedback workshop there were 3,5 years. In the week leading up to the workshop the participants were given access to the online version of the Trace tool, with access to the barriers and enablers for their company. They were given a short explanation of the categorization scheme and directions for use and encouraged to explore the tool and the data therein. The goal of the preparation was to familiarize them with the tool and give them the opportunity to explore the content on their own without being directed by the findings.

In the workshop itself I presented the participants with the analysis of their company, and with that as a reading guide they went through the barriers and enablers in the Trace tool. After they had the opportunity to explore the analysis and the underlying data I discussed with them whether they considered the analysis to be an accurate description of issues in their company. Next I presented the cross-case analysis through a PowerPoint presentation and offered the participants the possibility to respond and discuss the conclusions. During the workshop three researchers were present: one to lead the workshop, present the results and moderate the discussion, and two to observe and take notes. The workshop was recorded on video, and I transcribed the relevant parts (participant responses to working with the Trace Tool, the analysis of barriers and enablers at their company and to the overall conclusions).

After the workshop each participant was sent the context description of their development group and were asked to indicate whether the description was an accurate description, whether important issues had been overlooked, and whether parts of the description should be changed or removed because of confidentiality.

Based on the participants' input, both the overview of barriers and enablers per company and the context descriptions were changed. Additionally a summary was written of their reactions on the cross-case analysis.

4.5.2 Responses to the barriers and enablers per company

Overall, most of the mechanisms were found to be an accurate description of what was happening at the development groups at the time.

AV2go: *Yeah, it's very recognizable.*

EnRoute1:	*Well I think it was at that time it was relatively true. Eh, over time things change fortunately as well. I think I can agree with most of the observations.*
WashCare:	*All in all it fits very good, it still does for the large part.*

In the HomeControl case, during the interviews the focus on one particular (rather successful) project during the interviews, and a very experienced (external) user-involvement consultant was interviewed, which seems to have skewed the barriers and enablers towards a somewhat positive picture of how HomeControl worked.

HomeControl1:	*I think it is a little bit too good. I don't think it will happen all the time in this kind of manner. (….) What you describe here, a lot of good things are in there, but it is not always that these kind of things are happening.*
HomeControl2:	*I recognize a lot of the things that I have said, but of course when I did the interview you asked things about a broader experience with a whole variety of clients. And what has happened probably that a lot of information that also came from the expertise in other projects is also projected into these enablers and barriers that come out now. And sometimes these are not directly linked to <HomeControl1 name> case. Or it was just this only project and <HomeControl1 name> has a very big scope of all kinds of projects and doesn't recognize what's happening in all these other projects. Perhaps.*
HomeControl1:	*<confirming> Hmmhmm.*

The primary contact from AV2go observed that interviewees at AV2go would sometimes mention certain process steps or tools that were a part of the development process, but she indicated that the fact that apart from the presence of tools and process steps, the execution is also very important.

AV2go:	*So sometimes this sounds like everyone is just highlighting all the different checklists and processes I have in place, and yes they're all there, but then the fact that they're there does not ultimately guarantee a good, usable product.*

4.5.3 Responses to the cross-case analysis

In the following section, the responses of the workshop participants to the presentation of the cross case analysis are presented. The responses are structured in the same way as the cross-case analysis: by the main categories of the product development categorization scheme, starting with the phases of the development process, and then the other main categories: team, project, company (no input was given regarding that fell into the 'market' category).

About some of the conclusions from the cross-case analysis discussion arose, which could be primarily attributed to differences in viewpoints because of the different situations at the development groups, which were then discussed by the participants. In a few cases (some of the) participants disagreed with conclusions drawn in the cross case analysis, but it can be stated that for the most part the participants seemed to agree with most of the observations presented.

Process

Phase: Design brief formulation

• Aligning the organization with user needs: The representatives from EnRoute confirmed the observation that the company had changed its organization to align with user needs. Additionally, this process was still continuing as EnRoute had recently gone through another organizational change by merging with a map data company, which was attributed to the goal of providing a better user experience.

• Dealing with input from sales channels: At HomeControl they are a bit hesitant in taking input from the sales organization at face value, because this group, due to their role, has a somewhat limited (sales-oriented) view of what’s important.

• Innovative projects: When the researcher pointed out that innovation is mostly mentioned as a threat to usability the representative from AV2go countered that innovating a product or UI also provides a big opportunity for improvement. The representative from HomeControl pointed out that innovating a product can have a major impact upon the time planning of a project, to which the participant from AV2go responded that maybe innovative projects should not be performed in regular product development cycles, which supports a suggestion made in the original interviews.

Phase: Requirement setting

• Asking people what they want: Various participants indicated that they agreed that asking people what kind of product or functionality they want might produce unreliable results, but also the possibilities of alternative methods such as observational research or generative tools are pointed out.

• Elaborate functionality: With regard to the downsides of having too elaborate functionality in products the representative from AV2go pointed out that having too little functionality does not necessarily make products usable (or successful), as users might initially only want basic functionality, but they learn by using the product and then may want to use additional functions, a view that seems to be supported by representatives from HomeControl and WashCare. One of the representatives from HomeControl (supported by WashCare and EnRoute) pointed out that having too little functionality might negatively influence customer appeal of a product, as customers may consider it advantageous to have a product with a lot of functionality, which they may not need right now, but that might prove useful someday.

The representative from AV2go elaborated on how in software-based products the abundance of technological possibilities, and in some cases the relative ease of implementing new functions, can lead to extensive and inappropriate functionality. For each function that it is *possible* it should be critically reviewed whether it's *desirable*. However, as the representative from EnRoute pointed out, adding new functionality is also a commercial consideration; that the market expects new features every year or even half year.

• 'Non-functional' requirements: The representative from AV2go stressed that for setting the requirements it is useful to know what functions are used most and to focus on the most used functions, but to make an engaging product more than just the 'functional' requirements should be taken into account. To make an engaging product also the more 'emotional', non-quantifiable considerations should be taken into account.

Phase: Design

• Design is also platform design: The representative from AV2go drew the conclusions that, although their development process only defined one design step, the actual development of AV2go's products included two design steps: one for the design of the technological platform, and one for the design of the product 'on top' of that. Usability considerations only seemed to play a role in the second design step. Within EnRoute in recent years the user experience group had gotten involved in the selection of the technological platform, because it was acknowledged that this component could have considerable consequences for the user experience. But EnRoute's representative also pointed out that the qualities of the technological platform might not be as limiting for designing a good user interface as they are sometimes made out to be: a good UI design is also possible within the limitations of a platform. When the researcher pointed out that he found only one mention of an interface designer asking development engineers about the limitations of the technological platform, the representative from AV2go responded that there should be a balance between designers knowing and acknowledging the limitations of the technological platform, and designers 'pushing the envelope'. In innovative projects or at the start of projects is good to have designers pushing the engineers to get the most out of the platform, because you get a better product, but also because it makes the engineers conscious of what their platforms need to deliver (in the future). However, as the project progresses, in view of time planning increasingly the limitations of the platform should be taken into account, in which case it is good that the UI designers are aware of them. This view seemed to be supported by EnRoute.

Phase: Production

• The goal and representativeness of testers in beta testing: With regard to beta testing the representatives from AV2go and HomeControl stressed that the main goal of beta testing is to identify bugs, for which the representativeness of the participants does not matter as much. However, as a side effect you might indeed get feedback about the product, which you have to evaluate critically, in view of who the testers are.

• Delaying product launch: It was indicated that a product with too many bugs might not be launched, but that is less likely to happen if the product has poor usability.

Phase: Sales

• Marketing selling product on different proposition: In response to the incidental observation in the cross-case analysis that a company's marketing material may set customer expectations too high, the representatives from EnRoute indicated that customer expectations might not match with what the products offer, but this was not attributed to marketing efforts, but more to the fact that customers don't know what to expect from advanced new features.

• Marketing a product as easy to use: A discussion arose on whether it is beneficial (for sales) to market a product as being easy to use. The representative from AV2go doubts whether labelling a product as 'easy' might be stigmatizing potential buyers as 'dummies', and one of the representatives from EnRoute points out that labelling something as 'easy' may create expectations, that one should then deliver upon. However, examples are also made of successful use of usability as a sales argument.

• Good sales reducing motivation to improve?: The observation that good sales might reduce the motivation to improve a product initially provoked a reaction of disbelief from representatives of HomeControl and one of the EnRoute representatives. On the other hand, the other EnRoute representative and the one from AV2go explain why they could imagine the issue occurring: a company might be unwilling to adopt the product to an expanding, changing user group, because it was successful with the initial (early adopters) user group, and a product development team might be less motivated a motivated to fix usability issues if the product is selling well, and more motivated if these usability issues can be argued to negatively influence sales.
The representative from WashCare pointed out that some people within the development group, especially from marketing, seem unwilling to change the product because they assume the product is fine as customers are not complaining, without actively having probed for complaints. Additionally, a representative from HomeControl pointed out that the sales department might not want to change a successful product, because the company's clients (installers) are conservative.

Phase: Product in use

• After sales feedback: Participants from HomeControl, EnRoute and WashCare thought that within their company they could do more with the feedback coming back in from the market: using it as input for the development of the next generation of a product. At HomeControl after sales feedback was not being analyzed for information on how to improve the product. However, with regard to analyzing after sales feedback, the representative from AV2go points out the dilemma of having raw, rich, potentially overwhelming, data versus neatly analyzed and categorized, but very engaging, information: reading the original transcripts can be cumbersome but gives a better insight into what customers are going through. Representatives from EnRoute and WashCare, who subsequently manage a user experience and interaction design group, indicate that they, as indicated in the cross-case analysis, are not one of the recipients of after sales feedback within the organization, but they would like to be.

Overall

• Separation between hardware and software development: The issue of limited control of the interaction designers over the choice and design of the technological platform prompted the representative from WashCare to indicate that within WashCare there is a certain amount of discussion about which product properties fall within the responsibility of the design department. EnRoute indicated that because its user interface is primarily on-screen, at EnRoute this is less of an issue, thus indicating that the amount of control of interaction designers over the design of controls is a relevant factor.

Team 

Interaction designer on the team

The importance of interaction designers and/or usability specialists being part of the product development team was underlined in this discussion between representatives from EnRoute, where interaction designers are a part of the team, and AV2go, where that's not the case. The representatives from EnRoute stress that their user experience group pro-actively approaches project teams, and that interaction designers, who are part of these teams are in a unique position to monitor what's going on and to request testing if needed.

Experience and domain knowledge

In the cross-case analysis experience and domain knowledge were mentioned as important qualities for team members. Participants from AV2go, EnRoute and WashCare supported the observation, although it was also indicated (EnRoute, WashCare, HomeControl) that having new, less experienced people in the team can lead to refreshing new ideas and insights, even though there's a danger of new team members wanting to leave their mark, and thus changing product properties that do not need or should not be changed. It was stressed that more experienced people develop sort of a 'feel' for the user and what is good in terms of usability. This feel is very hard to transfer from person to person, even with the help of knowledge management systems.

Project 

Planning: formalizing user involvement or not

The representative from EnRoute pointed out that EnRoute did not have formally documented user-involvement steps in its process, but still user testing and iterations are taking place. At AV2go user involvement is ensured by formally documenting methods and steps in the product development process, which does ensure that each team pays attention to these issues, but there's also a chance of the formalization backfiring, leading to a 'checklist mentality' among product development teams: they perform the required exercises, but not thoroughly or do not act upon the results.

Budget: product versus project budget

The representative from AV2go pointed out the difference between project budget and product budget, which is very relevant in the high-volume low margin market of AV2go. Project budget refers to the cost of product development activities, whereas product budget is the cost producing the product. For AV2go product budget is very tight and fixed, whereas in the project budget there's a little more room to work with. The representative from HomeControl pointed out that product and project budget also depend on the return of investment a company requires and on the profit margins.

Management and control

The representative from AV2go added that the biggest benefit of being able to measure usability the ability to monitor whether the products of a company are improving in terms of usability as a consequence of investments.

Company

Local company versus global clients, consequences for testing

The representative from AV2go confirms the observation that companies that serve a global user group, but develop their products in a centralized location run into trouble at finding representative users when doing user testing locally, and that when user testing is conducted in the target market the team cannot visit the tests. Using edited video clips to support the major conclusions of the study, which requires additional time and budget, can compensate the latter.

4.5.4 Responses to the Trace tool

By logging visits to the online Trace tool I were able to see that most of the participants in the workshop logged into the Trace tool website at least once and from several participants I got initial reactions (via email) to the tool and the content. Though the feedback workshop was not intended as an evaluation of the Trace tool several remarks were made about the workings of the tool, which are presented here. It can be concluded that the Trace tool and the categorization scheme needed some introduction before the participants could work with it effectively, that it enabled them to see the perspectives of the different roles within their company, that it was sometimes difficult to distinct between what barriers and enablers referred to an actual situation, and which were pointing to a desired situation, and finally, that the participants appreciated that the tool showed the quotes as well as the interpretation on which the barriers and enablers were based.

Somewhat overwhelming

The participant from AV2go described the content of the tool as a bit hard to read and overwhelming.

AV2go:	*I think it's kind of hard to read. And of course I would just like a nice 'one-pager' outlining what I have to do.*

After initial use of the online version of Trace the representative from WashCare reported via email that he did not find it obvious how it worked.

WashCare: *I have been trying around with the research tool today and got a rough understanding of the main concept. <…> I have got the impression that I could draw much more information out of Trace with a better understanding of the tool.*

Seeing different roles

Participants from EnRoute and WashCare indicated that they got insight into the different views and approaches among the different disciplines in their company, which may be attributed to the workings of the Trace tool, which makes it possible to view the barriers and enablers per discipline.

EnRoute1: *I think it is very clear the different roles also look different to each problem. That is to be expected I think. (….) Things that are experienced differently.*

WashCare: *And so, well, that's a bit different, but maybe from a different point of view in the process it is an act of communication and for me sometimes then as a receiver of this information it is more received as a passive information flow.*

Difficult to distinguish actual and desired situation

The participant from WashCare wondered whether the barriers and enablers were all based on what the interviewees had said or whether they also contained proposals for improvement by the researcher. At HomeControl there were similar questions.

WashCare: *But what is a bit difficult to draw out where you make a proposal and where you just well show the result of the, the interviews... So it would be good to have it drawn out a bit more what your conclusion is.*

Seeing quotes and connection with researcher interpretation

The interviewees found it sometimes rather confronting to read the conclusions and what they had said during the interviews.

WashCare: *This is really astonishing at some... So in this interview situation you don't get it word by word what you said, and now you... well, wrote it down word by word it becomes much more drastical than... it's...*

Researcher1: *Confronting...*

WashCare: *Confronting yeah...*

A representative from HomeControl indicated she appreciated that she could see what the conclusions that were drawn were based upon.

HomeControl2:	*But now it is just fun to see on what basis you draw these conclusions. That is rather nice to find back.*

This may have contributed to the fact that though some of the findings were rather negative and confronting, there was hardly any disagreement with the analyses.

4.6 Conclusions

The aim of this study was to get insight into the primary barriers and enablers for usability in the product development of electronic consumer products. To this end I identified barriers and enablers for usability and how these are related (the 'mechanisms'), and described the product development groups that I studied. The primary source for the analysis were interviews with the various actors in product development at five product development groups, which led to the identification of more than 1730 barriers and enablers for usability in product development, across the five product development groups. To provide an overview, barriers and enablers were categorized using a categorization scheme in which the main categories were the product development process, knowledge, and the properties of the team, project, company and market. This categorization scheme was used to create a software application for browsing barriers and enablers in product development: the Trace tool. Additionally I provided rich context descriptions of the five product development groups, which enables product development professionals and (future) case study researchers to assess to what extent the results are applicable to the situation in their company or to the situation they are studying.

The conclusions below are based upon the context descriptions of the product development groups (paragraph 4.3), the cross-case analysis (paragraph 4.4) and the reactions on these that were collected during a feedback workshop (subparagraph 4.5.3). The conclusions are an overview of the most salient mechanisms of barriers and enablers identified in this study.

The conclusions are structured according to the main categories of the categorization scheme for usability in product development (as described in paragraph 4.2.3). The sections 'Process: creating usable products' and 'Process: evaluating usability' fit into the process domain of the categorization scheme (Figure 34, page 117). Subsequently I discuss conclusions that fit into the other main categories, namely knowledge, team, project and company properties.

4.6.1 Process: Creating usable products

The danger of too much functionality

In all the development groups, developing a product with (too) much and not the right functionality was considered one of the biggest barriers for creating usable products. In general products with elaborate functionality were considered harder to use. An additional negative effect of elaborate functionality was that these products cost more effort to design, evaluate and implement in a user-centred way. However, it should be noted that users were considered to gain more experience with a product over time, and that what is initially sufficient and appropriate functionality may over time become too limited.

Too much and non-user-centred functionality was considered to be primarily influenced by a desire to keep up with the functionality in competitor products, and by retail channels and sales departments demanding non-user centred requirements. Though it was widely believed that offering products with elaborate functionality would cause products to be harder to use, it was also believed that products with limited functionality are harder to sell. Additionally, it was pointed out regularly that development team members who are (technical) specialists might find it hard to consider the product from the user's perspective, and thus might have a tendency to add unnecessary functionality to a product. Finally, setting user-centred requirements was considered to be positively influenced by having knowledge about and a feel for the user group, its needs and potential usability issues. To arrive at the appropriate functionality product requirements need to be critically evaluated. However, few methodical approaches for the evaluation of requirements were mentioned, and they were hardly used.

Creating a usable design: everything but design

When discussing what design strategies were employed to make easy-to-use products, most interviewees referred to things that *facilitated* making a usable design, such as designing from the user perspective, having enough time, and evaluating the design, but hardly made references to techniques or methods that influenced act of designing itself.

Because of the fierce time pressure on the development projects, it was considered unwise to design a new UI from scratch, as this involved a huge amount of work and because of the lack of a predecessor would limit the team's knowledge of the usability of the design and of potential usability issues. It was considered advisable to base designs on predecessors or a UI concept that was shared across a product line.

The design of the UI was said to be hampered if styling was prioritized over usability, which was likely to occur, as styling was believed to increase the consumer appeal of the product. This problem was increased by the fact that the design of the physical part of the user interface (controls, knobs, etc) was usually not made by the interaction designers, but by the product designers, who were less inclined to prioritize usability.

The technological platform: potentially limiting

The properties of the technological platform were often indicated as a limitation for implementing the original design or changing the design to deal with usability problems that were identified. Because of the long time required to develop it, the design of the technological platform usually preceded the development of the product itself, which means that decisions about the technological platform are usually taken at a time when the product requirements are not yet known, and by team members that are more technology than user-oriented. It was suggested that if interaction designers would have more knowledge of the limitations of a technological platform, they would create more feasible designs and implementing these would not be so problematic.

4.6.2 Process: Evaluating usability

User testing primary evaluation method

User testing with simulations and prototypes was mentioned most often - by far - as usability evaluation method. User testing with 'rough' prototypes such as paper prototypes, mock-ups, and PowerPoint presentations were only used to a limited extent. Many of the interviewees attributed this to the lack of appropriate stimulus material in the early phases of product development. Expert appraisals of designs were performed, but the use of methodical usability inspections was very uncommon.

Concerns regarding user testing

With regard to the setup of user testing the primary concerns was the 'representativeness' of test participants and stimulus material. Whether and how user testing was conducted depended on whether time was available (which could depend on whether user testing was included in the project planning), and on the availability of project budget and staff.

The quality of execution of user testing was also a concern, which was considered to be influenced primarily by the properties of the user testing facility, the evaluator's skills and experience, and his/her knowledge about the product and of the method being used.

Communication of usability evaluations

When communicating user test results it was considered important that the development team members are exposed to rich information of 'real' people interacting with the design, which can be achieved by showing them video clips of user tests or by having the product development team visit user tests or team members conducting user tests themselves.

After sales feedback: very useful, but underused

After sales feedback, the information about a product that surfaces when a product hits the market, emerged as an underused but potentially valuable source of information about usability issues, which was appreciated because it originated from real-world users. It originated from sources such as customer service, customer satisfaction questionnaires, monitoring consumer and press reviews, and logging product use. Depending on the resolution of the information (which was often relatively low) determining the cause of a usability issue based on after sales feedback can be hard.

Secondly, information coming from customer service – one of the most important sources of after sales feedback – is usually self-reported by customers: they describe how they experience an issue; product developers cannot observe the issue at hand. Thus it has to be taken into account that the information might be inaccurate and that, secondly, there might be a threshold for customers to complain; if no complaints or questions are received this does not mean that there are no usability issues in the product, only that customers do not complain or ask questions about it. Unfortunately after sales feedback was mostly communicated only to the product and project managers, and hardly found its way back to the designers, engineers and usability specialists, who did deem it a valuable source of information.

The value of usability evaluations is in the follow up

Early usability evaluation of designs was considered essential, because in the later stages of product development there is very limited possibility to actually implement the results of the usability evaluations. Iterating a design can be performed in four different ways. Firstly, a design can be iterated as a result of an evaluation within the design phase. Secondly, an evaluation in a later phase, such as implementation or production, can trigger a 'phase iteration' back to the design phase. The third approach was to redesign the current product based on input collected after product launch. Whether companies did this was dependent on how long the product would remain on the market and on their ability to update the product remotely (i.e., via the Internet). Finally, when not improving products while on the market, 'generation iteration' was an important alternative: using the knowledge gained from a product to improve a next generation.

4.6.3 Knowledge

User-centred product development is a knowledge-intense activity. Knowledge was found to act as an intermediary between the different activities of the basic design cycle and the phases of product development. Generally, analysis and evaluation activities produced knowledge that would form the input for synthesis, decision and iteration type of activities.

Seven categories of knowledge were found to play a role when developing usable products. The teams applied knowledge about 1) user group properties, 2) user needs and preferences, 3) how people use a product (category), 4) (potential) usability issues, 5) usability issues, 6) user appreciation of concepts and products, 7) and possible design solutions and usable designs. These categories of knowledge were produced through a multitude of methods. Knowledge about potential usability issues, for example, could be the result of a cognitive walkthrough, a user test with a flash simulation, or a previous project. On the other hand, a single activity could also produce multiple types of knowledge. For example user testing can produce knowledge about user group properties, user needs, potential usability issues, and product usage.

4.6.4 Team

Early and throughout involvement of UCD roles

Involvement of interaction designers and usability specialists was considered very important, but was occurring only to a limited extent. Usability specialists were often only consulted near the end of the process, barring them from sharing their knowledge in the early phases, and not being involved in early design decisions that influence usability, such as decisions about the functionality of the product and the technological platform. If people with knowledge of interaction design and usability are a part of the product development team they are in a unique position to monitor a project for usability issues and request assistance (user testing, reviews) when needed.

'Seeing' the user perspective

The most important skill that a team needs to create usable products can best be described as 'seeing the user perspective': the ability to understand what is important to users and anticipate how they might use the product. However, a certain degree of 'home blindness' (not seeing the particularities of a design) can occur, because the team members have too much knowledge of their product (they designed it themselves), and because they are more 'advanced' than the average user. Another reason for not seeing (or not being willing to see) the user perspective was described as 'falling in love with your own design'. More experienced team members were reported to develop what was described as a 'feel' for the user and what is good in terms of usability. This 'feel' is very hard to transfer from person to person or through knowledge management systems.

Attitude towards usability

The attitude towards and prioritization of usability by team members has an effect throughout the product development process. Whether usability is prioritized seems dependent on the benefits for the company that team members attribute to usability (i.e., that usability is important to the target group, that it improves sales, and prevents costs), on whether the company's brand position or strategy includes usability-related statements, and whether a company culture can be described as user-centred. Usability is more likely to become a part of the company culture or philosophy if upper management or another 'usability champion' promotes usability, and if it the brand position includes usability. The degree to which team members are exposed to users (i.e., in field studies or through user testing) was also seen as a contributor to a more user-centred attitude. This often depends on the kind of role someone fulfils: engineers were far less-likely to be invited to visit user tests.

No (explicitly) shared definition of usability

Although measuring usability was a concern that often surfaced, and usability was regularly pointed out to be part of the project aims, none of the participating companies had explicitly defined what usability meant to them. In some cases interviewees indicated that they thought within their company everyone had a different view on usability, whereas in other companies even though usability was not explicitly defined, the team members did seem to have some sort of common understanding of what usability comprised.

4.6.5 Project

Planning & budget

Time planning (or time pressure) and availability of budget have a large effect on user involvement and the creation and implementation of user-centred designs. Companies that have short product development cycles and very distinct seasonal sales peaks seem to suffer from higher time pressure than companies with longer cycles and less strict deadlines. The product budget (the cost of producing the product) is influenced by whether a company sells high-end products (higher product budget) or high-volume low-margin products (lower product budget).

Formalizing user involvement

Formally including user involvement activities (user research, interaction design and usability evaluation) in the product development process can ensure that all product development teams plan for and execute user involvement, but has the possibility of backfiring. Teams may start exhibiting a checklist mentality: they perform the required steps, but not thoroughly or they do not act upon the outcomes.

Degree of innovation

Introducing a new product, platform, user interface, or content introduces risks to the usability of the product, because it decreases the knowledge of a usable design, the knowledge of potential usability issues, and because creating a new design costs a lot of time and effort which enlarges the risk of not being able to implement the design as planned. Developing a product over generations and/or having a UI paradigm (a UI concept that is shared across a product line and generations) are ways to prevent having to create a (UI) design from scratch for each product, and additionally between-product consistency makes it easier for users to use a company’s products, because they know the UI from other or predecessor products.

4.6.6 Company

Serving an international user group, but centralized product development

When a company conducts its product development activities in a centralized location but sells products worldwide, the product development team members have less contact with the user group (as they don’t live among them) and it is harder for them to visit user tests (if these are conducted in the target market), or the user tests have to be conducted with participants unrepresentative of the anticipated user group. This results in reduced knowledge of the user group, needs and preferences, product usage and usability issues.

Disconnect: hard/software, interaction/product design, design/engineering

In all of the development groups, team collaboration had more of a multidisciplinary than collaborative character. They all featured multidisciplinary teams, but the office layouts would be arranged by discipline and not by project, the development of hard- and software were separate processes, and usability specialists would usually be more affiliated with the software development organization than with the design and development of the hardware and embodiment. Especially the design departments were positioned (or had positioned themselves) as quite isolated from the rest of the development group. Product designers and interaction designers were often only cooperating to a limited extent, limiting the influence of the interaction designers over the physical aspects of the user interface (such as displays, buttons and peripherals). Overall, the disconnected way of working seemed to cause serious communication issues, which are especially relevant for non-quantifiable product qualities such as usability. Development engineers would develop the hardware platform without input, designers would not know limitations of a platform, (product) designers would not visit user tests, and interaction designers would not be present to advice software engineers when they had questions about how to implement a design.

Usability departments understaffed or not present

Even though within most of the companies usability was valued, in three out of the five companies the usability department was understaffed (they were not able to deal with all the requests for user testing), and in one it was non-existent. Limitations in staff were inhibiting the (timely) performance of user testing.

Willingness to align the organization with user needs

Electronic consumer products are becoming more and more connected with other products and services. The degree to which a company had control over the 'product eco-system' was found to determine to what extent it could influence the user experience. Some usability problems simply cannot be solved with a better user interface, but need a different technological platform or need to be extended with a service. In other words: 'product usability' or 'system usability' may be more important than 'user interface usability'. One of the companies in this study took the desire to have control over the eco-system so far as to change the nature of its company twice: from being a software company to becoming a consumer products company, and then from a product to a product-service provider. This enabled the company to align with the user needs and deal with the usability issues it had observed.

4.7 Discussion

In the following section I reflect on the conclusions of this study as well as on the consequences of the methods applied.

4.7.1 About the results

Too much functionality: not just 'guys in labs designing for guys in labs'

Popular belief has it that it is the engineers who are to blame for the development of products with too elaborate or non-user centred functionality (Nussbaum and Neff, 1991). However, this study showed that the consumer-oriented departments in a company, such as product management, marketing, and sales, are likely to demand products with elaborate functionality, because they consider products with elaborate features (which often equals elaborate functionality) sets to sell better. Additionally, I found that a product development group's sales channels (e.g., telecom provider in the case of mobile phones, or retail stores in the case of MP3-players) may interfere with the setting of user-centred requirements, demanding requirements that align with their (commercial) goals.

No participatory design: due to 'downward empathy'?

Participatory design, in the form where the user is really a part of the product development team (Buur and Boedker, 2000), was not observed in any of the development groups. It may be that a participatory approach is more appropriate in product development projects where the user is more of an expert on the product than the designers are; where there is a bigger 'gap' between the user's knowledge and what the designer knows. Nielsen (2008) identifies three 'levels' of designer-user gaps:

- The designer is the user (he completely understands how the product works, and so do the users);
- The designer understands the product (and the designer is in the dangerous position of knowing more than the user group);
- Designing for a foreign domain (where the designer has the problem that he knows much less than the user group).

For example, an engineer developing a military aircraft is not likely to have the same experience flying aircraft as the pilot for whom he is designing, and a software developer making software for trading on the financial markets cannot be expected to be as much of an expert on this system as his/her users are. These are cases that require what I would call 'upward empathy': the development team needs to understand human-product interaction for a highly specialized situation. In this case users can participate in development to extend the team's knowledge.

However, in the case of electronic consumer products, the product development team usually knows more about a product category and especially about the product that they are working on than the users[21]. In this case, to anticipate how users would use the product the team needs to 'unlearn' what they know, which is a situation that I would label 'downward empathy'. Perhaps the fact that in electronic consumer products mostly require 'downward empathy' explains the fact that none of the development groups I studied included users in the design phase.

4.7.2 About the research design and method

Case sample

When comparing the case context descriptions of the development groups, in some areas distinct parallels can be identified, though on other levels the groups differ. For example, AV2go was a somewhat formalized, complex organization, whereas EnRoute as relatively young, small, and informal. Another example is HomeControl that worked with external user-centred design consultants, as opposed to having a usability department, which was common in the other cases. However, both development groups dealt with the same market dynamics of the consumer electronics market: fast development cycles (and thus high time pressure), and a tendency to include ever more functionality in the products. In retrospect, when comparing the context descriptions of the development groups, it seems that the selected cases were comparable enough to produce coherent case study, but diverse enough to arrive at new insights because of the differences between the cases.

An interview-based study

This study is primarily interview-based. I asked (experienced) product developers what they considered to be barriers and enablers for product development. This allowed me to 'cover a lot of ground': I could study quite a few development groups in the time that was available (Eisenhardt and Graebner, 2007), and in each of the groups could get a perspective on the phenomenon from different angles, because the interviews each played a different role in the product development process. However, basing the study on interviews also had some downsides. As I were not discussing specific projects, the interviewees would sometimes talk in somewhat general terms about how they dealt and should deal with usability, offered little detail outside of examples, and some degree of 'lip service' (people supporting the idea of usability only in words) may have occurred. As soon as interviewees started discussing projects or examples as opposed to the general way of working at their group, their answers became much richer and specific.

Focus: design brief to market introduction

Though in this study I did take the process phases preceding the design brief (what the development team should deliver) into account, I paid more attention to how the product

---

[21] Of course users do know more about their personal situation and usage of a product. They remain what Sleeswijk Visser (2009) calls the 'experts of their own experience'.

was developed based on that design brief, than on how the development group had arrived at that design brief. The focus of this study was: once you have decided you will make an mp3-player with a certain product proposition: what makes that mp3-player easy to use or not. Even though, the interviewees made many remarks about the intricacies of formulating the right design brief and requirements, and evaluating this. It might be that even more issues surrounding this issue would have been found if I had put more focus on that phase.

The Trace tool

I developed the Trace tool to help me to structure and reduce the large amount of data, to provide an overview, and because graphical feedback is considered to lead to faster and more complete learning than numerical feedback (Meyer, 1991). As a researcher I personally experienced the Trace tool by developing it and using it during data analysis. For me as a design researcher, Trace proved to live up to the intentions for which it was developed: providing an overview of barriers and enablers and showing relations between them, as well as providing the possibility to iterate between the original quotes and my interpretations.

I also demonstrated Trace to, and discussed it with, experienced design researchers and product development practitioners, as well as having the primary contacts from the companies work with it prior to and during the feedback workshop. The tool proved to be usable in the feedback workshop: showing the original quotes, in combination with the researchers interpretation seemed to be appreciated by the participants; it seemed to increase their confidence in the results and during the workshop the interpretations I had made were hardly challenged. Any comments they made about the results usually referred to the sample: they did not challenge that what I claimed was said during the interviews, but they suggested that in some cases what was discussed was not completely representative for how they actually worked. Additionally, several participants in the workshop remarked that they were intrigued by the barriers and enablers that other team members with different roles had made. Using Trace seemed to enable them to see the perspective of their co-workers.

The feedback from experienced design researchers and product development practitioners I consulted about Trace seemed to indicate that in its current form – especially due to the large amount of highly specific data it holds – Trace is mainly suitable as a design research tool, though, if the content would be recommendations and conclusions on how to deal with usability in product development, Trace might be applicable in product development practice.

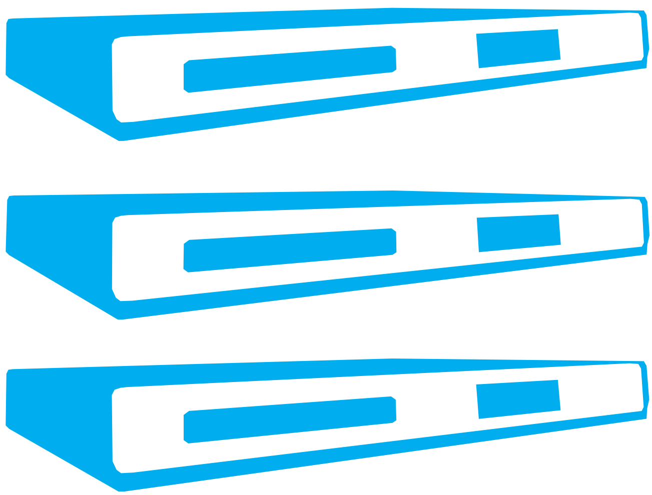
4.7.3 Implications for the subsequent study

This study provided a good overview of how the groups dealt with usability in general, and of the influence of contextual factors (team, project, company, market) on the product development process. However, in some instances it remained unclear how some of the barriers and enablers would influence usability, and due to the setup of this study and the nature of the data, I was unable to dig deeper into this subject. Secondly, in this study informants would provide more detailed descriptions when discussing specific projects as opposed to how the development group worked in general.

For the next study it seems recommendable to study specific projects, because the interviewees would be more specific, and I could relate the activities performed in the product development process to the usability of the end result: the product. It should also be attempted to base the case on more sources than just interviewees.

Chapter 5 | Case study III

Tracing the origins of usability issues in three product development projects



Chapter 5: Case study III

Tracing the origins of usability issues in three product development projects

The previous case study identified barriers and enablers for usability in the product development process, team, and context (i.e., project, company, and market). That study was not investigating specific product development projects but focused on how product development groups generally deal with usability. Secondly, the interviewees in the previous study gave much more specific and richer answers when they discussed a particular product development *project* then when discussing in general how their product development group dealt with usability. In addition, both previous studies (chapter 3 and 4) consisted of expert interviews about usability, without assessing the level of usability of the products of the companies where the interviews were held. And finally, from studying the overview of barriers and enablers, it became clear that a more detailed insight was needed into barriers and enablers that occur in the various steps of the development process. Thus the aim of the case study discussed in this chapter is to identify what triggered usability issues to arise and persist in products, by studying documents and interviewing product developers who made these products.

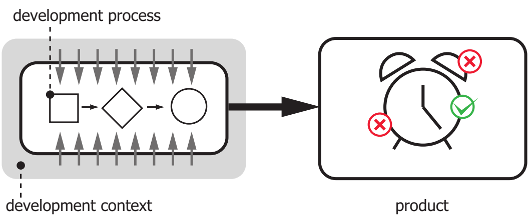


Figure 45: The product development context (left, grey area) is assumed to influence the development process (left, white area), which in turn results in usability strengths and weaknesses in the product (right).

A basic assumption underlying the study was that there is a relation between the level of usability of a product and the way it is created: I assumed that properties of the product development process (i.e., design guidelines, user evaluation and the overall structure of the process) are related to the usability issues (both strengths and weaknesses) in the product (Figure 45). In turn, the context in which product development takes place (i.e. development group organisation, team properties, project properties) was assumed to influence the development process, and thus indirectly influence the usability of the product.

This study had the following main research question:

- What variables in development projects of electronic consumer products influence the usability of these products and how are these related?

Based on the findings in the previous study I presumed that usability strengths and weaknesses of a product could have the following causes:

- Knowledge about (potential) usability issues, or a lack thereof;
- The ability to design something that prevents or solves usability weaknesses;
- The extent to which a design can be implemented.

Which resulted in the following sub-questions:

- What factors in product development projects cause usability strengths and weaknesses to arise?
- What factors in product development projects cause or prevent detection of usability strengths and weaknesses?
- What factors in product development projects cause or prevent usability weaknesses from being solved?

In these research questions the term 'factor' refers to variables in product development that have been identified to influence usability.

In paragraph 5.1 the overall research approach is outlined. Paragraph 5.2 contains the case context description, which consists of a description of the development group as well as of the three development projects that were studied. The next three paragraphs are used to describe the three parts that make up the overall case study. In each paragraph the method as well as the results for that part of the study are provided. First, in paragraph 5.3, it is described how the usability issues (strengths and weaknesses) in the products were identified. Then, the following paragraph (5.4) presents the development of a description of how usability was dealt with at AV@home. Paragraph 5.5 contains the development of causal networks per usability issue, which are analyses of events and circumstances that played a role in the rise & prevention, detection, and solving or improving of usability issues. In paragraph 5.6 it is described how, based on the causal networks per usability issue, I developed causal models for usability in product development. These causal models outline the most important variables that influence usability in practice, as well as the relations between them. The models are discussed in depth, and their accuracy and generalizability is assessed. Finally in paragraph 5.7 conclusions are presented, followed by a discussion of the scope and limitations of the study in 5.8.

5.1 Research design

The following paragraph describes the design of the case study, its unit of analysis, the criteria for selecting the product development group and the development projects, the researchers involved, and an overview of the three parts that make up the study.

Single embedded case design

From the previous case study I concluded that a more detailed insight was needed into the dynamics of dealing with usability in product development projects. The previous study investigated the influence of the product development context on the team and process. In this study, however, the focus is on the development process itself. I therefore decided to investigate three product development projects within one product development group, thereby keeping the product development context as similar as possible across the projects. The design of this study is a single embedded case study with three embedded units of analyses (Yin, 2009, p.59).

Unit of analysis

The unit of analysis defines what the 'case' is about (Yin, 2009, p.29) and can be considered to have a focus and a context (Miles and Huberman, 1994, p.25). The focus of this case study was the coming into being of usability strengths and weaknesses in three electronic consumer products, and the context consisted of the properties of the development project and group.

Case selection

Selection criteria were used to choose the development group that was the context for the case study, and a second set of criteria was used to select the appropriate development projects within that group, which were the focus of the case. For the selection of the development group similar selection criteria were used as in the previous case study (Chapter 4): it should develop electronic consumer products in-house and have the ambition to make usable products.

The goal was to investigate a case that could be described as being 'typical' (Miles and Huberman, 1994, p.28) for the way product development groups of electronic consumer products worked at the time. Based on what I knew about AV@home[22], and by comparing this to the five development groups in the previous case study, AV@home was indeed identified as fairly 'typical', and at least not a unique or an outlier case.

---

[22] Previous to this case study I was already familiar to some extent with the AV@home product development group, because in the case study described in Chapter 4 I conducted more interviews than only those that were included in the analysis. I conducted interviews at both AV2go and AV@home and afterwards decided only to include AV2go in the analysis (as the two development groups belonged to the same parent organization, and were fairly similar). The interviews at AV@home however dit provide me with a considerable amount of information on how the development group was organized and worked.

Within AV@home I had a primary contact person who served as the liaison to the product development group, helped to select the appropriate projects, and provided information and documentation. Due to his role, the primary contact was very familiar with the intricacies of the organization, and at least to some extent familiar with development projects being performed within AV@home. The conditions for selection of product development projects (Table 25) were discussed with the primary contact, which led to a shortlist of projects.

Table 25: Conditions for product development projects to be shortlisted for selection.

Condition	Details
Recent project	The product is developed recent enough for the product development team members to recall the project correctly.
Product is on the market	Possibility for the researchers to subject the product to a usability test.
	Market feedback (i.e., helpdesk calls and customer satisfaction surveys) available.
Recent project + designed in-house	Access to the development team members, which means: • the product is primarily conceived and designed (but not necessarily developed) in-house; • the team members are still employed by the company.
Usability evaluation performed	Data are available on usability issues that played a role during the product development project.
Usability weaknesses present	The product features (at least some) usability weaknesses.

From this shortlist projects were selected using a "dimensional sampling approach", which means the researcher lays out the dimensions on which variability is sought (in this case the types of development projects that AV@home was engaged in) and then takes a 'typical' case or informant for each contrasting dimension (Miles and Huberman, 1994, p.29, quoting Johnson (1990)). The dimensions used for the final project selection (see Table 26) were product type, product proposition (high-end products are likely to have more resources), in-house or external development, and the amount of usability weaknesses.

Table 26: Overview of the selected product development projects, which differed in the extent to which they were developed in-house, whether it was a high or low level product proposition, and the amount of usability issues the primary contact assessed the product had.

Product	Proposition	In-house/external	Usability weaknesses
DVD-recorder	Low-end	External software/hardware platform	Limited
Hard-disk recorder	Low/Mid-end	Designed and developed completely in-house	Severe
Home theatre system	High-end	External software platform, hardware partly proprietary.	Some

Researchers

This study was planned and executed by the author of this thesis, assisted by a research assistant who focused on the home theatre system case[23]. Table 27 describes which researchers were involved in setting up and executing this case study, their backgrounds, and what parts of the research they conducted and/or supervised.

Table 27: An overview of the researchers that set up, executed and oversaw the study.

Researcher	Background	Tasks
Primary researcher	PhD candidate, author of this thesis	Plan and execute case study
Secondary researcher	Graduate student from the Master's program Design for Interaction of the faculty of Industrial Design Engineering (TU Delft).	Contributing to case study setup Identify usability issues Home Theatre System Conduct interviews Home Theatre System Create causal networks for usability issues of Home Theatre System
Supervisor A	Experienced researcher in the domain of observational research and supervisor of the PhD candidate	Supervise graduate student
Supervisor B	Experienced researcher in the area of qualitative organizational research	Supervise graduate student

Research setup

The approach taken in this case study can be divided into three distinct phases. These are shortly outlined below and visualized in Figure 46, and described more in depth in (sub)paragraphs 5.3.1, 5.5.1, and 5.6. In the first part of the study, the usability strengths and weaknesses of the three selected products were identified, based on documents that contained information about the usability studies, such as user test reports, customer satisfaction surveys, and online consumer reviews.

The events and circumstances that had led to usability issues were identified based on documents and interviews with product development team members (par. 5.3). Cards with descriptions of the usability issues were used to sensitize the interviewees in advance of the interviews and to keep the interview focused. Based on the interviews and collected documents I wrote a description of how usability was affected at AV@home (par. 5.4).

Next, I attempted to capture the findings in a form that was less context-specific. For each of the identified usability issues I created causal networks of the events and circumstances that had led to the issue (par. 5.5). From the causal networks and from the interviews and

[23] In this chapter 'we' is used to describe activities in which both researchers were involved, 'the secondary researcher' to described activities undertaken solely by the graduate student, and 'the primary researcher' or 'I' to describe activities and decisions by the PhD candidate.

documents I then derived two causal models that contain variables that influence usability in practice and indicate the relations between them (par. 5.6).

In several phases of the study the results were presented to participants and informants involved in the case, in order to corroborate or disconfirm essential facts and evidence (Miles and Huberman, 1994, p.275; Yin, 2009, p.182, quoting Schatzmann & Strauss, 1973). The description of how AV@home dealt with usability and the causal models were verified for accuracy during a feedback workshop at AV@home (par.5.4.3, par. 5.6.5), and in workshops at 'sister' development groups of AV@home within the same parent company it was discussed whether the models would fit these groups as well (subpar. 5.4.3).

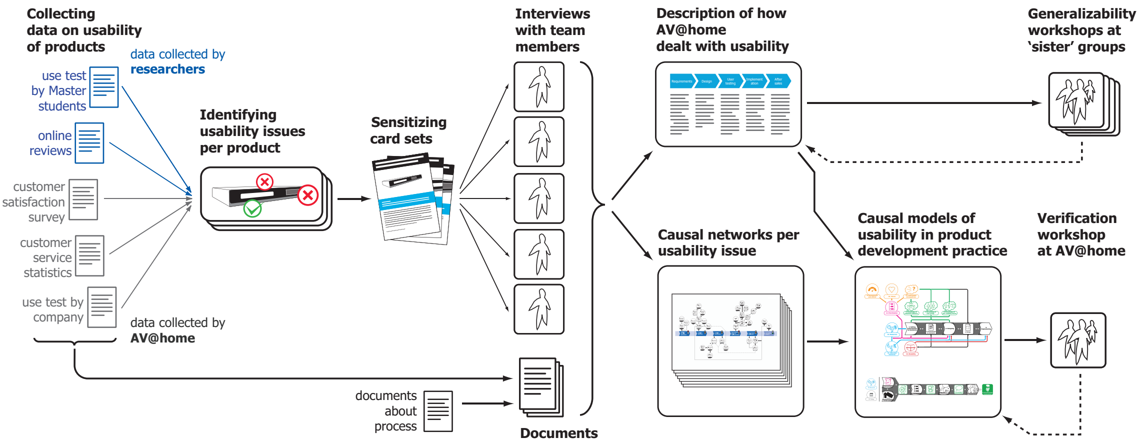


Figure 46: The method followed for conducting this case study. Based on documents, usability strengths and weaknesses were identified (par. 5.3) which were presented to interviewees through a sensitizing card set. Based on the information from the interviews and on the collected documents I wrote a description of how AV@home dealt with usability (par. 5.4), of which the generalizability to other development groups within AV@home' parent organization was checked through workshops (par. 5.4.3). Next, causal networks per usability issue were developed, outlining what circumstances and actions had led to usability strengths and weaknesses (par. 5.5). Based on description of how AV@home dealt with usability and the causal networks per usability issue causal models of usability in product development were inferred (par. 5.6), which were verified for accuracy by conducting a verification workshop at AV@home (par. 5.6.5).

5.2 Context description: product development group and projects

This paragraph provides a description of product development group's organizational structure and approach to product development at the time of the research. Secondly, it provides a description of the three product development projects that formed the embedded cases of the study. Providing an in-depth description of the case context is an important contributor to the quality of a case study (Malterud, 2001b). It provides the reader with a possibility to assess to which extent the situation s/he is dealing with as a product development professional or researcher is similar.

5.2.1 The AV@home product development group

At the time of research, AV@home was[24] a business group that was part of the consumer products division of a large, multinational developer of both professionals and consumer electronics, with over 50.000 employees worldwide. AV@home was situated in Asia and developed audio-visual home entertainment products, such as home theatre systems, DVD players, DVD recorders, streaming and connected products[25]. AV@home was a premium brand that had recently been positioned to promise technology that is easier to experience and designed around the consumer's needs, while maintaining at the forefront of technology.

Organization and location

Table 28 outlines what actors were involved in product development and how they were distributed over the departments at AV@home. Some of the departments belonged to the AV@home business group, while others were part of other organizational units of the parent company. Product Management, Quality Management and Engineering were part of the business group AV@home, whereas the Design department and User departments were housed in the same office building, though in different locations. Product Management, Quality Management, and Engineering were in the same part of the building, though seated by discipline. The Design Department and the Consumer Experience Group were located in other, not freely accessible (a pass was needed to enter), parts of the building.

AV@home's employees had 5 to 10 years of working experience in consumer electronics and personnel turnover was considerable. Upper management was only involved to a limited extent in the content-wise aspects of product development projects, but monitored the projects on process and resources.

---

24 I chose to report context descriptions in past tense, as these describe a situation that existed at a certain point in time. Though they were 'true' then, and actually occurred, I do not make claims that this is always the case; there is no general truth to the description.

25 Streaming products are products that are able to play audio and video content from the Internet, connected products are products that can be connected to each other to form a home network.

Table 28: An overview of the development team members and what departments they belong to.

AV@home business group	*Product management department*	Product planner Product manager Project manager Consumer experience test coordinator Business planner consumer interaction
	Development engineering department	UI function manager Mechanical project leader Electrical project leader Software project leader
	Quality management department	Quality project leader Customer service manager
Company design group	*Local design department*	Product design consultant Interaction design consultant
Internal consumer experience consultancy	*Consumer Experience Department*	Consumer experience consultant

Product development process

AV@home's product development process can be divided into two major parts: the pre-development and the development phase. In pre-development the product concept was defined, which was referred to as 'value creation'. During development the concept was refined, implemented and brought to the market, which was also referred to as 'value delivery'. Table 29 shows a simplified representation of AV@home's product development process.

Pre-development

In this phase of product development, which was a newly established part of the process and thus not yet very structured or formalized, value propositions were formulated and a rough notion of the aesthetics and functionality of the product was determined. In addition the technical and commercial feasibility of the product was evaluated. Product designers and engineers explored design solutions that could fulfil the value proposition.

Development

The development process was formally documented, and each phase had explicitly defined deliverables, which had to be presented in milestone meetings, where project leaders had to convince their colleagues and the upper management that the project was on track. Requirement setting was an important element of AV@home's development process. In the development projects a lot of disciplines had to cooperate, and the people from each discipline had to have a clear overview of the project and product requirements, as this would determine their tasks.

Table 29: Simplified representation of the AV@home product development process between concept creation and mass production.

<table>
<tr><th>Pre-development</th><th>Disciplines</th><th colspan="6">Product development process steps →</th></tr>
<tr><td rowspan="5">Formulate value propositions and define product requirements</td><td>Cons. Experience</td><td>-</td><td>-</td><td>Test consumer experience</td><td>Test consumer experience</td><td>-</td><td>-</td></tr>
<tr><td>Mechanical</td><td rowspan="3">Formulate and agree on requirements per discipline</td><td rowspan="3">Create a detailed design per discipline. The mechanical prototype is finished at the end of this phase</td><td>Design production equipment</td><td rowspan="3">Optimize for industrialization</td><td rowspan="3">Prepare for market introduction</td><td rowspan="3">Apply running changes</td></tr>
<tr><td>Electrical</td><td>Integrate and test printed circuit board</td></tr>
<tr><td>Software</td><td>Integrate and test software modules</td></tr>
<tr><td>Quality</td><td>Create quality plan</td><td colspan="4">Perform quality tests</td><td>-</td></tr>
</table>

User involvement and representation

At AV@home user involvement and representation during product development occurred in three ways: evaluations based on user interface guidelines, usability testing and systematically evaluating feedback from the field.

- User interface guidelines: AV@home had a set of guidelines that could be used to assess whether a product (design) met the group's quality standards. These requirements included usability-related aspects, such as response times and standardized UI behaviors.
- Usability evaluation: Use tests, in which externally recruited participants interacted with early samples or prototypes were usually conducted twice during product development projects. In a first test, which had a formative character, the goal was to highlight what product aspects could be changed to improve usability, primarily for the initial phases of use, such as 'unpacking', 'installing' and 'first use'. A (possible) second test, which had a summative character (see page 65), had the goal of assessing whether the product's overall user experience – again, mostly for initial use – was acceptable for consumers. In both user tests on of the most important subjects to be investigated was the usability of the products.
- Feedback from the field: Usability feedback from the field was gathered through home tests of early products by employees, customer service contacts (through telephone and Internet), product returns, and customer satisfaction questionnaires. At the time of research customer satisfaction had recently been introduced as a new measure of product success.

Product development team

In the pre-development phase a relatively small team conceived and explored the initial product concept. In this phase the team consisted of a product planner, product manager (to some extent), product designer and the heads of the teams in the engineering disciplines (mechanical, electrical, software). Once actual development starts this team was expanded, but the initial team coordinated efforts and made the most important decisions.

The development teams at AV@home were rather segmented. Product Management, Design, User Experience, and Development Engineering were all in separate parts of the building, and often part of separate organizational units. As a consequence informal communication was limited, and the teams relied a lot on meetings and e-mail/PowerPoint to communicate. The teams' reliance on e-mail and PowerPoint to communicate was also described to be a result of the company culture.

5.2.2 The product development projects

In the following section for each of the product development projects a description is given of the product and project characteristics, and an indication is given of the level of usability of the product.

Case 1: Hard disk recorder

Product description

This product could record TV programs on an internal hard disk, from which the recordings could then (eventually) be archived to DVD. Recordings could be programmed through an on-screen TV guide. Another important feature was the 'continuous recording' function. The product stored the last 3 hours of the channel that the user watched to hard disk, allowing the user to pause or rewind a live TV program (s)he was watching. The device also played music and could show photographs, from either CD/DVD or a USB stick.

The target group for the product was described as traditional, family-focused and risk-averse, while seeking status and wanting to be in control. They were considered to be avid TV-watchers, but hardly ever made recordings (on their VCR) because they were very busy and found programming a VCR cumbersome. In the product proposition ease of use was explicitly mentioned as a user benefit. The product was targeting a low-to-mid end price segment.

Project description

This product was developed almost entirely in-house, based on requirements that were set by the development group itself (as opposed to purchasing a platform or product from third party suppliers). The hardware and software architecture were inherited from a predecessor product. The user interface was the first full-fledged implementation of a new UI paradigm that had recently been inherited from the TV development group. The product was described as complex and extensive (in comparison to for example DVD recorders and home theatre systems). The aesthetics of the physical product were based on a styling strategy that the design department had determined for that year, and the remote control had a standardized layout that was used for a large part of the product line.

The project featured a distributed software development team. The one on-site team worked on the user interface, a team in Asia (not in the same country as AV@home) developed the system software, and a team in Europe wrote the drivers for the hardware components. Though all software developers were part of AV@home's parent company, they worked on contract basis, which meant that they could only spend a limited amount of time on the project.

The project ran for almost two years - which is relatively long for AV@home - due to large problems with the stability and performance of the system arising during implementation, which led to a number of delays and a lot of discussion between the local and the off-site software development teams. The industrial/mechanical design and engineering seems to have gone relatively smooth. Overall the project was described as 'challenging', 'intense' and 'eye-opening'.

In the project above-average attention was paid to collecting user feedback from previous projects, and to user testing. However, because of the problems of getting the software of the product stable, user tests could only be performed late in the process. Two user tests were performed: one when the design of the product was fairly detailed, and one just before product launch (on the final product). In addition, in an early phase the product was subjected to a UI guidelines and response times benchmark.

Case 2: The DVD-recorder

Product description

This product only offered basic recording, and no on-screen TV guide or advanced connectivity. The product only offered limited functionality, as this was AV@home's most basic, entry-level DVD-recorder.

The target group for the product was described as traditional, family-focused and risk-averse, while seeking status and wanting to be in control, who liked to watch TV and might own a camcorder. They would like to archive home videos and TV programs they enjoyed. They were described as looking for a no-nonsense, good value for money product that looks fairly decent. It was explicitly stated that the product should be easy to use.

Project description

The hardware-software platform was purchased from a third-party supplier, and had been used in a previous product, which had received favourable customer reviews. The user interface was an integrated part of the software platform and – also because of the contract with the supplier – could only be adapted to a very limited extent. Basically only the colour scheme and labels of menu items could be changed. The appearance of the product was based on the overall styling strategy for that year, and for the physical remote control design the standard remote control design for the whole range was used.

An internal team at AV@home developed the product in cooperation with the aforementioned third party supplier. From project start to market launch the project took about one year, of which the implementation (from product proposition to production) took about 6 months. The project was described as very straightforward and smooth and it was finished within the projected timeframe. Cost was a very dominant decision making criterion in this project, because the product was intended as a low-margin, high volume product, and thus for this project achieving the projected sales price was very important. A considerable number of compromises had to be made with regard to the aesthetics because of cost considerations. Changes had to be made to the physical elements of the user interface, and some were cut completely.

During product development a usability guidelines benchmark and formative user test were performed, but no pre-launch summative user test was performed.

Case 3: The Home Theatre System

Product description

This product offered the possibility to watch DVDs and television programs in Dolby Surround Sound. It was a high-end product with a new, distinctive physical appearance: the product could be mounted on the wall (below a flat-screen television). While traditional home cinema sets come with five speakers and require a lot of cable connections, for this product only an additional subwoofer was needed to generate a Dolby Surround experience, because of the application of innovative technology, developed by AV@home's parent company.

The target group for the home theatre systems was described as sophisticated, established, but not showy. They were considered design-oriented and (intended to) own a flat-TV.

Project description

The components that were innovative were developed in-house, but more standard components were purchased from third party suppliers, which included the basic hardware/software platform of the product. The user interface was an integrated part of the software platform, and could therefore not be adapted too much. The software platform (and the UI) had been applied in earlier models.

The physical product was designed and engineered by an in-house team, as well as the innovative technological components. As the project would introduce a new product proposition and technology on the market, the project was given a high priority and thus received extra attention from management. More time was spent on discussions during milestone meetings and the product planner, who usually was not involved after pre-project work was finished, was also present during these meetings. Team members that dealt with the development of new product aspects felt that there was more time pressure than for more common projects, because even though the product was very innovative, not much extra time had been budgeted to develop the new solutions that were required. Fitting all the product components into the limited dimensions (because of the unique form factor) was a very challenging part of this project.

In an early phase of the project a physical mock-up of the cable connection bay was made and evaluated by the team members. Later in the project a benchmark of adherence to usability design guidelines was executed, and two formative user tests were performed.

5.3 Identifying usability issues in the products

As mentioned in paragraph 5.1 this case study consists of three steps: identifying the usability issues (both strengths and weaknesses) in the products, creating a description of how usability is influenced at AV@home, and finally deriving causal models of variables that influence usability. Usability issues are instances in human-product interaction where the combination of a user, goal, product, symbiotic products, environment, and other people, leads to a situation where the extent to which a user can interact with the product with effectiveness, efficiency and satisfaction is either so low that can be labelled as problematic (a 'usability weakness'), or so high that it can be labelled as better than the norm or expected (a 'usability strength'). Usability issues can both be identified based on the assessment of users/participants as well on analyses by product development professionals.

The following section is about the first of these steps: the identification of usability issues. In this section I describe what documents were used to create an overview of usability issues and how they were identified and clustered. In the final paragraph I give a short overview of the usability of each of the products.

5.3.1 Method

Data sources

To identify usability issues of the products, we collected and analysed documents that might contain information about the usability of the products (Table 30), such as reports of usability studies, user satisfaction surveys, and customer service statistics (all from AV@home), a usability test of the product as sold in stores (by IDE Master students), and online consumer reviews (collected by the researchers).

Analysis

We labelled the information from the documents as referring to usability issues (both strengths and weaknesses) if they described situations in which the effectiveness, efficiency or satisfaction about use were affected, which are the dimensions of the ISO definition of usability (ISO, 2007b).

Table 30: An overview of the sources used to determine the usability issues in the products, indicating when the information was collected and by whom, and what type of data the study yielded (qualitative descriptions or quantitative summaries), and the level of detail of the data.

Data source	**Moment of evaluation**	**Conducted by**	**Type of data**	**Level of detail**	**Description**
Formative user experience test	During development (using an early sample)	AV@home usability consultant	Qualitative	High	Usability test conducted by the User Experience Group for AV@home. The aim of the study was to identify issues that should be improved in the remaining development time.
Summative user experience test	During development (using a late sample)	AV@home usability consultant	Qualitative and quantitative	High	User experience test with a summative character. The goal of this pre-release test is to assess whether the level of usability of the product is sufficient for the product to be launched.
UI guidelines benchmark	During development (using an early sample)	AV@home Benchmark expert	Quantitative	Low	Benchmark test, designed to assess whether a product adheres to internal guidelines with regard to terminology, dialogue screens and response times.
Customer satisfaction questionnaire	After development (on the final product)	AV@home Market research	Quantitative	Low	Satisfaction questionnaire among product owners that registered themselves with the company. Indicates the satisfaction of users about the product, and product aspects that contributed to this opinion.
Customer service data	After development (on the final product)	AV@home Market research	Quantitative	Low	Categorized overview of the amount of questions or remarks from people who called the company's customer service line.
User tests at TU Delft	After development (on the final product)	IDE Master students	Qualitative	Medium	Per product, two groups of students conducted a usability evaluation of the products, including a user test. One group focused on the out-of-the-box experience (installing and first use) and the second group on the everyday usage of the product.
Online customer reviews	After development (on the final product)	Researchers	Qualitative	Low	Analysis of consumer questions and reviews collected from three websites (Kieskeurig/ CNET/ Amazon.co.uk). Does not provide very detailed information, but does show what product aspects users are (dis)satisfied about.

We wanted to identify which of the usability issues surfaced in multiple documents, thus conducting triangulation of sources, but to do so we would need to define when a usability issue could be considered similar or overlapping. As defined in Chapter 2, the components of human-product interaction are the user, the task or goal, the product and the context. The descriptions of the usability issues in the reports of the user tests (see Table 30) would usually contain references to two of these components:

- The task that the user was aiming to perform when running into an issue (e.g., recording a TV program, connecting device); and
- The component that was involved (e.g., on-board display, remote control).

Therefore we labelled all descriptions of usability issues by task and components, and by doing so we could cluster usability issues that referred to the same components and tasks, and were thus similar with regard to the task users were trying to complete and the components that played a role.

5.3.2 Results: overview of usability issues per product

In this section an indication is given of the usability of each of the products that were studied. An overview of the usability strengths and weaknesses per product can be found in Appendix E. The majority of the usability issues that were identified proved to be usability weaknesses; only a limited number of usability strengths were identified.

Hard-disk recorder

From user tests, as well as from the after sales feedback (help desk and customer satisfaction questionnaire) it became evident that the usability of this product was judged as poor. It had a considerable amount of usability weaknesses, among which a number of serious ones, with a severe impact on usage and/or on primary use cases. A large number of usability weaknesses was related to slow response times, button labelling, the UI concept for continuous recording (replaying recent broadcasts from short-term 'working memory'), how to program timed recordings and the (lack of) feedback that the device was recording.

DVD recorder

The usability of this product was evaluated as rather good. In the after sales feedback (customer care and satisfaction questionnaire) the usability of the product was evaluated positively. The biggest usability weaknesses to emerge in the user tests were how to install and setup the product (especially in combination with a cable- or satellite receiver). A number of smaller problems surfaced in the recordings dialogue and with the responsiveness of the remote control.

Home theatre system

Overall the usability of this product was considered fairly good with regard to daily use, but installing it and setting it up was more complicated. The majority of the usability weaknesses were related to the physical installation (making cable connections etc.) and setup (choosing the right settings) of the product. In addition a number of usability weaknesses was identified with regard to playing media (music, video, photos).

5.4 Describing how usability was dealt with at AV@home

5.4.1 Method

This section describes how data about the product development projects, usability issues, and the way of working at AV@home was gathered, and how I developed a description of how usability was dealt with at AV@home based on that data.

Data collection

Though supported by information from documents, in this study most information about the origins of usability issues originated from interviews, the setup of which is discussed below.

Selecting what usability issues to discuss
As it was impractical to discuss every single usability issue that was discovered (about 40 per product) with the interviewees, a selection had to be made of which issues to discuss. We decided to select usability issues that would cover a broad range of tasks as well as components, because different types of usability issues might be caused by different underlying variables. In the end we selected twenty usability weaknesses and five strengths per product. We felt that including a number of positive issues might help to prevent the interviewees from feeling threatened and adopt a defensive attitude during the interview. A complete overview of the selection guidelines can be found in Appendix F.

Sensitizing the interviewees
At the time of the interviews the development projects had taken place between one-and-a-half and two years before. To 'jog their memory' about the project we gave the interviewees a sensitizing card set (Figure 47) containing 20 usability weaknesses and 5 strengths. Besides sensitizing the interviewees, a second reason for the use of the card set was to keep the focus of the interview on the usability issues of the product. We asked the interviewees to go through the cards before the interview and to select the five issues they wanted to 'definitely discuss' (green stickers) and 'discuss if there's time' (orange stickers).

We asked the interviewees to fill out the back of the cards, which contained questions about the interviewee's familiarity with the issue, and when it was discovered, discussed and dealt with. We personally delivered the cards to the interviewees several days prior to the interview, and stressed the importance of going through the card set before the interview.

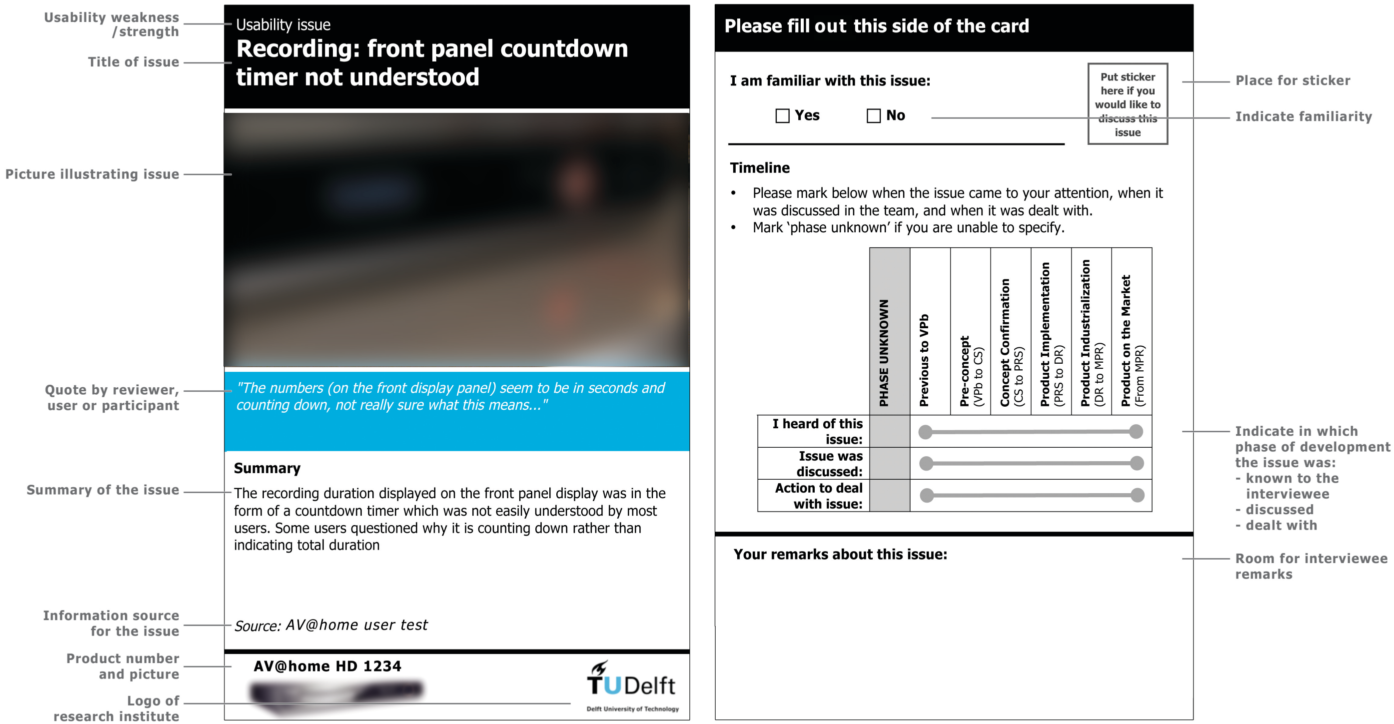


Figure 47: The front (left) and back (right) of the sensitizing card set (with blurred picture and anonymized serial number)

Interviewees
To mitigate retrospective sensemaking by image-conscious informants, Eisenhardt and Greabner (2007) suggest using numerous and highly knowledgeable informants who view the local phenomenon from diverse perspectives. The 19 interviewees fulfilled different roles in the product development teams (see Table 31) and most of them had been deeply involved in the product development projects we were studying. They were selected on the basis of the actor descriptions that were defined in the conceptual framework (Chapter 2), experiences from the previous case study, and in cooperation with the primary contact person. The roles at AV@home can be divided into primary and secondary actors. The primary actors are product development team members who work in a specific product development project. The secondary actors are members of the product development group who are either not involved in any development projects and have a facilitating role, or who are involved in a lot of projects simultaneously in a - somewhat distant - coordinating or advisory capacity.

Advance introduction
The primary contact person briefed the interviewees about the goals and setup of the case study. Just before arrival at the site the researchers sent the interviewees an e-mail in which they (re)introduced the study and themselves. The introduction included information about the project, anonymity of the interviewees, the duration of the interview, and what the goal and the subjects of the interview were.

Conducting the interviews
The interview setup was a combination of the general interview guide and the focused interview approach. In the semi-structured guided interview the researcher uses an interview guide (see Appendix G) to ensure that with all interviewees the same basic lines of inquiry are explored, but within each of the subject areas the researcher "is free to explore, probe and ask questions that will elucidate and illuminate that particular subject" (Patton, 1990, p. 343). The focused interview is an interview strategy aimed at eliciting information on specific topics or events that the interviewee was a part of (Merton and Kendall, 1946).

The interviews were recorded on video, because I anticipated the interviewees might point out things on the card set. Interviewees in the previous case study did so with the drawing of the development process. The interviews were scheduled to last about an hour. Both researchers were present during the interview: one conducted the interview, and the other took notes, operated the audio and video recording equipment, and checked whether all topics of the interview guide were covered. The interviews took place in on site meeting rooms.

Data processing

All interviews were transcribed in full by the researcher that had conducted the interview. Non-verbal communication (sighs, silences) was not transcribed and the transcriptions were 'streamlined' slightly, for example by removing repetitions of words that were not used to express meaning. Most interviews were conducted in English and those that were not were translated to English while transcribing them. The transcriptions, as well as the documents that were used to determine the usability issues were entered in the Atlas.ti qualitative data analysis software package.

Table 31: Overview of interviewees, whether they were primary or secondary actors, and which of the projects they were involved in.

Primary actors	**Description**	**DVD recorder**	**Hard disk rec.**	**Home theatre**
Product planner	Conceives the idea for the product, identifies the target group, what user needs the product should target and in what way.	-	-	●
Product manager	Responsible for getting the product from the product concept stage, through development, to market introduction.	●	●	●
Project manager	Coordinates the development project, guards the planning and budget.		●	●
Product designer	Designs the physical appearance of the product, and partly the physical user interface of the product.	●	●	●
Interaction design	Designs the on-screen user interface of the device, and partly the physical UI.	●	-	-
Development engineer(s)	Responsible for designing and implementing the software, hardware and embodiment of the product.	-	-	●
Usability specialist	Conducts usability tests and evaluations.	●	-	-
Quality manager	Responsible for the extent to which the product meets quality standards as stated by legislation, by AV@home in general and for a specific project.	●	●	●
Secondary actors	**Description**			
UI function manager	Responsible for the user interface concept that is used in a majority of AV@home products. Acts as a usability consultant for important development projects.	-	●	-
Business planner consumer interaction	Coordinates cross-project and strategic activities to improve the overall user experience of the products. Acts as a usability consultant for important projects.	-	●	●
UI guidelines test coordinator	Executes benchmark tests during product development of the time-response and UI design guidelines.	●	●	●
Usability test coordinator	Plans and coordinates the execution of user tests.	●	●	●
Customer service manager	Coordinates the distribution of after sales feedback from help-desks with in the business group.	●	●	●

Data analysis

The first step of the data analysis was to identify and label the *content areas* in the interview text, which are the parts of the text that address a specific topic in an interview (Graneheim and Lundman, 2004). The content area labels indicated for example which usability issue was being discussed, or whether the interviewee was talking about the general organizational structure of the business group. Through a process similar to that followed in the previous study (page 113), the content areas were broken down into meaning units, which were subsequently accompanied by condensed meaning units (Graneheim and Lundman, 2004) to form an equivalent of 'jointly told tales' (van Maanen, 1988, p.95).

Creating the description of how AV@home dealt with usability

Based on the documents, products, on site observations and interviews, I wrote an initial case description (Yin, 2009, p.131) outlining the main most important ways in which usability was influenced at AV@home. The case description is reported in the form of an illustrated general condensation: a compact description of common characteristics found throughout the transcriptions (Miles and Huberman, 1994, p.87), illustrated with quotes by the interviewees. The goal was to provide a rich, accessible description of how the development group dealt with usability. I clustered descriptions according to the primary activities in AV@home's product development process (requirement setting, design, evaluation, implementation, after sales) and in one cluster containing team aspects. This description is presented in the following section.

5.4.2 Results: how usability was dealt with at AV@home

In this section it is described how the usability of products is influenced at AV@home. The descriptions are clustered by the following categories:

- Requirement setting;
- Design;
- Evaluation;
- Implementation, and
- Team properties.

Requirement setting

Prioritization

During requirement setting the focus of the teams was on creating a product proposition that would sell well and on setting up a feasible project, and thus they seemed to prioritize product functionality, project resources (e.g., costs and time), and business considerations (e.g., who are the preferred suppliers?).

UI manager:	*You have a whole list of requirements for suppliers. Price is a fairly important one. Availability, time to market, quality, etcetera, etcetera... and then there's usability.*

This led to product properties that negatively affect usability, such as extensive functionality, hardware platform limitations, not selecting the supplier that offers the most, and copying previous software designs.

Product manager:	*The software in this product was to a large part reused from a previous generation of products, in order to save costs, but also not to cause problems all over again.*
UI function manager:	*So our supplier would be like: "Hey, we give you an application, no customization". One other A-brand basically got full customization, but they paid a lot of money for this that we would never really invest. (….) We tried to do our own EPG, get our own data feed. But in the end the cost of having this all did not justify the whole business case, so we had to go back to them <the supplier, ed.>.*
Product designer:	*The idea was to have a big round light-guide, which would make it clear to you straight away that it was recording. This was cut because of the lack of space. In the original button cluster it would have fit, but that cluster was considered too expensive, and was cut.*

Knowledge about the user group

Selling products globally, but designing and developing them in one single location negatively influenced the development group's knowledge about the user group, such as what products they owned (and had previously owned). That knowledge was needed to determine with which other products the new product would be connected, as well as the level of experience of the users, and it also helped to focus their efforts on the most important functions of the product.

UI function manager:	*And sometimes you need to look at market data: what is the usage of set-top boxes out there, what proportion of users uses a set-top box? How many users actually watch from analogue tuner, watch from digital tuner, have both? This kind of information helps you to balance it. (….) But it's always difficult to foresee what the environment is that the product will be used in.*

Between-generation iteration

When starting a new project, teams were likely to use the product requirements document of a previous project as a starting point without knowing the weak points of that previous product in terms of usability. Thus usability weaknesses were inadvertently copied from one product to the next.

Product manager:	*And what we were dealing with was a legacy design. We were already using these kinds of solutions. Although back then it was untested because we weren't so much into a validation type of design proofing.*

Recently, some initiatives had been taken to enable knowledge transfer between projects, such as workshops in which the after sales feedback of previous products was analysed, but this was not quite institutionalized yet.

UI function manger:	*We need to make sure that when we do a next generation we don't just start randomly from scratch, but we start from what we did the last generation, but hopefully have taken into account all those findings. (….) But somebody needs to prepare this, somebody needs to involve all the right people, it costs time and resources and this is the risk that this is not spent.*

The transfer of knowledge of usability weaknesses between projects was indicated to happen best if the team of a previous product also worked on the next.

Product planner:	*The advantage is that the product manager also was involved in the entire previous project. This year's product just was a next generation, not a revolution. So that had a lot of advantages.*
UI designer:	*As I told you the person who is working on this: she quit. So I don't have any other information of what's happening in the previous project.*

Requirements document

The requirements document had to be very specific as it formed the basis for all the work of the design department, development engineers and third party suppliers. Especially for software and hardware developers – both internal and external – the requirements document served as a 'contract' for what would be developed. As a consequence the requirements document became very extensive and had to be finalized in an early phase, preventing iteration based on new insights.

UI manager:	*And if you don't do this in an early stage, in a majority of the cases it simply is not possible to change it in a later stage. (….) At the moment we are trying to do that more: to share our most important timing requirements with suppliers upfront.*

Basically, the product planner and manager had to design product perfectly - all in text - straight from the start. And additional issue was that the technological platform had to be developed before the requirements document was finished, preventing user requirements from being taken into account in platform development or selection.

Quality manager:	*No, during the time that we were discussing this, they <the engineers, ed.> have done the pre-discussion already with the suppliers.*

Design

User-centred design proficiency

Designs often contained aspects that usability evaluation experts or other team members at first sight considered negative for usability, which then indeed surfaced in usability tests.

User test consultant:	*I mean, obvious problems like this <points at cards>, pressing hold and stuff, can be identified way earlier, without the user telling us.*

Limited anticipation of the consequences of design decisions for usage was identified as one of the causes for the suboptimal UI designs. This 'blindness' was attributed to a person taking design decisions having too much knowledge of the design, not being representative for users and not being equipped with usability evaluation methods.

Quality leader:	*Because I was involved with the project, and I know how the product works, I know what to expect. But for people who first time use this product, they will somehow get confused the first time.*

The capability and motivation to make a user-centred design varied to a great extent between team members, and was dependent on someone's role, background (education, working experience) and previous experiences with UI design and usability testing. The following example illustrates the influence of user-centred design skills on the end result. Software developers, instead of by interaction designers or usability specialists, created the instructions in a warning message, which turned out to be confusing to users.

Quality manager:	*Basically, because it was only after the user test that the feedback was there, Quality and Software really worked on this one.*

One of the most challenging UI design issues was labelling. The development group had a lot of trouble with, and put a lot of effort in, finding suitable terms for button labels and on-screen menu items. Button labelling was complicated even more because multiple products shared one physical remote control design, which limited the designers in putting relevant buttons next to each other.

UI function manager:	*So, you have now a different set. You could actually take the remote control from the other set. You don't need the 'MPEG' key, but instead you need - let's say - a USB key. Now conceptually the USB key would have to be up there <points at the top row of buttons>. But there is no space there anymore. But the position of the MPEG key just got cancelled, so the key ends up down there. These kinds of things happen a lot.*

When making user interface design decisions there was a strong focus on consistency. Once the group had decided that a certain design (e.g., a button label) was the best one, it was consistently implemented across the whole product line and less consideration was given to whether the solution was appropriate for that specific product. In earlier product lines there had been a wide variety in terminology, which still served as a cautionary tale, and decreased the motivation to deviate from a guideline once it was set, even though that might have been more appropriate for that specific product.

Product manager:	*If it is in any way possible we strive for alignment. Not that on one product is called disc and the next is called DVD. We had that a number of years ago, and to prevent that we decided there should be alignment between the products.*
Product designer:	*Sometimes I get the notion that - and I am not the only one who has that feeling - that there is a book with a set of guidelines, and those*

guidelines should be followed. But if you then ask whether a certain guideline is relevant for a specific product, are you sure that that applies here? Then they just say: "It's in the book. These are the guidelines."

As time pressure on projects was very high it was highly beneficial not to have to design a user interface from scratch. A mature (well-developed) user interface was considered a good starting point for a team to build upon, providing that the usability of the inherited user interface is high. A mature UI design could come from a UI paradigm, predecessor product, or a UI design integrated in a third party platform.

Product manager: *The first product based on this platform was a [sub-brand] product, and everybody thought it was great, fantastic. So before we started on the DVDR they already new that the UI was good.*

Prioritization of usability weaknesses

If usability weaknesses were identified in a design, they needed be receive a high priority for any changes to be designed and implemented. However, usability weaknesses hardly ever received a high priority. Considerations that reduced the priority of a usability weakness during design were that other products, of AV@home as well as of competitors, suffered a similar problem, and that a particular standard that the development group or industry had agreed upon prescribed a certain design.

User test coordinator: *We have pointed it out many, many times, but one reason, people say that: "Well that's an industry standard. You have name those technical terms."*

In general the design department prioritized aesthetics over usability, and designers were reluctant to change their design if it would change the appearance.

UI function manager: *I think there is a very strong tension between aesthetics and using.*

Product designer: *Because you do your best to make the set as sleek and stylish as possible, and then you don't want a huge label saying 'USB port: HERE'.*

Product planner: *So the display was hard to read. And our product manager tried to work on that. Let's see what happens if we use a different colour display. And then the design department got all agitated.*

The way of working of the designers was attributed to the fact that the design department was effectively a semi-external design consultancy, which reduced the involvement of designers in product development projects to a very limited timeframe.

UI designer: *You go to the project manager and he will tell you: "Hey, for the next two weeks you will be doing this project, you will 'theme' this UI." And by at that time things have sort of been locked up.*

Their role as semi-external consultants prevented the designers from getting feedback about their designs as they were not invited to usability tests and not provided with after sales feedback.

Product designer:	*I'm hearing this only now. But that's kind of logical, because in general we don't get feedback like this, as Design, if it's not directly focused at design, we don't hear about it. Unless it's something really big.*
UI designer:	*Like if you tell me, the [product], now it's in the market really, what does the user feel? I've worked on this product. I've seen part of the menu; I know it's an issue. But actually, it would be interesting to hear what the users are saying. So know I see these (points at cards), and now I know.*

Basically, the design department's primary responsibility in the organization was to safeguard a consistent product appearance across product lines.

UI designer:	*So in this project, basically our work was just the visual appearance, it was not so much the usability.*
Product manager:	*They decided to base the hard disk recorder on the UI paradigm, because of brand identity considerations, but also because the UI paradigm contained elements that were proven to be positive for usability.*

Designers were hardly given the possibility to move beyond that role, and were the only discipline in the organization that did not have customer satisfaction as performance indicators. Within the design department the most important performance indicator was whether products received design awards.

Design mutability

Design mutability – the degree to which changes could be made – was very often limited, due to a number of mechanisms. First of all development teams often had to use components to which they could make no changes, such as a third-party supplier hardware/software platform with integrated user interface or an electronic programming module (also from a third party supplier).

UI designer:	*So when you buy it from a supplier a lot of things are constrained. You cannot change the interaction.*
UI function manager:	*That product was built on predecessor models, so you start from a legacy. That's like carved in stone, and any changes to the legacy are difficult.*

Another example of limited mutability was a physical remote control design that had to be used for a whole product range because of cost considerations.

Researcher:	*Why don't you make a dedicated remote control per product?*

UI manager:	*Too expensive. Way too expensive. We use less diversity to reduce costs.*

Technically it was possible to change third party components, but the suppliers would not do so, due to the contract they had with AV@home.

Product planner:	*And if you ask them: "Could you change this for me?" they will be like: "Well, pay up then."*

Additionally, early design decisions often influenced (limited) the mutability of the product/design in later phases. For example, if the software architecture of a product was poorly structured, that made it hard to deal with changes later on in the process. The selection of a certain hardware platform limited the UI designs that could be implemented on it.

UI manager:	*It also very much depends on the hardware that is chosen. And if you don't take user requirements in account in this early stage, in a majority of the cases it simply is not possible to change it in a later stage.*

Usability evaluation

Lack of early knowledge of usability weaknesses

User testing was performed quite late in the development process. The 'official' user tests, that were a part of the development process document, were only conducted once early prototypes or production samples were available. One usability evaluator remarked that he preferred performing user tests on prototypes or production samples over mock-ups and simulations.

User test consultant:	*If you give consumer a simulation, he cannot see what is the overall thing, so he cannot give a good feedback. That's a concern for me as well. Because I would like to present the truth. The right thing. I don't want to present 'white noise'. You just complicate things.*

Additionally, conducting user tests with simulations or mock-ups was not common. Within the design department these methods were not a regular part of the process. For one there was hardly any time to apply these methods, but also the department was not, very familiar with usability evaluation and inspection methods. Secondly, the product development teams seemed less inclined to acknowledge the results of tests where the representativeness of usage was reduced (simulation instead of product, participants instead of 'real' users).

User test coordinator:	*And people questioned the methodology in user tests. They say: "Ah this is just the first use of the product, if people can't get it right first time and you know they will continue to try for a second time, for a third time, and slowly they will learn." (....) So in the end I don't think anything really was done to rectify this issue.*

A possible cause was the focus of the AV@home organization on 'validated', quantative research results, which conflicts with the tentative, qualitative output of early user tests. This tendency also seemed a barrier for the acceptance of conclusions from expert reviews and the usability guidelines benchmark, which did provide an early source of knowledge on usability weaknesses.

Representativeness of usage

When conducting usability evaluations representativeness, the extent to which the human-product interaction in a usability evaluation is representative for the actual usage of the product, was a major concern. In a number of instances usability weaknesses did not surface in user testing because the human-product interaction during the test was not representative for eventual real-world usage.

Product manager: *It's my experience that you can have the device on your desk, but that's not the same as taking the device home and using it under the circumstances it was intended for.*

To generate data on a certain usability weakness, the use case in which it might occur had to be a part of the user test. Two major reasons were found why an important use case would not be included: an unrepresentative context of use during usage evaluations and use cases not being part of the test protocol.

In some cases the context of use did not allow for the use case to be performed, because, for example, a broadcast signal was not available that was required for a certain function of the product to work.

User test coordinator: *It's for the European market, but for the development test we tested locally in <Asian city>. So a lot of scenarios we can't really simulate the actual European scenarios.*

Some usability weaknesses only surfaced when the product was used in combination with other products, but those other products were not part of the test setup.

UI manager: *What a problem is here in <Asian city> is that we don't have set-top boxes, so we don't test with set-top boxes. So I am actually quite amazed that it comes up here.*

In some instances use cases were simply not part of the test protocol, which was task-driven: participants were asked to perform a specific task as opposed to using the product as they saw fit.

User test consultant: *I did not test direct recording. So I did not get this problem.*

There were also issues with the representativeness of the users. The products were often aimed at the American or European market, but as the user tests were performed on the development site, the participants in the user tests had to be recruited locally, where only a limited number of Americans and Europeans resided, of which it was doubted whether they were representative for the actual users.

Product manager: *"So one of the end results for us was that we said that the final user test must take place in one of the target markets, where you are dealing with the actual consumers that will potentially buy the product. And not here in <Asian city>, because that is too artificial."*

Finally, the user tests were mostly conducted in the lab and thus could only take into account installation and first use. As a consequence problems related to long(er)-term use, such as inconsistencies in the UI, were less likely to be detected.

Product manager: *I don't see this issue surfacing in testing, but that's also because the tests we did often include people that use the product for the first time, so then there also is a certain unfamiliarity with the product. I noticed personally, that when I use products at home, that I really got annoyed that if you were in something, and use the back button to get back to where you came from, and it's not working.*

Strong focus on participant's comments

During user testing a great deal of attention was paid to what participants said, as opposed to what they did. Participants' remarks were featured prominently in the user test reports and alternative solutions that users suggested were included as design recommendations in the report. The focus on people's opinions might be attributed to the marketing and market research background of a substantial part of the staff of the user experience group.

Communication of usability weaknesses

In the user test debriefings no videos were used (even though all user tests were recorded on video) and in general the designers and development engineers hardly visited user tests, even though interviewees indicated that seeing user struggle – live or on video – increased engagement and empathy among team members, which in turn prompted action.

Response times tester: *User test results are usually treated with more emphasis, because you are testing a product with real people, rather than going through a checklist that might be open to some different interpretations.*

Product manager: *We asked software engineers to sit in during the consumer tests and see with your own eyes how consumers use your product, that you are working on. In part to create ownership in the terms of possible issues, and not just having them thinking "there you have this annoying product manager again with his weird ideas", but to have them see this is really something that people experience. (....) I think that for some of them it was something like a turning point of how they see things. They got a very pro-active attitude.*

Inviting the development engineers was not customary, even though it was indicated that if engineers do not see or feel the urgency of fixing a usability weakness, the chances decrease that a solution will be found or implemented. Because of the design department's consultancy model every hour that the designers worked had to be accounted for, and it was unclear who had to pay for the designers visiting the user tests: the design department whose designers would learn and thus become better designers, or the client (the AV@home business group) whose usability weaknesses could be solved.

User test consultant: *Of course when I do a study like this, I didn't want it to be just product-specific; if people also learn from it that would be good, less mistakes means, less changes next time.*

Remarkably, often knowledge about a certain usability weakness that surfaced in a user test had already been present in the team before the test, originating from a previous project, a response times benchmark test, or one of the team members trying out an early prototype at home.

Product manager: *I learned about the sluggishness of the device from my own hands-on experience with the product. During the project I use the product myself on a regular basis. I also take it home, to test it myself, in a 'normal' environment, with my family members.*

However, in those cases there was a danger of usability weaknesses not being acknowledged by the team, and acknowledgement and understanding of a usability weakness was found to be essential.

Product manager: *There were a lot of discussions with the team, making clear why from a consumer perspective, in certain tasks the sluggishness really was problematic. An explanation to the technical people of the team why from a consumer perspective those things were not good enough. Creating understanding for the problem. And then subsequently trying to get the problem higher on the agenda of what needed to be done.*

Detecting a usability weakness in a user test made it more ‘official’, and the team could no longer ignore it. In the user tests reports serious usability weaknesses would be indicated as ‘must fix’. Without fixing those problems the team would not be allowed to launch the product. Another factor that may have played a role in the high impact of user tests was the engagement that is triggered by seeing users struggle.

High time pressure on projects seemed to increase the chance of a development team ignoring or not acknowledging a usability weakness. First of all, in those cases the motivation of the team to learn about user test results by visiting the test or the debriefing session decreased, because they anticipated not being able to fix the reported usability weaknesses. This limited ability to fix the problems also seemed to trigger a behaviour described as ‘contesting the results’ of a usability test. If the team expected not to be able to fix a usability weakness, they might argue that certain aspects of the test, such as the participants, task or context, were not representative, and thus the results were false positives.

User test coordinator: *And people questioned the methodology in user test lab. They say: "Ah this is just the first use of the product, if people can't get it right* *first time and you know they will continue to try for a second time, for a third time, and slowly they will learn."*

User test consultant: *And also the other feedback <from the team, Ed.> was that people here in <Asian City> are not really familiar with the situation... like SCART and everything.*

Finally, communicating those usability weaknesses that could not be fixed in the current project, but that would be valuable information for a subsequent project was problematic, as AV@home had no infrastructure in place to communicate this information to a 'next project' of which the team had not been formed yet.

Assessment of usability weaknesses

The priority of usability weaknesses was set based on their influence on human-product interaction and on its projected occurrence, which both influence how the users would react to a usability weakness.

User test consultant: *Occurrence meaning to say that how often does this problem come up. Severity is how would this problem affect the use, the experience of use of the user. Let's say you have a DVD recorder that automatically shuts down once every month, then the severity is high, occurrence is low. But I will still put it high up, because a once-a-month shutdown is not acceptable to users. People will still take it and bring it back.*

Quality manager: *Because at that time it was also decided, somehow, that we decided to keep it as is. As it would not cause any returns. Since this is a just a one time operation.*

Usability weaknesses were more or less negotiable: their severity, impact or even existence were continuously up for debate. For usability weaknesses to get a high priority they had to have a big influence on product usage and customer reaction. As a consequence usability weaknesses with little influence on product usage, but that were widespread throughout the company (as a consequence of UI harmonization guidelines or the use of same third party platforms) were hardly dealt with.

Use test coordinator: *In general many of our products, in the user menu, there are quite a number of difficult to understand technical terms. (….) We have pointed it out many, many times also, but for one reason, people say that: "Well that's an industry standard. You have name those technical terms."*

However, in general usability teams found it hard to assess the potential consequences of a usability weakness for product usage and customers' reaction to that. Usability was considered a somewhat invisible, and subjective or at least non-quantifiable product property.

UI guidelines tester: *When it comes to roadblocks like this, then they'll have to accept or is it ok to carry on. So that's where the product manager, comes in to give his or her assessment. How major is this use case? How annoyed will people be? And of course all this is subjective as well, so it's very much up to their judgement.*

Finally, a major component in determining whether a usability weakness should be fixed or not was the assessment of the amount of effort required to fix it.

Product manager: *You know, these are things... if it's just about the wording then it's really easy: we just change it. That doesn't take a lot of software coding, doesn't take effort. This is very simple.*

Implementation

Prioritization of usability weaknesses

By the time that most knowledge about usability weaknesses surfaced, during implementation, the biggest concern of the development team was to fix problems that would cause costs because of product returns and customer support. This meant that during implementation their top priority was to deliver a reliable, bug-free, product. The reasoning was that products that were unreliable had a much higher chance of being returned than products that were - to some degree - unusable. Only usability weaknesses that were anticipated to cause a lot of helpdesk questions or product returns (because users might think they were broken or could not get them setup properly) would get a (relatively) high priority.

User test consultant: *The follow up is always done by the product managers and they are very busy. So, it's really up to their own initiative to take the issues from the user test to rectify. Initially we had all the issues listed for them, and then they say: "Well, it's just too many issues, I can't take them up all." Later on we developed a tool to segment the issues into 'must rectify' and 'good to rectify', 'nice to rectify'.*

Use test coordinator: *Yeah, that's the argument. And if it is just nice to rectify, and well, also because maybe this is probably a smaller use case in terms of navigating in the user menu. So that's nice to rectify.*

Product manager: *I will consider the issue. The decision whether or not the problem should be fixed depends on whether it concerns a common use case, how confusing it will be to the user, and what the consequences are of that confusion.*

After sales feedback

On the one hand after sales feedback was considered valuable, because its representativeness of use was high, but on the other hand the richness of after sales data was low, because usability weaknesses were communicated by the customer service department to the business group mostly in quantitative form, indicating how often questions were asked in a certain category, accompanied by very concise and ambiguous descriptions of individual consumer complaints.

User test coordinator: *It is consumer feedback, but the questions we asked, are very general. Because we can't really go into product details also. (….) So it tells you the area where it goes wrong. But the level of detail is not sufficient.*

Therefore after sales feedback was considered a red flag that a problem was present, but to have limited value as input for design decisions. The method of collecting after sales feedback influenced the data that was collected. There seemed to be a threshold for customers to call the help desk or return the product: they would not call or return the product for every (usability) problem they encountered. They only seemed to do so if their problem was serious enough and if they expected the help desk to be able to help them improve the situation.

Product manager: *If it doesn't work, they'll try something else, and they find out that pressing the menu key or going back to the home menu also is a solution and then they learn to do that and it drops off their radar as being a problem.*

Through the customer satisfaction questionnaire on the other hand, customers were approached pro-actively with questions about the user experience. Unsatisfied customers that did not call the helpdesk or return their product did surface through this channel.

UI manager: *The customer satisfaction questionnaire is actually there to get feedback from people that are not calling the helpdesk, but are still giving their satisfaction by a survey on which elements they like and don't like.*

Another issue regarding after sales feedback was that because of the short development time of the products the feedback for the previous product was not received before the next version of the product had to be designed.

UI function manager: *So now, the moment the product hits the market, we already want to have the next generation.*

Team

Team composition

During most of the phases of product development there was no interaction designer or usability specialist/evaluator present in the team, which was attributed to the consultancy-like role of the design department and the user testing group.

Researcher: *Why is it... why aren't you involved earlier?*

User test consultant: *I would say it's cost. (….) We act as different businesses you see. When we do a project like this, we charge. We do charge. To earn our keep.*

UI designer: *We don't sit in-house together. I don't sit together with the engineer. (….) What happens is the engineers will previously discuss everything that they want. And the next thing is: "Let's go to Design." <snaps fingers> "Design a theme. <snaps fingers> Oh, and see what you can do to the mappings."*

Because interaction designers and usability evaluators were not a part of the team, they were not present when (early) decisions about the platform were taken and when the software engineers implemented their design.

UI designer: *But some of the things had really already been established without having been discussed: how is this being done, how much time do we need.*

The lack of early involvement of the usability evaluation consultants also seemed to play a significant role in the creation of designs that were suboptimal with regard to usability. Because they were not involved in an early phase, their knowledge and experience could not be used in early decision making.

User test consultant: *I think that what is good is to involve people like us, the usability people, in an earlier phase, when you define how the user interface will look like, the wording, etc. It doesn't mean that we have to be the 'checkpoint', but we can actually go in and say: "This looks strange." Obvious problems like this <points at cards> can be identified way earlier, without the user telling us.*

Performance indicators

It was indicated that it is essential that the whole product development team feels responsible for delivering products with good usability, because people from all disciplines are needed to create and implement a usable design.

Product planner: *I think that one of the most important things is that the whole product development team is responsible for the usability and the consumer experience. And that's just not happening.*

Performance indicators were considered an important mechanism to steer the focus of product development team members. However, software engineers, designers and upper management were not judged by the usability of the products.

Product manager: *Software engineers' performance indicators are partly based on whether they make the software for the assigned budget, and it is not specified as such what the quality of the implementation is.*

Product planner: *At this moment our managers are not being managed in the right way. They have targets to deliver products on time, within budget,*

	but there is no target that says that the product they deliver should be usable as well.

The introduction of customer satisfaction a performance indicator was seen as a positive influence, though costs and time to market remained very dominant decision-making criteria.

UI manger:	*On the one hand there is the indication about the higher quality of the remote controls - and of course better products - on the other hand a project team is pushed to make a product at a minimum of costs.*
Researcher:	*How are they managed, what are their targets?*
UI manager:	*Costs. Also a new target, consumer satisfaction. Yeah, time to market. Time to market, within the requirements, and costs.*

5.4.3 Feedback workshops

Setup

To assess the accuracy of the description of how usability was influenced at AV@home, and to explore its generalizability to other product development groups within AV@home's parent company, the description was discussed in feedback sessions at AV@home and at other business groups within the multinational that AV@home was a part of. The primary researcher presented the description to the interviewees and informants who had been involved in the case as well as to their colleagues. In order to encourage the audience to share their views, it was indicated that the research was qualitative and exploratory, and that the results were based on the analysis of 'only' three development projects, and that they contained interpretations by both the interviewees as well as the researchers. It was stressed that the informants' feedback was very much welcome, as the presentation was about work in progress. On several moments during the presentation the presenter explicitly invited the audience to provide feedback. The attendees were prompted to indicate factual errors in the case description and to nuance statements if they think that was required. They were also asked whether they thought the case description still applied to the present day situation, keeping in mind that the products that had been studied had been developed two years earlier. The description was presented to the following audiences within the multinational:

- Internal corporate consultancy group of AV@home's parent organization;
- Corporate design group:
    - Head office;
    - Dedicated design group for home appliances and consumer electronics group;
- Television business group:
    - User testing department;
    - Management team;

Of these presentations write-ups were made directly after the presentations. The input from within the AV@home group was used to modify and nuance the original description, and the input collected at 'sister' development groups was used to arrive at an assessment of the generalizability of the results of the study within the parent company.

Results

Below the most salient issues brought to the table during the workshops are highlighted.

AV@home

The mechanisms affecting usability at AV@home were considered very recognizable by the participants in the feedback session, as indicated by this reaction:

UI design manager:	*Yeah, I don't find anything surprising about that at all. I mean, I think it's right. I think it's very right. I think those are all real factors and I think they all continue. I think they're valid today.*
Primary contact:	*Oh yeah, I think for sure. I think in general our way of working has not changed, no.*

Corporate design department

At the design department the description was considered accurate and it seemed to trigger some reactions expressing frustration about the current way of working:

Senior manager 1:	*You have outlined very well how we are currently working.*
Senior manager 2:	*Finally someone who is saying this!*
Designer:	*Are you presenting this to upper management?*
Other designer:	*Yes, to our CEO please!*
Senior designer:	*Even within the design department segmentation occurs: people used to be seated by discipline (materials, product design, interaction design, project management, etc), but now we are changing our offices to get domain-related teams to sit together.*

Internal corporate consultancy group

At the internal consultancy group there were some doubts whether the description applied for development groups that develop professional products, and the increasing segmentation within AV@home was addressed.

Consultant:	*I am not sure it all applies to professional sectors, like medical equipment or the more basic consumer products. Medical products are kind of a different sector than consumer electronics, with lead times and stuff, and the simpler consumer electronics may not be as challenging usability-wise.*
Senior consultant:	*Originally, with the introduction of our current development process, the product development team was should be in one room. Somehow we stopped doing it. We are getting more and more segmented.*

TV development group

At the TV development group, both at the user-testing group as well as at product management, for the most part the description was considered applicable for their group.

General manager:	*A large part of this is valid for TV as well. Some of it is not or to a lesser extent. (….) Our collaboration with the design department is problematic as well. There is no integration; they work almost autonomously, not collaboratively. They only present near-final results to us and by that time it has become their 'baby'.*
Marketing manager:	*We indeed have a culture that is very quantitatively oriented. 'Qual research' can safely be ignored. Only if there are sufficient numbers will results be accepted. (…) The product planners are supposed to be the representatives of the user in the team. However, they are only involved in the beginning, and the product managers cannot fulfil that role. (….) It's very much an organizational thing.*
Tech. product manager:	*This is all very recognizable; we have a lot of comparable situations.*
User manual specialist:	*If you sit in a corner, with a small team, separate yourself from the rest and work closely together, then you move much quicker. Everyone knows this. But then people start saying that you did not follow procedure, or that they were not included…*

Conclusion

Even though I actively probed for counterevidence, during the feedback sessions it became clear that the informants considered the description recognizable to a large extent. Within the AV@home development group the description was considered accurate, and no serious opposition was voiced against it, though for some observations an explanation was provided, or some nuances were added. At AV@home's 'sister' development groups, the description was found very recognizable, and probably applicable to most development groups that develop products for the consumer market with a certain level of complexity.

5.5 Creating causal networks per usability issue

The previous step of the analysis resulted in a description of how AV@home dealt with usability issues. However, the description is quite specific for the situation of AV@home and the factors that influence usability in product development and their relations are not easily communicated through the description. Therefore I performed further analysis of the data with the aim of capturing the findings in a more decontextualized form that would be more easily applicable beyond AV@home, and that would facilitate communication.

Why develop models?

The primary research question of this case study was to identify what variables in product development influence the usability of electronic consumer products, and how these factors are related. One of the ways of answering this research question could be through the development of a model: a more worked-out theory, which includes a series of connected propositions that specify a number of components and the relations among them (Miles and Huberman, 1994, p.144-145) quoting (Rein and Schon, 1977)). Thus, this phase of the analysis focused on explanation building. Miles and Huberman (1994, p.144) quote Draper, who defines explanation as: "*…giving reasons, supporting a claim, or making a causal statement*" (Draper 1988), and Kaplan (1964) who describes it as "*concatenated description… putting one fact or law into relation with others,*" thus making the description intelligible. The goal of this analysis was to induce a theory – a map that seeks to generalize the story at hand (Miles and Huberman, 1994, p.144-145, quoting Rein and Schon) – based on the available documents and interviews. Eisenhardt and Graebner (2007, p.25-26) argue the suitability of theory building from case studies: as case studies are "*deeply embedded in rich empirical data, building theory from cases is likely to produce theory that is accurate, interesting, and testable*".

The first step: creating causal networks

The first step towards the development of models was to analyse the origins of usability issues for 35 usability strengths and weaknesses across the three products. Events and circumstances were identified that had led to the issues, which were then and arranged in causal networks. Below, it is first described how the causal networks were generated, and then a sample of one of the networks is provided.

5.5.1 Method

The first step of the analysis (see Figure 48) was to identify the events and circumstances that had led to a usability issue. I made a selection of usability issues that were to be studied, based on the amount of available interview data. Next, the events and circumstances that interviewees or documents indicated to have led to a usability issue were identified and arranged in tentative temporal/causal networks (Figure 49). These networks per interviewee were then merged into integrated causal networks (Figure 51) that were our 'map' of the causal and temporal chain of events and circumstances that had led to the usability issue, based on the input of multiple interviewees and evidence from documents.

Selection of usability issues to analyze

Not all usability issues in the sensitizing card set were discussed with all interviewees, or to an equal extent, because not every interviewee had equal knowledge about the various issues. For further analysis I only selected those usability issues about which sufficient information had been collected, which meant they had been discussed to some extent by multiple interviewees or very elaborately by a single interviewee. This resulted in an overall selection of 35 usability issues (DVD recorder: 13, hard disk recorder: 13, home theatre system: 9) (see Appendix E).

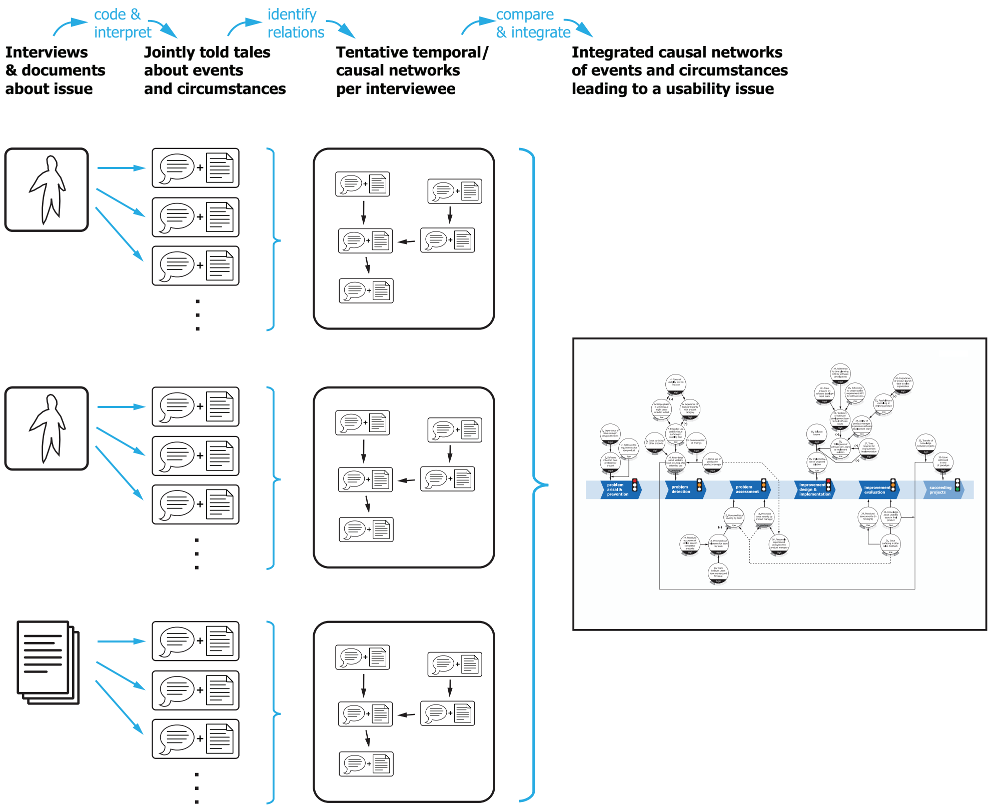


Figure 48: Visualization of the development of the causal networks per usability issue. Interviews and documents were analyzed to identify events and circumstances that had (potentially) influenced usability. The original quotes were accompanied by an interpretation by the researcher. These 'jointly told tales' per interviewee were then arranged in tentative temporal/causal networks. All the tentative networks concerning a usability issue were integrated into one causal network.

Exploring temporal and causal relationships per interviewee

The events and circumstances that according to one interviewee had led to a specific usability issue were arranged in a tentative temporal/causal network, which represent what Miles and Huberman (1994, p.152) call 'the map in the head of local informants': "*...they [local informants, ed.], too, walk around with a map in their heads that provides a frame for action and perception and explains what causes what in their world*". The tentative temporal/causal networks served as a starting point to reconstruct the timeline of events and an exploration of temporal and causal relations, based on input by a single interviewee. As can be seen in Figure 49, the tentative temporal/causal networks contained both the meaning units (original quotes, yellow icons) and condensed meaning units (interpretation by the researcher, red pen icon).

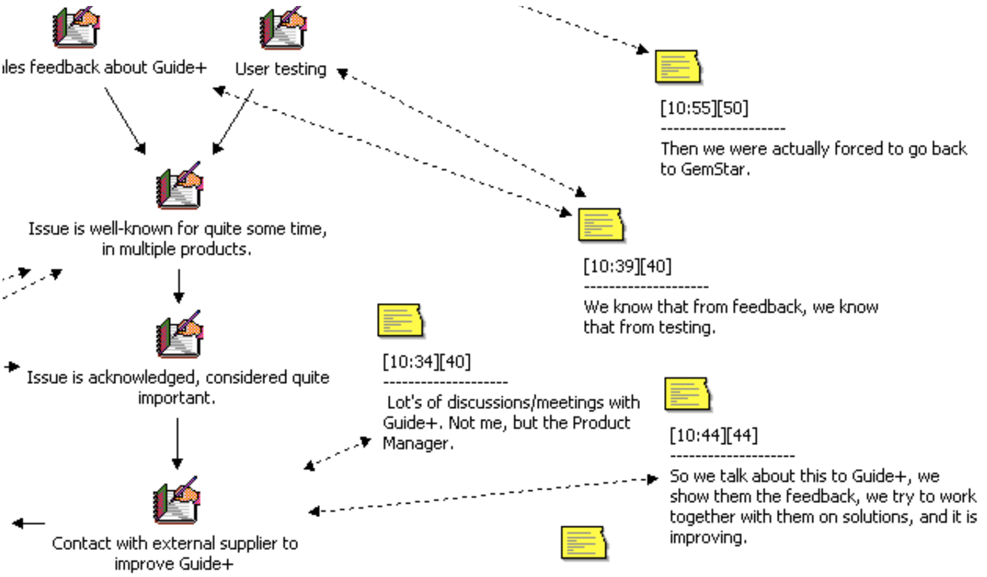


Figure 49: a segment of one of a tentative causal/temporal networks, showing both the condensed meaning units (memos) forming the 'backbone' of the network ('pen' icons) and the quotes where they originated from ('text' icons).

Creating causal networks per usability issue

Next I combined the information from the individual tentative temporal/causal maps that obtained from the local informants, in order to compose my own map. As Miles and Huberman put it (1994, p.152): "*Much of field research has to do with schema absorption and re-elaboration; you go around recording individuals' cause maps, putting them together and making connections with your own evolving map of the setting.*" For each selected usability issue a causal network was created, which is a "*display of the most important independent and dependent variables in a field study (shown in boxes) and of the relationships among them (shown by arrows)"* (Miles and Huberman, 1994, p. 153). For creating causal networks I followed a procedure proposed by Miles and Huberman (1994, p.156). Because I used the causal networks as a means to analyse the origins of a usability issue, I kept the variables in the networks at a 'local', concrete level (e.g. 'user testing', and not 'generating knowledge on usability issue'). In addition to the approach by Miles and

Huberman I added an indication of sources, so that for each variable it can be seen which interviewees had mentioned it. For an explanation of the elements of the causal networks, see Figure 50. A more elaborate overview of the possible relationships between variables and how they are visualized can be found in Appendix H.

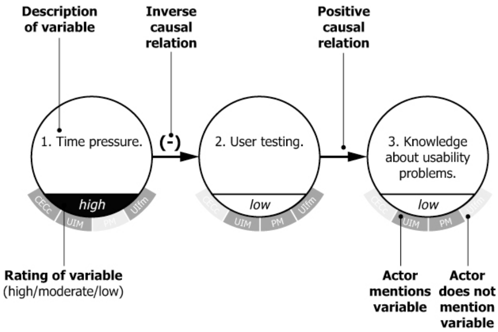


Figure 50: explanation of the components of the causal networks. Each circle represents a variable in which a numbered textual description (e.g., user testing) indicates the variable. Inside the lower part of the circle it is indicated to what extent this variable was present (low/medium/high), which is based on an assessment by the researcher. Outside the lower end of the circle it is indicated which actors or documents support the presence of the variable. Arrows indicate that variables that have some kind of relationship, e.g., more of one means less of the other.

To facilitate understanding the causal networks are accompanied by a narrative describing the variables and the connections among them (Miles and Huberman, 1994, p. 153). The variables in the causal networks were clustered according to the stages of what I call the 'usability issue life cycle' (Table 32), for example, rise/prevention, detection, and assessment. These categories were based on the initial presumptions of the study and further refined by performing open coding of the events and circumstances. In the visualizations to each of these phases a traffic-light-like symbol was added (Figure 51), to indicate whether to our assessment that stage had been performed without problems (green), with some problems (orange) and with a lot or severe problems (red).

Table 32: Categories of the 'usability issue life-cycle', used to cluster the events and circumstances in the causal networks.

Life-cycle stage	**Description**
Rise/prevention of an issue	Rise or prevention of the issue, in the current or previous projects.
Issue detection	How (a member of) the development team learned about an issue and how the issue was communicated to the team.
Problem assessment	The acknowledgement and assessment of a usability weakness by the development team, resulting in a perceived severity and priority of fixing the issue (refers to usability weaknesses).
Improvement design & implementation	Designing and implementing solutions to address a problem that was discovered (refers to usability weaknesses).
Improvement evaluation	Events through which the team gained knowledge about the usability of the implemented solution (refers to usability weaknesses).
Succeeding project(s)	Events and results in successor or subsequent products.

Verification of the causal networks

The primary and secondary researcher reviewed each other's causal networks to verify whether they agreed the networks were logically sound and understandable. Both researchers were familiar with the content of each other's cases (the products), which allowed them to assess whether the networks were an accurate description.

5.5.2 Results: sample from a causal network

Below is a sample of one the causal networks that were created, consisting of an explanatory text (below) and a visualization in Figure 51 (next page). The numbers in the explanatory text refer to the numbers in Figure 51. The usability issue (a weakness) described here surfaced in the hard disk recorder. The back button, which is used to exit a menu screen, did not work consistently throughout the product's user interface.

Fragment of causal network: 'Back button not working in some menus'

Rise and prevention of problem

The software architecture of the product – including its modular structure – was inherited from a predecessor product (3). It was decided to use existing software because of the time that would save (1). The product manager indicates that he sees this as a conscious trade-off that was made; in the ideal case the software architecture would have been made from scratch so software and hardware could have been designed to work together (2).

Problem detection

The issue did not surface in the usability development test (7), which might be due to the test setup, which focused on first use of the product (4). First time users (6) use the product for a relatively short while, directed by tasks, which might result in a more advanced use case not being performed in the test (5). The product manager discovered the issue when he was using an early sample of the product at home (11), and communicated it to the team (9). The CEC coordinator indicated she was familiar with the issue, because it also surfaced in other products (8). All in all, even though the issue did not surface in the usability test, the team did seem to have obtained knowledge about the issue (10).

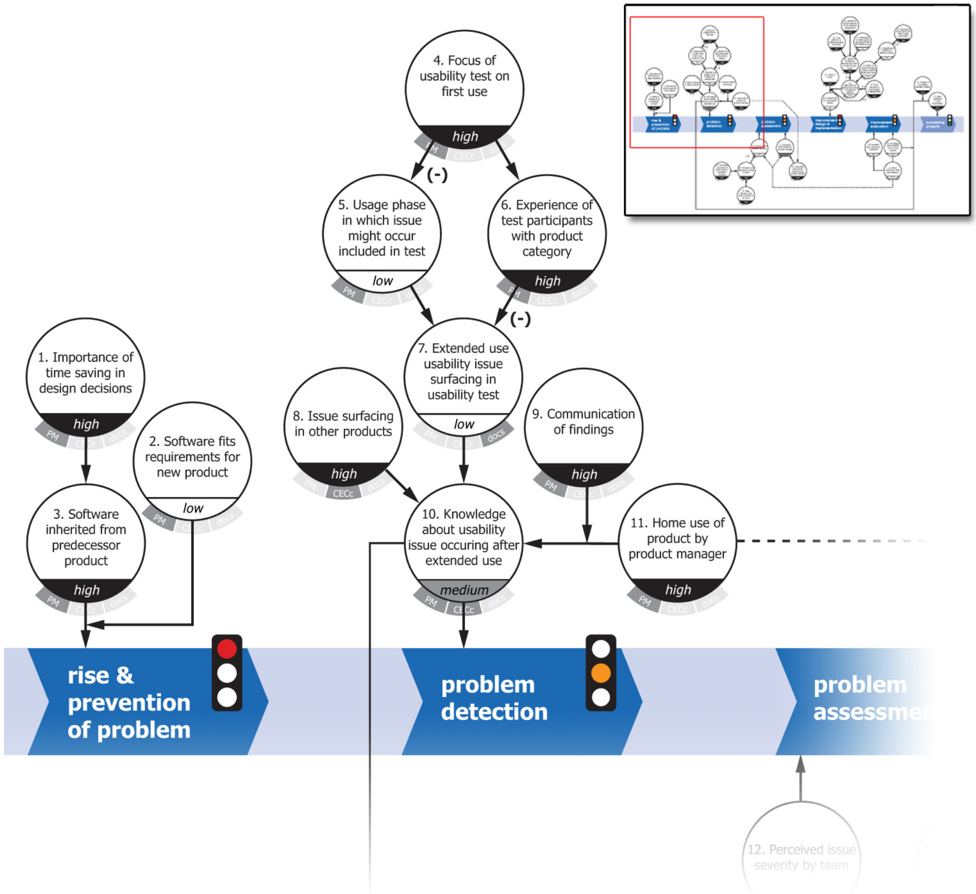


Figure 51: Part of the visualized causal network for the usability issue 'Back button not working in some menus', covering the phases 'rise & prevention of problem' and 'problem detection'. The complete network is visible in the upper right corner. The traffic light icons were a means for the researcher to tentatively indicate whether s/he considered that step of the usability issue life cycle (Table 32) to have been problematic or not.

5.6 Inducing causal models from causal networks

This paragraph describes how, on the basis of the previously described causal networks per usability issue, I derived causal models consisting of the most impactful factors to influence usability in product development practice. First the method followed for the creation of the models is described, and then the models are explained. The first model, the 'usability issue lifecycle', represents what variables play a role in how usability issues arise, are prevented, and solved (or not). The second model describes the process of generating shared knowledge and understanding about usability issues in product development teams based on usage evaluation activities. Finally it is explained how a member check of the models was performed and an indication is provided of the 'groundedness' (to what extent were they based on the empirical evidence) and accuracy (are they a good description of the practice).

5.6.1 Method

From the events and circumstances identified in the documents and interviews I derived two causal models, which are "*empirically grounded networks of variables with causal connections, drawn from multiple case analysis, with the goal of deriving a testable set of propositions about the complete network of variables and interrelationships*" (Miles and Huberman, 1994, p.222). Causality as defined by Miles and Huberman (1994, p.153) refers to relations that "*exert an influence on others: X brings U into being or makes Y larger or smaller.*" The authors also stress that due to the complexity and contextual nature of causal relationships the developed models might have more of an explanatory than a predictive nature. The causal models described in this paragraph should be considered an empirically grounded set of testable propositions, and not a 'validated' model of reality that can be used to predict outcomes.

Product development is a highly complex activity in which everything may be connected to everything. Only the most salient variables were included in the models, as an important consideration while developing models is to offer a maximum of explanatory power with a minimum amount of variables (Singer, 1961). An important step in reducing the number of variables on the models was 'factoring' the events and circumstances in the causal networks. Factoring is the identification of commonalities or patterns in disparate facts or words, the qualitative researcher's equivalent of factor analysis, the statistical technique used to "*represent a large number of measured variables in terms of a smaller number of unobserved, usually hypothetical, variables*" (Miles and Huberman, 1994, p.256).

For the creation of the causal models I took an approach based on the four 'rules of thumb' for the creation of causal models proposed by Miles and Huberman (1994, p.224), modified at some points. Instead of creating tables of variables and indicating the presence of a variable for each usability issue, I took an iterative approach (Figure 52), as suggested by Eisenhardt and Graebner (2007) and Yin (2009, p.143).

The variables and their relations as derived from the first causal network (Figure 52, upper left) were visualized in a first version of a model (Figure 52, upper right), after which the second causal network was analyzed, which led to modifications of the initial model: variables and relations were added, deleted, merged, and 'parked' (put aside, but not completely discarded yet). I continued this process until I had analyzed the causal networks for all 35 usability issues. Then I went through all causal networks from the beginning, to check whether the models were 'stable'; that going through the data did not warrant additional changes.

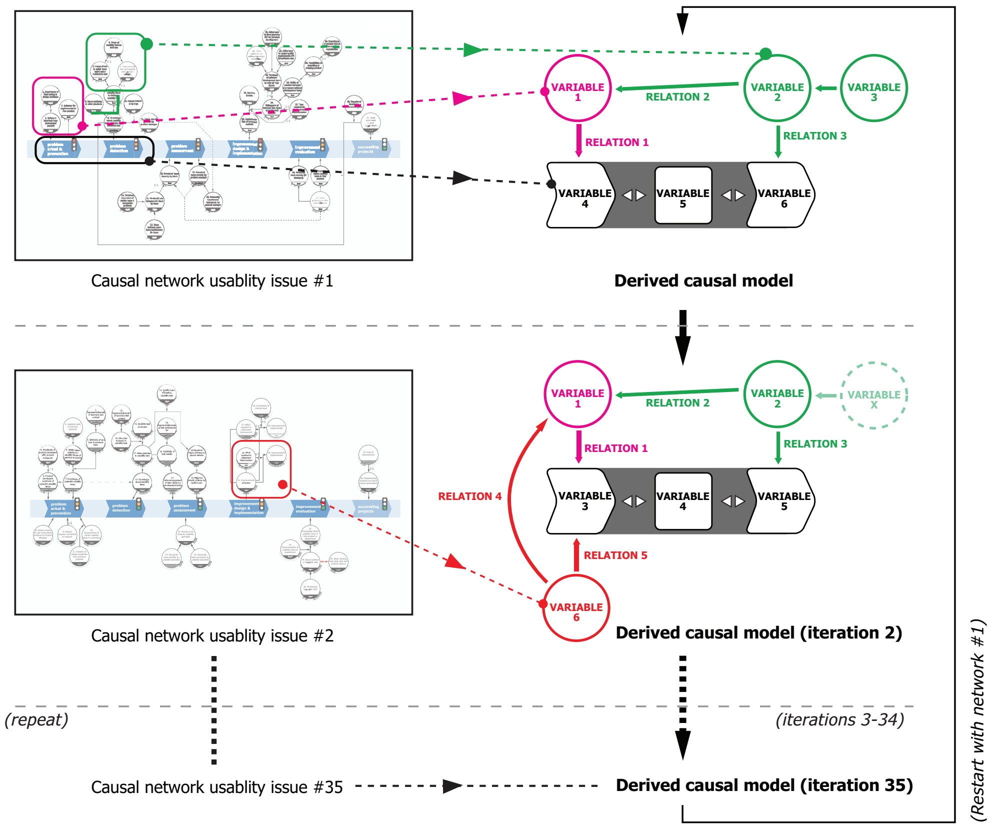


Figure 52: Visualization of the development of the causal models (right) based on the causal networks (left). In each of the causal networks the underlying variables that had possibly impacted usability were identified, as well as the relations between them. Then, a second causal network was analyzed, and from this iteration new variables emerged, while other variables were not present in the second causal network and thus deleted from the network (e.g., variable X in the second derived model). This process was repeated with the causal networks of all 35 selected usability issues, and then repeated once more overall.

Once the models were stable, I stopped going through the causal networks. Appendix I provides an overview of the intermediary versions of the usability issue lifecycle model, which exhibits the process of elimination, merging, and addition of variables and relations. Besides the causal networks, I used information from the documents and from parts of the interviews that touched upon the general way of working at AV@home. By going through this process two causal models were derived, the first of which aims to explain how usability issues arise and are dealt with in the product development process: the usability issue lifecycle. The second model focuses on a specific part of the usability issue lifecycle: the generation of shared knowledge about usability issues in product development teams. The first model – the usability issue life cycle – was induced on the basis of the causal networks. For the second model, the Data-Information-Knowledge-Wisdom hierarchy by Ackoff (1989) was used as a basis, and thus the development of this model was a combined inductive-deductive effort.

5.6.2 Results: causal models of usability in product development

Based on the causal networks, interviews, and documents I derived two causal models. The *usability issue life cycle model* (described in detail in subparagraph 5.6.3) pertains to the following research questions:

- What factors in product development projects cause usability strengths and weaknesses to arise?
- What factors in product development projects cause or prevent usability weaknesses from being solved?

The model was an inductive effort, based on the causal networks of events and circumstances that led to the individual usability issues.

The second model (described in detail in subparagraph 5.6.4), on the generation of shared knowledge and understanding about usability issues pertains to the following research question:

- What factors in product development projects cause or prevent detection of usability strengths and weaknesses?

For presenting an emergent theory Eisenhardt and Greabner (2007) suggest to write each proposition, and to link it to the supporting empirical evidence for each construct and for the proposed relationships between the constructs, and in addition provide a visualization of the theory "in boxes and arrows". In the following paragraphs, the models are built up step-by-step, adding new variables and relations to the model in each step, and explaining these in the accompanying text. For each variable and its relations to other variables evidence is provided from the case studies in the form of examples from the three development projects (see Appendix J and Appendix K).

5.6.3 Model 1: The usability issue lifecycle

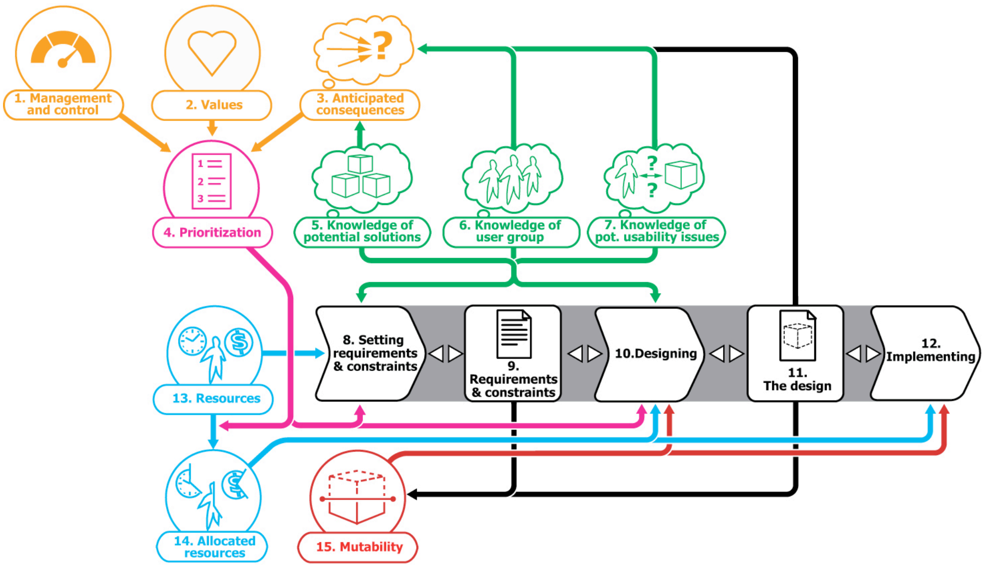


Figure 53: The usability issue lifecycle model.

This model consists of the following variables (and the relations between them), which play a role in the rise and prevention of usability weaknesses, as well as solving them:

1. Management and control: ways to influence decision making through the allocation of means, communicating priorities, and rewarding results.
2. Values: values and beliefs of product development team members.
3. Anticipated consequences: expectations that team members have about the effects of their decisions and actions.
4. Prioritization: arranging tasks, problems and product properties by importance.
5. Knowledge of potential solutions (e.g., technologies, components or designs).
6. Knowledge about the user group (e.g., demographics, needs, living context).
7. Knowledge about potential usability issues (e.g., cause, severity and occurrence).
8. Setting requirements and constraints: determining requirements the product should fulfil and indicating limitations.
9. Requirements: benefits a product should offer to people, or the effect it should have on them (appeal, sales, usability).
   Constraints: limitations with regard to the solution space and the resources.
10. Designing: translating requirements and constraints into specifications.

11. The Design: proposed properties, arrangement and behaviour of product components at the expense of specified resources.
12. Implementing: turning the design into reality, mostly development engineering activities, at the expense of specified resources.
13. (Available) resources: scarce means a product development team can apply to fulfil product requirements.
14. Allocated resources: those resources that a team decides to spend on a creating or implementing a design.
15. Mutability: degree to which a design or product can and is allowed to be changed

The 'backbone' of the model is formed by the ability of a team to conduct user-centred product development (8-12), into which knowledge (5-7) about the design solutions, the user group and about (potential) usability issues is fed. To what extent knowledge can be applied depends on the available resources (13), and on to what extent the development team has the freedom to create or modify a design (15). Prioritization of usability (problems) (4) plays a major role in design decisions and the allocation of resources (14).

Below, the elements of the model and their relations are defined and explained. For each of the variables and relations between them supporting empirical evidence in the form of examples from the three product development projects is provided in Appendix J.

User-centred design proficiency

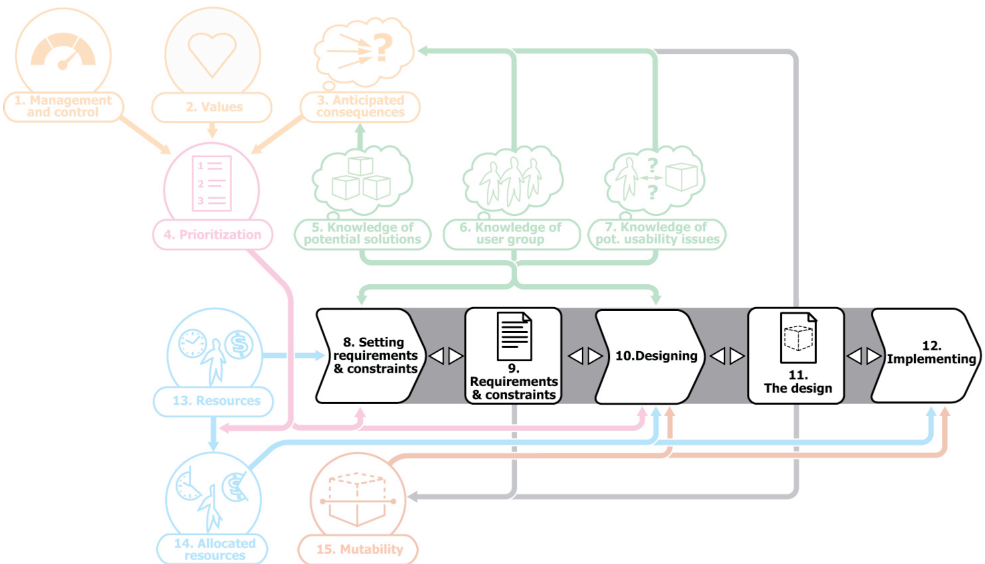


Figure 54: The steps (arrows) and results (squares) of the product development process form the backbone of the usability issue life cycle model.

The basis of the model is formed by a development group's ability to execute a user-centred product development process: user-centred design proficiency (black, 8-12). From the phases of product development identified in the previous study (Chapter 4) in this case study three phases were identified as crucial for usability: requirement setting, design, and implementation. A distinction is made between activities (arrow-shaped) and results (squares). The categorization is conceptual rather than chronological: in practice, elements of the design may already be implemented before other design decisions have been made. The two-way arrows indicate the iterative nature of product development.

Shared knowledge about solutions, users and usability issues

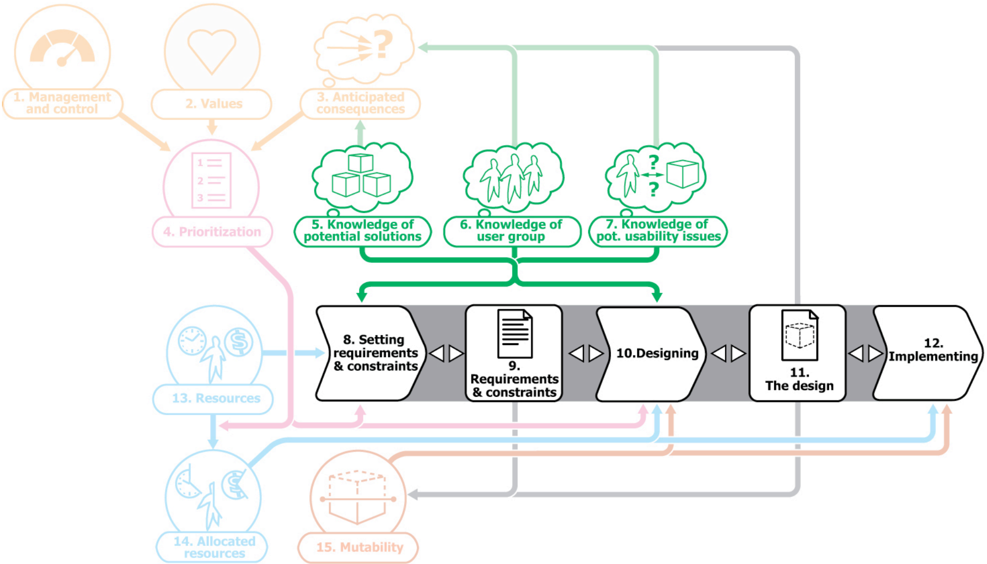


Figure 55: The influence of knowledge (green) of potential solutions (5), properties of the projected user group (6) and of potential usability issue (7) on requirement setting (8) and designing (10).

Three types of knowledge (5-7, green thought-clouds) were found to enable the development team to set user-centred requirements (8) and create a usable design (10): knowledge of potential design solutions (5), about the user group (6) and of (potential) usability issues (7).

Knowledge of potential solutions (5)

The more knowledge of potential technologies, UI designs and product designs (5, green) a team has, the wider the range of options it can consider when setting requirements and constraints (8) or when creating the design (10). This knowledge can originate from the company's own products, competitor products, research projects, and more indirectly from team members' experience and education.

Knowledge of the user group (6)
From the data it became evident that the more a team knows about the projected user group (6, green), the easier it is for them to set appropriate user requirements (8) and to create a usable design (10), and to identify the most important use cases, on which they have to focus of their efforts. The teams needed knowledge about a user group's:

- Needs
- Preferences,
- Expectations,
- Dimensions, skills and capabilities
- Behaviour with a product category,
- In what kind of context the products were used (other products, physical context, social context).

Knowledge of (potential) usability issues (7)
If knowledge of a potential usability issue (7, green) is known upfront, teams can include requirements (8) or propose designs (10) that solve a usability weakness or maintain a usability strength. If this knowledge emerges during the development process a redesign can be made (10) to deal with a usability weakness. The generation of knowledge of potential usability issues is discussed in a separate causal model (paragraph 5.6.4).

Design freedom

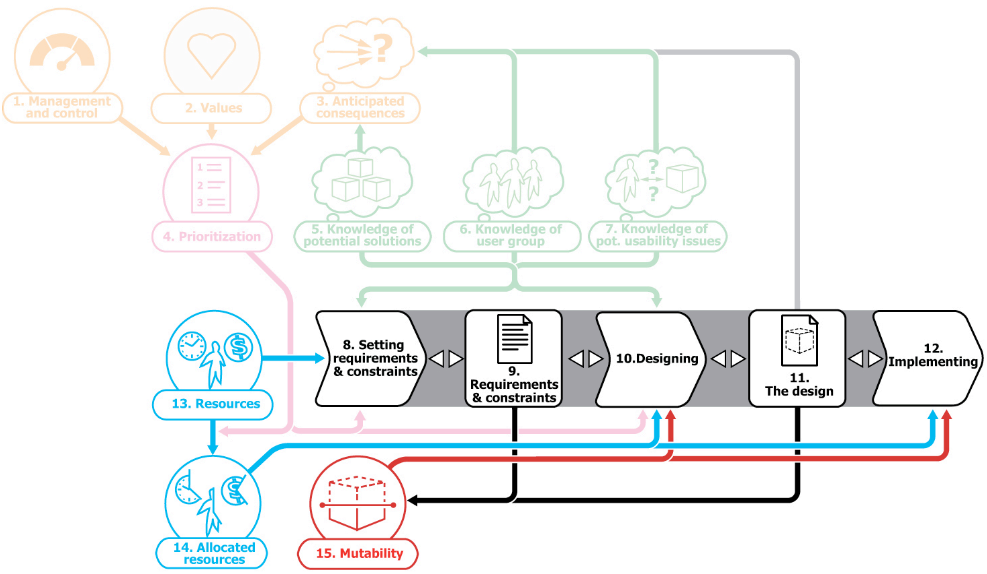


Figure 56: Design freedom is determined by the available resources (13, light blue), allocated resources (14, light blue) and mutability (15, red). These three variables have an iterative relation with the product development activities.

Mutability (15)
Mutability (15) refers to the degree to which a design or product can and is allowed to be changed. The degree of mutability is one of the determinants for whether the available knowledge (5-7) can be applied. In general, as a product matures the mutability of a design decreases, as more product properties have been specified (11), which places more limitations (15) on subsequent design decisions (10). Through software updates some products remain mutable even after production of the hardware and installation in the home. In addition, as a product matures, it becomes more 'intertwined', and changing one part of the design can have (unexpected) consequences for another. Guidelines, requirements and constraints (9) reduce the mutability by not allowing the designer to take certain design decisions.

Available resources (13)
Available resources (13) are the scarce means that a product development team can apply to fulfil product requirements (9), in the form of:

- Product budget (what can be spent on product components).
- Project budget (what can be spent on development activities).
- Working hours (mostly depending on team size and time, in turn dependent on project budget).
- Time (some activities require a minimum time span to be executed).

As development projects progress, the available resources decrease: financial resources and working hours are spent, investments have been made (e.g., on tooling), and the remaining time until to product launch decreases. The available resources (13) seem to depend on the product's priority, projected sales price and profit margin, and the stage of development the project is in.

Allocated resources (14)
Available resources (13) influence allocated resources (14), which are those resources that a team decides to spend on a creating (10) or implementing (12) a design.

Prioritization of usability

Prioritization (4)
Prioritization (4) refers to putting tasks, problems and product properties in order of importance, in order to deal with the most important issues first. Two categories of priorities were identified: product priorities (appearance, quality/reliability, price, branding, and usability) and project priorities (deadlines, project budget, and team size). Prioritization influences decisions that are taken during requirements setting (8) and while designing (10). Prioritization also influences the allocation of resources (13→14), and thus indirectly influences the design phase (10) and implementation (12) phase. If a (usability) problem is considered important enough, a team will free resources to deal with it.

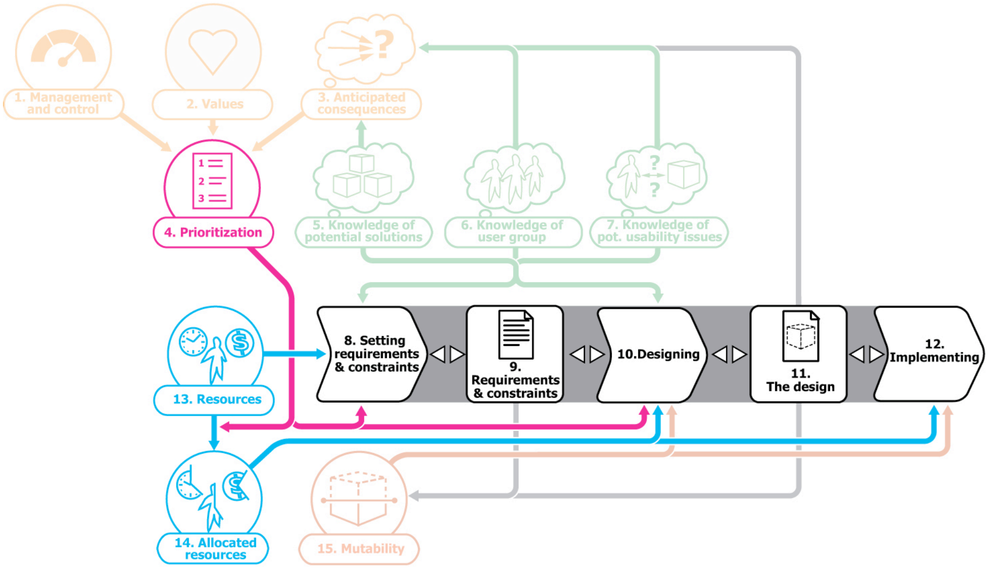


Figure 57: Prioritization (4, pink) impacts the allocation of resources (13+14, light blue), the setting of requirements and constraints (8, black) and designing (10, black).

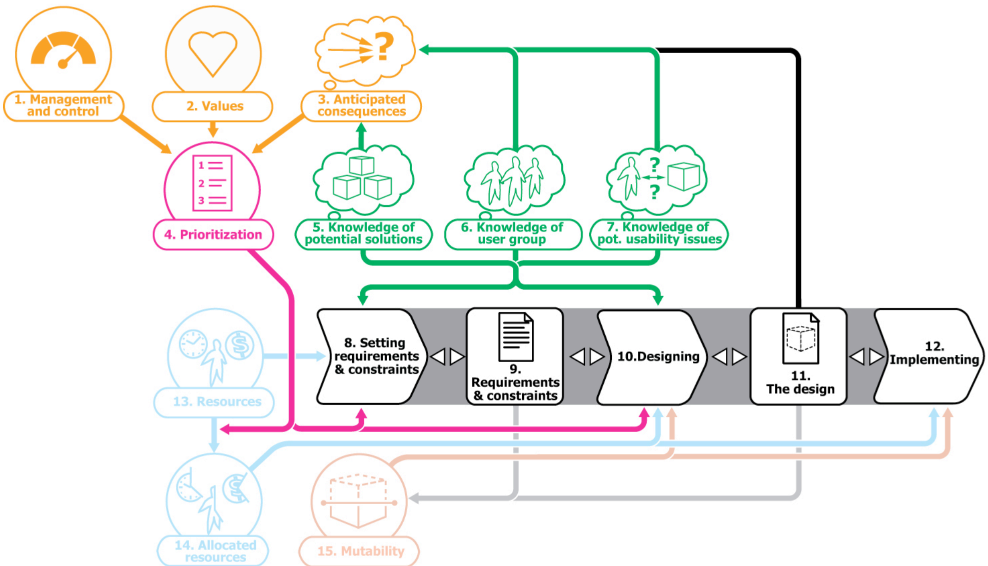


Figure 58: Variables that influence the prioritization (4) of usability and usability issues are management and control mechanisms (1, orange), the values and beliefs of team members (2, orange) and anticipated consequences (3 orange).

Three variables were found to influence prioritization of usability (issues) during product development:

- Management and control mechanisms (1).
- Values (2) of the team members.
- Anticipated consequences (3) of design decisions.

Management and control (1)
Management and control mechanisms (1) constitute a way to influence decision making through the allocation of means, communicating the priorities of the development group, and rewarding results. An example of management and control measures are the key performance indicators of the team members (e.g., customer satisfaction, sales numbers, profitability, time to market, etc.).

Values (2)
Values (2) refer to the values and beliefs that individual product development team members have. Values and beliefs are influenced by team members' roles and responsibilities, previous experiences, company/department culture, and education.

Anticipated consequences (3)
Anticipated consequences (3) are the expectations that team members have about the effects of decisions or actions, of which four categories were found:

- Consequences for product properties, e.g., price, appearance, and reliability.
- Consequences for a project, e.g., budget overruns, planning, profitability, etc.
- Consequences for the usage quality of the product (are users able to reach goals, or just annoyed by usage?) and anticipated improvement of a usability weakness as a consequence of changing a design. Whether a team anticipates a possibility to improve is (among others) dependent on their knowledge of possible solutions (5).
- Reaction/result: What will customers do because of the projected product and usage properties? Will they return the product, call the help desk, not buy it? For usability weaknesses the anticipated reaction depends on knowledge of a usability issue (7) and the user group (6).

5.6.4 Model 2: Generating shared knowledge about usability issues

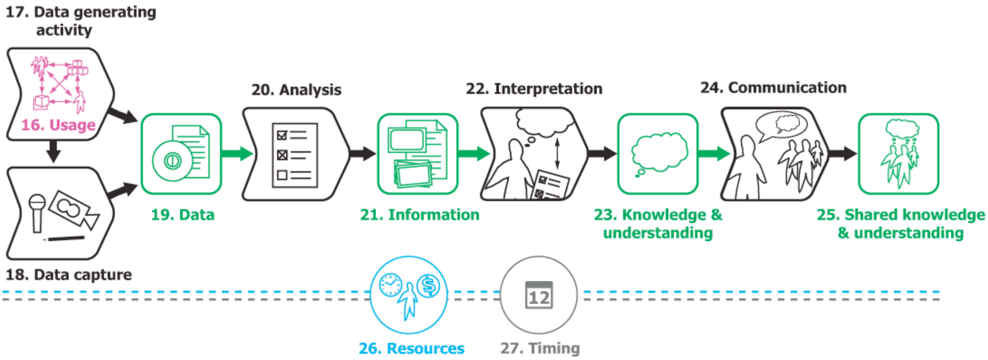


Figure 59: Causal model of knowledge generation on usability issues, with activities displayed as black arrows, and outcomes of those steps in green squares.

This model (Figure 59) is a representation of the activities (black) and outcomes (green) that play a role in the generation of shared knowledge about and understanding of usability issues[26] (both usability strengths and weaknesses), and of communicating that knowledge in product development teams. The model consists of the following variables:

16. Usage: simulation of human-product interaction (involving e.g., participants, a prototype, lab or field, etc.)
17. Data generating activity: how the simulation of human-product interaction is evaluated (e.g., cognitive walkthrough, user testing).
18. Data capture: how the generated data is stored (e.g., through video, notes).
19. Data: symbols that represent objects, events, and/or their properties.
20. Analysis: examination, selection and categorization of data.
21. Information: data that is processed to be useful; contained in descriptions.
22. Interpretation: creating understanding, offering explanations.
23. Knowledge & understanding: Knowledge is contained in instructions; it is actionable. Understanding is contained in explanations.
24. Communication: transfer of knowledge from a sender to a receiver with the help of a medium.

[26] An important distinction to make is between (actual) usability issues that occur when the final product is used by real users in the real context of use, and on the other hand potential usability issues, which are identified based on simulated human-product interaction. The latter are 'predictions' (which can be accurate to a larger or smaller extent) of real-life usability issues.

25. Shared knowledge & understanding: the spread, acknowledgement and penetration of knowledge and understanding in organizations.
26. Resources generation of knowledge: the scarce means that a product development team can apply to generate shared knowledge about and understanding of usability issues.
27. Timing of generation of knowledge: at what point during product development knowledge is generated and available to a team.

The model was developed in addition to the usability issue lifecycle model because the amount of empirical evidence justified modelling the phenomenon of generating shared knowledge about usability issues, but including it in the previous model would make that too extensive. The final variable of this model, shared knowledge and understanding (of usability issues), feeds into the first model, where it appears as variable nr.7: knowledge of potential usability issues (see Figure 55).

This model is an adaption of Ackoff's hierarchy of data, information, knowledge and wisdom (DIKW) (Ackoff, 1989). Below, for each of the variables it is indicated whether it was present in Ackoff's original hierarchy and what changes were made it, based on the data from this study. Compared to Ackoff's hierarchy the biggest modifications are the starting point and final stage of the model.

Ackoff's hierarchy does not specify how the data is generated, but from this study three variables emerged that influenced the generation of data about usability issues specifically: the data generation activity (i.e., a usability evaluation method), the representativeness of usage during that activity, and finally how usage is captured (see Figure 60).

In Ackoff's hierarchy the transfer of knowledge from one person to the next is not explicitly discussed, but Ackoff does state that "*knowledge can obtained from experience, or from someone who has obtained it from experience, their own or that of others*" (Ackoff, 1999, p.15). In the analysis of the origins of usability issues the transfer of knowledge about usability issues was identified as a critical step, therefore I decided to include it in the model as a separate activity or variable.

Finally, in Ackoff's hierarchy the final 'level', following knowledge (and understanding), is wisdom, whereas in this model the final stage is shared knowledge and understanding. I did not investigate how product development practitioners develop 'wisdom'.

Below a step-by-step introduction is provided of the variables that constitute the model and the relations between them. For each of the variables it is indicated whether and how it is defined in Ackoff's hierarchy, and for each of the variables and the relations between them supporting empirical evidence in the form of examples from the three product development projects is provided in Appendix K.

Data generation & capture

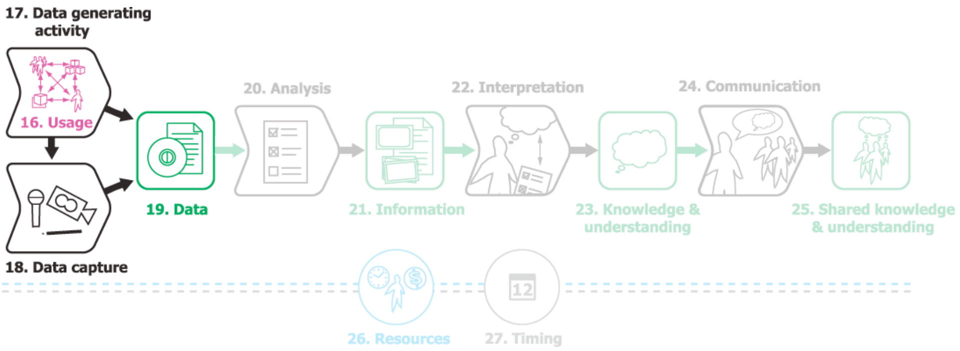


Figure 60: The generation of data about usability issues (19) requires an activity through which the data is generated (17) in which product usage occurs or is simulated (16), which is then captured (18).

Representativeness of usage (16)

Representativeness of usage is one of the terms that informants used to describe to what extent the usage of the 'product' (which can be a simulation at the time) by participants during data gathering is representative for the usage of the final product by real users in real life (see discussion on page 64).

Representativeness of usage was indicated to depend on the representativeness of the:

- Product: what the user interacts with;
- Context of the interaction: physical environment (e.g., lighting conditions), data streams, other products that the product will or can be connected to;
- Users: people that interact with the product, and
- Goals: what people (want to) do with the product.

Data generating activity (17)

In order to create knowledge about usability issues, first data (19) has to be generated (17) from which knowledge can be distilled. Data is captured (18) from an event in which human-product interaction (16, pink) takes place or is simulated. The type of data generation activity (17) influences the potential representativeness of usage (16) and type of data capture (18). A wide range of activities was found to generate data about human-product interaction:

- Personal experience by one of the team members
- Expert evaluation of a UI design
- Design guidelines benchmark
- User tests
- Analysis of customer support contacts
- Customer satisfaction questionnaires
- Field Studies

In the different types of data generation products and users were represented differently, which can be arranged according to representativeness, as can be seen in Table 33. Previous products can be very representative for the current product, depending on the similarity between product generation and across the product portfolio. Participants in user tests can be very representative for the final user group, depending on how they were recruited and the knowledge of the team about the properties of the final user group.

Table 33: Types of simulations and participants in human-product interaction (data generation) arranged from least to most 'representative'.

Representativeness	**Simulation**	**Participants**
LOW ← → HIGH	• Final product • Samples (early production) • Prototypes (first implementation) • Interactive simulations (2D/3D) • Sketches/drawings/renderings • Textual description	• Real users • Friends/family • Colleagues (outside of the team) • Other team members • Designers
Low/High	• Previous products (dependent on between-generation similarity)	• Participants (Potentially high if recruited properly)

How users are represented during data generation determines whether the representativeness of user properties and skills, such as knowledge of the product category, cognitive skills, etc. are representative for those of actual users.

The representativeness of goals during usage is determined by the type of data generation method, of the participants, and the context. Representativeness of goals can assumed to be high if representative participants are allowed to use a product as they see fit, in their 'natural' environment. If data generation takes place through a lab-based, task-based ("*Please find radio station X, and store it*") test with unrepresentative participants, the goals the participants may be less representative.

Data capture (18)

Data capture refers to capturing events in a form that allows further processing, and can be performed through audio and video recording, making notes, logging product use, transcribing, but also in the form of memories of team members. The type of capture determines in what form and resolution the data that is generated is stored.

Data (19)

Data are "symbols that represent objects, events, and/or their properties. They are products of observation" (Ackoff, 1989).

Two important data properties were found to play a role in generation knowledge on usability issues: the comprehensiveness and resolution of the data that were collected. If data generation is set up in such a way that a usability issue cannot occur, then this usability issue will also not surface during analysis and interpretation. Therefore the data set has to be as comprehensive as possible, to be able to generate knowledge on all potential usability issues. For a maximum of comprehensiveness of the data all user groups perform all use cases in all contexts. The higher the resolution (the detail) of the data, the easier it will be for analysts to identify and interpret usability issues, to communicate them, and the easier it will be for designers to generate solutions. So in addition to capturing all potential usability issues (comprehensiveness) they should be captured in sufficient detail (resolution) in order to be turned into knowledge.

Information generation

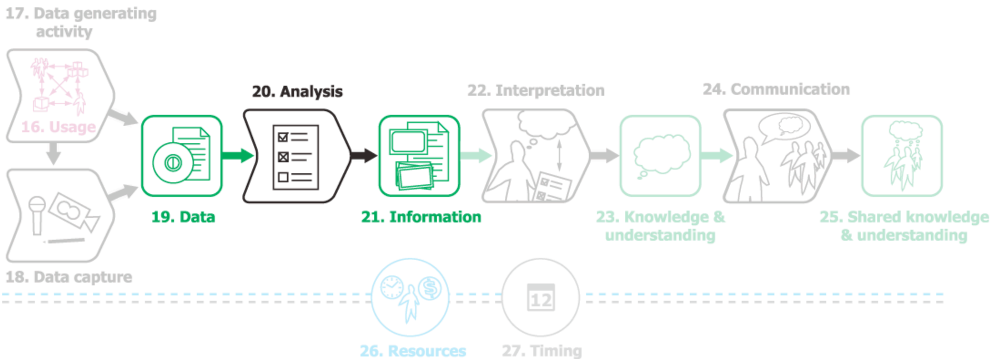


Figure 61: The analysis (20) of captured data (19) results in information (21) - data that is processed to be useful and that answers 'who', 'what', 'where - about usability issues.

Analysis (20)

Analysis refers to the "examination, selection and categorization of data" and typically includes activities like coding, sorting, categorizing, selecting and linking parts of the data set (Ackoff, 1989).

In the case of generating knowledge about usability issues, this is for example identifying what use case is taking place, which participant is interacting, and adding this information to the data. In formal data generation approaches, such as user testing or an expert reviews, the analysis is conducted by usability evaluators, but in other cases it can be conducted by other development team members, such as a software developer running into an issue.

Information (21)

Information is data that is processed to be useful. It is contained in descriptions, and answers questions that start with "who", "what", "where", "when", and "how many" (Ackoff, 1989).

In this study it was found that information on usability issues consists of:

- Descriptions of usage behaviour (task, user, components involved);
- Comments that users made;
- User properties;
- Product properties.

In addition to the content a number of information properties were observed to play a role in subsequent steps (interpretation (22) and communication (24)).

- Comprehensiveness: are all usage situations (product/context/users) covered?
- Accuracy: do the descriptions accurately describe what happened?
- Precision: amount of detail;
- Representativeness: is the interaction representative for real-life product usage? Influenced by data generation (17), capture (18), and analysis (20).

Knowledge generation

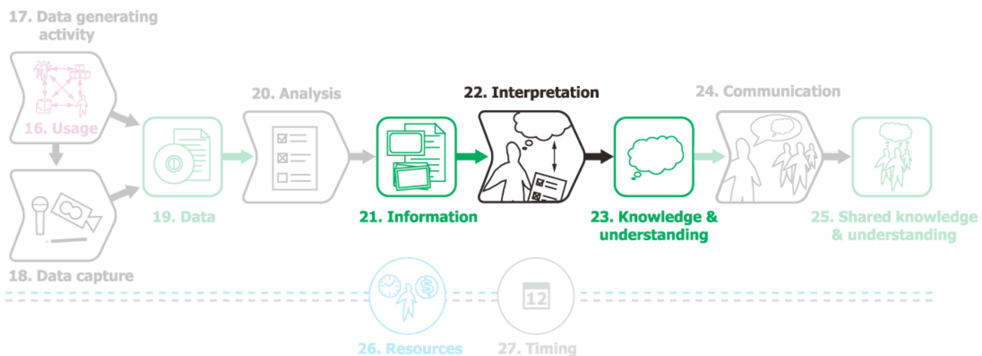


Figure 62: Interpretation (22) of information (21) about usability issues results in knowledge and understanding (23) – actionable instructions, answering 'how' and 'why' questions.

Interpretation (22)

In this model the activity of turning information into knowledge is labelled 'interpretation'. The goal of interpretation is to create understanding, offer an explanation for what has happened. This is done by making comparisons within the information that was collected, by comparing the current information with information from previous knowledge and by reflecting on the findings.

Knowledge and understanding (23)

Knowledge is contained in instructions; it is actionable. It answers "how" questions, for example how a system works, or how to make it work. Understanding is contained in explanations, answers to why questions (Ackoff, 1989).

In this study it was found that knowledge about and understanding of usability issues (23) has the following properties:

- Descriptions of usability issues: what are the use cases that users have (no) difficulty to complete, the degree of effort users have to invest, and how do they evaluate the interaction?
- Identification of causes: what properties of the product, context (environment, data streams and other products), and participants are causing the issue to occur?
- Indication of the impact on product usage: how often can this usability issue be expected to occur in the final product (occurrence), and what will the influence on usage be (severity)?

Knowledge transfer

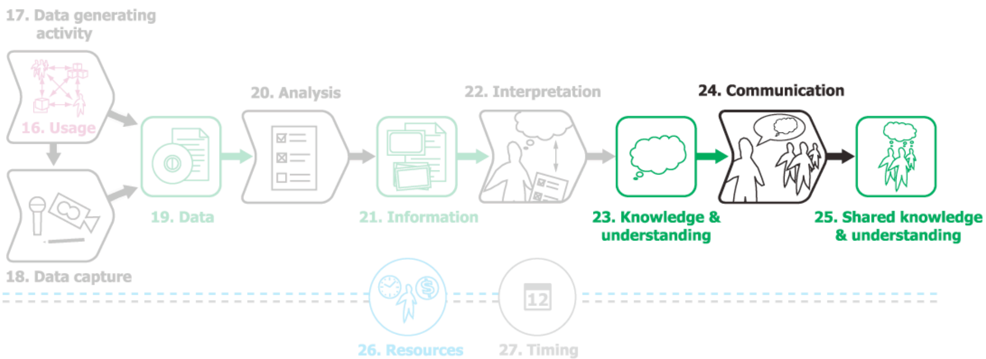


Figure 63: The process of communicating (24) knowledge about and understanding of a usability issue (23) from the person who gained this knowledge to the rest of the team in order to arrive at shared knowledge and understanding (25) of usability issues.

Communication (24)

Knowledge can be acquired from personal experience or it can be obtained from someone who has obtained it from experience, their own or from others (Ackoff, 1989). Communication refers to the transfer of knowledge from a sender to a receiver with the help of a medium ((Andersen 1979) in (Chiu, 2002)).

In this study it was often observed that the person that discovers a usability issue has to transfer this knowledge to the rest of the team. Communicating usability issues is a key step in the generation of knowledge on usability issues. First of all, communicating the knowledge to the team is a condition for the team to learn about an issue, and subsequently take action. Secondly, a product development team that sees the results of a usability test of a product they worked on learns and can be expected to apply this knowledge in a succeeding project.

In this study successful communication of knowledge about usability issues was found to be influenced by the following:

- Content: the knowledge or 'message' that was communicated;
- Resolution of information: numbers, descriptions, audio, photo, and video;
- Medium: document, presentation, first hand observation, person;
- Audience: role, knowledge, values, personal involvement, anticipated consequences.

The content (message) has a considerable effect on successful communication. If the message has negative implications for the team (a usability weakness with a high impact on usage and a small possibility to fix), the team was prone to ignore or contest the results, for example by challenging the representativeness of usage in data generation. Secondly, the resolution of the information plays an important role in successful communication, especially on acknowledgement of usability weaknesses and the 'buy-in' by the team (their willingness to fix the problem). The higher the resolution during communication, for example by using videos or by having team members watch a user test, the more successful communication is likely to be. Thus documents (reports) were considered a less effective way to communicate usability issues, as opposed to presentations and – even better – first hand observations by team members.

Finally, the properties of the audience influence successful communication. Obviously whether they are present or not plays a role. Presence seems to be influenced by whether the team anticipated being able to act upon the knowledge, and on their role. Another important audience property was whether they actually wanted to learn about the usability issues. Again, this seemed to depend on whether they anticipated being able to fix the problems. The basic attitude team members had towards user testing (beneficial or not) also seemed to be influenced by whether they previously attended usability tests, or user test debriefs. Finally, corporate culture may also influence communication of usability issues: whether or not an organisation is accustomed to dealing with qualitative information, or whether there is a preference for quantification.

Within AV@home, when usability weaknesses were communicated, also a possible solution, or solution space, was suggested. Both the usability weakness and the suggested solution formed the basis for the prioritization of the problem (see prioritization in the usability issue life cycle model). Problems that were considered impossible to fix received a lower priority.

Shared knowledge and understanding (25)
In this model shared knowledge and understanding is defined as the spread, acknowledgement and penetration of knowledge in the organization, which depends to a large extent on how the knowledge is communicated (24). Two important variables of the distribution of knowledge are its extent of distribution and the timing. The degree of distribution describes to whom the knowledge has been transferred, and the timing of the distribution is when they know it. In this study successful communication was found to have the following effects:

- Understanding: do team members understand a usability issue and its causes?
- Acknowledgement: do team members believe the issue will occur in real life and is relevant?
- Empathy: can team members relate to the usability issue?
- Engagement: do team members feel responsible for the issue?

If all of the above effects occurred that raised the chances that action would be taken to deal with a usability issue.

Conditions

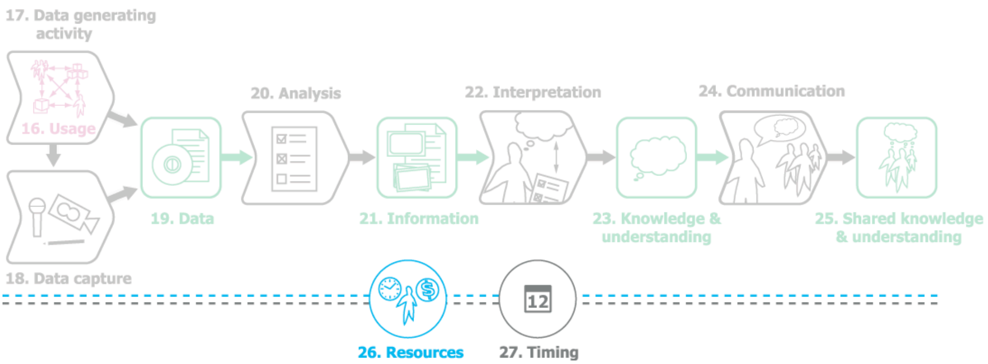


Figure 64: Influence of conditions (resources and timing) on the generation of shared knowledge and understanding of usability issues.

Resources (26)
The availability of resources – time, working hours, budget and facilities (e.g., cameras, usability lab) – was found to influence the overall process of generating knowledge on usability issues. It influences a development group's ability generate and capture data, and subsequently analyse, interpret and communicate it.

Timing (27)
The timing of the data generation activity influenced the representativeness of the stimulus material to be used in data generating activities. In the early stages of product development

only rough simulations or prototypes are available. In addition, the timing of knowledge about usability issues influences whether the team will be able (and willing) to deal with them. In the early phases the design is more mutable, and more resources are available (see usability issue life cycle model).

5.6.5 Exploring groundedness and accuracy

Method

As described in paragraph 5.4.3, feedback sessions were held within AV@home's parent company in order to verify the accuracy and generalizability of the description of how usability was influenced at AV@home. In the presentations that were held within the AV@home product development group the causal models were also evaluated. In the feedback session the limitations of the research were stressed, and the audience was invited to share their comments. With regard to the causal models I specifically prompted them to point out missing or redundant variables or relations in the causal models (Miles and Huberman, 1994, p.163). In addition to the presentation, I gave the informants handouts of the causal models with an invitation to email comments they might have and provided some of the informants with CDs containing the presentation and the causal models, on the condition that they would provide additional feedback via email. I later contacted these informants via email to give their individual reaction, allowing them to voice strong opinions without their colleagues hearing these. Of the six informants that received a CD, five provided additional feedback via email. Presentations took place at:

- AV@home product development group (including the design department),
- AV@home user testing consultancy group, and to
- Management team of the personal and home electronics business group of which AV@home was a part.

The presentations were recorded using audio equipment and transcribed. Based on the transcriptions and the reactions via email I adjusted the models.

Indication of groundedness

To provide a sense of to which extent the model was grounded in evidence from empirical data (Eisenhardt, 1989), in Table 34 it is indicated which of the variables were present (black) or not (white) in the causal networks that represented the events and circumstances that led to a usability issue. The overview should not be considered a validation of the models, as the models are based on the very same data. Instead, Table 34 should be considered an indication of the connectedness of the variables in the models to the empirical data.

Table 34: An indication of groundedness for the variables that make up the two causal models that were developed. Left: the usability issue lifecycle model (see par.5.6.3), right: the model for generating shared knowledge about usability issues (see subpar. 5.6.4). For each usability issue it is indicated whether the variable was found (black) in the causal network or not (white).

		USABILITY ISSUE LIFE CYCLE MODEL															**GENERATING SHARED KNOWLEDGE ABOUT USABILITY ISSUES**											
	Usability Issue	Management & control	Values	Anticipated consequences	Proritizing	Knowledge of pot. design solutions	Knowledge of the user group	Knowledge of pot. usability issues	Requirement setting	Requirements & constraints	Creating the product design	The design	Implementing the design	Available resources	Allocated resources	Mutability	Representativeness of usage	Data generation	Data capture	Data	Analysis	Information	Interpretation	Knowledge	Communication	Shared knowledge	Resources	Timing
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
DVD recorder	Automated channel installation					■		■			■		■				■	■		■		■		■		■		■
	Connecting device			■	■	■		■		■	■	■	■		■	■	■	■		■	■	■	■	■	■	■		■
	Country listing										■						■	■		■		■						
	'Disc' label		■	■	■	■		■		■						■	■	■		■		■	■	■	■	■		■
	Disc space warning			■	■	■		■		■	■	■	■	■	■		■	■		■	■	■	■	■	■	■		■
	Exiting timed recording menu			■	■	■	■	■		■	■	■	■		■			■		■		■	■	■	■	■		
	Recording feedback			■	■						■	■		■	■	■		■			■	■						
	Overwriting a recording			■	■	■	■	■		■	■	■	■	■	■		■	■		■	■	■	■	■	■	■		
	Remote control layout	■		■	■			■		■	■				■	■		■		■	■	■	■	■	■	■		
	Unresponsive device/control	■		■	■	■		■		■	■	■	■	■	■	■		■		■	■	■	■	■	■	■		
	Standby required for rec.			■	■	■		■	■	■	■	■	■		■	■		■		■	■	■	■	■				■
	'Timer' label	■		■	■			■			■				■	■		■		■	■	■				■		
	Timed recording easily found			■	■	■		■			■	■					■	■		■	■	■		■	■			■
Hard disk recorder	Back button not working	■		■	■	■	■	■	■	■	■	■	■	■	■		■	■		■			■	■	■	■		
	Channel installation slow			■	■	■		■	■	■	■	■	■		■	■	■	■		■	■	■	■	■	■	■		■
	Connecting device to set-top box			■	■	■	■	■	■	■	■	■	■		■	■	■	■		■		■		■				■
	Device is slow	■		■	■	■		■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■		■
	Feedback during content transfer			■	■	■		■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■		■
	EPG hard to install/operate	■		■	■	■		■			■	■	■	■	■	■	■	■		■	■	■	■	■	■	■		■
	'HDD-list' button label			■			■	■		■	■		■			■	■	■		■		■		■			■	■
	Power on takes long			■	■	■		■		■	■	■	■	■	■	■		■		■	■	■	■	■	■	■		■
	Recording countdown feedback			■	■	■	■	■			■	■	■	■	■	■	■	■		■	■	■	■	■	■	■		■
	Time shift buffer			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■		
	Timed recording button				■	■		■	■	■	■	■	■			■		■		■	■	■	■	■	■	■		
	Finding the USB latch		■		■			■			■		■			■		■		■		■		■	■	■		
	On-screen UI well understood		■		■	■		■	■	■	■					■		■		■		■	■	■	■	■		■
Home theatre system	FM antenna connector			■	■	■		■	■	■	■	■	■	■	■		■	■		■	■	■	■	■	■	■		■
	Front panel display legibility			■	■	■		■	■	■	■	■	■		■		■	■		■	■	■	■	■	■	■		■
	HDMI setup not understood			■	■	■	■	■	■	■	■	■	■		■	■		■				■	■	■	■	■	■	
	Remote control interference			■	■	■		■	■	■	■		■	■		■	■	■		■	■	■	■	■	■	■		■
	iPod navigation			■	■	■		■		■	■		■	■	■		■	■		■	■	■	■	■	■	■		■
	Rear panel / cable management			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
	Disc compartment lock			■	■	■		■			■	■	■	■	■	■	■	■		■	■	■	■	■	■	■		■
	'Subwoofer' label on rear panel			■	■	■		■			■	■	■					■		■	■	■	■	■	■	■		■
	Top tier icons navigation			■	■	■		■	■	■	■	■	■	■	■	■		■		■	■	■	■	■	■	■		■
	Total number of mentions	**6**	**3**	30	32	29	**9**	33	15	25	34	25	28	17	25	24	22	35	**1**	33	25	34	27	32	28	29	**2**	22

From Table 34 it becomes apparent that some of the variables I included in the models are not present that frequently in the causal networks. The following variables were found less then fifteen times in the 35 causal networks of usability issues.

- (1) Management and control mechanisms (mentioned 6 times);
- (2) Values (mentioned 3 times);
- (6) Knowledge about the user group (mentioned 9 times);
- (18) Data capture (mentioned 1 time), and
- (26) Resources (2 times).

Some of these variables are less likely to show up because of the methodology employed in the study (interview-based, retrospective, causal networks, etc) and other variables were not derived from the causal networks but from parts of the documents and interviews that were not related to a specific usability issue but more generally to the way of working of AV@home.

Below I will provide a motivation for including variables in the models that were not frequently identified in the causal networks.

Management and control mechanisms (1) were mentioned six times in the causal networks. However, the recent introduction of customer satisfaction did seem to have caused a significant shift at AV@home in attitude towards and prioritization of usability (if compared to a previous visit to the development group). Additionally, from literature it is known that an incentive scheme can influence actor's behaviour. So even though I did not find the variable 'management and control' that often in the causal networks, I did decide to include it in the model.

Values (2) only surfaced in three causal networks. This may be partly due to the retrospective, self-assessment setup of the study: when talking about their decisions and actions people may be less inclined to attribute their decisions to the values they have. However, when I compared the approaches, opinions and actions of the different product managers, a distinct difference in prioritization emerged that may not be completely attributable to 'rational' considerations, but also seemed to depend on values and beliefs that actors have. The presence and influence of values was supported by the informants in the feedback presentation that was held at AV@home (though there were differences in opinion in exactly what way values exerted influence, see next paragraph).

Knowledge of the user group (6) surfaced nine times. However, in the cases that it was mentioned it was identified as having a very strong influence on the usability of the design. Secondly it should be taken into account that the focus of the case studies was not on the front part of product development (i.e., design brief formulation), which is a phase where user research can be expected to be conducted most. Due to its large influence and the methodological bias it was decided to include 'knowledge of the user group' in the model.

In the model of knowledge generation on usability issues, the presence of the variables 'data capture' (18), and 'resources for generation of knowledge on usability issues' (26) were induced from the interviews, documents and observations, but not explicitly found in the interview data specifically concerning the usability issues.

Accuracy

During the feedback sessions the models were generally considered accurate and comprehensive, though a bit exhaustive, as reflected in these comments by informants present at the feedback presentation at AV@Home:

User test consultant 1:	*Ok, most of it looks eh... Is there anything glaringly missing?*
User test consultant 2:	*No. This represents the workflow pretty much.*
User test consultant 1:	*Yeah. Everything that should be there seems to be there.*
Senior user test cons.:	*It [your presentation, ed.] reflected the current usability situation in AV@home in most cases. […] The framework is quite comprehensive to me.*
Development Manager:	*You developed a lifecycle [model, ed.] with 20 circles and many relations that is very complex. I wonder whether it can be simplified, so it will be more understood/accepted. […] The same goes for the generation of knowledge.*

Because the models were considered somewhat daunting and exhaustive I merged a number of variables and improved the layout (see Appendix F). Based on input from the feedback presentations and emails that I received afterwards from informants some relationships between variables were added to or removed from the model, as illustrated with the examples below.

The informants suggested that the available resources for a project influence the requirements that are set. This relation was added to the network.

Software developer:	*Doesn't setting product requirements also depend on the available resources?*
Researcher:	*The available resources... Could you explain that a little bit?*
Software developer:	*From this, available resources, to the setting of the product requirements. Because there is still effort involved in laying out the requirements.*
Researcher:	*So, depending on what you have in the project to spend, you set your requirements at the beginning?*
Software developer:	*[confirming] Hmmm-hmm.*

In the model that was shown in the feedback session there was a distinction between 'design mutability' and 'product mutability', which prompted the following remark from an informant, which was one of the reasons to merge 'design mutability' and 'product mutability' into a single variable: mutability.

User test consultant:	*I think that the 'design mutability' element should present at the 'product' phase with the 'product mutability' as well, because normally*

design changes are required even after the design is implemented and product is made.

A product designer present at the feedback meeting responded in a later email that he very much recognized the effect of the 'prioritization' variable.

Product designer: *I must say that one of the conclusions that struck me most was the one that certain usability problems originate from prioritizing aesthetic considerations over usability. I can't say that I completely disagree with that. Actually, when I am completely honest it is one of my biggest annoyances of working in product design. And I think I am not the only one. If you ask me we indeed are too focused on making 'beautiful things' than making usable and feasible products.*

With regards to the 'values' variable, different opinions were expressed, as can be seen below. In the end the 'design proficiency' variable was merged with 'designing' and thus the 'values' variable was kept in the model.

Development manager: *I think that 'values' can be removed, because it is a part of 'design proficiency'. The development team's values have little or no influence on setting the priorities. The values implicitly make it into products via the 'design proficiency'.*

UI Design Manager: *I think values have to do with culture. It has to do with the culture - like the national culture - of the developing team. It also has to do with the corporate culture. So that different group of people with a different set of values will develop a different product. And that makes a difference whether they come from, whether there's an engineering focus or a more social focus.*

5.7 Conclusions

The aim of this study was to identify what factors in product development cause usability issues to arise, to be detected (or not), and solved (or not). To meet this aim a retrospective analysis was performed of events and circumstances leading to 35 usability issues (strengths and weaknesses) in three electronic consumer products developed by one product development group (AV@home). First, a description was created of how usability was dealt with at AV@home (5.4.2). Subsequently I induced two models that describe what variables influence usability and how these variables are related: the usability issue life cycle model (described in section 5.6.3), and a model that describes the generation of shared knowledge and understanding of usability issues (section 5.6.4).

The usability issue life cycle model describes what variables influence the rise or prevention of, and dealing with usability issue in product development, and thus provides the answer to the following key research questions:

- What factors in product development projects cause usability strengths and weaknesses to arise?
- What factors in product development projects cause or prevent usability weaknesses being solved and the usability of a product being improved?

The second model, of the generation of shared knowledge and understanding of usability issues, describes what variables influence the detection of usability issues and the spread of this knowledge in a product development organization, thus answering the key research question:

- What factors in product development projects cause or prevent detection of usability strengths and weaknesses?

5.7.1 On the usability issue lifecycle

The usability issue lifecycle model is made up out of 15 variables, which were grouped into four drivers for the creation of usable products; a driver being a collection of related or similar variables. Companies need to have the (1) skill to create a user-centred design (user-centred design proficiency), to which end they need (2) knowledge about solutions, the user group, and (potential) usability issues. However, they also need the (3) freedom to apply theirs skills and knowledge, to which end (4) usability needs to be prioritized.

User-centred design proficiency

A product development team needs to be able to set user-centred requirements, translate these into a usable product design, and finally implement this design as well. This means that within the team there should be sufficient knowledge of and experience with user-centred design methods.

Shared knowledge

Knowledge about three subjects was identified to contribute to the creation of usable products: knowledge of potential design solutions, of user group properties, and of (potential) usability issues.

- Having knowledge about available technologies, and interaction and product designs, enables the generation of more usable solutions: both the quantity of solutions that designers can conceive (more usable-solutions) as well as the usability of the solutions conceived (more-usable solutions).
- Knowledge about the user group allows the product development team to set the right requirements and to prioritize the most important use cases in the product. It also facilitates the creation of user-centred designs, because the designers have a better understanding of the user group, usage and the context of use.
- Knowledge about potential usability issues allows the product development team to create more usable (re)designs. This knowledge can be obtained through a wide variety of methods (e.g., user testing, after sales feedback, reviewing).

Design freedom

To be able to make use of the shared knowledge and the user-centred design skills of a team there needs to be 'design freedom', which is determined by the mutability of the design and the available resources. Mutability refers to the degree to which a design or product can and is allowed to be changed. The available resources, the scarce means that a team can apply to create and implement a design (such as time, budget, working hours and facilities), determine whether the required process steps can be executed and whether the most suitable design solutions (e.g., components) can be selected. To draw a parallel, if you are sketching, the size of your paper represents the mutability, and the crayons and time you can spend are your resources.

Having the required knowledge and user-centred design proficiency mostly influenced the *ability* of the product development group to design a usable product, while design freedom and the prioritization of usability influenced whether that ability and knowledge could actually be *applied*. At AV@home the lack of design freedom, resulting in user-centred designs not being implemented, seemed to be more of an obstruction for usability than a lack of knowledge about usability issues. Often usability weaknesses were well known, but the teams were simply unable to deal with them. Design freedom was reduced considerably by using third party components and platforms, and by the high time pressure and low budget the teams had to work with. Design freedom decreased with time, as more and more of the available resources were spent, and the design became increasingly less mutable as it was maturing. This stresses even more the need for early knowledge about usability issues.

Prioritizaton of usability

What priorities a team sets, influences decision-making about the requirements and the design, and which of the available resources are allocated to design and implementation activities. Thus prioritization of usability has an impact throughout the whole product development process. Prioritization is influenced by management and control mechanisms (e.g., key performance indicators), team member values (e.g., products should always look good) and anticipated consequences of design decisions (e.g., product returns).

In none of the development phases was usability a top priority. During the requirements and design phases the team was mostly occupied with creating a proposition and design that would appeal to consumers and thus lead to sales. In the early phases team members expected for example aesthetics, price and functionality to have a more positive influence on sales numbers than usability would have. In addition, during requirement setting and while designing there was not much knowledge about potential usability issues, which is something that might have increased the priority of usability. When that knowledge did surface, during implementation, the biggest concern of the development team was to deal with problems that would cause costs after the product had been sold. This meant that their top priority was to deliver a reliable, bug-free product. The reasoning was that products that were unreliable had a much higher chance of being returned than products that were (to some degree) unusable. Only usability weaknesses that were anticipated to cause a lot of helpdesk questions or product returns (because users might think they were broken or could not get them setup properly) would get a (relatively) high priority.

5.7.2 On generating shared knowledge about usability issues

User testing most effective source of information (but not the only one)

Within AV@home there was a large number of potential sources for knowledge about usability issues, ranging from expert reviews and helpdesk calls about previous products to user testing. However, the teams took most action to fix usability weaknesses upon knowledge that originated from user tests. Suggested explanations for this effect were that first of all, contrary to other activities that generate knowledge about usability issues, user tests were an 'official' part of the development process and teams were required to take action upon the results. Secondly, user tests allowed team members to witness usability weaknesses first hand, which was reported to increase their understanding, and acknowledgement of the issues.

Communication of usability critical: knowledge and acknowledgement

Usability issues were often identified by a single person (the usability specialist or another team-member), who then needed to communicate this knowledge to the rest of the team. As product development team members often considered usability a somewhat subjective and hard to quantify concept, the communication of usability issues was a critical step in the establishment of shared knowledge and understanding about a usability weakness. The chances of usability weaknesses being dealt with effectively increase if team do not only know about it, but also understand and empathize with it. Creating acknowledgement of and empathy for usability issues is facilitated by using a medium with a high resolution (video or presence of the team during testing), if the issue is found in a situation with a high representativeness of usage (this increases the confidence the team has in the accuracy of the results), and by a team anticipating to be able to deal with the issue (this increased the relevancy of the knowledge to the team members).

Centralized development and global sales: limits knowledge

The AV@home product development group developed products for other markets than the one where it was geographically located. This limited the knowledge that team members had about the user group, because they were not in direct contact with it. Gaining that knowledge, through for example field studies, would require a significant investment in terms of time and budget. Secondly, being geographically remote from the intended user group made it harder to conduct user tests with representative users and in a representative context. The lack of knowledge of the user group resulted in suboptimal requirements being set, and the lack of representativeness in user testing resulted in number of usability weaknesses not being detected (false negatives).

5.8 Scope and limitations of the study

The following paragraph provides a reflection on the methods applied in this study.

Models: a first step

In literature a number of quality criteria for a model or theory based on qualitative research can be identified. They should be a highly accurate description of the phenomena, and must therefore correlate with reality and coincide with empirical referents as much as possible (Singer, 1961; Glaser, 1978), which can be achieved by sticking to all of the available, relevant data (Miles and Huberman, 1994, p.144) and by iterating continuously between the ideas (theory) and the evidence (data) (Ragin, 1987; Eisenhardt and Graebner, 2007). Furthermore, Glaser (1978) suggests that a good theory is one that is relevant to the core of what is going on; that can be used to explain, predict and interpret what is going on (Miles and Huberman, 1994, p.144).

When developing the models I stuck closely to the data, iterating back and forth between the causal networks of the individual usability issues on the one hand and the causal models, interviews and documents on the other hand. Secondly, to verify the accuracy of the models I performed a member-check (Miles and Huberman, 1994, p.163; Malterud, 2001b) at the company were the study was performed. The models were considered an accurate description of how usability was dealt with at AV@home. Secondly, addressing the other aforementioned criteria, the models are very relevant to the aim of the study as they can be used to explain and especially to interpret and communicate how usability is dealt with in product development of electronic consumer products. The models were induced based on a case study in which they are thoroughly grounded, but I have not validated them by comparing them with new, independent evidence, nor have I assessed their generalizability to other product development groups (neither within or outside of AV@home's parent organization). The models are a first step in interpreting, explaining and communicating how usability is influenced in product development of electronic consumer products.

Retrospective analysis: limitations in reconstructing timelines

Though Eisenhardt and Graebner (2007) state that in retrospective cases interviews are an efficient source to build up the number and depth of cases, when analyzing the history of usability issues it proved to be very hard to separate the *design* of solutions from their *implementation*. When designing, possibilities of implementation are already taken into account. Interviewees could recall much better what designs couldn't be implemented because they ran into obstacles, than what all the options were that they had considered, maybe even for just a moment. It proved nearly impossible for interviewees to fill out the timeline of the discovery, discussion and (possibly) improvement of usability issues, as indicated on the back of the sensitizing cards. They could describe in quite some detail the events that had taken place and the reasons for taking decisions etc, but could not identify at what point in time or in what phase of product development these had taken place.

Multidisciplinary approach: less between-source triangulation

Eisenhardt and Graebner (2007) state that interviewing informants with diverse background strengthens a qualitative study, because it offers multiple perspectives of the same subject and prevents retrospective sensemaking of a (sensitive) issue by a single informant. In this study interviewing people with different backgrounds indeed proved to be an advantage as interviewees rarely pointed out their own contribution to a usability weakness, but did point out what others had done or failed to do. As most of the interviewees acted this way, in the end I did get a perspective on the influence of all roles. However, the diverse backgrounds of the interviewees led to limited overlap in the causes that interviewees attributed to an issue, whereas Yin (2009) mentions triangulation of sources as one of the methods to ensure some accuracy in case studies. However, due to the difference in background and involvement in the project of each of the interviewees, the lack of overlap in explanations is neither surprising nor problematic.

More usability weaknesses than strengths

Much more information surfaced when discussing usability weaknesses with the interviewees than when discussing usability strengths. The interviewees were able to recall and explain much better what had gone wrong and why, than what had caused a certain aspect of the product to be very good in terms of usability. Because of this lack of information on the usability strengths, the results of the study apply more to usability weaknesses than to usability strengths.

The sensitizing card set

We experienced the sensitizing cards as an effective tool to get the interviewees to recall the project and to keep the focus of the interview on the usability issues. However, because the interviewees themselves performed the selection of what cards to discuss, selection bias may have occurred in the sample of usability issues that were discussed. The usability issues that interviewees wanted to talk about usually were those issues that they had put a lot of effort into, were frustrated about or knew a lot of. Usability weaknesses that had escaped the attention of the interviewees during product development were usually not selected for discussion and sometimes even dismissed as untrue. This may explain the large role that was attributed to a lack of mutability in the rise of usability weaknesses: the team members were less likely to be conscious of a usability weakness that was caused by not knowing about the problem than of a problem that they did know about but could not fix.

Researchers lacked knowledge and understanding about usability issues

We had not personally conducted any of the usability studies on which we based the overview of usability issues per product. This proved to complicate the selection of usability issues for the card set, as we had no ‘feel’ for the issues and sometimes not even a clear understanding. During the interviews this also prevented us from providing interviewees with extra details about a usability issue if they inquired about it. The problems due to our lack of knowledge and understanding align with the conclusion from this study that using a high-resolution medium facilitates the knowledge and understanding of usability issues. When conducting a similar study it seems recommendable for the researchers to personally conduct or at least be present during the usability studies.

Limited knowledge-transfer infrastructure at site

In the conclusions I stated that within AV@home communication of knowledge seemed to happen best through people. It should be noted that at the time of the research at AV@home there was a very limited knowledge-storage and transfer infrastructure. There was, for example, no project archive or information management system. This may have made the teams (even) more reliant on people to transfer knowledge and made it more complicated for us to get our hands on documentation about the development projects.

Chapter 6 | Conclusions, discussion and recommendations

Chapter 6

Conclusions, discussion and recommendations

The goal of this research was to obtain insight into how companies deal with usability in the current practice of product development of electronic consumer products. The primary research questions were:

- **How is usability dealt with in the current practice of product development of electronic consumer products?**
- **What factors in product development practice contribute to or obstruct the usability of electronic consumer products and how are these factors related?**

Because it was not yet known what variables are relevant, a (quasi-) experimental approach was unsuitable, and a case study approach was chosen.

Three cases studies were conducted. In study I (Chapter 3), an exploratory study, 19 product developers were interviewed at four companies in markets adjacent to electronic consumer products, namely automotive, professional printing, office coffee machines, and fast moving consumer goods. This study was conducted in adjacent sectors to get insight into how companies across different markets deal with usability, and to test and refine the research design and method.

In study II (Chapter 4), I interviewed 31 product development professionals at five development groups of electronic consumer products that developed personal media players, personal navigation, laundry care equipment, mobile phones and thermostats. The results of this study were descriptions of how each of these development groups was organized and dealt with usability as well as an overview of barriers and enablers for usability per company. The cross-case analysis resulted in mechanisms affecting usability clustered by the following main categories: 1a) Process: creating usable products, 1b) Process: evaluating usability, 2) Knowledge, 3) Team, 4) Project, 5) Company, and 6) Market.

In the final study (case study III, Chapter 5) three product development projects were studied at a development group of home audio and video products. Based on usage evaluations and documents we (myself and a fellow researcher) identified usability issues in these products, and then conducted interviews with 19 of the product development team members that had developed them, as well as studying documentation about their product development process. Based on the interviews I wrote a description of how the development group dealt with usability. Based on the interviews and an analysis of the origins of each usability issue I induced two causal models describing variables and the relations between them that influence (1) how usability issues are arise, are detected and improved, and (2) the generation of shared knowledge about and understanding of usability issues.

Paragraph 6.1 discusses the overall conclusions of the three case studies. The discussion (paragraph 6.2) contains a comparison to existing research, a reflection on the results, a reflection on the research design and method, and an evaluation of using a weblog as a tool for dissemination, dialogue and reflection. In paragraph 6.3 I provide suggestions for future research on usability and product development, and in 6.4 recommendations for industry.

6.1 Conclusions

In the following section I outline why making usable electronic consumer products requires an organisational approach, and then outline the four primary drivers for usability, which are collections of similar or coherent variables that influence usability. The four drivers are used as a structure to present the most salient mechanisms of barriers and enablers for usability in the electronic consumer products industry.

6.1.1 Creating usable products requires an organisational approach

At the start of this project I argued that research on usability in practice should focus on more than just usability evaluations; that it should investigate how usability is dealt with throughout a user-centred development process. Especially in cases II and III it was shown that the value of usability evaluations is in the follow up: what the team is willing and able to do with the information gained from the evaluation. Additionally, conceiving the initial idea or design brief, setting appropriate requirements and constraints, and implementing the design as planned, turned out to be tremendously important for the ability of a company to deliver usable products. User-centred *design* is not enough: the whole product development process needs to be user-centred.

The studies also showed that how product development takes place is only partly determined by the prescribed process. It also depends on the team that performs the process, how the project is set up, and the organization within which the project is executed. This in turn is influenced by the type of market a company operates in. The skills and attitudes of the product development team influence how the individual steps within the process are executed. The properties of the organization and the market a company operates in have a considerable influence on the resources that are available to a development team, and the conditions they have to deal with. Finally, the increasing functionality and networked character of electronic consumer products demand collaboration between development groups that previously were in charge of their own individual products. The ability to conduct a full-fledged user-centred product development process depends on the properties of the team that executes it, of the project they work in, the company they work for, and the market that company operates in. In other words: making usable products requires an integrated, organizational approach.

And with every element of the organisation that is more aligned with the end goal - making usable products - the chances increase that a company's products *will* be usable. But considering that the smallest details in a design may influence a product's usability, and then the enormous amount of details in products, and finally the complexity of product development: there's never a guarantee; just a better chance.

6.1.2 Four primary drivers for usability

Case study III resulted in the identification of four primary drivers for usability in product development. Drivers are collections of related or similar variables that influence usability. The drivers for usability are:

1) User-centred design proficiency: the ability to execute a user-centred product development process;
2) Shared knowledge within the product development team (about users, design solutions and potential usability issues);
3) Design freedom: the extent to which a development team is able to make the most appropriate design, determined by design mutability and available resources;
4) Prioritization of usability: the extent to which usability is prioritized during product development and within the product development organization.

Below I will discuss these four primary drivers and subsequently use them as a structure to discuss a number of mechanisms of barriers and enablers for usability present in the electronic consumer products sector.

User-centred design proficiency

User-centred design proficiency[27] refers to the ability of a product development team to execute a user-centred product development process. To do so, a user-centred product development methodology and methods should be available, and a development team should have sufficient knowledge of and experience with the methodology and methods.

Shared knowledge about users, design solutions, and usability issues

Knowledge in three areas was found to contribute to the creation of usable products: knowledge about the user group, potential design solutions, and usability issues.

---

[27] In Chapter 2 the user-centred design cycle was introduced, which encompasses analysis, synthesis, simulation, evaluation, decision, and iteration. Thus the term 'user-centred design proficiency' does not only refer to synthesizing designs, but also to the ability to analyze (e.g., field studies), simulate (e.g., prototypes) evaluate (e.g., user testing), and iterate (redesign).

Knowledge about the user group

Knowledge about the user group allows the product development team to set the right requirements and to prioritize the most important use cases in the product. It also facilitates the creation of user-centred designs.

Knowledge of design solutions

Having knowledge about available technologies, and interaction and product designs enables the generation of more usable solutions: both the quantity of solutions that designers can conceive (*more* usable-solutions) as well as the usability of the solutions conceived (*more-usable* solutions). Design solutions do not only refer to user interface designs; some usability issues can simply not be solved by a better user interface design, but need a better product or engineering design.

Knowledge about usability issues

Knowledge about usability issues allows the product development team to create more usable (re)designs. This knowledge can be obtained through a wide variety of methods (e.g., user testing, after sales feedback, and reviewing).

Design freedom

To be able to make use of knowledge and user-centred design proficiency, there needs to be 'design freedom', which is determined by the mutability of the design and the available resources. Mutability refers to the degree to which a design or product can and is allowed to be changed. The available resources, the scarce means that a team can apply to create and implement a design (such as time, budget, working hours and facilities), determine whether and how well activities can be executed and whether the most suitable design solutions (e.g., components) can be selected. Knowledge and user-centred design proficiency mostly influence the *ability* of a product development group to design a usable product, while design freedom influences whether that ability and knowledge can actually be *applied*.

Prioritization of usability

There are two levels on which the prioritization of usability plays a role: 1) the organizational support for usability, and 2) decision making in product development projects. The priorities that team members set influences requirement setting and designing, as well as the allocation of resources to design and implementation activities. Thus prioritization of usability has an influence throughout the whole product development process. Prioritization of usability in development projects is influenced by:

- Management and control mechanisms (e.g., key performance indicators)
- Team member values (e.g., products should always look good) and
- Anticipated consequences of design decisions (e.g., product returns).

6.1.3 Underlying mechanisms influencing usability in the electronic consumer products sector

Below, a description is provided of mechanisms of barriers and enablers that influence usability in product development of electronic consumer products. The mechanisms are grouped according to the four primary drivers for usability: user-centred design proficiency, knowledge, design freedom, and prioritization of usability.

User-centred design proficiency

Lack of user-centred design skills in product development teams
Usability specialists and interaction designers were roles that were most likely to contribute user-centred design skills to product development teams. However, usability specialists were not found to be an established discipline in the electronic consumer products industry. In many of the participating companies, usability departments had been established only recently, were not present at all, or were understaffed. Often the usability departments were considered to provide a service *to* the product development team, instead of usability specialists being *part* of the team. Early and throughout involvement of usability specialists and interaction designers was an exception.

In a number of companies usability-related roles were not fulfilled by people with an HCI-background. Often usability testers had a background in consumer or marketing research, and products, especially the physical part, were designed by people with an industrial design background (as opposed to interaction design). Their background seemed to negatively influence knowledge of user-centred design methods and skills to apply them.

User-centred design methods
The application of user-centred design methods varied between the cases; in the electronic consumer products industry early and throughout user-involvement certainly is not yet the norm. Pragmatic considerations, such as time, budget, available staff and facilities are a dominant influence on what user-centred design methods were applied.

- User research activities such as field studies were often mentioned as valuable, but limitations in resources (time, staff, costs) limited their application;
- When discussing what strategies were employed to create usable products most interviewees referred to things that *facilitated* making a usable design, such as 'considering the user perspective', having enough time, and methods for evaluating the design, but hardly made references to techniques or methods for synthesizing the design itself;
- With regard to evaluation, lab-based user testing is the most applied method.

Selecting appropriate functionality considered hard
Developing a product with (too) many and not the right functions was considered one of the biggest barriers for creating usable products. An additional negative effect of elaborate functionality is that due to their complexity these products cost more effort to design, evaluate and implement in a user-centred way. Too much and non-user-centred

functionality was considered to be influenced primarily by a desire to keep up with competitors, and by retail channels and sales departments demanding non-user centred requirements. Though it was widely believed that offering products with elaborate functionality would negatively influence usability, it was also believed that products with limited functionality are harder to sell. Product development teams did not seem to have trouble *identifying* possible functions for a future product, for example, by analyzing competitor products or observing users. What seemed to be lacking was a method to subsequently *select* the appropriate functions.

Lack of collaboration in product development teams

Most product development teams did not work in a style that Kleinsmann (2006, p.38) would label truly collaborative, i.e., actors from different disciplines sharing their knowledge about design content and process in order to integrate and explore their knowledge and to develop the new product. Teams were often distributed over different locations (within one city, but also in different countries), and those that were in one location were seated per discipline instead of per project. In only one product development group out in the case studies product development team members worked in collaborative project teams. In this development group team members from various departments were assigned to a project and worked together in a shared space (while maintaining in touch with their departments), which was experienced as positive by the interviewees. On the other hand, many informants in product development groups where a collaborative way of working had not been adopted expressed a desire to do so, or mentioned instances where they had found a way to work together face-to-face with a small group and found this effective.

Some of the design departments were positioned (or had positioned themselves) in quite an isolated position from the rest of the development group. Product designers and interaction designers were often only cooperating to a limited extent, limiting the influence of the interaction designers on the physical aspects of the user interface (such as displays, buttons and peripherals). Additionally, a separation between software and hardware development was observed, which possibly facilitated parallel (and thus faster) development, but that also led to lack of alignment between software and hardware designs. Usability specialists would usually be more affiliated with the software development organization than with the design and development of the hardware and the embodiment.

Overall, the disconnected way of working seemed to cause serious communication issues, which is especially relevant for dealing with non-quantifiable product qualities such as usability. Development engineers developed the technological platform without input from usability specialists or interaction designers, designers did not know limitations of a technological platform, (product) designers did not visit user tests, and interaction designers were not be present to advice software engineers when the latter had questions about how to implement a design. Communication within development teams was described as mostly occurring in a formalized setting such as project meetings or reviews.

No shared definition

Even though usability was considered a fuzzy and ungraspable concept by most product developers, none of the participating companies had explicitly defined usability, though in a few cases there seemed to be an implicit common understanding about usability. Only a few participants considered the lack of shared understanding with regard to usability problematic. One development group that had an implicit common understanding about usability, communicated through stories, slogans and examples, was very ambitious in and fairly successful at making usable products.

Experience fosters the 'feel for the user' and domain knowledge

As opposed to purely relying on process to ensure usability, informants pointed out several times that over time product developers can develop what they described as a 'feel for the user': an intuition about user needs and preferences, and usable solutions, which is gained through experience and is hard to transfer from one person to the next. Bearing this in mind it seems unfortunate that the results of usability evaluations were often not shared with the whole team. After sales feedback was mostly communicated to the product and project managers, and in many cases did not find its way back to designers, engineers and usability specialists, who would have appreciated receiving this information as they considered it very valuable. This lack of feedback prevented product developers from learning from their mistakes, and thus from improving their (design) skills.

In addition, domain knowledge (knowing a product, its eco-system and the market) was identified as beneficial for usability. A market researcher in the personal navigation industry believed that her company's single-minded commitment to the product category was an enabler for the usability of its products: "*We breathe navigation.*"

Both issues, the feel for the user and domain knowledge, seem to benefit from experience, from working in a sector for a continued period and receiving feedback about the usability of one's designs. As a product manager in personal media players put it: "*The worst thing to happen to a project is a new product manager and interaction designer because they want to change things you should not change. Everybody wants to leave their mark*."

Shared knowledge about users, design solutions and usability issues

Communication of usability issues: knowledge versus acknowledgement

Usability issues are often identified by a single person (usually the usability specialist), who then needs to communicate this knowledge to the rest of the team. As product development team members often consider usability a somewhat subjective and hard to quantify, the communication of usability issues was a critical step in the establishment of shared knowledge about and understanding of a usability issue. For a usability weaknesses to be dealt with effectively, the development team needs to understand it, but also needs to acknowledge and empathize with it. Creating acknowledgement of and empathy for usability issues was facilitated by using a medium with a high resolution (showing video or presence of the team during testing), if the issue was found in a usage situation with a high representativeness (this increases the confidence the team has in the accuracy of the results), and by a team anticipating to be able to deal with the issue (this increased the relevancy of the knowledge to the team members).

User testing most applied and effective method for evaluating usability
User testing with simulations and prototypes was mentioned most often - by far - as evaluation method. User testing with 'rough' prototypes such as paper prototypes, mock-ups, and PowerPoint presentations were reported as only being used to a limited extent. Expert appraisals of designs were commonly performed, but that was not the case for methodical usability inspections, such as a cognitive walkthrough.

Product development teams seemed to mainly take action to fix usability problems when the knowledge about usability issues they received originated from user tests. Possibly this is due to the 'official' status that user evaluations sometimes have in product development (i.e., a so-called 'gate' or 'milestone'), which requires a team to deal with user test results. In addition, user tests allow team members to witness usability problems first hand, which as mentioned previously increases their understanding and acknowledgement of the issues.

After sales feedback useful, but underexploited
After sales feedback, the information about a product that surfaces when a product hits the market, emerged as an underused but potentially valuable source of information about usability issues. This information was highly appreciated by product development teams because it originated from real-world users. It can be obtained from sources like customer service, satisfaction questionnaires, monitoring consumer and press reviews, and logging product use.

Knowledge about usable design solutions decreases with innovation
A user interface design that is known to be usable is a valuable asset that often evolves over multiple generations of products. Because even small changes in a user interface can result in large usability problems, innovating the user interface or a product as a whole introduces a huge risk of poor usability. Most product developers prefer to improve a product over generations, and to only innovate the user interface if it is really necessary. Developing a user interface paradigm (a user interface concept that can be applied across a product category, see Chapter 2, page 54) is a very effective means for sharing a usable user interface design across a product family and over generations.

Centralized development location + global user group = limited knowledge
Though having a centralized product development location can be positive for team collaboration, when the same company in addition sells its products worldwide the product development team members have less contact with the user group (as they do not live among them) and it is harder for them to conduct and be present at user involvement activities (if these are conducted in the target market), or user involvement activities have to be conducted with unrepresentative participants. This results in reduced knowledge of user group properties, needs and preferences, product usage and potential usability issues.

Design freedom

Design freedom decreases during development: need for early evaluations

Design freedom decreases as the development process progresses, as more and more of the available resources have been spent. In addition the design becomes less mutable because more and more design decisions have already been taken (and possibly implemented). This explains the need for early user involvement: in the early phases of product development it is still possible to fix usability problems.

Technological platform has considerable impact on usability

Some of the more serious usability weaknesses of products that I studied could only be improved marginally by changing the user interface design. In those cases an underlying (technological) problem had to be dealt with for the usability to improve, which often required a technological change or innovation. Purchasing a technological platform from third party suppliers, a trend seen in some sectors of the electronic consumer products industry, stifles product mutability, as third-party suppliers benefit from selling an identical platform to multiple clients. A product development group that does not have the capability to innovate technologically, because it outsources all technological development, reduces its ability to solve usability weaknesses.

Resources are dominant considerations

Time pressure and availability of budget have a high impact on user involvement and the creation and implementation of user-centred designs. Time pressure on product development projects is usually high, because of fixed deadlines, contracts with retail channels about product launch dates, and because of the high speed at which new technologies and models are developed. Companies that have short product development cycles and very distinct seasonal sales peaks seem to suffer from higher time pressure than companies with longer cycles and less strict deadlines. Secondly, dependent on the type of product, the available resources can be limited, because in certain categories of electronic consumer products prices are under pressure.

Increasing complexity of ecosystems

The increasing complexity of the ecosystem of electronic consumer products proved a challenge for product developers. If a company does not 'own' certain components, products or services this very much limits design mutability. But even if companies did produce multiple products of an ecosystem, alignment between products was often hard to achieve if these products were developed in different organizational units. On the other hand, one of the investigated companies changed its organization twice in order to have control over the eco-system, which according to the informants contributed to an improved level of usability in their products.

Though standardization was also suggested as a way to ensure that users would have an ecosystem of products that work well together, it was also indicated that it is very hard to agree on an industry-wide standard because of the large amount of parties involved, and that some product developers don't adhere to the standards completely in order to motivate consumers to purchase all products from one (their) brand.

Prioritization of usability

Anticipated consequences

Many informants considered usability a fuzzy and intangible concept, which made it hard for them to assess the usability of a design or product. In turn this made it hard for them to assess 1) the potential consequences of a usability issue for the consumer reaction once the product was on the market (e.g., will users really consider it problematic or not, will it cause complaints, product returns?), and 2) the consequences for the project of fixing a problem (e.g., time, working hours, budget). Usability is not easy to quantify and thus hard to include in a risk analysis, which makes it harder to assess and communicate about usability issues than about, for example, the reliability of a technical component. Because usability was considered ungraspable, and its consequences hard to assess and relatively long-term, product development teams were likely to consider usability less important than concrete, short-term considerations such as product reliability, aesthetics, functionality, and project budget and deadlines.

Most of the informants did not believe that for buyers usability was an important purchase consideration, as opposed to price, functionality, performance and styling. Neither was usability considered the most important reason for customers to be unsatisfied, return the product, or complain or ask for support. In contrast, reliability problems were considered a very important reason for consumers to return or complain about products. If this perception is correct, the usability of electronic consumer products being under pressure is partly due to the priorities that consumers set during purchase: if usable products do not result in a commercial advantage (improved sales and/or improved satisfaction) product development companies are less likely to invest in creating usable products.

Usability is unlikely to be, and maybe *should* not be, more important to development teams than consumer appeal (during requirements and design) and reliability (during implementation). A company that would not value consumer appeal and reliability over usability would soon cease to exist because it would not sell any products and would suffer immense numbers of product returns.

Values

Whether development team members value usability seems dependent on the benefits for the company that team members attribute to usability (e.g., that usability is important to the target group, that it improves sales, and prevents costs), on whether the company's brand position or strategy includes usability-related statements, and on whether a company culture is user-centred.

Usability is more likely to become a part of the company culture if upper management or a 'usability champion' promotes usability, and if the company's brand position includes usability. The degree to which team members are exposed to users (i.e., in field studies or through user testing) was also seen as a contributor to a more user-centred attitude.

Management & control mechanisms
In addition to the rational mechanism of anticipated consequences and the more belief-oriented influence of values, introducing management and control mechanisms can influence the prioritization of usability in product development. Product developers can be given incentives to prioritize usability in the form of (1) bonus or performance indicators, (2) usability assessment in stage-gates of the development process, and (3) providing development teams with design and process guidelines.

Introducing customer satisfaction as a performance indicator was reported to increase the prioritization of usability, both because it influenced a team member's financial reward, but also because it was a clear signal from management what they considered important.

Introducing usability as an element of a stage-gate or milestone in the development process forced product development teams to consider how they would deal with usability and take action. Additionally, it is a way to attach short-term consequences to usability: the project will not pass to the next phase if usability has not been paid attention to or is not at a certain level. As with performance indicators, including usability as an element in stage-gates is also a way for management to communicate priorities.

Finally, providing teams with design and process guidelines is a way to guide their actions and to counter the default tendency not to prioritize usability. For example, if there is a guideline that a certain font size has to be used, it is no longer a decision for the team to make. Thus the prioritization of usability in these decisions is ensured by the guideline.

6.2 Discussion

In the first part of the discussion (subpar. 6.2.1) the results of this research are compared to existing literature on usability in product development practice. Next a number of salient findings are highlighted and discussed in subparagraph 6.2.2. In the reflection on the research design and the method (subpar. 6.2.3) I discuss the trustworthiness of my studies, by reviewing their credibility, transferability, dependability and confirmability. Finally, in subparagraph 6.2.4 I reflect on the use of a weblog as a tool for dissemination, dialogue and reflection.

6.2.1 Comparison to existing research

In the review of existing research on usability in practice (subparagraph 2.1.1) I discussed a number of themes in existing literature on usability in product development practice. Below I compare my findings to these themes. It should be kept in mind that most of the existing studies had been performed in software and IT system development, so the following can be considered more of a comparison between industries than as a confirmation of previous findings.

Many existing studies point out that user involvement is a very important enabler for usability, but that early and throughout user involvement in the product development process is often limited. I reached similar conclusions based on the findings in my case studies. A second finding that was congruent with previous studies was that there was considerable variation in which methods for user-centred design were applied, but that user testing was found as the most commonly applied method. The most dominant reasons for choosing a specific user-centred design method (i.e., lab-based user test, field study, cognitive walkthrough) were pragmatic: required costs, time, effort, and skills. Contrary to findings in previous studies, I did not find usability inspection methods to be commonly applied. A cause for this may be that in the electronic consumer products sector the knowledge and/or acceptance of usability inspection methods do not seem to be at the same level as in the HCI community.

The case studies conducted in this project confirm earlier findings that whether a product development process facilitates user involvement and the iteration of a design are important enablers for usability. In my studies especially iteration was a salient issue: often knowledge about a usability issue could not be acted upon. In existing literature concerns are found with regard to prescribing a user-centred development process, as this may lead to inappropriate methods being applied and a check-box mentality with regard to these methods ("Management wants us to do this. Let's do it and be done with it."). Informants in my studies also expressed this concern, though it was also suggested that prescribing a user-centred methodology or methods could ensure that there would be sufficient time, budget, and staff.

The widely reported finding that user-centred product development requires a multi-disciplinary approach and that teams should have user-centred design skills (early in and throughout the project) was confirmed. The suggestion by some authors that a team member's domain knowledge (knowledge about a sector or product category) might positively influence usability also surfaced in my studies.

Team collaboration and communication proved a very salient theme in the studies I conducted, even more so than in existing literature. Whereas in existing literature a shared understanding of usability and terminology for user-centred design was often mentioned as an enabler, I found that very few product development groups had a shared understanding of what usability was.

The subject of presence and position of usability specialists also surfaced in my studies. As was found in most previous studies, I concluded that usability specialists and interaction designers should be an integrated part of the product development team, but that in many cases early and throughout involvement of usability specialists is not yet common. Whereas usability departments in software industry seemed to have been present for some time, in my studies usability departments were often quite young and not fully developed.

Two subjects in existing literature with regard to design - whether an explicit design phase should be present in the development process and whether usability specialists should have design skills - were less of an issue in my case studies. As opposed to in software development, in the development of electronic consumer products the design phase and design departments are well established.

Organizational support for usability is a very dominant theme in existing literature, and this is also the case in my studies. As in literature, a company culture and upper management that promote usability were identified as important enablers, as was the individual attitude of team members towards usability. As in previous studies, creating understanding for usability among colleagues and explaining the value of user-centred design was considered important by many usability specialists. Similar to mechanisms described in previous studies, I found that in electronic consumer products the anticipated benefits of usability are sometimes hard to grasp and long-term, which may lead to a reduced priority, which in turn leads to usability being compromised in decision-making. Finally, as opposed to what was reported in a number of existing publications, the inclusion of usability-related project goals was not an important subject in case study II, though in the final case study the development group was observed to have included a certain 'level of usability' in the stage-gate criteria of product launch.

6.2.2 Reflection on the results

Here I highlight a number of salient findings from the case studies and relate them to literature about that subject.

Being user-centred: process or people?

In literature, having a user-centred product development process is mentioned as one of the primary safeguards for usability and in my studies many interviewees believed that a company's 'official' development process should facilitate or even prescribe the application of user-centred design methods. However, I also encountered informants that expressed a concern with regard to mandatory user involvement in the product development process. They feared that this would lead to a checkbox mentality in teams, causing them to 'go through the motions' instead of applying user-centred design methods because they need and want the results. Secondly it was thought by some that the development process should by tailored to the specific needs of each product development project, that a single one-size-fits-all process cannot be applied to all projects.

Bødker *et al.* (1998, p.109) suggest that a way of working should not be cast in stone as methods are made by working in specific contexts and situations and designers use their experience in adapting rules, procedures, and methods to actual situations. Jenkins (2008) argues that a prescribed process clashes with how designers prefer to work:

> *"The cult of rigorous process as salvation insists that an activity will produce a good outcome if only the people concerned follow a rigorous procedure (which all too often*

> *means applying a set of preordained steps without having to think too hard). Designers, however, prefer to proceed with a flexible toolbox of heuristics and an agile, curious mind."*

Some interviewees argued that a company culture could provide a 'pull' for user-involvement: product development teams should *want* to apply user-centred design methods, because they see the value of it. These interviewees argued that being user-centred (also) refers to the people that execute the process, not (just) to the process itself. In support of this notion, Löwgren and Stolterman (1999) argue that only optimizing a development process is ineffective if no attention is paid to improving the skills and abilities of the designers: "*The results of any process will never be better than the people who participate in the process.*" Gullikesen et al. (2006) argue that focusing solely on process is undesirable as they consider qualifications and skills, as well as knowledge and experience, as inseparable from the individual. Fred Brooks, author of 'The Mythical Man-Month', dismisses the value of process by claiming that: "Great design does not come from great processes; it comes from great designers" (Kelly, 2010).

Fostering the 'feel for the user' by providing developers with feedback

I found that quite often the results of user tests and after sales feedback (e.g., customer service calls, customer satisfaction questionnaires) did not make their way back to the designers and engineers who had created the product, a phenomenon that was also observed by Busby (1998). Apart from being experienced as frustrating by the developers involved ("*I never know what people think of my product*"), it might be argued that not exposing product developers to user tests and after sales feedback limits their ability to learn, as getting feedback on actions is an essential part of a learning system.

There are several authors that argue in favour of providing professionals with feedback about their actions. Ulrich and Eppinger (2004, p.3) state that one of the characteristics of successful product development is an increase in development capability:

> *"Are the team and the firm better able to develop future products as a result of their experience with a product development project? Development capability is an asset the firm can use to develop products more effectively and economically in the future."*

In other words: a product development project is a possibility to learn. However, Ackoff (1989) defines a 'complete learning system' as one that detects errors, diagnoses them and prescribes corrective action, thus implying that in a system that does not include detection and diagnosis of errors (e.g., team members not receiving feedback) learning will not occur. In support of this, Lauche (2005) identified feedback about results as an important element for corrective action and learning. Exposure to feedback enables understanding, which in the end may result in product developers who are able to take useful action, because they can synthesize new knowledge from what is previously known (Ackoff, 1989).

The powerless designer

This is an era in which business leaders have embraced design, in which 'design thinking' is encouraging managers to think like designers, be solution-oriented, and think up technologically and business-wise feasible, market-changing opportunities (Brown, 2008). Design is finally becoming a powerful discipline, also because product appearance is attributed with being a competitive advantage (Bloch *et al.*, 2003). In scientific journals on design, as well as in the Delft curriculum, designers are often considered the 'spider in the web', integrating and coordinating the efforts of specialized disciplines. I found that though design thinking is being embraced, and strategic design consultancies like IDEO may have gained a seat at the board-room table, in-house designers in large-scale product development companies, which often feature a considerable specialization and separation of roles and departments, hardly ever work in integrated design teams and are often left what can only be described as powerless. They are not involved in user research because that is what the market research or usability specialists do, they do not set the requirements because that is what product management does, and often they do not even design, as they only get a mandate to 'skin' a product: get the appearance of a product to align with the corporate design language. Finally, designers I interviewed reported that during implementation they are often left to wonder why the engineers mutilate their design into something they hardly recognize as being based on their design.

In part the blame may be put on the uncollaborative way of working of many product development teams in the electronic consumer products industry, in which team members all work in their own departments and only perform the tasks they are assigned. Designers are only brought in when the design actually has to be made. Thus they have little opportunity to discuss the requirements with the product managers and planners, little opportunity to familiarize themselves with the project (including user research and the limitations of the technological platform), little time to create the design, and are often left out of the loop during implementation and thus cannot propose alternative solutions that keep the integrity of their design intact.

However, designers may also have themselves to blame. Some designers, and this seems to apply especially to industrial designers, have isolated themselves in design departments, claiming that they are 'different' and should be somehow independent. Sometimes they adopt a consultancy-like role even though they are a part of the same company as the rest of the product development team, thus very effectively placing themselves in a position where it is easy and even preferable - because it is cheaper - to involve them as little as possible. Unintentionally, by wanting to be labelled as 'different' and 'special' these designers have effectively contributed to what Jenkins (2008) refers to as the design-unfriendly cult of competition and empire building. When writing about 'designers', design researchers should describe the designer they are studying or have in mind, as the role designers have and the environment they work in can seriously influence the work they do.

Include iterations to simulation and evaluation in the basic design cycle

The basic design cycle as visualized by Roozenburg and Eekels (1991, p.79) does not include iterations to simulation and evaluation activities (see Figure 22, page 53). This suggests that if an evaluation leads to the conclusion that a design does not meet the criteria that were set based on analysis, it is not questioned whether simulation and evaluation were conducted appropriately and changing the simulation setup or conducting a different evaluation is not an option. However, in all three case studies I found evidence that development teams question, adapt and repeat simulations and evaluations, and that thus these iterations should be included in the basic design cycle. For example, it was found that if product development team members disagreed with the results of a user test they would question the representativeness of the participants or of the prototype. Another example is that usability specialists were often conscious that the type of evaluation method applied - e.g. cognitive walkthrough versus user testing or goal-based versus task-based user testing - could influence the findings. These examples show that when considering the outcome of an evaluation, product developers question the simulation and evaluation, which suggests that iterations to these activities should be included in the basic design cycle.

Managing by resources or by goals?

In literature on usability in practice as well as in the case studies upper management was considered an important power broker when it comes to taking decisions that improve usability, as well as to establish a user-centred process, team, and culture in a company. This does require upper management to understand usability and its potential value, especially when making decisions in development projects, as decisions that improve usability may result in higher costs and postponed deadlines. It is the classic trade-off of product quality against resources (time, budget, staff, equipment). In companies that were more likely to prioritize product (usability) over project (resources) upper management often knew their products inside out, understood what usability meant for their products, and prioritized usability. In contrast, some product developers had to deal with corporate management that knew very little about the products their company made, and who (as a consequence?) almost solely managed on resources. Or, as one product developer I spoke to put it: "What do you say when you make personal audio players and upper management thinks that 'this MP3-thing will blow over?'"

Including usability in performance indicators

The product development group that I studied in study III used customer satisfaction as a performance indicator, as suggested by Reichheld (2003). It seems that this did not only provide an indication for product developers as to what their priorities should be according to management, but also made the effects of usability visible and quantifiable. Quantification of non-quantifiable product qualities (NQPQs), such as 'design' or 'usability', is one of the strategies that Guldbrandsen (2006) identified that companies use to be able to deal with non-quantifiable product qualities. Using customer satisfaction as a performance indicator seems a way to balance some of the long-term interests of the company (satisfied customers, repeat sales) with the more short-term interest in the individual product development projects (introducing the product on time, on budget, and selling lots of it).

Prioritizing usability: comparing web, software, and consumer products

As pointed out, prioritizing usability during product development has a considerable impact on the usability of electronic consumer products. However, there are several mechanisms causing product developers not to prioritize usability in design decisions. Jakob Nielsen (2004) argues that one of the causes for consumer products (like cars and home audio and video equipment) to suffer from poor usability is a lack of prioritization of usability, which he attributes to buyers not having a user experience until after they have purchased the product. In the case of consumer products, people first play the buyer role, and only then the user role (see Chapter 2, page 42). Nielsen as well as other authors (Donahue, 2001; Mao *et al.*, 2005) point out that the reverse is true for e-commerce websites, such as web-stores (books, consumer products, real estate) or online content suppliers (news, streaming video). In these cases people need to be able to interact with the website before they can generate profits for the company owning the website: first people are users, and only then do they become buyers. Similarly, in the case of consumer software, people can often try a free or discounted version of the software before purchasing the complete software, which makes them able to experience the product before purchase, including usability.

BOX TEXT

"Yes, but Apple..."

While conducting the case studies I found that putting the subjects 'usability' and 'electronic consumer products' together in a sentence leads to discussing Apple more often than not. The 31 interviewees in case study II spontaneously mentioned Apple 43 times and the iPod 32 times (the iPhone was not yet on the market). Indeed Apple's products are often described as being usable (Linzmayer, 2004; Young and Simon, 2005; Vogelstein, 2008) and its products receive positive reviews from usually critical reviewers (Mossberg and Boehret, 2007; Levy, 2009; Pogue, 2010). That does not make the company perfect: it has produced its fair share of failed products (Kunkel, 1997) and flaws can be found in Apple's UI designs (Nielsen, 2010). I have no means of confirming that the usability of Apple products is truly as high as it is often regarded. I do know that many product developers consider it a company that makes very usable electronic consumer products. Therefore it may deserve some attention in this thesis. I took the following approach. The case studies produced barriers and enablers for usability and the relations between them. By studying literature on Apple and its products I identified properties of Apple that had been marked barriers and enablers in the development groups I studied. I only included those properties of Apple that can be confirmed by observing the company 'from the outside'. So below are only those properties of the Apple that I can confirm first-hand, and that were described as barriers and enablers in the case studies.

Owning the ecosystem

Many product managers in the studies I conducted complained about the lack of control their company had over the product's eco-system (see page 31), which limited the implementation of usable designs.

> Apple controls many (if not all) components of the eco-system required for its products to function (Young and Simon, 2005; Buxton, 2007, p.279; Breillatt, 2008). For example with the iPhone the company controls the hardware (iPhone), firmware (iPhone OS), software (apps), symbiotic software (iTunes), content delivery service (iTunes Store) and software delivery service (AppStore).

Evolution of UI designs

In the studies I conducted, developing products over generations was identified as an enabler, whereas innovating the user interface was considered a barrier for usability.

Apple's products and user interfaces usually evolve over time, which allows them to be improved over generations, as for example with the iPod (Buxton, 2007, p.56-57).

Own retail

Several product development groups in the case studies reported that because they were dependent on retailers and service providers to sell their products to consumers, they could not change product release dates and were sometimes forced to include non-user-centred requirements. Secondly, product developers often pointed out that they believed that for buyers usability was not an important purchase consideration, because usability can only be experienced after purchase.

> Apple has set up a chain of Apple stores and selected Apple resellers, where consumers can try products and get advice and help from knowledgeable in-store assistants. This allows people to experience the user experience of Apple's products first hand before having purchased them (Lincoln and Thomassen, 2007, p.127).

Premium products

In my case studies having premium products was mentioned as positively influencing a company's capability to direct sufficient resources at product development.

> Apple's products are premium priced.

Technology

Many of the participants in my studies described how the lack of control over the technological platform was a barrier for usability.

> Apple does not base its products on 'as-is' third-party technological platforms, but develops its own custom platforms (which may include 'outside technology'). The company recruits skilled engineers, and purchases companies that develop technologies it considers essential (Young and Simon, 2005, p.268; Vance and Stone, 2010).

6.2.3 Reflection on the research design and method

Though I might be somewhat of a 'suspect advocate', in this section I review the limitations of the case studies that were conducted to provide an indication of their trustworthiness. To do so I relate the research I conducted to four criteria for trustworthiness for qualitative studies, as suggested by Guba (1981):

- *Credibility:* Deals with the focus of the research, and refers to confidence in how well the data and process of analysis address the intended focus (Malterud, 2001b). This is qualitative researchers equivalent of 'internal validity' (Shenton, 2004).
- *Transferability:* Refers to the extent to which the findings can be transferred to other settings or groups (Malterud, 2001b); in qualitative research this is used in preference over the term 'external validity' or 'generalizability' (Shenton, 2004).
- *Dependability:* The qualitative researcher's equivalent of reliability, which in quantitative studies refers to whether the results would be similar when repeated with the same methods and participants (Shenton, 2004).
- *Confirmability:* Refers to whether the work's findings are the result of the experiences and ideas of the informants, rather than the characteristics and preferences of the researcher (Shenton, 2004).

For each of these criteria I will discuss below how I addressed them (or not) in the case studies. For each of the criteria proposed by Guba (1981), Shenton (2004) suggests provisions that the qualitative researcher may employ to meet them, and Malterud (2001b) provides an overview of guidelines to assess the quality of qualitative research. These provisions and guidelines are the basis for the following evaluation.

Credibility

In order to address this issue I will discuss whether the aim of this research was sufficiently defined, whether the research design and methods were appropriate and well-established, the influence of using interviews as a primary source of information, how cases and participants were selected, whether thick descriptions of the phenomenon under study were provided, the background of the investigator(s), peer scrutiny and debriefing sessions, and finally the execution of member checks.

A well-defined aim

To be able to assess whether the design of a study aligns with its aim, that aim must be well defined (Malterud, 2001b). In the introduction I argued the relevance of studying the practice of usability in product development and provided a clearly stated aim: identifying what factors in product development are barriers and enablers for usability.

Research design and methods

Credibility is improved if researchers can motivate why a qualitative research approach was appropriate, and if established qualitative methods have been applied (Malterud, 2001b; Shenton, 2004).

• *Research design:* In Chapter 1 I argued why insight into how usability is dealt with in product development practice is needed, and why the current state of the art does not provide this knowledge. Thus the goal of this research project became to explore what factors influence usability in product development. A survey of literature produced a number of factors, but because most of the existing studies on usability in product development practice had been conducted in software and IT systems development, I could not rely on the same variables and relations being present in and relevant for the electronic consumer products industry. This lack of insight into the relevant variables made a (semi-) experimental research approach unsuitable. Therefore I considered a qualitative approach appropriate, as this would allow for the identification of factors that influence usability in product development. According to Miles and Huberman (1994, p.10) qualitative research can provide a "*strong handle on what 'real life' is like*" and "*has often been advocated as the best strategy for discovery, exploring a new area, developing hypotheses*".

• *Methods:* When conducting the case studies I relied on established qualitative research methods, provided an in-depth overview of how the methods were applied, and when modifying established methods provided a motivation for this as well as a description of the modifications. I applied case studies as the main research method, as case studies are a suitable methodology for explanatory studies into "*a contemporary set of events over which the investigator has little or no control*" (Yin, 2009, p.13). While analyzing the data I applied and adapted established methods for qualitative data analysis from, among others, Yin (2009), Miles and Huberman (1994) and Malterud (2001b).

• *The impact of interviews as primary information source:* Though in the final case study documents and products were also used as a source of information, the case studies were primarily interview-based. Interviews are an efficient way to build up the number and depth of cases, which enable a researcher to cover more informants and include more cases (Eisenhardt and Graebner, 2007). Additionally, as pointed out in the introduction, I was very much interested in the perspective of product development practitioners on how to deal with usability in product development. Through their (possibly extensive) experience they may arrive at insights that outsiders, such as researchers, might not encounter.

However, apart from the commonly known disadvantages of interviews such as poor recollection or bias, this choice may have influenced the results in additional ways. I noticed that the interviewees rarely were very critical of themselves. Deliberately or not, they would not often remark that they lacked a certain skill, or had executed a project poorly. More often did they point to external factors that limited or enabled them, which also included other actors. However, Eisenhardt and Graebner (2007) do point out an advantage of interviewing informants with diverse backgrounds, as was done in this research, is that it offers multiple perspectives of the same subject and prevents retrospective sensemaking of a (sensitive) issue by a single informant.

I also found that, in study II, when discussing the product development process and the methods applied within that process, interviewees would describe *what* steps were executed, but these descriptions were not very much in-depth, and in study III, when discussing the timing of events in specific projects it proved very hard for the interviewees to reproduce a chronology of events. For studying exactly what steps are executed in a product development process and how they are executed, a real-time study of product development projects seems more appropriate.

• *Ensuring honesty in informants:* In accordance with Shenton's (2004) suggestions I encouraged participants to be frank, and aimed to establish rapport early on or before the interviews. It was stressed that the researcher belonged to an independent research institution and was not conducting the study on behalf of the participating company. Every interviewee was guaranteed that his/her identity would not be disclosed inside or outside of the company.

Data collection and sampling
Shenton (2004) suggests that sampling of informants should be random to negate for researcher bias, whereas Malterud (2001b) considers it more important that the strategy for data collection is clearly stated, motivated and aligned with the study's research questions.

• *Case sampling:* The sampling of companies was purposeful. First I conducted a case study at four companies operating in sectors adjacent to electronic consumer products, with deliberate variation in the products these companies made. The second case study focused on the electronic consumer products sector, involving five companies that did not directly compete. Selecting companies that did not directly compete was initially done for confidentiality reasons, but it also provided for a certain degree of variation in products and market properties among the cases. Finally, in the third case, I 'zoomed in' even more, investigating three development projects within one development group. For all case selections the criteria and considerations were provided in the method sections.

• *Sampling of informants:* With regard to the sampling of informants, a purposive approach was followed. In the beginning of the project I reviewed existing literature on product development and usability in practice, and conducted exploratory interviews with four experts on usability in product development. Thus I arrived at six roles to focus on while conducting the case studies: the product manager, market researcher, product designer, interaction designer, development engineer, and usability specialist. Throughout the case studies people fulfilling these roles were interviewed. This ensured that for each site I received multiple perspectives on the same phenomenon, which allowed for triangulation.

• *Sampling of usability issues:* Finding out what makes products usable proved much more problematic than finding out what caused products to feature usability problems. In study II the barriers and enablers mentioned were often related to the prevention of usability problems, not to making a product that excels in terms of usability. In case study III the sources based on which the usability issues were identified contained much more information on usability problems than on usability strengths. This is logical, as usability evaluations are usually conducted to find out what can be improved. But it also seemed that it's easier to identify a usability problem than a usability strength. When is something a usability problem? When the user or observer notices that effectiveness, efficiency or satisfaction of the interaction is suboptimal. But does this mean that something is usable if it lacks usability problems? Or can something also excel in terms of usability? Usability has been described as being like oxygen: it's everywhere around us, but we only notice it when it's gone.

In addition, in case study III the interviewees found it relatively easy to suggest causes for usability problems, but could hardly provide any explanation for the usability strengths. It is like asking a colleague who has just finished her routine commute how she managed to make it to work without having an accident. She may well have trouble answering that question. But if she had had an accident she would probably be able to single out a few situations that amounted to the accident. People are more prone to notice what deviates from the norm, what goes wrong. This makes it harder to identify usability strengths and the contributing factors in product development.

Thick descriptions
Detailed or 'thick' descriptions of the cases can promote credibility, as these help to communicate the actual situation that has been investigated as well as the contexts that surround them (Malterud, 2001b; Shenton, 2004).

For each of the cases an in-depth description of the case context (the product development group) is provided, which enables the reader to understand the properties of the product development group. This understanding could help a design researcher conducting a similar study on usability in product development practice to explain similarities and differences with this research. Secondly, in-depth context descriptions could enable product development professionals to assess whether the conclusions and recommendations of this study apply to their company.

Apart from the context descriptions, in study II the Trace tool provides peer reviewers access to in-depth descriptions (the original interviewee quote, in combination with the researcher's interpretation) of the barriers and enablers that were identified. In case III, how the product development group dealt with usability was described in-depth and illustrated with quotes, and the variables and relations between them in the causal models are supported with examples.

Investigator background
The credibility of the researcher is important in qualitative research, as s/he is the major instrument in data collection and analysis (Shenton, 2004) quoting (Patton, 2002), and therefore biographical information about the researcher(s) should be supplied. Malterud (2001b) also points out the importance of disclosing the researcher's background, as well as the motives for the study, perspectives and preliminary hypotheses.

In the introduction I provided the motives for and context of my research. In the back of this thesis a CV is included of the primary researcher (the PhD candidate), and in each of the case studies a concise description is included of each of the other researchers that executed and supervised the case. Each of the researchers involved is knowledgeable in at least one of the following domains: product development, usability, and design research.

The less-experienced researchers worked in close collaboration with and under supervision of more experienced researchers.

Debriefing sessions and peer scrutiny

Shenton (2004) suggests that during the execution of a qualitative research project, frequent debriefing sessions, in which the researcher can discuss the setup, execution and results of the research with supervisors or colleagues. Secondly he argues that opportunities for peer scrutiny by colleagues, peers and academics should be welcomed.

In the exploratory study (case study I) the research assistant cooperated with the author of this thesis, and was supervised by experienced researchers. In study II, when identifying barriers and enablers, for two out of five cases all interpretations by the primary researcher were checked by a second researcher, and for the third case the second researcher verified interpretations that the primary researcher doubted. In case study III, the primary and secondary researcher discussed and verified each other's interpretations. Overall, being a PhD candidate, the primary researcher continuously discussed the setup, execution and results of the studies with his supervisors, who are experienced researchers and practitioners in usage observation, ergonomics, and product design and development. During the course of the research project presentations about the project were held at conferences, and at other gatherings in the academic community.

Member checks

Member checks have been suggested to be the most important provision to enhance a study's credibility (Shenton, 2004) quoting (Lincoln and Guba, 1985).

For all of the cases, context descriptions have been verified by at least the primary contact in a company, and in some cases also by other informants. At the end of each case study a feedback and verification workshop was held during which the informants could comment on the findings. The readership of the researcher's weblog was invited to comment on the recommendations for industry.

Examination of previous research findings

To assess the degree to which a project's results are congruent with those of past studies, an examination of previous research findings should be conducted (Shenton, 2004).

In Chapter 2 a review of the state of the art of research on usability in product development practice is provided, and in paragraph 6.2.1 of this chapter the results of this research project are compared to existing findings.

Transferability

In order to address this issue I will discuss the number of the organisations that participated in this study and where they were based, the number of participants taking part in the study and how these were recruited (Shenton, 2004), and the implications of this for the transferability of the results.

Number, locations and industries of participating organisations
All case studies featured a multiple case design: four companies in adjacent sectors to electronic consumer products (study I), five electronic consumer products companies (study II), three product electronic consumer products development projects (study III).

In study II all product development groups were based in Europe and active in the domains of professional printing, high-end automotive, office coffee machines, and fast moving consumer goods. In the second case study, four product development groups were based in Europe, and one in Asia. These development groups were active in the following markets: personal media players, personal navigation systems, laundry care, mobile phones, and thermostats. Study III was executed at an Asia-based developer of home audio and video products. Both Asia-based development groups were subsidiaries of a company operating worldwide.

Differences between sectors
On a generic level product development processes proved similar across sectors. For example, they all featured idea formulation, requirement setting and implementation, and often there was a distinction between an explorative pre-development and a highly focused and structured development part. However, the character of the phases – what was done, for how long, and why – differed strongly between sectors. The differences between companies developing electronic consumer products were not so strong. Secondly, the prioritization of usability seemed to depend to a considerable extent on the product a company makes and the market it operates in. Because the prioritization of usability can have a large effect on user-centred design proficiency, knowledge and resources, how usability was dealt with varied considerably between product development groups. Again, the differences were most noticeable between the product development groups of case I. The type of product a company develops also influences the applicability of user-centred design methods, which seems one of the factors to cause the difference in application of these methods across companies.

Geographical differences
When discussing the results of the case studies with an experienced user-centred product development professional, who had worked in both the US and in Europe, I got the impression that there might be a difference between how established user-centred design is in the US versus in Europe. He said the following:

> *"European companies seem to be behind in how well they understand user research methodologies, ethnography, usability, and user experience as an end-to-end journey for their customers/users. They often don't have much internal expertise or integration of these methods into their existing research, innovation and product development, or for strategic product planning and marketing. Sometimes I see quite dramatically naïve organizations when it comes to user experience design, even within large, globally successful brands/companies in the EU."*
> *(Strategic interaction design consultant, personal communication)*

This notion is supported by the fact that both the ACM/SIGCHI and the Usability Professionals Organisation are US-based organisations and predominantly feature US members.

Differences between disciplines
Usability as a concept originates from the HCI domain. As do a large number of user-centred design methods. The largest contingent of UPA and CHI members work in the HCI domain. And most of the studies on usability in product development practice have been conducted in IT systems or software development. User-centred design seems to be more established in software development than in the development of electronic consumer products. However, the factors that influence usability, identified in the state of the art (paragraph 2.2, page 32), overlap considerably with the findings of the case studies. The mechanisms of barriers and enablers seem similar between the HCI and the electronic consumer products sector, but which of the mechanisms are most prominent my differ.

Changes over time
Finally, the electronic consumer products industry is one that changes quickly. At most of the development groups I studied, by now (the end of my research) major organizational changes have taken place, and the products they make have changed as well. These changes occur because parent companies decide to reorganize, product development is outsourced, markets become more mature or decline, new technologies or business models disrupt the status quo, or a development group grows and as a consequence needs to change the way it conducts product development. This is why the context descriptions included in this thesis are so important. They provide insight (as rich as was feasible to provide within the constraints of a thesis) into the product development context at the time of research.

The quickly-changing nature of electronic consumer products development groups also points out the value of generalization, of developing the causal models in case III. Even though the context differs between companies and individual companies change over time and thus how they deal with usability varies, the variables identified in the final case are present in all the case studies conducted. However, how those variables are set and how strong the relations to other variables are, differs per company.

It should be noted that the causal models in study III are based only on the data from this study; they have not been validated against new, independent cases, and as such should be seen as a first step. The 'usability issue lifecycle model' may be generalizable beyond the domain of usability; it might be a basis for design researchers studying other product properties such as sustainability, production quality and profitability. However, specific barriers and enablers that the electronic consumer products industry at the time of this research had may not apply to other sectors, as these depend to a large extent on the characteristics of products, market, and organizational structures that are specific to this sector.

Number of informants

Overall, interviews with 69 product development professionals were conducted and analyzed. Additionally, I had a large number of informal conversations with user-centred design professionals. The primary selection criteria for informants in all case studies was whether they worked in one of the six roles I had specified to be most relevant to usability, and in the final case study there was the additional criterion of whether they had worked on a specific project. The participants were recruited through the primary contacts within the development groups. Apart from the obvious practical reason that the researchers would not know who fulfilled what role in an organization and thus who to approach, by having the primary contact recruit the participant the researchers had no or limited influence in who was recruited. However, the primary contacts thus did have the opportunity to recruit (or not recruit) certain people, and thus may have influenced the opinions, beliefs and descriptions the researchers were exposed to.

Number and length of collection sessions

When conducting the interviews we (me and the researchers I collaborated with during the case studies) spent from one to two weeks at the product development groups. Afterwards, we remained in touch with the product development groups. Between data collection (the interviews) and the final feedback and verification workshop there was a considerable time span, from 6 months in the first case, 3 years in the second case and one year in the final case.

Dependability

Dependability is addressing the issue of reliability: whether if a work were repeated, in the same context, with the same methods and with the same participants, similar results would be obtained (Shenton, 2004).

An important question is to what extent the results of this research were dependent on who executed it. Did the fact that the case studies were executed by researchers with a background in design research influence the results that were found? I believe they did. Being educated as and industrial design engineer, having worked as a strategic design consultant, and conducting my research at the Faculty of Industrial Design Engineering must have fitted me with a particular set of glasses: a product developer's. And this has influenced the results. An organizational psychologist or a sociologist would have most probably made different observations and interpretations. This does not mean that the results are biased and thus useless, but it does mean that when considering the results, one should keep in the back of the head that one is looking through the eyes of a product developer.

In addition, Shenton argues that in qualitative research, reproduction of the study is problematic, due to the changing nature of the phenomena under study, and because the investigator's observations are tied to the situation in the study, and thus he suggests that: "*to address the dependability of a qualitative study, the processes within the study should* *be reported in detail, thereby enabling a future researcher to repeat the work, though not necessarily to gain the same results*" (Shenton, 2004, p.71).

For each of the case studies the research design and its implementation were reported. In all cases setup and topics guides for the interviews were provided, though because of practical reasons the interview questions were not all included in the thesis, but these are available for access by peer reviewers. In the method sections of study II and III attention was paid to reporting in detail how the data were analyzed. Finally, though not included in the report, the data and researchers interpretations from the second case study are available to peer reviewers in the form of the Trace tool, as are the causal networks of the usability issues that formed the basis of the causal models in case study III. At the end of each of the case studies I evaluated its execution, and discussed the implications of the method applied.

Confirmability

I addressed this issue by documenting my preconceptions and hypotheses at the start of the study, in study II by providing other researchers access to the data and interpretations through the Trace tool, and in study III by providing a description of what steps were taken to arrive at the emerging constructs from the original data: an 'audit trail'.

Documenting preconceptions and hypotheses

The preliminary hypotheses that arose from a survey of the state of the art on usability in product development practice and interviewing product development professionals were captured in a conceptual framework, thus explicitly communicating my perspective on the subject to be studied. The conceptual framework formed the basis for the research setup and method, resulting, for example, in the topics of the interview guide. When analyzing the data, the conceptual framework provided a basis for the initial coding scheme.

Access to interview data

All interviews were recorded. For study I the relevant sections were transcribed, and for study II and III the interviews were transcribed literally and in full.

The Trace tool

The Trace tool, as described in Chapter 4 (page 119) is an Adobe Flash application developed for the purposes of this research, than can, based on the categorization scheme, provide a categorized, interactive, browsable overview of the barriers and enabers for usability. Barriers and enablers can be viewed per company or per role (e.g., interaction designers, product managers). By clicking a certain category the one gets an overview of the barriers and enablers in that category and gets access to the complete 'jointly told tale' underlying each of the barriers or enablers, thus allowing access to the original interview quotes in combination with the researcher's interpretation.

Audit trail

To improve confirmability, Shenton (2004) suggests to provide the reader with an 'audit trail', which allows any observer to trace the course of the research step-by-step via the decisions made and procedures described, which may be represented diagrammatically.

In study III a visual overview was provided of the research design (figure 2, page 252), indicating all steps from identifying the usability issues in the products, conducting the interviews, analyzing the interviews and documents, and synthesizing the description of how the product development group dealt with usability, as well as the causal models of usability in product development.

Strategies not followed

A number of suggestions by Shenton (2004) to improve trustworthiness I did not employ.

• Random sampling of informants was not possible because the goal was to interview people who fulfilled specific roles.

• Triangulation of methods was beyond the scope of this project; all studies were conducted using the case study approach. In the final case study triangulation of sources was applied: documents and the products themselves were used as additional sources.

• Iterative questioning in interviews to uncover deliberate lies was not employed as an interview strategy, as the informants were mostly interviewed only once.

• A negative case analysis was not conducted, as up until the final case study theory was still being induced. The models generated in the final case study do provide a good starting point for conducting a negative case analysis.

• Finally, though at the end of each case study a discussion of the method is provided, the researcher's reflective commentary was not captured nor reported.

6.2.4 Using a weblog as a tool for dissemination, dialogue and reflection

As described in more detail in Appendix A, during this research I kept a weblog about consumer product usability. I encountered several other PhD candidates who did the same. Throughout his PhD research Dan Lockton (architectures.danlockton.co.uk) published about the development of his Design with Intent method. He disclosed intermediary versions of the method, allowing for designers and design researchers to try it and comment on it. The blog of the 'Wiskundemeisjes' ("math girls", www.wiskundemeisjes.nl), two PhD candidates in the department of Mathematics at Leiden University, led to a weekly column in the science section of the Dutch newspaper 'De Volkskrant'. There may be a trend here, as weblogs in a scholarly context have been identified as a new 'genre' in the information sciences (Kjellberg, submitted). The question is whether keeping a weblog is a useful way of spending the limited amount of time a PhD candidate has.

My experiences with disseminating conference proceedings and a journal paper through uselog.com indicate that a weblog can be an effective way for making sure research finds its way to practitioners as well as researchers. Weblogs and scientific research seem a powerful combination: posting pre-print publications on a weblog allows articles to reach a much wider audience than when only publishing through a journal. The peer-reviewed nature of the publications lends credibility to what is written, thus increasing the motivation of readers to read it and disseminate it further. And, reversely, by posting scientific articles on a weblog, visitors are directed towards the websites of scientific journals.

For researchers of practice, for example in design, nursing or business administration, a weblog can be a great way to establish a dialogue with the community one is studying and researching for. As weblogs are a medium in which it is considered fairly legitimate to be opinionated, a blog can also be an excellent place to float ideas and to get feedback on them. I have received a large amount of valuable input from product development practitioners as well as from fellow researchers.

Having a weblog makes the author visible to the community of practitioners, which 1) facilitates the researcher-initiated acquisition of case studies and 2) may prompt inquiries from practitioners offering opportunities for studies. Finally, I experienced writing about consumer product usability as a very powerful way to provoke continuous reflection on the phenomenon I was studying as it facilitated a continuous 'dialogue' between ideas and data (Ragin, 1987).

Something that withheld me from publishing more of my tentative results than just the recommendations for industry was that I was somewhat anxious that spreading my findings prematurely would limit their attractiveness once I would try to publish them 'for real' in scientific publications. On the other hand publishing tentative results may also be a way of 'claiming' a certain subject or insight.

So, was it worth the effort? In my case, conducting practice and practitioner-oriented research and being part of a research project that explicitly valued dissemination of knowledge to practice, I would say it was. But it did take some effort. I think that writing a weblog is only for those who enjoy writing to begin with, and then still, at times uselog.com felt like the plant in the Little Shop of Horrors, demanding to be fed when I really did not have anything to feed it or was too busy to do so. But as the political commentator and blogger Andrew Sullivan put it: "*A blog is a broadcast, not a publication. If it stops moving, it dies.*"

Depending on the extensiveness of the posts I strived for between one and two posts per week. Being on the lookout for content and writing the posts cost me at least half a day per week. Add to that the design and maintenance of the website, and on the whole you are looking at half a day to a day of precious research time. As this is quite some resources to invest, the organization the author is working for should support her/him in doing so. One idea has motivated me tremendously while writing on uselog.com: that the value of research results, of knowledge, increases if its distribution does.

6.3 Recommendations for future research

Below I make suggestions for future studies. In general it could be said that the variables that influence usability and the relations between them, as identified through this research project, should facilitate the setup for more focused case studies, but also for (quasi) experimental studies of product design and evaluation.

'Live' case study

In future research that aims to identify the causes of usability issues I would recommend to study a product development project real-time. This makes the researcher less reliant on the recollections and interpretations of interviewees, enables easier access to project documentation, and provides a more detailed insight. The results from this research should facilitate the identification of projects in which (serious) usability problems are likely to occur and on which aspects to focus on during a live study. A special topic of interest in such a study could be how to improve the user-centeredness the synthesis phase, the actual creation of the designs, as this proved very hard to assess through retrospective interviews.

Creating awareness of the risk of usability problems

This research project has produced insight into barriers and enablers for usability. Based on the overview, a set of indicators could be developed to help development teams become aware of the risk that a development projects runs of encountering usability problems.

User-centred design cycle as the unit of analysis

In current literature on methods for user-centred design, much emphasis is on the accuracy and reliability of usability evaluation methods. The results of the studies in this thesis suggest that the value of a usability evaluation is in the follow-up: to what extent does the product get improved. And that does not only depend on the accuracy and reliability of the evaluation method, but also on whether the results are actionable. Secondly, I believe it is important to develop methods that allow designers to arrive at a usable design in the first place, not just focus on methods for evaluation. This suggests that future studies in user-centred design to take the user-centred design cycle (par. 2.5.2) as the unit of analysis. The research question should be "what makes products more usable?" not just "how do we consistently identify the largest possible amount of usability issues?"

Designer-centred methods

When developing and testing (user-centred) design or development methods, design researchers should keep in mind that required resources (time, working-hours, budget, equipment) and skills are very dominant factors for the applicability in product development practice. Product developers are unlikely to use a very effective and accurate method if it is hard to learn and requires too much resources to execute.

How to sell usable products?

All throughout the cases, an important concern of product developers was whether usability would lead to better sales numbers. This seemed to seriously influence their prioritization of usability. And the product developers' concerns may be justified.

In a retrospective case study into the development and market introduction of the Philips Easy Line, Mak (2009) investigated the reasons for the lack of commercial success of a product line specifically designed to be easy to use. The case study showed that developing and marketing products with ease of use as a unique selling point has some serious pitfalls, among which achieving usability through a reduction of functions and how to communicate a product's usability in marketing.

In an exploratory study I have investigated what product properties influence expected usability and how expected and experienced usability relate after use (van Kuijk *et al.*, 2009). It proved complicated for participants to assess the usability of a product based only on the design of the product, and secondly, the importance of usability seemed to be more important after use than prior to use, which aligns with findings by Thompson and Rust (Thompson *et al.*, 2005).

From the aforementioned studies, as well as from the case studies described in this thesis, two possible explanations for buyers not purchasing usable products seem to emerge: 1) buyers do not prioritize usability during purchase or 2) buyers are not able to assess the usability of the products during purchase. Future studies could further investigate these propositions, for example by studying how products can communicate that they are usable and how usable products should be positioned (in terms of marketing message). If companies can gain commercial success by offering usable products, the chances of future electronic consumer products in becoming more usable will increase.

Developing the Trace tool

In case II I applied the Trace application to map barriers and enablers for usability in product development, but it could also be used to map barriers and enablers in product development for other product properties, such as sustainability, profitability or reliability. The tool is still in an experimental stage and tailored fully to the needs of a very limited target audience: me. However, it would be worthwhile to study whether Trace is valuable to other design researchers, both as a tool for analyzing qualitative data as well as communicating the results to participants, and then develop it further. The applicability of Trace might even go beyond design research. In essence it is a tool to map qualitative data on a conceptual framework or categorization scheme, while preserving access to the underlying data. This means that if the user would be given the opportunity to build up his/her own categorization scheme in the tool, the applicability of the tool could be useful to qualitative researchers beyond the domain of design research.

6.4 Recommendations for industry (or how I would do it)

Based on what I have learned in this research project I wrote 25 recommendations on how to organize a company if the goal is to make usable products. I tried to write the recommendations in the spirit of the book '*101 things I learned in architecture school*' (Frederick, 2007): providing concrete handles for practitioners, but also the underlying, more abstract principles. I would like to point out that most of the recommendations I did not conceive myself but encountered them through my case studies and in literature. So I would by no means take credit for them; they are what I considered to be existing best practices. Together they are 'how I would do it' if I were to organize a product development group that had to make usable electronic consumer products

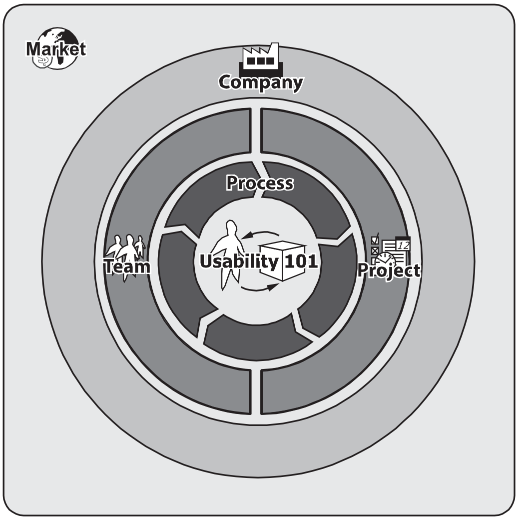


Figure 65: Visualization of the categories of the recommendations for industry, which is based on the main categories of the categorization scheme that emerged in case study II.

The recommendations range from very pragmatic and easily applicable (e.g., use guerrilla HCI techniques) to more high-level and challenging (e.g., align the organization with user needs). As a consequence, per recommendation the target audience might differ: upper management, product managers, managers of NPD teams, interaction and product designers and – of course – usability specialists.

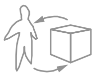
The themes by which the recommendations are grouped are the same main categories as used in the categorization scheme developed in case study 2 (see Figure 34, page 117). Figure 65 contains a visualization of the categorization of the recommendations, which was developed within the Design for Usability research project of which this thesis is a part. The categories of the recommendations are (from the inside out in Figure 65):

- Usability 101: how to define usability and assess its consequences?
- Process: what does a user-centred product development process look like, and what methods to apply, and how?
- Team: how to assemble a team that is capable of executing a user-centred product development process?

- Project: how to organize, facilitate and plan user-centred product development?
- Company: how to organize a company so that it facilitates user-centred product development?
- Market: what are appropriate retail and marketing strategies for companies that make usable products?

To assess to what extent the recommendations made sense and were relevant to product developers over the course of five weeks the recommendations were published on uselog.com (see Appendix A) and readers were invited to comment. Based on two rounds of feedback I made adjustments to the recommendations. The version published in this thesis includes the input from this 'user testing'. Below each of the recommendations is shortly summarized. Of the complete version a card set was made which is published alongside this thesis, and the recommendations can also be found online at:

> http://www.uselog.com/2010/07/complete-list-of-recommendations-for.html.

Usability 101 

1. Understand what usability is and what it means for your products
Product developers often describe usability as fuzzy and ungraspable. But in order to reach a goal, you have to know what that goal is. In order to improve usability, product developers should have a shared understanding of usability. Because creating usable products requires cooperation of many disciplines, this understanding of usability should extend beyond just the interaction designers and usability specialists.

2. Analyze the consequences of usability for your company
Based on the definitions, examples, stories and analyses from the preceding step, take stock of how usability manifests itself in your products in:

1) Human-product interaction: quantity and quality of output, errors made (effectiveness), time and effort required (efficiency);
2) The user experience: confirming or exceeding expectations (satisfaction about use).

And the consequences this may have for:

3) The response of users to the user experience: customer support requests, complaints, product returns, word-of-mouth
4) The resulting consequences for the business performance of your company: financial costs, staff, repeat sales, cross-purchases, productivity, extra equipment required.

3. Decide whether usability should be a priority for your company
Implementing a user-centred product development process is likely to require organizational changes, significant investment in resources, and support from upper management. Thus a conscious choice should be made whether usability should be a priority at all. Based on the aforementioned analysis of usability, and of the consequences of usability for your company, decide whether usability should a priority.

Process

4. A development process that facilitates user-centred methods

The structure of a product development process should facilitate the integration of methods for user-centred design. Consider the product development process the 'spine' to which all the individual activities are attached. This spine should thus feature sufficient time, resources (and staff) to execute methods for user-centred design, but the process should also be designed to deal with the outcomes of these methods.

5. Think development rather than design

A design that will lead to an extremely usable product is worthless if your company does not have the skills and means to implement this design. Interaction designers and usability specialists should be conscious of the limitations posed by resources, technology and business models. This is facilitated by all disciplines working 'under one roof'. An 'ok' design that gets realized is more usable a dream-design that gets mutilated beyond recognition.

6. Think concept as well as detail

To develop usable products carefully select the appropriate UI concept, and then refine and implement it without compromise. Move with caution when selecting an interaction concept, as some concepts offer a much higher potential level of usability than others. Once a UI concept has been chosen it should be developed further through many iterations of evaluations and redesigns, each time zooming in further on properties of the product that can be improved.

7. Apply guerrilla usability techniques

In product development practice pragmatic considerations, such as costs, required time, and staff have a strong influence on whether a user-centred design method is applied or not; more important in fact than the perceived effectiveness of that method. Practitioners benefit more from methods that are widely applicable and mostly accurate, than from methods that are one hundred percent reliable but hardly applied. Many small-scale tests and iterations are preferable over a single, late and half-hearted iteration.

8. Early user research, simulation and evaluation

Early in the product development process there is still much 'design freedom' (design mutability in combination with available resources). This explains the desire for the early availability of user research (to make a usable design), and early usability evaluations (to iterate this design).

9. Inside-out approach to user research and evaluation

For both user research and user evaluations: take an inside-out approach. When conducting user research for a new product, start by using the product yourself, then observe and interview colleagues at work, and after that you can - informally - study family and friends. Finally, study people that are thought to be representative for the actual user group. The same approach goes for evaluations.

10. Rich communication of user research and evaluations

Human-product interaction is very hard to capture in words, let alone numbers. Product development teams’ understanding of the results can be improved by communicating the results of user research or user testing in a 'rich' way - by the team being present at user tests or at least by showing videos. This also increases their trust in and empathy with the results.

11. Select the appropriate functionality

Extensive functionality can have a twofold negative effect on usability: a product with extensive functionality is likely to be less usable because (1) the user has more functions to learn and choose from, and (2) the development team has more functions to design, implement, and integrate into a fluent whole.

Team

12. User-centred design skills on the team early and throughout

User-centred design skills should be present in the team throughout the product development process, from the very first start. User-centred skills are knowledge of and the ability to execute user research, synthesize usable designs, prototype designs, and evaluate them. In the early phases of product development important decisions with regard to product definition and the technological platform are taken and usability specialists and interaction designers should be involved in, or at least be informed about, these decisions.

13. One roof: all disciplines - in one room - throughout the process

The development of usable products requires the involvement of all disciplines, from the interaction designer to the product manager, from the usability specialist to the development engineer. In product development of electronic consumer products these disciplines are usually seated in separate departments. Try to make them work in truly collaborative teams. Especially in the phases in which the product is defined and designed, but also during implementation, opt for project teams working in a shared project space to allow for continuous informal interaction.

14. Feed the 'feel for the user': provide product developers with feedback

Make sure the results of user tests are not only communicated to product managers and usability specialists, but also to the interaction designers and product designers, or - even better - to the whole team. The same goes for after sales feedback: don't let customer complaints, field studies, and customer satisfaction studies stop at the product manager, but share them with the whole development team. They'll learn from it.

15. Get and keep experienced people

Experienced product developers have a better understanding of the intricacies of a product category and over time product developers develop a ‘feel for the user’ that is very hard to transfer from person to person. Secondly, having gone through several development projects increases a team member’s understanding of the development process and of other roles in the development team. So, keep product development teams intact over product generations. Consider a product launch a release of a version, not of the definitive product.

16. Don't let designers do their thing
Synthesizing the design is one of the most influential and yet most ungraspable steps in the development process, where all information is integrated. This is where a designer can make a huge difference: given the same amount of resources, one design may fulfil all (user) requirements, while another one falls short. If the goal is to make usable products, opt for designers that are less like gods and more like servants; hire designers that lean towards the analytical and that have thorough knowledge of user-centred design methods.

Project

17. Increase design freedom
You can feed all the knowledge you have about the user group, design solutions and usability issues into an extremely sophisticated user-centred design process, executed by the most user-centred team imaginable, if they can't *apply* their knowledge and talents, it is all useless. To make use of a team's knowledge and user-centred design proficiency product developers need design freedom: sufficient resources (budget, staff and time) and design mutability (being allowed and able to change a design).

18. Do not innovate the user interface
In the electronic consumer products sector the speed of product development is so high and the product portfolios are so large that it is impossible to develop the user interface for each product from scratch. Secondly, introducing a new function, content, interface or entire product increases the risk of poor usability, due to increased uncertainty. To prevent having to design a new user interface design for every product, using a UI paradigm as the basis for the UIs of individual products is an effective and efficient solution.

19. Don't prescribe methods for user-centred design
Prescribing what methods for user-centred design a team should use in the development process could ensure user involvement. However, it may also lead to a situation where a team does not apply the *right* method, but the prescribed method. Or to team members simply conducting an activity because the process prescribes it and otherwise they can't pass a milestone. It should be indicated that user involvement is desired, or even required, but which methods for user-centred design are appropriate to apply should be left up to the development team.

Company

20. Align the organization with user needs
Companies should be willing to cut through the silos of their organizations in order to create a great user experience. Product development companies' raison d'être is to develop products. In the end the organization should be designed to create successful new products; products should not be designed to fit the existing organization.

21. Upper management that gets and prioritizes usability

One of the most influential factors to determine whether a company can successfully deal with usability is upper management (development group managers as well as corporate managers). Upper management decides about the resources that are assigned to development projects and groups, is the only actor that can ensure multiple product development groups cooperating on a product or product family, and the attitude of upper management can seriously impact company culture.

22. Establish a user-centred company culture

Product development means compromising. Development teams have to weigh product properties and then figure out how to realize as many of them as possible considering the available resources. To create usable products, usability should be prioritized in at least some of the decisions. This can be positively influenced by a user-centred attitude among product developers, which in turn can be fostered by a user-centred company culture.

Market

23. Merge 'buy' and 'try' in retail

Because consumers can have a hard time judging a product's usability before purchase usability is usually considered a long-term benefit: initially it may not increase sales, but it does increase customer satisfaction, thus brand loyalty, and thus may lead to repeat sales. But sales numbers could benefit directly from products being usable. If you believe your products really are usable, you might want to let potential buyers experience that usability already in the store.

24. Control your retail channels

Retailers and service providers - that in the end sell a product development group's products to consumers - often have their own ideas about what a product should do, based on their own interests. One strategy for a product development company to become less dependent on third-party resellers is to set up its own retail, in the form of retail stores, shop-in-shop concepts, and online shops.

25. Don't explicitly advertise usability

There have been a considerable number of electronic consumer products marketed specifically 'as easy to use'. They never seem to last or to achieve mainstream success. Usability is a must-be requirement: people simply *expect* a product to be usable. Advertising a product as usable is like saying: "Hey people, we did NOT fail this time." There's one case in which usability might be a successful explicit sales argument: if a wide audience is very conscious of a usability problem with a certain product category.

References

Ackoff, R. L. (1989) "From Data to Wisdom." Journal of Applies Systems Analysis Volume 16: 3-9.

Ackoff, R. L. (1999) "On learning and the systems that facilitate it." Reflections: The SoL journal 1 (1): 14-24.

Antonides, G., W. M. Oppendijk van Veen, W. F. van Raaij and J. P. L. Schoormans (1999) Product & Consument, Uitgeverij Lemma, Utrecht.

Bachman, B., D. Valiulis, F. Aliaga and M. Treinen (2003) Four strategies for promoting common UI guidelines within Adobe. 2003 conference on Designing for user experiences, San Francisco, California, ACM Press.

Battle, L., N. Bevan, D. Degler, C. Smith, B. Werner and C. Wilson. (2004). "(Preview of the) Usability Body of Knowledge." Retrieved August 14, 2010, from http://www.usabilitybok.org.

Bekker, T. (1995) An analysis of user interface design practice : Towards support for team communication. Industrial Design Engineering. Delft, Delft University of Technology. PhD.

Bevan, N. (2003) UsabilityNet Methods for User Centred Design. Human-Compuer Interaction: Theory and Practice (Part 1), Volume 1 of the Proceedings of HCI International. Heraklion, Crete, Greece, , Lawrence Erlbaum.

Bevan, N., i. J. Kirakowsk and J. Maissel (1991) What is usability? 4th International Conference on Human Computer Interaction, Stuttgart, Elsevier.

Bevan, N. and M. Macleod (1994) "Usability measurement in context." Behaviour & Information Technology 13 (1-2): 132-245.

Bloch, P. H., F. F. Brunel and T. J. Arnold (2003) "Individual differences in the centrality of visual product aesthetics: concept and measurement." Journal of Consumer Research 29: 551-565.

Bodker, S. (1998) "Understanding Representation in Design." Human-Computer Interaction 13 (2): 107 - 125.

Boess, S. and H. Kanis (2008) Meaning in product use: A design perspective. Product Experience. H. N. J. Schifferstein and P. Hekkert. Oxford, UK, Elsevier.

Boivie, I., C. Aborg, J. Persson and M. Lofberg (2003) "Why usability gets lost or usability in in-house software development." Interacting with Computers 15 (4): 623-639.

Boivie, I., J. Gulliksen and B. Goransson (2006) "The lonesome cowboy: A study of the usability designer role in systems development." Interacting with Computers 18 (4): 601-634.

Bont, C. J. P. M. d. and J. P. L. Schoormans (1995) "The effects of product expertise on consumer evaluations of new-product concepts." Journal of Economic Psychology 16 (4): 599-615.

Borgholm, T. and K. H. Madsen (1999) "Cooperative usability practices." Communications of the ACM 42 (5): 91-97.

Bouwmeester, K. d. and E. Bosma (2006) Phases of use: a means to identify factors that influence product utilization. CHI '06 extended abstracts on Human factors in computing systems. Montreal, Canada, ACM.

Bouwmeester, K. d. and G. Stompff (2006) Bridging the gap between literature and practice: usability testing. IEA2006: 16th World Congress on Ergonomics, Maastricht, The Netherlands.

Breillatt, A. (2008) You can't innovate like Apple. The pragmatic marketer. Scottsdale, USA, Pragmatic Marketing Inc. 6: 4-10.

Brombacher, A. C. (2005) "Reliability in strongly innovative products; a threat or a challenge?" Reliability Engineering & System Safety 88 (2): 125-125.

Brombacher, A. C., P. C. Sander, P. J. M. Sonnemans and J. L. Rouvroye (2005) "Managing product reliability in business processes 'under pressure'." Reliability Engineering and System Safety 88 (2005): 137–146.

Brown, S. L. and K. M. Eisenhardt (1995) "Product Development: Past Research, Present Findings, and Future Directions." The Academy of Management Review 20 (2): 343-378.

Brown, T. (2008) "Design Thinking." Harvard Business Review (June 2008).

Bruno, V. and M. Dick (2007) Making usability work in industry: an Australian practitioner perspective. Proceedings of the 19th Australasian conference on Computer-Human Interaction: Entertaining User Interfaces. Adelaide, Australia, ACM.

Bruseberg, A. and D. McDonagh-Philip (2001) "New product development by eliciting user experience and aspirations." International Journal of Human-Computer Studies 55 (4): 435-452.

Buchenau, M. and J. F. Suri (2000) Experience prototyping. Conference on Designing interactive systems: processes, practices, methods, and techniques, New York City, New York, United States, ACM press.

Buijs, J. and R. Valkenburg (2005) Integrale Productontwikkeling. Utrecht, Uitgeverij Lemma.

Busby, J. S. (1998) "The neglect of feedback in engineering design organisations." Design Studies 19 (1): 103-117.

Butler, K. A. (1996) "Usability engineering turns 10." Interactions Volume 3 (Issue 1): 58 - 75.

Buur, J. and S. Boedker (2000) From usability lab to "design collaboratorium": reframing usability practice. Designing interactive systems: processes, practices, methods, and techniques, New York City, New York, United States, ACM Press.

Buxton, B. (2007) Sketching User Experiences: Getting the Design Right and the Right Design, Morgan Kaufmann.

Carroll, J. M. (2000) "Five reasons for scenario-based design." Interacting with Computers 13 (1): 43-60.

Chiu, M.-L. (2002) "An organizational view of design communication in design collaboration." Design Studies 23 (2): 187-210.

Cho, Y., I. Im, R. Hiltz and J. Fjermestad (2002) "The effects of post-purchase evaluation factors on online vs. offline consumer complaining behaviour: Implications for customer loyalty." Advances in Consumer Research 29: 318–326.

Clegg, C., C. Axtell, L. Damodaran, B. Farbey, R. Hull, R. Lloyd-Jones, J. Nicholls, R. Sell and C. Tomlinson (1997) "Information technology: a study of performance and the role of human and organizational factors." Ergonomics 40 (9): 851 - 871.

Connell, I. W. (1998) "Error analysis of ticket vending machines: comparing analytic and empirical data." Ergonomics Volume 41, (Number 7): 927 - 961.

Cooper, A. (1999) The Inmates Are Running the Asylum : Why High Tech Products Drive Us Crazy and How To Restore The Sanity. Indianapolis, Sams.

Cooper, R. G. (1990) "Stage-gate systems: A new tool for managing new products." Business Horizons 33 (3): 44-54.

Cooper, R. G. (1994) "Third-Generation New Product Processes." Journal of Product Innovation Management 11 (1): 3-14.

Creusen, M. E. H. and J. P. L. Schoormans (2005) "The different roles of product appearance in consumer choice." Journal of Product Innovation Management 22 (1): 63-81.

Cross, N. and N. Roozenburg (1993) "Modelling the Design Process in Engineering and in Architecture." Journal of Engineering Design 3 (4): 325 - 337.

Cushman, W. H. and D. J. Rosenberg (1991) Human Factors in Product Design. Amsterdam, Elsevier Science Publishers.

Davenport, T. (1993) Process Innovation: Reengineering work through information technology,. Boston, Harvard Business School Press.
De Visser, I. M. (2008) Analyzing user perceived failure severity in consumer electronics products : incorporating the user perspective into the development process Department of Technology Management. Eindhoven, TU Eindhoven. PhD**:** 205.
Demir, E., P. M. A. Desmet and P. Hekkert (2009) "Appraisal Patterns of Emotions in Human-Product Interaction." International Journal of Design 3 (2): 41-51.
den Buurman, R. (1997) "User-centred design of smart products." Ergonomics Volume 40 (Number 10 / October 1, 1997): 1159 - 1169.
Den Ouden, E. (2006) Development of a design analysis model for consumer complaints : revealing a new class of quality failures Department of Technology Management, Section Product and Process Quality. Eindhoven, Eindhoven Technical University. PhD**:** 165.
Den Ouden, E., L. Yuan, P. J. M. Sonnemans and A. C. Brombacher (2006) "Quality and Reliability Problems from a Consumer's Perspective: an Increasing Problem Overlooked by Businesses?" Quality and Reliability Engineering International 22 (7): 821-838.
Doane, S. M., J. W. Pellegrino and R. L. Klatzky (1990) "Expertise in a Computer Operating System: Conceptualization and Performance." Human-Computer Interaction 5 (2): 267 - 304.
Donahue, G. M. (2001) " Usability and the bottom line." Software, IEEE , Vol.18 (no.1, Jan/Feb 2001): 31-37.
Donoghue, S. (2006) "Dissatisfied consumers' complaint behaviour concerning product failure of major electrical household appliances – a conceptual framework." Journal of Family Ecology and Consumer Sciences 34.
Dul, J. and W. P. Neumann (2009) "Ergonomics contributions to company strategies." Applied Ergonomics 40 (4): 745-752.
Dumas, J. S. and J. C. Redish (1999) A practical guide to usability testing. Exeter, Intellect.
Eisenhardt, K. M. (1989) "Building Theories from Case Study Research." The Academy of Management Review 14 (4): 532-550.
Eisenhardt, K. M. and M. E. Graebner (2007) "Theory building from cases: opportunities and challenges." Academy of Management Journal 50 (1): 25-32.
Faust, D. (1982) "A Needed Component in Prescriptions for Science: Empirical Knowledge of Human Cognitive Limitations." Science Communication 3 (4): 555-570.
Forlizzi, J. and K. Battarbee (2004) Understanding experience in interactive systems. 2004 conference on Designing interactive systems: processes, practices, methods, and techniques, Vienna, Austria, ACM Press.
Forlizzi, J. and S. Ford (2000) The building blocks of experience: an early framework for interaction designers. Designing interactive systems: processes, practices, methods, and techniques, New York, United States.
Frederick, M. (2007) 101 things I learned in architecture school. Cambridge, Mass., MIT Press.
Frøkjaer, E., M. Hertzum and K. Hornbaek (2000) Measuring usability: are effectiveness, efficiency, and satisfaction really correlated? Proceedings of the SIGCHI conference on Human factors in computing systems. The Hague, The Netherlands, ACM.
Frøkjær, E., M. Hertzum and K. Hornbaek (2000) Measuring usability: are effectiveness, efficiency, and satisfaction really correlated? Proceedings of the SIGCHI conference on Human factors in computing systems, The Hague, The Netherlands, ACM Press.
Fulton Suri, J. and M. Marsh (2000) "Scenario building as an ergonomics method in consumer product design." Applied Ergonomics 31 (2): 151-157.
Garmer, K., J. Ylven and I. C. MariAnne Karlsson (2004) "User participation in requirements elicitation comparing focus group interviews and usability tests for eliciting usability requirements for

medical equipment: a case study." International Journal of Industrial Ergonomics 33 (2): 85-98.
Glaser, B. G. (1978) Theoretical sensitivity: Advances in the methodology of grounded theory. Mill Valley, CA, Sociology Press.
Goodman, N. (1991) The problem of counterfactual conditionals. Conditionals. F. e. Jackson. New York, Oxford University Press.
Gould, J. D. and C. Lewis (1985) "Designing for usability: key principles and what designers think." Communications of the ACM 28 (3): 360-411.
Graneheim, U. H. and B. Lundman (2004) "Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness." Nurse Education Today 24 (2): 105-112.
Gray, W. D. and M. C. Salzman (1998) "Damaged merchandise? A review of experiments that compare usability evaluation methods." Human-Computer Interaction 13 (3): 203-261.
Green, W. S. (1999) Essential Conditions for the Acceptance of User Trialling as a Design Tool. Human Factors in Product Design; Current Practice and Future Trends. W. S. Green and P. W. Jordan. London, Taylor and Francis.
Green, W. S. and P. W. Jordan (1999) Ergonomics, usability and product development. Human Factors in Product Development. W. S. Green and P. W. Jordan. London, Taylor and Francis.
Greenberg, S. and B. Buxton (2008) Usability evaluation considered harmful (some of the time). Proceeding of the twenty-sixth annual SIGCHI conference on Human factors in computing systems. Florence, Italy, ACM.
Grudin, J. (1991) "Obstacles to user involvement in software product development, with implications for CSCW." International Journal of Man-Machine Studies (34): 435-452.
Grudin, J. (1992) "Utility and usability: research issues and development contexts." Interacting with Computers 4 (2): 209-217.
Guba, E. G. (1981) "Criteria for assessing the trustworthiness of naturalistic inquiries." Educational Communication and Technology Journal 29 (1981): 75-91.
Guldbrandsen, M. (2006) How companies embed non-quantifiable product qualities through their product development process. School of Industrial and Manufacturing Science, Cranfield University. PhD**:** 229.
Gulliksen, J., I. Boivie and B. Göransson (2006) "Usability professionals--current practices and future development." Interacting with Computers 18 (4): 568-600.
Gyi, D. E., R. Cain and R. I. Campbell (2006) Facilitating 'user push' in the design process. IEA2006: 16th World Congress on Ergonomics, Maastricht, The Netherlands.
Haighton, M. (2009) Saneerder met een hart voor boeken. De Volkskrant. Amsterdam, PCM Publishers.
Han, S. H., M. H. Yun, J. Kwahk and S. W. Hong (2001) "Usability of consumer electronic products." International Journal of Industrial Ergonomics 28 (3-4): 143-151.
Hartevelt, M. A. and E. P. G. Vianen (1994) Development of the NASA-TLX (Task Load Index) Results of emperical and theoretical research. Human Mental Workload. P. A. Hancack and N. Meshkati. Amsterdam, North-Holland: Elsevier.
Hartson, H. R. and D. Hix (1989) "Human-computer interface development: concepts and systems for its management." ACM Comput. Surv. 21 (1): 5-92.
Hassenzahl, M. (2003) The Thing and I: Understanding the Relationship Between User and Product Funology: From Usability to Enjoyment. M. A. Blythe, K. Overbeeke, A. F. Monk and P. C. Wright. Dordrecht, The Netherlands, Kluwer Academic Publishers**:** 31-42.
Hassenzahl, M., A. Platz, M. Burmester and K. Lehner (2000) Hedonic and ergonomic quality aspects determine a software's appeal. SIGCHI conference on Human factors in computing systems, The Hague, The Netherlands, ACM Press.

Hekkert, P. and P. Desmet (2007) "Framework of Product Experience." International Journal of Design 1 (1): 57-66.

Helander, M. G. and M. P. Tham (2003) "Hedonomics-affective human factors design." Ergonomics Volume 46 (13-14): 1269 - 1272.

Hertzum, M. (1999) User Testing in Industry: A Case Study of Laboratory, Workshop, and Field Tests. User Interfaces for All: Proceedings of the 5th ERCIM Workshop, Dagstuhl, DE, GMD, Sankt Augustin, DE.

Hertzum, M. (2010) "Images of Usability." International Journal of Human-Computer Interaction 26 (6): 567-600.

Hertzum, M. and N. E. Jacobsen (2001) "The Evaluator Effect: A Chilling Fact About Usability Evaluation Methods." International Journal of Human-Computer Interaction 13 (4): 421-443.

HHS. (undated). "Usability.gov - your guide for developing usable and useful web sites." Retrieved August 14, 2010, from http://www.usability.gov.

Hoefnagels, S. (2009) Designing the Windows 7 Desktop Experience. Ten Top Talks, Delft University of Technology, The Netherlands.

Holtzblatt, K. and S. Jones (1993) Contextual Inquiry: A Participatory Technique for System Design Participatory Design: Principles and Practice. D. Schuler and A. Namioka, Lawrence Earlbaum, Hillsdale, NJ.**:** 180-193. .

Hornbaek, K. and E. L.-C. Law (2007) Meta-analysis of correlations among usability measures. Proceedings of the SIGCHI conference on Human factors in computing systems. San Jose, California, USA, ACM.

Horrigan, J. B. and S. Jones (2008) When Technology Fails. Pew Research Center Publications, Pew Research Center.

Howard, J. A. (1994) Buyer behavior in marketing strategy. Englewood Cliffs, New Jersey, Prentice-Hall.

ISO (1998) ISO 9241-11 Ergonomic requirements for office work with visual display terminals (VDTs) - Part 11: Guidance on usability. Geneva, Switzerland, International Organization for Standardization.

ISO (1999) ISO 13407 - Human-centred design processes for interactive systems. Geneva, Switzerland, International Organization for Standardization.

ISO (2006) ISO 20282-1:2006 Ease of operation of everyday products -- Part 1: Design requirements for context of use and user characteristics ISO 20282, International Organization for Standardization.

ISO (2007a) ISO 20282-3: Ease of operation of everyday products -- Part 3: Test method for consumer products. ISO 20282. Geneva, Switzerland, International Organization for Standardization.

ISO (2007b) ISO/PAS 20282-4:2007 Ease of operation of everyday products -- Part 4: Test method for the installation of consumer products. ISO 20282. Geneva, Switzerland, International Organization for Standardization.

ISO (2008) ISO DIS 9241-210:2008. Ergonomics of human system interaction. Part 210: Human-centred design for interactive systems (formerly known as 13407). Switzerland.

Jääskö, V. and T. Mattelmäki (2003) Observing and probing. 2003 international conference on Designing pleasurable products and interfaces, Pittsburgh, PA, USA, ACM Press.

Jacobson, I., M. Christerson, P. Johnsson and G. Övergaard (1992) Object-Oriented Software Engineering. A Use Case Driven Approach. Addison-Wesley Publishing Company, Wokingham, UK.

Jeffries, R., J. R. Miller, C. Wharton and K. Uyeda (1991) User interface evaluation in the real world: a comparison of four techniques. SIGCHI conference on Human factors in computing systems: Reaching through technology, New Orleans, Louisiana, United States, ACM Press.

Jenkins, J. (2008) "Creating the Right Environment for Design." Design Management Review 19 (3).

Ji, Y. G. and M. H. Yun (2006) "Enhancing the Minority Discipline in the IT Industry: A Survey of Usability and User-Centered Design Practice." International Journal of Human-Computer Interaction 20 (2): 117 - 134.

Jiao, J., T. Simpson and Z. Siddique (2007) "Product family design and platform-based product development: a state-of-the-art review." Journal of Intelligent Manufacturing 18 (1): 5-29.

John, B. E. and D. E. Kieras (1996) "Using GOMS for user interface design and evaluation: which technique?" ACM Trans. Comput.-Hum. Interact. 4 (3): 287-319.

John, B. E. and S. J. Marks (1997) "Tracking the effectiveness of usability evaluation methods." Behaviour & Information Technology 16 (4-5): 188 - 202.

Jokela, T. (2004) "When good things happen to bad products: where are the benefits of usability in the consumer appliance market?" Interactions 11 (6): 28-35.

Jokela, T., N. Licari, J. Matero and M. Karukka (2003) The standard of user-centred design and the standard definition of usability: analyzing ISO 13407 against ISO 9241-11. Proceedings of the Latin American Conference on Human-Computer Interaction, Rio de Janeiro, Brazil, ACM publishers.

Jordan, P. W. (1994) What is usability? Contemporary Ergonomics. S. Robertson, Taylor and Francis, London**:** 454-458.

Jordan, P. W. (1995) Pleasure in Product use. Contemporary ergonomics, Taylor and Francis.

Jordan, P. W. (1998a) "Human factors for pleasure in product use." Applied Ergonomics 29 (1): 25-33.

Jordan, P. W. (1998b) An Introduction To Usability, Taylor and Francis.

Jordan, P. W. (2000) Chapter 1: Pleasure with products. Designing pleasurable products, An Introduction to the New Human Factors. P. W. Jordan, Taylor and Francis.

Jordan, P. W., B. Thomas and B. A. Weerdmeester (1996a) Usability Evaluation In Industry, Taylor and Francis.

Jordan, P. W., B. Thomas, B. A. Weerdmeester and I. L. McClelland (1996b) Chapter 26: Issues for Usability Evaluation in Industry - Seminar Discussions. Usability Evaluation in Industry. P. W. Jordan, B. Thomas, B. A. Weerdmeester and I. L. McClelland. London, Taylor & Francis.

Kahmann, R. and L. Henze (1999) Usability Testing under Time-Pressure in Design Practice. Human Factors in Product Development. W. S. Green and P. W. Jordan. London, Taylor and Francis**:** 113-123.

Kaikkonen, A., A. Kekäläinen, M. Cankar, T. Kallio and A. Kankainen (2005) "Usability Testing of Mobile Applications: A Comparison between Laboratory and Field Testing." Journal of Usability Studies 1 (1): 4-16.

Kanis, H. (1998) "Usage centred research for everyday product design." Applied Ergonomics 29 (1): 75-82.

Kanis, H., M. F. Weegels and L. P. A. Steenbekkers (1999) The uninformativeness of quantitative research for usability focused design of consumer products. Human Factors and Ergonomics Society 43rd Annual Meeting, Houston, USA.

Karapanos, E., J. Zimmerman, J. Forlizzi and J.-B. Martens (2009) User Experience Over Time: An Initial Framework. CHI 2009. Boston, Massachusetts, USA.

Karat, C.-M., R. Campbell and T. Fiegel (1992) Comparison of empirical testing and walkthrough methods in user interface evaluation. SIGCHI conference on Human factors in computing systems, Monterey, California, United States, ACM Press.

Keijzers, J., E. den Ouden and Y. Lu (2008) Usability benchmark study of commercially available smart phones: cell phone type platform, PDA type platform and PC type platform. Proceedings of the 10th international conference on Human computer interaction with mobile devices and services. Amsterdam, The Netherlands, ACM**:** 265-272

Keinonen, T. (1997) Expected usability and product preference. Designing interactive systems: processes, practices, methods, and techniques. Amsterdam, The Netherlands: 197-204.

Keinonen, T. (1998) One-dimensional usability - Influence of usability on consumers' product preference. Smart Products Research Group. Helsinki, University of Art and Design.

Kelly, K. (2010) Master Planner: Fred Brooks Shows How to Design Anything. Wired. New York, Condé Nast publications.

Ketola, P. (2002) Integrating Usability with Concurrent Engineering in Mobile Phone Development. Department of Computer and Information Sciences. Tampere, Finland, University of Tampere. PhD: 142.

Kim, J. and J. Y. Moon (1998) "Designing towards emotional usability in customer interfaces--trustworthiness of cyber-banking system interfaces." Interacting with Computers 10 (1): 1-29.

Kjellberg, S. (submitted) " I am a blogging researcher: motivations for blogging in a scholarly context."

Kleinsmann, M. (2006) Understanding Collaborative Design. Industrial Design Engineering. Delft, Delft University of Technology: 309.

Koca, A., M. Funk, E. Karapanos, A. Rozinat, W. M. P. v. d. Aalst, H. Corporaal, J. B. O. S. Martens, P. H. A. v. d. Putten, A. J. M. M. Weijters and A. C. Brombacher (2008) "Soft Reliability: An Interdisciplinary Approach with a User–System Focus." Quality and Reliability Engineering International 25 (1): 3-20.

Krishnan, V. and S. Gupta (2001) "Appropriateness and Impact of Platform-Based Product Development." Management Science 47 (1): 52-68.

Kunkel, P. (1997) AppleDesign: The Work of the Apple Industrial Design Group, Watson-Guptill Publications.

Kurosu, M. and K. Kashimura (1995) Apparent usability vs. inherent usability: experimental analysis on the determinants of the apparent usability. Source Conference on Human Factors in Computing Systems. Denver, Colorado, United States: 292 - 293.

Kuutti, K., K. Battarbee, S. Säde, T. Mattelmäki, T. Keinonen, T. Teirikko and A.-M. Tornberg (2001) Virtual Prototypes in Usability Testing. Proceedings of the 34th Annual Hawaii International Conference on System Sciences (HICSS-34), Hawaii, USA, IEEE Computer Society, Washington, DC, USA.

Lauche, K. (2005) "Job design for good design practice." Design Studies 26 (2): 191-213.

Lauesen, S. (1997) Usability Engineering in Industrial Practice. INTERACT'97, Discovering New worlds of HCI, Sydney, Australia, Chapman & Hall.

Lavery, D., G. Cockton and M. P. Atkinson (1997) "Comparison of evaluation methods using structured usability problem reports." Behaviour & Information Technology Volume 16, (Numbers 4-5): 246 - 266.

Law, E. L.-C., V. Roto, M. Hassenzahl, A. P. O. S. Vermeeren and J. Kort (2009) Understanding, scoping and defining user experience: a survey approach. Proceedings of the 27th international conference on Human factors in computing systems. Boston, MA, USA, ACM.

Lee, D.-S. and Y.-H. Pan (2007) Lessons from Applying Usability Engineering to Fast-Paced Product Development Organizations. Usability and Internationalization. HCI and Culture., Springer Berlin / Heidelberg: 346-354.

Leurs, B., P. Conradie, J. Laumans and R. Verboom. (2009). "Generic Work Process - Version 1.0." Retrieved August 14, 2010.

Levy, S. (2009). "Speed, Smarts Keep iPhone 3GS at the Front of the Mobile Race." Wired Retrieved May 15, 2010, from http://www.wired.com/reviews/product/iphone_3gs.

Lincoln, K. and L. Thomassen (2007) How to succeed at retail: winning case studies and strategies for retailers and brands. London, Kogan Page Limited.

Lindgaard, G. and C. Dudek (2003) "What is this evasive beast we call user satisfaction?" Interacting with Computers 15 (3): 429-452.

Lindholm, C., T. Keinonen and H. Kiljander, Eds. (2003) Mobile Usability. How Nokia changed the face of the mobile phone, McGraw-Hill.

Linzmayer, O. (2004) Apple Confidential 2.0: the definitive history of the world's most colorful company. San Francisco, No Starch Press.

Löwgren, J. and E. Stolterman (1999) "Methods & tools: design methodology and design practice." Interactions Volume 6 (Issue 1): 13 - 20.

Luckman, J. (1984) An approach to management in design. Developments in design methodology. N. Cross. New York, Wiley.

Mackie, J. L. (1974) Counterfactuals and causal laws. Philosophical problems of causation. T. L. B. (ed.). California, Dickenson**:** 95-105.

Maeda, J. (2006) The Laws of Simplicity (Simplicity: Design, Technology, Business, Life). Boston, The MIT Press.

Maguire, M. (2001) "Context of Use within usability activities." International Journal of Human-Computer Studies 55 (4): 453-483.

Mak, M. (2009) The Philips Easy Line; a retrospective case study. Faculty of Industrial Design Engineering. Delft, Delft University of Technology**:** 210.

Malterud, K. (2001a) "The art and science of clinical knowledge: evidence beyond measures and numbers." The Lancet 358 (9279): 397-400.

Malterud, K. (2001b) "Qualitative research: standards, challenges, and guidelines." The Lancet 358 (9280): 483-488.

Mao, J.-Y., K. Vredenburg, P. W. Smith and T. Carey (2005) "The state of user-centered design practice." Communications of the ACM 48 (3): 105-109.

Mathieson, K. and M. Keil (1998) "Beyond the interface: Ease of use and task/technology fit." Information & Management 34 (4): 221-230.

Matzler, K., H. H. Hinterhuber, F. Bailom and E. Sauerwein (1996) "How to delight your customers." Journal of Product and Brand Management 5 (2): 6-18.

Mayhew, D. J. (1999) "Business: Strategic development of the usability engineering function." Interactions 6 (5): 27-34.

Merton, R. K. and P. L. Kendall (1946) "The Focused Interview." The American Journal of Sociology 51 (6): 541-557.

Meyer, A. D. (1991) "Visual Data in Organizational Research." Organization Science 2 (2): 218-236.

Miles, M. B. and A. M. Huberman (1994) Qualitative Data Analysis; An Expanded Sourcebook. Thousand Oaks, Sage Publications.

Minderhoud, S. and P. Fraser (2005) "Shifting paradigms of product development in fast and dynamic markets." Reliability Engineering & System Safety 88 (2): 127-135.

Molich, R., M. R. Ede, K. Kaasgaard and B. Karyukin (2004) "Comparative usability evaluation." Behaviour & Information Technology 23 (1): 65 - 74.

Mossberg, W. S. and K. Boehret (2007) The iPhone Is a Breakthrough Handheld Computer. Wall Street Journal.

Muller, M. J. and S. Kuhn (1993) "Participatory design." Commun. ACM 36 (6): 24-28.

Nielsen, J. (1992a) Finding usability problems through heuristic evaluation. SIGCHI conference on Human factors in computing systems, Monterey, California, United States, ACM Press.

Nielsen, J. (1992b) "The usability engineering life cycle." IEEE Computer 25 (3): 12-22.

Nielsen, J. (1994) Usability Engineering, Morgan Kaufmann.

Nielsen, J. (2004). "Why consumer products have inferior user experience." Jakob Nielsen's Alertbox Retrieved April 14, 2005, from http://www.useit.com/alertbox/20040315.html.

Nielsen, J. (2008, March 17, 2008). "Bridging the Designer-User Gap." Jakon Nielsen's Alertbox Retrieved May 30, 2010, from http://www.useit.com/alertbox/designer-user-differences.html.

Nielsen, J. (2010). "iPad Usability: First Findings From User Testing." Jakob Nielsen's Alertbox Retrieved June 9, 2010, from http://www.useit.com/alertbox/ipad.html.

Nielsen, J. and R. L. Mack (1994) Usability inspection methods. New York, Wiley.

Norman, D. (1996) Design as Practiced. Bringing Design to Software. T. Winograd. New York, USA, ACM Press.

Norman, D. (2007a) "Simplicity is highly overrated (column: the way I see it)." Interactions 14 (2 (March + April 2007)): 40-41.

Norman, D. (2008) "Simplicity is not the answer." Interactions 15 (5): 45-46.

Norman, D. A. (2002) The Design of Everyday Things. New York, Basic Books Publishers.

Norman, D. A. (2005) "Human-centered design considered harmful." Interactions 12 (4): 14-19.

Norman, D. A. (2007b) "Three challenges for design." Interactions 14 (1): 46-47.

Nussbaum, B. and R. Neff (1991) I can't work this thing! Frustrated by high tech? Designers are getting the message. BusinessWeek**:** 36-41.

Otker, T., M. Schellekens, H. v. Leeuwen and R. Heutink (2005) True Loyalty - The predictive value of customer satisfaction indicators. ESOMAR 2005 congress; proceedings, part 1: customer focus, Cannes, France.

Park, C. W., L. Feick and D. L. Mothersbaugh (1992) "Consumer knowledge assessment: How product experience and knowledge of brands, attributes, and features affects what we think we know." Advances in Consumer Research 19 (3): 193-198.

Patton, M. Q. (1990) Qualitative Interviewing. Qualitative Evaluation & Research Methods. M. Q. Patton. London, UK, Sage Publications.

Patton, M. Q. (2002) Qualitative Reserch & Evaluation Methods. Thousand Oaks, CA, USA, Sage Publications.

Person, O., J. Schoormans, D. Snelders and T.-M. Karjalainen (2008) "Should new products look similar or different? The influence of the market environment on strategic product styling." Design Studies 29 (1): 30-48.

Philips. (2005, August 31, 2005). "Why Simplicity? - Royal Philips Electronics." 2006, from http://www.philips.com/about/brand/whysimplicity/index.html.

Pogue, D. (2010) Looking at the iPad From Two Angles. New York Times.

Preece, J., H. Sharp and Y. Rogers (2002) Interaction Design: Beyond Human-Computer Interaction, John Wiley & Sons Inc.

Preece, J., H. Sharp and Y. Rogers (2007) Interaction Design: Beyond Human-Computer Interaction, John Wiley & Sons Inc.

Ragin, C. (1987) The comparative method: Moving beyong qualitative and quantitative strategies. Berkely, University of California Press.

Rauch, T. and T. Wilson (1995) "UPA and CHI surveys on usability processes." SIGCHI Bull. 27 (3): 23-25.

Redish, J. G., R. G. Bias, R. Bailey, R. Molich, J. Dumas and J. M. Spool (2002) Usability in practice: formative usability evaluations - evolution and revolution. CHI '02, Minneapolis, Minnesota, USA, ACM publishers.

Reichheld, F. F. (2003) "The one number you need to grow." Harvard Business Review 81 (12): 46-55.

Rogers, E. M. (1995) Diffusion of Innovations. New York, Free Press

Rooden, T. (2001) Design models for anticipating future usage. Faculty of Industrial Design Engineering, Applied Ergonomics and Design. Delft, Delft University of Technology.

Rooden, T. and H. Kanis (2000) Anticipation of usability problems by practitioners. Proceedings of the Human Factors and Ergonomics Society 44th Annual Meeting, San Diego, USA.

Roozenburg, N. F. M. and J. Eekels (1991) Produktontwerpen, structuur en methoden. Utrecht, Uitgevery Lemma, 1991.

Rosenbaum, S., J. A. Rohn and J. Humburg (2000) A toolkit for strategic usability: results from workshops, panels, and surveys. SIGCHI conference on Human factors in computing systems, The Hague, The Netherlands, ACM Press.

Roth, G. and A. Kleiner (2000) Car Launch – The Human Side of Managing Change., New York, Oxford University Press.

Russo, B., S. Boess and P. Hekkert (forthcoming) "What's love got to do with it? Love in person-product relationships.".

Rust, R. T., D. V. Thompson and R. W. Hamilton (2006) "Defeating feature fatigue." Harvard Business Review 84 (2): 98-107.

Sanders, E. B.-N. and P. J. Stappers (2008) "Co-creation and the new landscapes of design." CoDesign: International Journal of CoCreation in Design and the Arts 4 (1): 5 - 18.

Sauer, J. r., K. Seibel and B. Rattinger (2000) "The influence of user expertise and prototype fidelity in usability tests." Applied Ergonomics 41 (1): 130-140.

Sawhney, M. S. (1998) "Leveraged high-variety strategies: From portfolio thinking to platform thinking." Journal of the Academy of Marketing Science 26 (1): 54-61.

Scriven, M. (1977) The methodology of evaluation. Curriculum and evaluation. A. A. Bellack and H. M. Kliebard. Berkeley, CA, McCutchan**:** 334-371.

Shackel, B. (1984) The concept of usability. . Visual Display Terminals. J. Bennet. Englewood Cliffs, New Jersey, Prentice-Hall, Inc.

Shackel, B. (1991) Usability - context, framework, definition, design and evaluation. Human factors for informatics usability. Cambridge, Cambridge University Press**:** 21-37.

Shenton, A. K. (2004) "Strategies for ensuring trustworthiness in qualitative research projects." Education for Information 22 (2004): 63-75.

Singer, J. D. (1961) "The Level-of-Analysis Problem in International Relations." World Politics 14 (1): 77-92.

Sleeswijk Visser, F. (2009) Bringing the everyday life of people into design. Industrial Design Engineering. Delft, Delft University of Technology. PhD**:** 271.

Sleeswijk Visser, F., P. J. Stappers, R. van der Lugt and E. Sanders (2005) "Contextmapping: experiences from practice." CoDesign: International Journal of CoCreation in Design and the Arts 1 (2).

Smith, R. P. and J. A. Morrow (1999) "Product development process modeling." Design Studies 20 (3): 237-261.

Song, X. M. and M. M. Montoya-Weiss (1998) "Critical Development Activities for Really New versus Incremental Products." Journal of Product Innovation Management 15 (2): 124-135.

Song, X. M., M. M. Montoya-Weiss and J. B. Schmidt (1997) "Antecedents and Consequences of Cross-Functional Cooperation: A Comparison of R&D, Manufacturing, and Marketing Perspectives." Journal of Product Innovation Management 14 (1): 35-47.

Standaert, A. A. (2004) Cognitive fixation in product use. Faculty of Industrial Design Engineering, Applied Ergonomics and Design. Delft, Technische Universiteit Delft. PhD.

Stanton, N. and M. Young (1998) "Is utility in the mind of the beholder? A study of ergonomics methods." Applied Ergonomics 29 (1): 41-54.

Steen, M. (2008) The fragility of human-centred design. Industrial Design Engineering. Delft, The Netherlands, TU Delft. PhD.

Steger, T., B. Sprague and D. Douthit (2007) Big Trouble with No Trouble Found: How Consumer Electronics Firms Confront the High Cost of Customer Returns. Accenture Communications & High tech, Accenture.

Sundgren, N. (1999) "Introducing interface management in product family development." Journal of Production Innovation Management 16 (1): 40-51.

Tamler, H. M. (1998) "How (much) to Intervene in a Usability Testing Session." Common Ground 8 (3): 11-15.

Tassoul, M. and J. Buijs (2007) "Clustering: An Essential Step from Diverging to Converging." Creativity and Innovation Management 16 (1): 16-26.

Thölke, J. M., E. J. Hultink and H. S. J. Robben (2001) "Launching new product features: a multiple case examination " Journal of Product Innovation Management Volume 18 (1): 3-14.

Thompson, D. V., R. W. Hamilton and R. T. Rust (2005) "Feature Fatigue: When Product Capabilities Become Too Much of a Good Thing." Journal of Marketing Research 42 (4): 431-442.

Tractinsky, N. (1997) Aesthetics and apparent usability: empirically assessing cultural and methodological issues. SIGCHI conference on Human factors in computing systems table of contents. Atlanta, Georgia, United States**:** 115 - 122.

Tractinsky, N., A. S. Katz and D. Ikar (2000) "What is beautiful is usable." Interacting with Computers 13 (2): 127-145.

Ulrich, K. T. and S. D. Eppinger (2004) Product Design and Development. New York, McGraw-Hill.

Väänänen-Vainio-Mattila, K. and S. Ruuska (2000) Designing Mobile Phones and Communicators for Consumer's Needs at Nokia. Information Appliances and Beyond: Interaction Design for Consumer Products. E. Bergman. San Fransisco, USA, Morgan Kaufmann Publishers.

van der Bijl-Brouwer, M. and M. C. van der Voort (2009) Strategies to design for dynamic usability. IASDR09, Seoul, South Korea.

van Eijk, D., Ed. (2006) Cultural Diversity & Design - Proceedings of the Inaugural Symposium of Prof.Ir. D.J. van Eijk. Delft, The Netherlands, Delft University of Technology.

van Kuijk, J., E. Preijde, E. Toet and H. Kanis (2009) Expected versus experienced usability: what you see is not always what you get. IEA2009, 17th World Congress on Ergonomics, Beijing, China.

van Kuijk, J. I. (2008a). "The beauty of desire paths (wear and tear and use II)." uselog.com | the product usability weblog Retrieved June 10, 2010, from http://www.uselog.com/2008/08/beauty-of-desire-paths-wear-and-tear.html.

van Kuijk, J. I. (2008b). "Customer-centered versus user-centered packaging." uselog.com | the product usability weblog Retrieved June 10, 2010, from http://www.uselog.com/2008/11/consumer-centered-versus-user-centered.html.

van Kuijk, J. I. (2008c). "Design strategies for sustainable behavior." uselog.com | the product usability weblog Retrieved June 10, 2010, from http://www.uselog.com/2008/05/design-strategies-for-sustainable-user.html.

van Kuijk, J. I. (2009). "Study: Expected versus experienced usability." uselog.com | the product usability weblog Retrieved 10 June, 2010, from http://www.uselog.com/2009/08/study-expected-versus-experienced.html.

van Maanen, J. (1988) Tales of the Field; on Writing Ethnography. Chicago, University of Chicago Press.

Vance, A. and B. Stone (2010) Apple Buys Intrinsity, a Maker of Fast Chips. New York Times**:** B7.

Venkatesh, V. (2000) "Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model." Information Systems Research 11 (4): 342 -365.

Venturi, G. and J. Troost (2004) Survey on the UCD integration in the industry Third Nordic conference on Human-computer interaction Tampere, Finland, ACM publishers.

Vermeeren, A. (2009) What's the problem? Studies on identifying usability problems in user tests. Industrial Design Engineering. Delft, Delft University of Technology. PhD.

Veryzer, R. W. and B. B. d. Mozota (2005) "The Impact of User-Oriented Design on New Product Development: An Examination of Fundamental Relationships." Journal of Product Innovation Management 22 (2): 128-143.

Vink, P., Ed. (2005) Comfort and Design: principles and good practice. Boca Raton, Florida, USA, CRC Press.

Virzi, R. A., J. L. Sokolov and D. Karis (1996) Usability problem identification using both low- and high-fidelity prototypes. Proceedings of the SIGCHI conference on Human factors in computing systems: common ground. Vancouver, British Columbia, Canada, ACM.

Vogelstein, F. (2008) Weapon of mass disruption: the untold story of the iPhone - and how Apple transformed the wireless industry forever. Wired. New York, Condé Nast publications.

Vredenburg, K., S. Isensee and C. Righi (2002a) User-Centered Design; An Integrated Approach. New Jersey, USA, Prentice-Hall.

Vredenburg, K., J.-Y. Mao, P. W. Smith and T. Carey (2002b) A survey of user-centered design practice. SIGCHI 2002 conference on Human factors in computing systems: Changing our world, changing ourselves Minneapolis, Minnesota, USA.

Weegels, M. (1996) Accidents Involving Consumer Products. Faculty of Industrial Design Engineering. Delft, Delft University of Technology. PhD.

Wever, R. (2009) Thinking-about-the-box; A Holistic Appeoach to Sustainable Design Engineering of Packaging for Durable Consumer Goods. Faculty of Industrial Design Engineering. Delft, Delft University of Technology. PhD**:** 191.

Wever, R., J. van Kuijk and C. Boks (2008) "User-centred design for sustainable behaviour." International Journal of Sustainable Engineering 1 (1): 9 - 20.

Wiklund, M. E., Ed. (1994) Usability in Practice; How companies develop user-friendly products. Cambridge, AP Professional.

Wilson, J. R. (2000) "Fundamentals of ergonomics in theory and practice." Applied Ergonomics 31 (6): 557-567.

Wixon, D. (2003) "Evaluating usability methods - why the current literature fails the practitioner." Interactions (July + August 2003): 28 - 34.

Wood, S. L. and C. P. Moreau (2006) "From Fear to Loathing? How Emotion Influences the Evaluation and Early Use of Innovations." Journal of Marketing 70 (July 2006): 44-57.

www.webuser.co.uk. (2008). "Millions of gadgets unused in Britain." Retrieved April 13, 2010, from http://www.webuser.co.uk/news/top-stories/370714/millions-of-gadgets-unused-in-britain.

Yin, R. K. (2009) Case study research: design and methods. Thousand Oaks, California, USA, SAGE publications, Inc.

Young, J. S. and W. L. Simon (2005) iCon: Steve Jobs, the greatest second act in the history of business. Hoboken, New Jersey, John Wiley & Sons Inc.

Ziefle, M. (2002) "The influence of user expertise and phone complexity on performance, ease of use and learnability of different mobile phones." Behaviour and Information Technology 21 (1): 303-311.

Appendices

Appendix A

Using a weblog as a tool for dissemination, dialogue and reflection

On February 16 2005, I wrote my first post on uselog.com | the product usability weblog. I had just started as a PhD candidate at IDE on usability in product development of electronic consumer products and read an article about Philips' new brand position 'Sense and Simplicity', something that was very much related to my PhD research project. I realized that, considering the practice-oriented nature of my research, I was bound to run into a lot of news, events and insights that would be relevant to my research. I decided to start a weblog, to capture my ramblings about products, research and events in the domain of consumer product usability. Uselog.com was to serve as my 'usability-thoughts safety valve', enabling me to empty my head now and then, without losing the ideas.

There was one other reason for me to start a weblog. I was going to study product development practice, and believed (and still do) that in the end the results of my research should be fed back into the product development community. The only problem was: designers, (product) managers, and usability specialists are usually not that keen on reading scientific journals or conference papers, either because they don't have the time for it or access to them. I was looking for a way to communicate my findings to my 'end-users'. And maybe even establish a dialogue with them. I assumed that in order to build up an audience, blogging about my life as a PhD candidate would not do the trick and instead decided to focus on the subject of consumer product usability, and mix my own insights, referrals to other blogs and posts about the findings of my research.

The following section describes the use of the weblog during my research project and how it functioned as a tool for disseminating my research, a platform for dialogue and discussion with the field, and how writing the weblog resulted in continuous reflection on (part of) my research phenomenon.

Approach

Goal

The goal of writing on uselog.com was to attract an audience of product managers, interaction designers and usability specialists by generating constant flow of news, research (by other authors than myself), opinions and examples relating to consumer product usability. Having this audience should provide the opportunity to disseminate my own research in the product development and human-product interaction community. Secondly - and this became apparent to me over time – a weblog can be a two-way street. It needn't or shouldn't just be me sending out my thoughts and research, but it could also be a way for me to engage in discussions with product development professionals and fellow researchers.

Subjects

To be honest, my main criterion to write about something was whether the subject struck a chord with me. But retrospectively the subjects fell into the following categories:

- Discussing examples of usability in electronic consumer products;
- Reflecting on user-centred design methods, methodologies, and practice;
- Discussing scientific research and publications that might contain an interesting take away for practitioners or design researchers;
- Referring to posts on other weblogs and magazine articles
- Advertising events, both from inside and outside of the faculty of IDE, for example, the UPA and CHI conferences, the IDE Contextmapping symposium, and Design for Usability symposium;
- Presenting my own publications.

Development of uselog.com

I claimed a blog via the blogger.com blog-publishing platform and started out with a standard blogger template to which I made small modifications over time. I had started out with the notion of "let's first see whether I can keep writing". A few years later I had found out that I could keep writing and it was now time for the appearance of the weblog to become a little more professional, and secondly, despite the use of the (modified) Blogger template resulted in fundamental limitations of the website design. So uselof.com got a completely redesign, while the Blogger platform remained the 'back-end' where the blog's content could be entered and edited.

Below is a timeline of the development of uselog.com:

- February 16, 2005: First post
- March 2005: RSS-feed added
- June 2006: E-mail updates added
- May 2008: full message via RSS, instead of summary
- September 2008: Website redesign implemented
- October 2008: online shirt shop opened
- May 2009: Twitter-feed added

Figure 66: Late iteration of the first version of the weblog, based on a modified Blogger template.

Figure 67: Redesign of the weblog, including submenus and subpages for links, relevant literature, my research, and about & contact.

Output

During a little more than five years of writing[28] an overall number of 422 posts were published on uselog, with an average number of postings of about once per week in the first year, and two per week in the subsequent years.

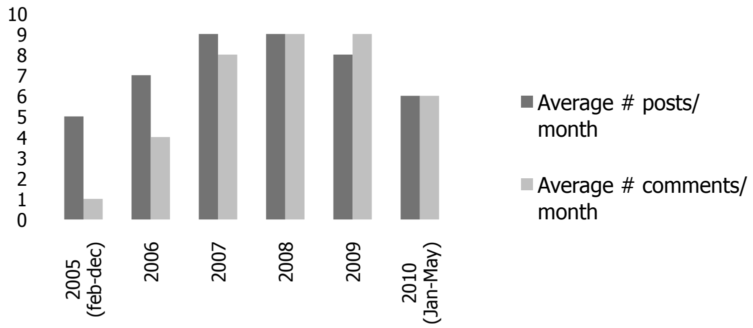


Figure 68: An overview of the number of posts and comments per month.

Results

The following paragraph discusses the amount and type of readers uselog.com had, and exhibits are provided of how the weblog functioned as a tool for dissemination of research, as a platform for discussion and dialogue, and for reflection.

Reach

At the time of writing uselog.com's Google Page Rank, which is a link analysis algorithm used by the Google Internet search engine to assess the relative importance of a webpage, had a value of 5 out of 10 (see Table 35). When searching Google with the queries 'product usability', 'consumer product usability', and 'consumer electronics usability' uselog.com was the first result to appear.

Table 35: A benchmark of the Pagerank of uselog.com

URL	Type of website	Pagerank
amazon.com	Online retailer (books, CDs, DVDs, electronics)	9
io.tudelft.nl	Website of the faculty of Industrial Design Engineering	7
core77.com	High frequency weblog about design (multiple authors)	7
architectures.danlockton.co.uk	Weblog of PhD candidate focusing on 'design with intent'	5
uselog.com	Weblog of the author of this thesis	5
usabilityblog.com	Weblog of UX professional Paul Sherman	4

[28] The benchmark date for the output as well as for the results in the next paragraph is May 18, 2010.

Below is an overview of the average number of page loads and unique visitors (sum of returning and first time visitors) per month.

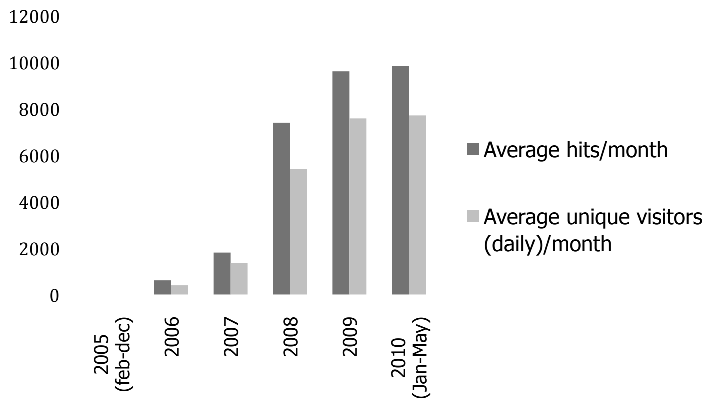


Figure 69: the number of average page loads (hits) and unique visitors per month from 2005 to 2010. Data for 2005 are not available.

The posts on uselog were not only published on the website, but also distributed through RSS (images and full text), a Twitter feed (alerts with link to posts), and an email newsletter (see Table 36).

Table 36: Overview of uselog reach through other channels than the webpage.

Channel	Reach
RSS feed	1400 (estimation by Feedburner RSS feed service)
Twitter feed	143 followers
Email newsletter	71 subscribers

Audience

Using a web traffic analysis allowed for the analysis of the geographical location of website visitors, as well as what institution or company the visitors were affiliated with. By monitoring the website traffic on an (almost) daily basis, and then storing what companies and institutions visitors were from I created a database of samples of uselog visitors[29]. Based on this data it became evident that about half my visitors were from academia, and

[29] It should be noted I could only identify those organisations and academic institutions that accessed the Internet through a server that was 'put in their name'. If a company for example leased offices, which included Internet access their name would not surface in the database.

the other half was from non-academic organisations (e.g., companies and (local) governments). The locations of the non-academic organisations was hard to confirm, as for example a company can be based in multiple countries, but of academic institutions the geographical location is well-known. Based on this information the right-hand diagram in Figure 70 was created. The distribution of academic and non-academic visitors in the database was about fifty-fifty. About a quarter of the academic visitors was from within the Netherlands, one-third from the rest of Europe, and an additional one-third was from US-based academic institutions.

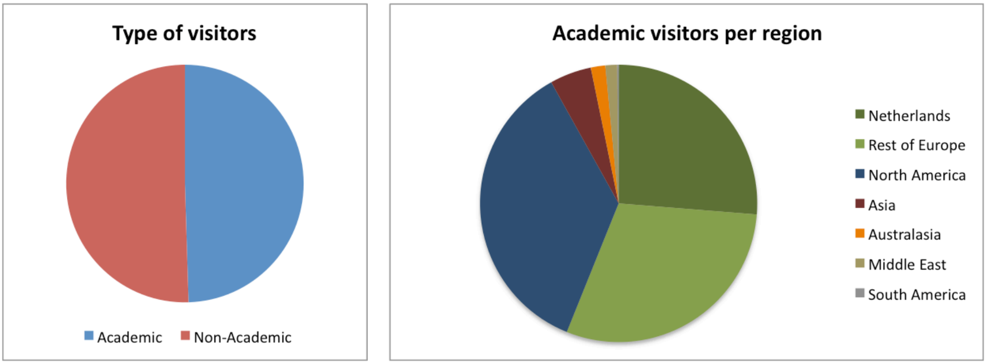


Figure 70: The origin of uselog visitors. Left: distribution of academic versus non-academic visitors. Right: The geographical distribution of academic visitors.

As an indication, the academic institutions from which most visitors came to uselog were: Carnegie Mellon University, Columbia University, Georgia Institute of Technology, Harvard University, KAIST, Leiden University (NL) Loughborough University, MIT, Northwestern University, Rochester Institute of Technology, Stanford University, TU/e (NL), TU Delft (NL), University of Washington, Universiteit Twente (NL), Universiteit Utrecht, University of Cambridge, University of California at Berkeley, University of Leeds, University of Minnesota, University of Toronto, University of Nottingham, Rijksuniversiteit Groningen (NL), Vrije Universiteit Amsterdam (NL).

In Figure 71 a so-called Worlde-diagram (www.wordle.com) indicates from which non-academic organisations visitors came to uselog. As the method of logging visitors was sample-based, the diagram is deliberately indicative: the size of the names does indicate the relative number of logged visits from that company, but does not give an indication of the exact number of visits.

Figure 71: Wordle-diagram in which the size of the names of organizations indicate their relative contribution to the visits of non-academic organisation to uselog.

Disseminating research

Below I will discuss two instances in which I disseminated publications that resulted from my PhD research through the product usability weblog: (1) a journal article entitled 'User-centred design for sustainable behaviour' and (2) a conference proceeding on 'expected versus experienced usability'.

Exhibit 1: Disseminating 'User-centred design for sustainable behaviour'

I put a summary of an article I co-authored (Wever *et al.*, 2008) on uselog (van Kuijk, 2008c), including links to a downloadable pre-print document of the article. Subsequently the publication was picked up by several design and interaction weblogs, such as for example the 'putting people first' weblog (Figure 72), an audience that I would have most likely not reached by publishing the article in a scientific journal only.

Figure 72: A post about the publication on the 'putting people first' user-centred design weblog

Exhibit 2: Disseminating 'Expected versus experienced usability'

On the 2009 World Congress on Ergonomics in Beijing I presented a paper on an exploratory study into expected versus experienced usability (van Kuijk *et al.*, 2009) to an audience of about 25 people. Directly after the presentation I put a summary online of the publication including links to a downloadable pre-print version (van Kuijk, 2009).

The posting generated a spike in visitors, and spawned 44 reactions on Twitter, with people picking up on the weblog post, but also 'retweeting' (forwarding) tweets about the publication to others (Figure 73). All in all, the amount of tweets about the paper was bigger than the amount of people in the audience when I presented at the conference. I would argue that having been presented at a conference and published in a journal lend these publications extra credibility, which may have increased how interesting they were to my audience.

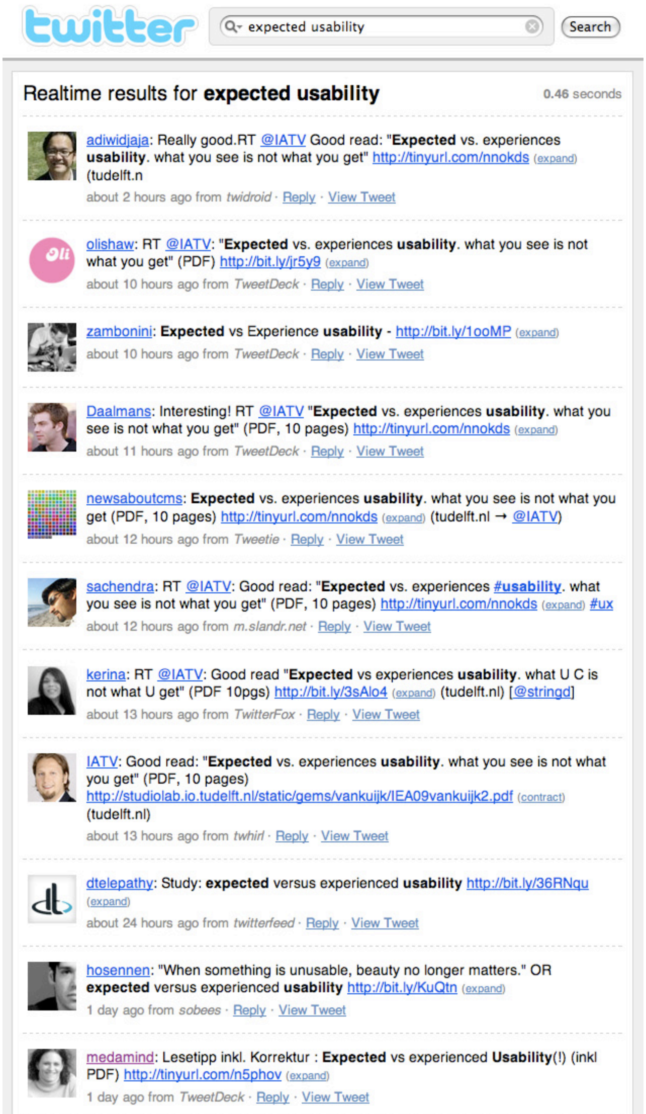


Figure 73: Reactions on Twitter on the post about the paper presented at the IEA09 World Congress on Ergonomics.

The exhibits above indicate that a weblog can be a tool for disseminating scientific publications among practitioners. When I wrote a post celebrating the four-year anniversary of uselog, and explained that one of my goals was to disseminate scientific knowledge to the product development community I got the following response in the comment section:

> ***Gwen***
> *As an industrial designer, I am glad you are blogging. I think for me, scientific journals is not about the difficulties of reading it is the access and the time to read them. Please keep sending some goodies...*

Platform for dialogue and discussion

As mentioned, over time I discovered the potential of uselog as a platform for discussion with the product development as well as the design research community. The posts received comments on a regular basis (Figure 68) and some sparked discussions about the subject of or an element in a post, which often helped me to improve my understanding or arguments. Below I would like so show a number of examples of discussions.

Exhibit 1: Suggestion for changing terminology

A post about packaging on which directions for use were hard to read, while large parts of the packaging were used from brand communication and advertising the product (van Kuijk, 2008b) was originally entitled 'Consumer-centered versus user-centred packaging'. After receiving the following reaction I changed the title to 'Customer-centered versus user-centered packaging'.

> ***Erik Dahl***
> *I couldn't agree more, with one caveat. Well, I guess it's more of a nit. I would user the word "customer" as opposed to "consumer." Customer explicitly focuses attention on the act of purchasing. Consumer can both describe the act of purchasing and also the act of actually consuming the product if it is a consumable. Before I read your post I had a hard time parsing the distinction you were making between consumer and user.*

Exhibit 2: Suggestions for sources of information

I wrote a post about so-called 'desire paths' (unplanned footpaths that come existence because they are worn out by pedestrians) in which I retold a story I had heard about an architect not putting footpaths around a building after it was finished, but instead waited for pedestrians to walk the grass and then creating official footpaths where these desire had formed (van Kuijk, 2008a). In the comment section I received the following reactions:

> ***Amy Hengst***
> *Fascinating. As for deliberate use -- I went to college at at the University of California, Santa Cruz. It started as a liberal arts college in the 1950s, and much of it is still forested and set apart on a hill from the rest of the town. I have heard that at first, the administration waited before paving many paths on campus, to allow students to*

create the paths they wanted. Once these paths were established by students as they desired, the administration paved them over.

Jasper
Hi Amy, thanks for the information. I was wondering whether the story of an architect/institution deliberately using this approach was true. It seems it is. That's encouraging ;-)

Gabe
Stewart Brand's book, How Buildings Learn, describes how exactly the same thing happened at MIT when it was first built.

Exhibit 3: Evaluating recommendations for industry

I published the recommendations for industry on uselog; one recommendation each day. Product development professionals and design researchers were invited to react to the recommendations via email or in the comment sections. After all recommendations had been posted I performed an iteration of the recommendations based on the input received and then solicited a second round of feedback. Below are two examples of comments received in the first feedback round.

Response to recommendation #5: 'Team: One roof: all disciplines - in one room - throughout the process':

Marieke Smets
As a design researcher at IDEO, used to working in multidisciplinary teams, I very much agree with the statements you are making above. Both in my work with project teams and with clients, I have found that on top of this, there is an important distinction between "meeting" and "working" together. Even if being situated full time in the same space is not an option, there is a lot to gain in organizing work sessions when you get the chance, as opposed to meetings. The difference in my mind is that the latter is focused on sharing information, talking through issues and challenges, the former is focused on working through design challenges together, as a (multidisciplinary) team. In my experience this results in a mind set that is much more positive, focused on solutions and understanding each other's perspective, instead of underlining problems, disagreements and company politics.

Response to recommendation #18: 'Do not innovate the user interface':

Janne Kaasalainen [30]
Re: UI innovation = high risk

[30] Janne Kaskaanen is a senior research or Nokia Research's UX team for Symbian devices, concepting the next generation interactivity.

I think this chapter needs clarification and/or more justification. Why is it that innovating diminishes knowledge of design solutions? Shouldn't it work the other way around? Why does this has anything to do with the knowledge of user group? Shouldn't it be that the original design is made with less knowledge of the user group? Also, not introducing some changes runs the risk of not having better usability. It might mean by UI innovations you are referring to something more specific, in which case defining that would be helpful. You might be correct on all of the above, but whether or not that's the case more clarifications would be appreciated.

Exhibit 4: Inquiries from industry

Apart from the dissemination of my own research, and as a platform for discussion, uselog also facilitated contacts with industry. I received requests for contributions to publications, inquiries about cooperating in (research) projects, a multitude of suggestions of products I could write about, and in some cases requests for input, such as below:

I am an Information Architect at <Company X>, a US <product A> manufacturer. We are placing added focus on the product quality and usability area of our total customer experience, and are trying to think outside of our usual "box" when it comes to product usability. Our goal is to define a more seamless product usability lifecycle for our customers (from pre-purchase to purchase to use of the product to servicing, and so on). In doing some online research into usability, I came across your blog, and noticed that you had done some usability research that includes electronic companies, including <product B>. Our industry is somewhat similar to the <product B> industry.
In doing your research, what would you say are the key tenets for ensuring robust product usability for the customer? What company would you say sets the gold standard for product usability/ease of use across their product lifecycle? Why? What sets that company apart?

Apart from being flattering, emails such as the one above show that a weblog can be a means to carve out a niche of expertise and advertise that. In addition I have the impression that the weblog has worked well when approaching companies to participate in case studies, because it allowed me to exhibit expertise on the subject at a time when I had not yet published through scientific outlets.

Tool for reflection

Writing about consumer product usability twice a week meant that I was confronted on a continuous basis with the phenomenon I was studying. I think that my research has benefited from this going back and forth between my ideas and 'reality'. In some cases early ideas I had were reinforced by examples I encountered, in other cases I had to change my original proposition. And because I was always collecting examples from practice, I ended up with a large collection of anecdotes, examples, and exhibits about themes such as the benefits of usability, how usability was used in marketing, what simplicity is, and usability problems with consumer electronics.

Appendix B Interviewee's definitions and descriptions of usability (Case Study I)

PrintPros

Role	Definition or description of usability
Interaction designer	"Within the practice of usability, being an interaction designer you are actually 90% of the time involved with judging the usability of your interface solutions."
Industrial designer	"Usability to me is most of all about the context in which a product is used. A machine may be designed well and having a beautiful interface, without a match with the context or location of use, the whole design may fail."
Usability engineer	"Usability as a concept is something independent of the tests that are conducted or the process that is followed: every discussion within the company is held based on the user's perspective. The general mindset is even rather from a user's point of view than a client's point of view. In my opinion, the products we produce here do have a standard degree of usability."
Software engineer	"Usability is related to the degree in which functionality of a product has been made accessible to the user. It is about the degree in which the user can access the available functionality. It is about easy accessibility."
Manager operating concepts	"Usability: the ease and intuitiveness with which a user can work with a machine and the speed and ease with which he is able to find and use the functions we offered. Without the need of consulting any manual or help function."

HighCar

Role	Definition or description of usability
Interior designer	"Usability means how to use it and that using is fun, because it works. At the moment aims are directed at having it also nicely styled. It has to be cool. Even when it is not useful, it still could be successful, as long as it is cool."
Ergonomics specialist	"Usability to me is the question of usage quality, of good usage, of self-explanatory and practical: whether it matches to everyday needs."
Developer operating concepts	"Usability is the property of a product that makes it usable, meaning that it makes it easy for a user to reach his goal with the least amount of effort. That people quickly know what to expect of a product. Products with a high usability won't frustrate people, they won't evoke a fear of technology, and people would accept the product as something that makes life easier."
Designer interior (supplying company)	"Usability is a focus originating in the discipline of ergonomics. It is about setting the creation of easiness as a goal. Usability attempts to set criteria to assess the achievement of goals at a later stage. The challenge of usability engineering in general is, in my opinion, to find the right criteria to be able to determine whether we did good or bad work."
Human factors specialist	"Usability is having the chance to put the real customer in the middle of our work. The car must fit to the customer, not the customer to the car. We know very little about our customers. The best would be to have a customer every day inside the company and to ask him: 'What do you do with our car?' And also: 'What is your expectation when you push this button?'."

Home@Work

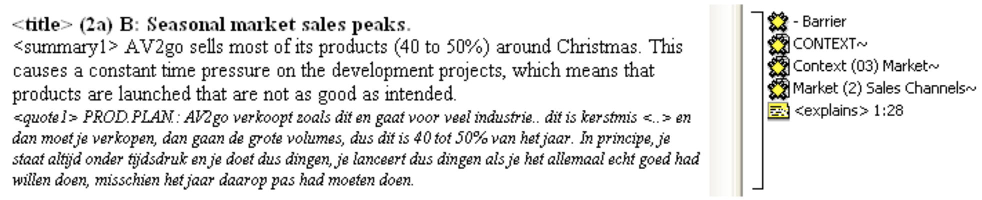
Role	Definition or description of usability
Marketing manager	"When I think of usability, first of all I think about the way in which the machine serves coffee. When you take a first glance at the machine, it should be instantly clear how to make the right choice. Usability is also important at the moment the machine has to be cleaned internally. It should definitely not be necessary to have a written guide assisting you during cleaning activities; it should be easily done within ten minutes."
Project manager	"There are many faces to user friendliness. Concerning coffee machines it relates to the fact that using it should be simple, safe and sensible. A user should not be frustrated. Coffee should be served without explanation. A cleaner should be able to do his work with minimal instructions."
Concept developer	"First of all, the machine has to answer to the needs of the user. The basis for usability lies in the concept of the machine. The machine should be self-explaining, logical. Next to that, the machine should give the user a sense that it does what the user expects."
Technical project manager	"My opinion is that a user interface extends beyond a display: it comprises the whole of a machine. Usability is about redundancy and efficiency."
Human-centred design consultant	"To me, usability is highly linked to software development. Usability is related to user testing. Mainly at the evaluation phase within a product development process usability issues are addressed. Some kind of interaction between user and machine should be available when you want to actually test usability."

CleanSweep

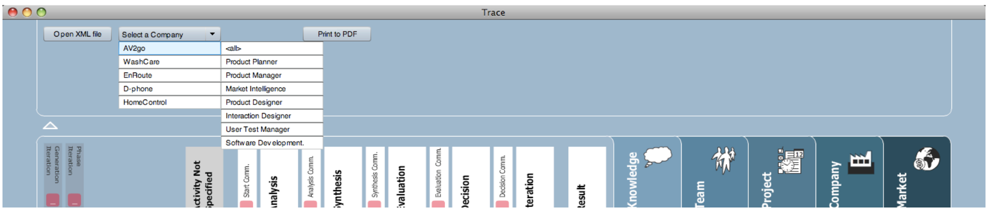
Role	Definition or description of usability
Design manager	"Usability to me is about the emotions evoked by a product, about how a user experiences the product."
Project engineer package and device development	"Personally I think that user friendliness is a much better word than usability, because it includes the word 'friendliness'. However, usability to me means: fit for use; that a product does what it should to be doing."
Package and device developer	"Usability is a better name than second moment of truth. To me it means: every product does whatever a consumer wants to do with it and however the consumer wants to use it. Doing it and using it without any stress, problem or thinking. Ergonomics. The best package for me is a 'transparent' package: a package that makes the consumer believe that there actually is no package. A package that is not noticed."
Product researcher	"Usability is about user instructions: are they understandable and readable. But, usability already plays a role when the product is on shelf: does it attract attention; is the function of the product instantly clear? Usability is also about whether the product can be taken home safely, whether it fits the storage cupboard at home and whether it is easy to open the package."

Appendix C How the Trace tool works (Case study II)

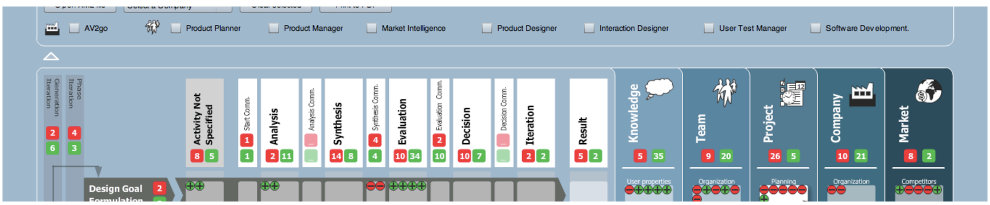
The following section outlines the workflow and possibilities of the Trace software application, including for example the formatting of the research data to import it in the application, selecting what data to view, and how to explore the data.



Step 1: *Adding categories and Trace mark-up language in Atlas.ti. In the Atlas.ti qualitative data analysis package a proprietary mark-up language is added (left), which identify the title, summary (interpretation by the researcher) and quote (excerpt from interview) of a barrier or enabler. Additionally, codes are added that indicate whether it is a barrier or enabler (on the right), in what category the barrier/enablers falls, and possibly to which barrier/enabler there is a relation.*

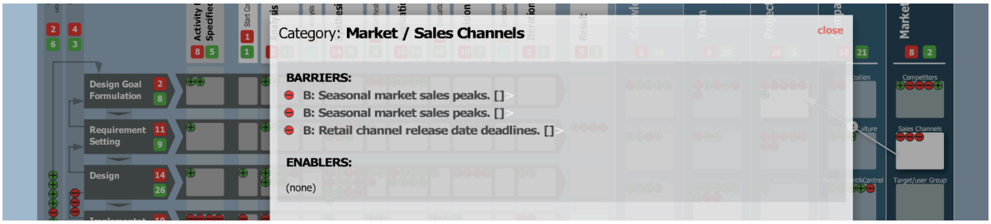


Step 2: *Selecting the company and interviewee. After starting the Trace application and selecting the XML database containing the data (button in the upper left corner), the user can choose for which interviewee to display the barriers and enablers. The interviewees are grouped per company. Thus users can choose to analyze the data for one company, or for a specific role across companies. Actors and companies can also be removed from the view.*

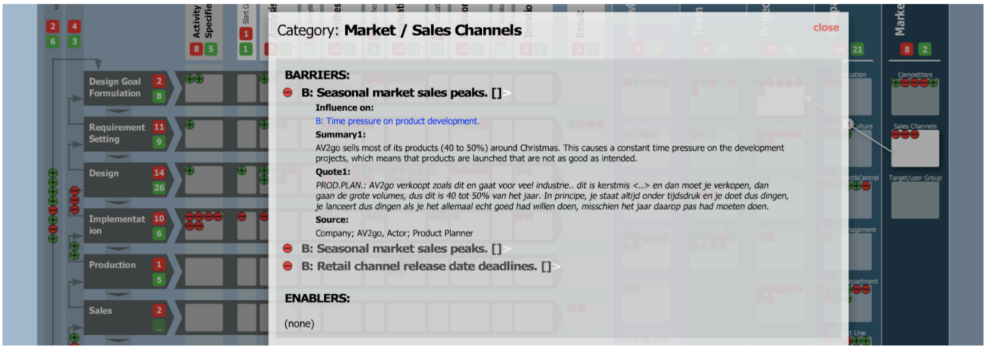


Step 3: *Exploring relations between barriers and enablers. If the user moves the pointer over a category incoming relations (grey) and outgoing relations (white) with other categories can be made visible.*

Step 4: *By clicking a category box once (in this case the category market/sales channels) the relations (arrows) between the categories are 'frozen', and when the mouse is moved over an arrow a preview (white rectangle) appears in which the relations between barriers and enablers from the connected categories are displayed. With a 'B:' or 'E:' it is indicated whether it concerns a barrier or enabler, and the '>>>' or '<<<' indication provides information about the direction of the relation. This allows for quick exploration of the relations between barriers and enablers.*



Step 5: *Viewing a listing of barriers and enablers in a category. By double clicking the category a pop up window is opened in which all barriers and enablers in that category are displayed. The category is listed in the upper part of the pop-up window. The '[]>' at the end of the barrier description indicate that these barriers have one outgoing relation.*



Step 6: *Viewing details of a barrier or enabler. Each of the barriers and enablers can be investigated in detail. Clicking the title of a barrier reveals the underlying interpretation by the researcher (Summary1) and the original quote from the interview (Quote1), as well as the company and interviewee where it originated from (Source).*

Appendix D Knowledge mechanisms (Case study II)

In the following section for each of the categories of knowledge it is indicated what it was found to consist of (what is it that the team needs to know?) where this knowledge originated from (what can you do to get this knowledge) and on what activities or properties the knowledge can exert influence.

Table 37: Knowledge about user group properties (properties and capabilities of the target group, such as demographics, anthropometrics, cognitive skills, previous experiences, etc).

Consists of knowing	Originates from	Influence on
• Who the target/user group is [1,2,3,5] • What the target/user group properties are [1,2,3,5] • How the user group defines usability [1,4] • Previous experiences of the user group with products/interfaces [4]	• Conducting interviews with users [1,5] • Voice of the Customer exercise [1,5] • Workshops with users [3] • Home visits [3] • Receiving feedback from local sales organizations [3,5]	• The target group description [2] • Setting user-centred requirements [1,4,5] • Creating a usable design [4,5] • Taking existing UI conventions into account during design [2] • Knowing which participants to ask to evaluate a product [2]

Table 38: Knowledge of user group needs and preferences (what would they like the product to do (functionality, needs, goals), and how they would like the product to do this (preferences)).

Consists of knowing	Originates from	Influence on
• User needs [1,2,3,4,5] • User preferences [1,2,3,4,5] • Customer expectations for a specific product [1,2,3] • User requirements for the product [1,5] • What users consider the most important product properties [5]	• User testing of new UI concepts [2,3,5] • Conducting concept tests (of product proposition) [5] • Analyzing online reviews of a product category [1] • Receiving feedback from local sales organizations [3] • Focus groups [2] • Workshops with users [3] • Interviewing users [4] • Home visits [3] • Observing users [4,5] • Conjoint analysis of requirements [5]	• The development or selection of the technological platform [1] • Setting user-centred requirements [4] • Creating a usable design [4] • Making decisions [4] • Creating an appealing product proposition [5]

Table 39: Knowledge of product usage (description or prediction of how (potential) users interact with a design or product (category) and in what kind of environment (physically and network) the product will be used).

Consists of knowing	Originates from	Influence on
• How users tend to use a product category [2,4] • How users will use a future product [1,2,4,5] • How users use a simulation/prototype of a design [1]	• Observing in the field how people use a product category [1,2,4] • Performing informal user tests with colleagues [1] • Beta testing with early production samples [1]	• Setting appropriate user requirements [1] • Refining a user interface concept [1] • Deciding what functionality the product should offer [2]

Consists of knowing	Originates from	Influence on
• How users use the final product when it's on the market [1,2,4] • The context in which a product will be used [3,4] • Whether users need the manual when using a product [2]	• After sales feedback [1,4] • Logging and remotely monitoring product usage [2] • Conducting a customer satisfaction questionnaire [2] • Monitoring Internet forums [2] • Analyzing the context of use [3] • User testing with simulations [3,4,5] • User testing in the field [4]	• Redesigning a product [2] • Mostly the design phase [3,4]

Table 40: Knowledge of potential usability issues (predictions about instances in which users that interact with a product cannot reach their goals or fulfil tasks with effectiveness, efficiency and satisfaction (about use)).

Consists of knowing	Originates from	Influence on
• About usability problems in a previous product generation [1,3] • Potential usability issues in a project [2,3] • About usability issues in a design [1,2,3,4,5] • Knowing what aspects of the design to improve [1,3] • Knowing about the quality of the cognitive aspects of the human-product interaction [1,4,5] • Knowing about the quality of the physical aspects of the human-product interaction [1,4] • The overall level of usability of a product or UI design [3,5]	• User testing earlier versions [5] • Focus group with resellers and installers of predecessors [5] • Early reviews of a product concept by UI specialists [1] • Designers evaluating mock-ups of their design [1,3,4,5] • Colleagues trying out a design/product [2,3,5] • User testing [1,2,3,4,5] • Beta testing [2,3] • Evaluating a design with the local sales organisations [3] • Verification of translations by people from target market [3] • Development team getting feedback from the customer service department [3] • Development team members having skill to anticipate usability issues [5]	• Iterating a design to improve usability [1,4,5] • Making changes during implementation or production [2] • Implementing improvements in the next generation of a product [2,5]

Table 41: Knowledge of usability issues (instances in which users that interact with a product cannot reach their goals or fulfil tasks with effectiveness, efficiency and satisfaction (about use)).

Consists of knowing	Originates from	Influence on
• What usability problems real world users experience with the product [1,3,4,5] • What functions or part of the current products need improvement [2] • The cause of usability issues in after sales feedback [2] • What parts of the product people don't understand [2,3] • Usability strengths and weaknesses in a previous product generation [2] • How many people encounter the usability issue [5]	• User testing off-the-shelf third party products [1] • Monitoring press reviews of products [1] • Conducting a customer satisfaction survey [1] • Monitoring and analysing customer service calls [1,2,3,4,5] • Discussing product usage with Internet forum moderators [2] • Monitoring Internet forums [2] • Receiving correspondence from customers [2] • Remotely logging and analyzing usage [2]	• Changing a product while it's on the market (often not possible) [1,2,3] • Improving the next generation of a product [1,2,3,4] • Ability of team members to anticipate usability issues in a design [2]

Consists of knowing	Originates from	Influence on
	• Local sales divisions providing feedback about questions that users have [3,5] • Longitudinal field studies with the real product [4] • Feedback from colleagues [4] • Team members trying out a product themselves [4]	

Table 42: Knowledge about user appreciation (whether people (will) evaluate a concept, design or product positively or negatively).

Consists of knowing	Originates from	Influence on
• How people appreciate new product concepts/functions/ideas [1,2,3,4] • Whether a product concept is valuable to the consumer [3] • The opinion of users about a product [1,2,3,4] • Whether a UI design is in line with user expectations [1,5] • Whether a product matches with user needs/preferences [5] • What aspects of the product users like/dislike [1] • Knowing the reasons for product returns [1] • What sales people think about a product once it is on the market [3]	• Input from the quality department, based on after sales feedback from previous products [1] • Beta testing [1] • User testing of product concepts [1,2,3,4] • User testing of a product design [1,3,5] • Customer satisfaction questionnaire [1,2,4] • Evaluating customer support contacts [1,2,3] • Monitoring Internet forums [2] • Marketing department providing feedback about a product proposal [4] • Clients (resellers) providing feedback about a design [5] • People who install the product providing feedback [5]	• Implementing improvements based on information found in beta tests [1] • Implementing improvements in a next generation of the product [1] • Empathy of development engineers for users [2] • Development engineers becoming more user-focused [4]

Table 43: Knowledge about design solutions (usable designs and alternative designs).

Consists of knowing	Originates from	Influence on
• What functionality competitor products offer [1] • Knowing the limitations of a technological platform [1] • Knowledge of existing UI design solutions [1,2,3,4] • Knowledge of appropriate (usable) UI design solutions [2,3,4,5]	• User testing of a predecessor product [5] • Analyzing competitor products [1,2,3] • Analyzing previously performed user tests and focus groups [1] • Asking users how to improve the design (negative!) [2] • User testing of simulations [4] • Reviews of a design [4] • Having a UI paradigm [4] • Having predecessor products with a usable UI [3]	• The creation of a usable UI [3] • Making UI designs that take into account the limitations of the technological platform [1] • Taking into account solutions in competitor products when making UI designs [1]

Appendix E Usability issues per product (Case study III)

Usability issues of the hard-disk recorder

Causal network	Issue description	Source					Task	Prod. components						
		AV@home test	TUD test	Satisf. quest.	Help desk	Online reviews		Main unit	Platform	Cables	Remote control	On-screen UI	QSG/manual	Packaging
Usability weaknesses														
✓	Back button not working in every menu		●				Overall					●		
✓	Device slow, interaction cumbersome					●	Overall		●			●		
✓	Starting up the device takes a long time (20-30 seconds)	●				●	Powering on device		●					
✓	Powering on device: late feedback	●					Powering on device	●				●		
✓	Channel installation: lasts long and insufficient feedback	●					Setup		●			●		
✓	On-screen TV guide installation procedure unclear		●	●	●	●	Setup		●			●	●	
✓	Connecting device in set-top box setup is complicated	●	●	●	●		Installation	●		●			●	
✓	Pushing ‘HDD list button’ only displays a list of recorded TV programs (not of other content, which is expected)		●				Play media				●	●		
	Home button not used by users to access hard disk contents	●	●				Play media				●	●		
	VPS/PDC option not understood	●					Setting timed recording					●		
	Timed recording dialogue: ‘next field function’	●					Setting timed recording					●		
✓	Unclear what remote control button to use to access timed recording menu	●	●				Setting timed recording				●			
✓	Recording: front-panel countdown feedback not understood	●					Direct recording	●						
	Recording in progress feedback only visible on main unit	●	●				Direct recording	●				●		
	Users confused by feedback when using Pause Live TV		●				Pause live TV					●		
	Resuming Live TV: hard to find appropriate control	●	●				Pause live TV				●			
	‘Info button’ not used to access time shift buffer	●					Navigating TSB				●			
	Navigating Time Shift Buffer not understood	●	●				Navigating TSB				●	●		
✓	Complicated to mark a segment for recording in Time Shift Buffer	●					Recording from TSB				●	●		
✓	Feedback when transferring content does not indicate transfer progress	●					Transferring USB contents					●		
	Users unsure whether to ‘unmount’ USB stick	●	●				Transferring USB contents	●				●		
Usability strengths														
	On-screen UI well understood		●	●		●	Overall				●	●		
	Connecting device (without a set-top box)	●					Installation	●		●			●	
	Pause Live TV & resume playback	●		●			Pause live TV				●	●		
	Unpacking (no issues)	●					Unpacking	●		●			●	●
	Accessing contents of USB stick	●					Accessing USB contents				●			

Usability issues of the DVD-recorder

Causal network	Usability issue description	Source			Task	Prod. components						
		AV@home test	TUD test	Online reviews		Main unit	Platform	Cables	Remote control	On-screen UI	QSG/manual	Packaging
Usability weaknesses												
✓	Connecting device (in setup with set top box) is complicated	●		●	Setup	●		●			●	
	Users confused about cables (where to connect, and what the use is)		●		Setup			●			●	
✓	Countries not listed alphabetically (in Dutch) during setup		●	●	Installation					●		
✓	Automated channel installation: takes long and insufficient feedback		●		Installation		●			●		
	Unclear how to bypass automatic channel installation	●	●		Installation					●		
✓	Starting timed recording requires device to be in standby	●	●	●	(Setting) timed recording		●					
	VPS/PDC option and 'quality' in timed recording menu not understood	●	●		Setting timed recording					●		
✓	Disc space warning does not point out possibility of reducing recording quality	●	●		Setting timed recording					●		
✓	Feedback message when (accidentally) exiting timed recording menu not clear	●			Setting timed recording					●		
✓	'Timer' button label (on remote control) not identified as access to timed recording		●		Setting timed recording				●	●		
	Feedback that device is recording only on main unit (not on-screen)		●		Recording	●				●		
	Meaning of 'title' label in on-screen menu unclear	●			Play media					●		
✓	'Disc' not the most obvious label for access to DVD-menu (on remote)	●	●	●	Play media				●			
	No feedback when skipping chapter with 'previous' and 'next'	●			Play media					●		
✓	Remote control lay-out (no clear hierarchy and grouping)	●	●	●	Overall				●			
✓	Remote control unresponsive	●	●		Overall				●			
✓	Device responds slowly		●	●	Overall	●	●					
	Directional keys lack press-and-hold	●	●		Overall				●	●		
✓	Overwriting a recording (not completely understood by users)	●			Setting recording preferences					●		
	Users cannot hide commercial without consulting manual	●			Editing recording					●		
Usability strengths												
	DVD playback	●	●		Play media				●	●		
	Easy to connect (for non-set top box users)	●			Installation	●		●			●	
✓	Timed recording easily found and programmable	●		●	Setting timed recording				●	●		
	Deleting a recording	●	●		Editing recordings				●	●		
	USB-access straightforward		●	●	Access USB contents	●			●			

Usability issues of the home theatre system

Causal network	**Usability issue description**	**Source**			**Task**	**Prod. components**						
		AV@home test	TUD test	Online reviews		Main unit	Platform	Cables	Remote control	On-screen UI	QSG/manual	Packaging
Usability weaknesses												
	'ACCESSORIES' labelling is not noticed	●			Unpack							●
	Cutting the box to unpack results in damaging the mounting bracket	●			Unpack							●
✓	The front panel display is difficult to read since it is too dim	●			Installation	●						
✓	Difficult to navigate top tier icons	●			Installation				●	●		
✓	HDMI set up (digital audio & LPCM) is not understood	●			Installation					●	●	
	The power cable is expected at the main unit (but is located at the subwoofer)	●			Set up			●				
	If 'Setup' is pressed and the TV turned off, front panel display hints to turn on TV.		●		Set up	●						
	Unclear when the power is on or off	●	●		Set up	●						
✓	The disc compartment accidentally slides open during unpacking	●	●		Set up	●						
	'Fix its end to the wall' in QSG not understood	●			Set up			●			●	
	User takes a long time to figure out how to open the rear panel cover	●	●		Set up	●						
✓	Label 'To Subwoofer' on the rear panel is confusing	●			Set up	●						
✓	Rear panel cover is difficult to close due to cables that are hard to fit in	●	●	●	Set up	●						
✓	Unergonomic cable management; too many connectors in a small place	●	●	●	Set up	●						
✓	The FM antenna and the FM connector seem not to fit together	●			Set up	●						
	Treble/Bass is not shown on screen (in contrast to other sound modes)	●			Play media					●		
	Difficulties in iPod navigation due to having to use two cables	●	●		Play media			●	●	●		
	Time lag between sound modes is considered to be too long	●			Play media		●					
	Wanting to manipulate slideshow unintendedly leads to rotating picture	●	●		Play media		●					
	'Auto play' (CD starts playing directly after loading) is disliked	●			Play media		●					
	User doesn't like that selecting a photo automatically leads to a slideshow	●			Play media		●					
	AV@home TV responds to HTS remote and HTS responds to TV remote						●		●			
Usability strengths												
	No wire mess that is common for multiple speakers system			●	Other			●				
	User is pleased with Velcro keeping together the interconnect cable		●		Other			●				
	The radio tuner is easy-to-use			●	Other		●					
	The subwoofer fits well with the interior			●	Other	●						

Appendix F Usability issue selection criteria (Case study III)

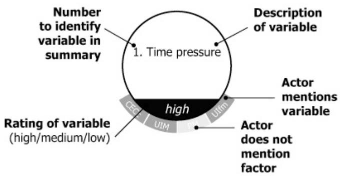
Considerations	Description
Only usability	Some of the information in the documents was not referring to usability issues, but to other product properties such as performance, aesthetics and reliability issues. These issues were not included in the cards.
Severity	The intention was to include the more severe usability issues in the overview. This was defined as the extent to which a usability issue was preventing a user from completing a desired task, causing a great amount of dissatisfaction among users, and the amount of participants/reviewers that encountered the issue.
Richness of information	The richness of the data had to be sufficient for the researchers to have a thorough understanding of the usability issue.
Priority of usability issue in development test	Usability issues that were included in the executive summary of AV@home's usability test were more likely to be included in the selection, as these were considered to be issues that the team had been paying attention to and actively trying to fix.
Both persisting and solved usability issues	To learn about the history both usability issues that were successfully dealt with as issues that could not be fixed, the overview of issues should include both issues that were fixed and not.
Spread in tasks and components	To have a broad scope of usability issues in the card set, the researchers strived for a spread in tasks and components that played a role in the usability issues that were selected.

Appendix G Interview topics guide (Case study III)

Interview section	Subjects
Introduction	• Introduction of the project and the researchers • Confidentiality of the results • Anonymity of the projects and interviewees • The role of the researchers during the interview (interviewer/note-taker) • The subjects, structure and duration of the interview: • Video recording and consent
The development project	• How did the interviewee experience this project, what does (s)he recall about it? • Role of the interviewee in the project • Involvement of the interviewee in the project
Card selection	• Reasons for selecting those particular cards
Per usability strength (max 2)	• Causes for the strength
Per usability issue	• Whether the issue was known, and how it was detected • Description of how and when the team dealt with the issue (discussions, actions taken, solutions considered) • Changes made to the product to deal with the issue? • Opinion of the interviewee on how the issue was dealt with • Alternative (hypothetical) solutions and reasons for not implementing these
Other usability issues	• Any usability issues or strengths that were not mentioned in the cards?
Wrapping up	• Possible changes to the product development process and organization to make products more usable products • Subjects the interviewee would like to mention • Questions the interviewee might have

Appendix H Components and relations of causal networks (Case study III)

Variables

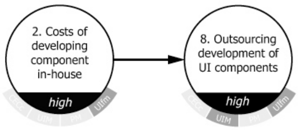


Based on quotes from the interviewees variables were identified that influenced the usability of the product, directly or indirectly. Each variable is assigned a rating (high/medium/low), based on the interview data, to indicate to what extent the variable was present for that particular issue.

Causal relations

Folowing the definition of Miles and Huberman (1994), in a causal network there is a causal relation between two variables if the value of one (initial) variable, determines to some extent the value of another.

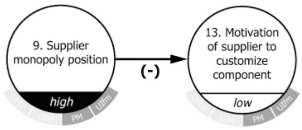
Positive causal relation



In a positive relation, if one variable is high, the influenced variable will also be high. If the initial variable is low, the influenced variable will be low. A positive relation is marked with an arrow.

Example: If the costs of developing a component in-house are high, chances increase that a company will outsource this activity.

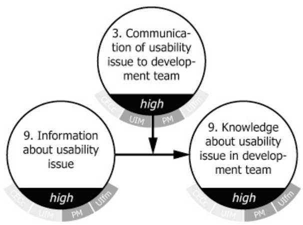
Inverse causal relation



In an inverse relation, if one variable is high, the influenced variable will be the low; if the initial variable is low, the influenced variable will be high. An inverse relation is marked by an arrow, accompanied by a minus sign: (-).

Example: If a supplier has a strong monopoly position it will be less motivated to customize a component.

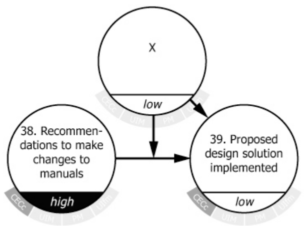
Conditional causal relation



In a conditional relation, a high rating for the initial variable will only lead to a high rating for the influenced variable under the influence of a third, conditional variable. The conditional influence is marked by an arrow pointing towards another arrow.

Example: A large amount of information on a particular usability issue will only lead to knowledge about the usability issue in the development team if the information is communicated to the team.

Unknown variable



In some cases, the influenced variable has a rating that differs from the value of the initial variable, but logically there is no reversed causal relation. In these cases the rating of the influenced variable might be influenced by an unknown variable X acting as a conditional or direct causal influence.

Example: Design proposals were proposed to deal with a usability issue (high) but these were not implemented (low).

Covariance

The value of two variables seems to covary, but there is no evidence for a causal relation between the two variables. Also used to indicated properties of another variable (i.e., time required to implement a proposed solution). Marked with a line (without an arrowhead).

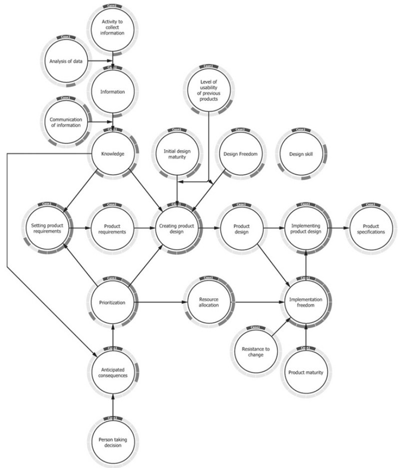
Tentative relation

A possible relation between two variables, not supported by the data from the specific case, but to be explored and verified with data from other cases. Marked with a dashed arrow.

Appendix I Evolution of the usability issue life cycle model

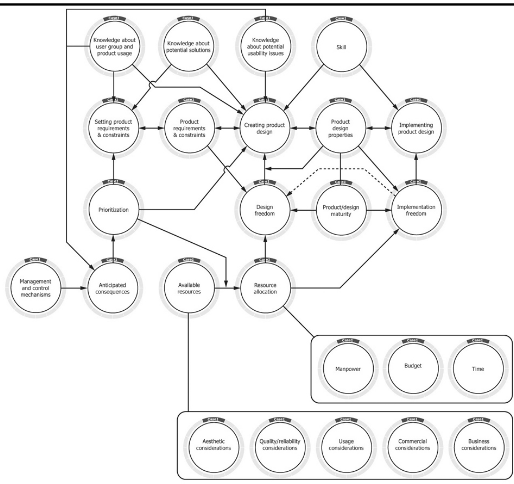
1.

After analysis of first few causal networks of usability issues of the hard disk recorder case



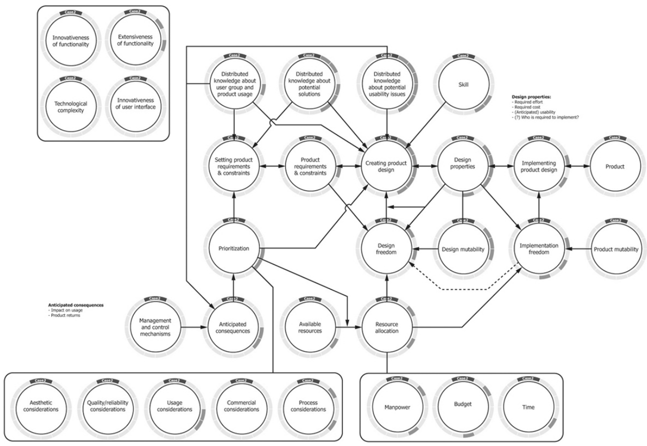
2.

After complete analysis of hard disk recorder case



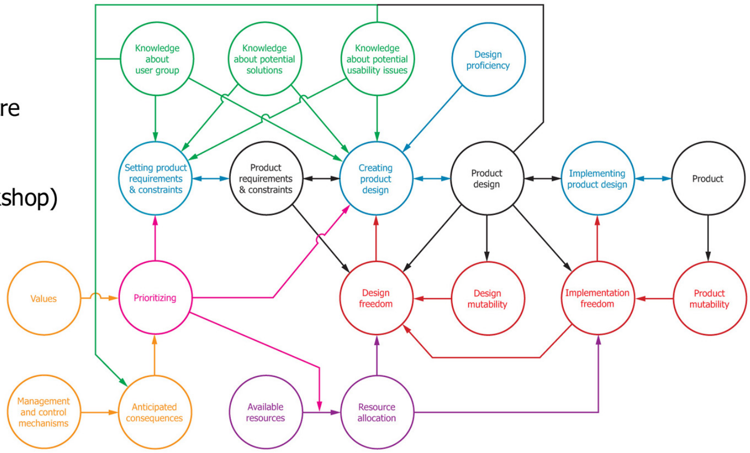
3.

After analysis of DVD recorder case



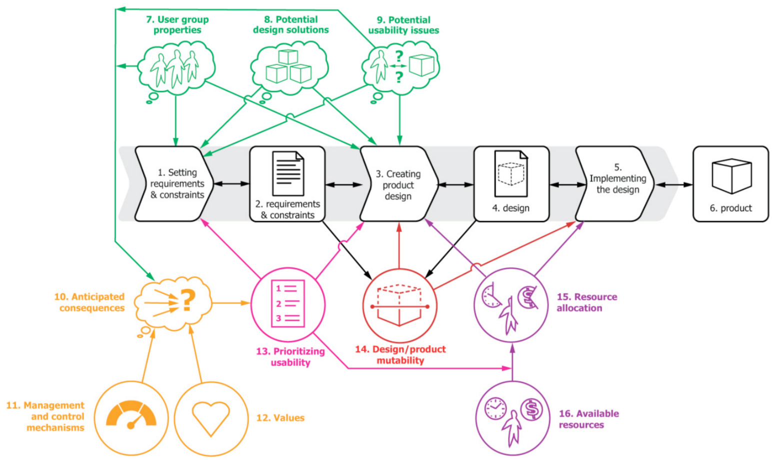
4.

After analysis of Home theatre system case (Before first feedback workshop)



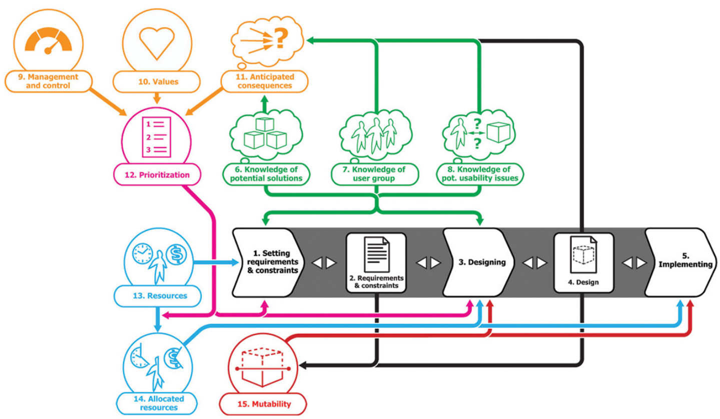
5.

After first feedback workshop



6.

After all feedback workshops and graphic optimization



Appendix J Supporting evidence for the usability life-cycle model (Case Study III)

1. Management and control → 4. Prioritization

- The design department's primary responsibility in the organization was to safeguard a consistent styling across product lines. Designers indicated that they were hardly given the possibility to move beyond that role. Designers were the only role in the organization that did not have customer satisfaction as performance indicators.
- The market AV@home operated in was very cost-focused, which made it a very real possibility that upper management would end development projects that went over budget. This made teams reluctant to choose more expensive components, even if this could significantly improve customer satisfaction.

2. Values → 4. Prioritization

- There was a considerable difference between the approach of the product manager of the DVD recorder and of the hard disk recorder. The DVD recorder product manager was project-focused: she wanted to deliver the product on time and within budget, and compromised the product significantly to achieve these goals. The product manager of the hard disk recorder was more concerned about the properties of the product, and compromised project goals.

4. Prioritization → 8. Setting requirements and constraints

- For the home theatre system minimizing the height of the product was very important, as this was a precondition for the product to be used when not mounted on the wall.
- During development of the hard disk recorder the team was not allowed to select a supplier with a more usable electronic program guide, because AV@home would be the supplier's only client, and thus the supplier would be too dependent on AV@home.

4. Prioritization → 10. Designing

- When designing the front panel of the DVD recorder costs were a dominant decision making criterion. As a consequence a number of controls and indicators were cut from the design.
- The UI paradigm was designed with light grey texts on a white background, which was known to reduce legibility because of the limited contrast, but it was considered to look more aesthetically pleasing and to better fit AV@home's brand image.

4. Prioritization → 13. Resources → 14. Allocated resources

- In a user test of the home theatre system a text label on a connector was found to confuse users. The usability evaluator classified the problem to have high impact and occurrence, but the team felt differently, and no resources were allocated to deal with the problem.
- The product manager of the hard disk recorder considered reducing the product's start-up time very important, but the engineers whose cooperation he needed to fix the

problem did not share his sense of urgency and did not put a lot of effort into fixing the problem. The product manager brought the engineers to a user test to witness participants' reaction to the problem, after which the development engineers started to explore solutions.

5. Knowledge of potential design solutions →3. Anticipated consequences → 4. Prioritization

- The development group had struggled for quite some time with what text label to put on the remote control button that leads the user to the menu of a DVD and a number of alternatives had been tried in previous models. In a user test the current button label was evaluated as suboptimal in terms of usability. However, because the team had run out of options, little improvement was anticipated, and improving the problem was not prioritized.
- In a user test of the hard disk recorder it was found that channel installation lasted long. The usability evaluator classified the problem as having a high priority to fix. However, the rest of the team thought there was limited possibility for improving the problem, as it was caused by the product's hardware and distribution of channels over a frequency band, which seems to have limited the priority the team gave to fixing the problem.

5. Knowledge of potential design solutions → 8. Setting requirements & constraints

- The development of a new audio technology led to the requirement that it should be possible to place the home theatre system on the wall and that it should only have an additional subwoofer, as opposed to the conventional Dolby surround setup which requires 5 speakers.
- In the case of the hard disk and DVD recorders, because no alternative solution could be conceived to reduce the complexity of the device's connectivity, conventional connectivity requirements were set, even though they were known to cause a lot of usability problems.

5. Knowledge of potential design solutions → 10. Designing

- The user interface paradigm that AV@home had developed was a way for the development group to share knowledge about a suitable (usable) design solution across projects. It enables designers to more quickly create a UI design for a new product.
- When developing solutions for a known usability problem in the hard disk recorder, the software engineers were able to propose technological solutions to the problem, which the interaction designer or product manager could not come up with, because they did not have the required engineering knowledge.

6. Knowledge of the user group → 8. Setting requirements & constraints

- Because the development group was based in Asia it had limited knowledge of the kind of network that people in the US and Europe (the target market) used their DVD and hard disk recorders in. For example, digital TV decoders were not common in the country where the products were developed, but its use was widespread in Europe and placed specific demands on the connectivity options a product should provide.

- When developing the home theatre system, very specific requirements were set for the maximum height of the product, because the team had learned that a considerable amount of users did not hang their flat TV on the wall, but put it on a stand. In that case the home theatre system would be placed in front of the TV and should not block the screen.

6. Knowledge of the user group → 8. Designing

- When designing the subwoofer for the home theatre system the team wanted to make the subwoofer a 'design statement' instead of hiding it. It had to be something that could be displayed in full sight and looked somewhat like a glossy coffee table. To create the design they needed to know about the home interiors and aesthetic preferences of the target group.

(6. Knowledge of the user group + 7. Knowledge of potential usability issues) → 3. Anticipated consequences → 4. Prioritization → 14. Resource allocation

- In a user test of the DVD-recorder the remote control was found to be unresponsive. Both the usability evaluator and the rest of the team anticipated this might cause customers to return the product. The team spent considerable time to invest the causes of the problem and changed the front panel design of the product to fix it.
- In both the DVD and hard disk recorder one of the options was in the recording menu was labelled VPS/PDC [31], which was not understood by any of the participants. Even though this was a known problem, the text label continued to be used throughout the product line of AV@home, but because it was anticipated to have little impact on product use and not cause help desk calls or product returns the priority of the problem was very low.
- In the hard disk recorder project the software architecture was inherited from a predecessor project, which caused the software development team to be very reluctant to make any changes to the software, as they feared the software to become unstable and a product that crashes is very likely to be returned or complained about.

7. Knowledge of potential usability issues → 8. Setting requirements & constraints

- In the case of the hard disk recorder, because it was known in an early phase that the electronic programming guide (EPG) suffered from usability weaknesses, it was studied whether an EPG from a different supplier could be used.
- Because the Development Engineer that set the requirements for the platform of the DVD recorder did not know about usability problems with previous products (that had to be put in standby before being able to record) he did not include the requirement that the platform should be able to record while the product was switched on.

---

[31] The VPS/PDC function enables the recorder to adjust the time of the recording if a broadcasting time is changed.

7. Knowledge of potential usability issues → 10. Designing

- Because it became clear from the usability test of the DVD recorder that the participants did not understand the warning text when a DVD did not have enough space for the recording, the team redesigned the warning message.
- That the 'back' button on the hard disk recorder remote control did not work consistently across menus did not surface in user testing. As a consequence, the test report did not mention the problem, nor were any changes made. Later in the project, the product manager discovered the problem when using an early sample of the product at home and conceived a solution for it.

9. Requirements & constraints → 15. Mutability → 10. Designing

- For the product line of which the DVD and hard disk recorder were a part the constraint was set that one common physical remote control design was to be used, of which only the button labelling could be changed, but not the layout of the buttons. This limited the (length of the) button labels that could be used and the possibility to put them in clusters of relevant buttons, such as 'recording' and 'timed recording'.
- In all development projects there were design requirements that prescribed response times or interaction dialogues. This limited the mutability during design, but in a way that ensured that usable designs would keep being applied.

11. The design → 15. Mutability → 10. Designing

- In the DVD recorder, the use of a supplier platform severely limited the amount of changes that the team was allowed to make to the user interface. In essence only the graphics and button labelling in the on-screen UI could be changed.
- In the home theatre system, the space that the mechanical engineer reserved for the cable connectors was so small that the possible arrangements of connectors that the industrial designer could explore were very limited.

11. The design → 15. Mutability → 12. Implementing

- The software architecture of the hard disk recorder was designed in such a way that once implemented, making changes to the software later in the process threatened the stability of the system, preventing proposed changes from being implemented.
- The hard disk recorder was designed in such a way that users could install software updates after purchase, thus maintaining a certain mutability even while the product was in use.

15. Mutability → 12. Implementing

- Late in the development of the home theatre system it was discovered in a user test of an early prototype that the door of the disc compartment could accidentally slide open while users were installing it. A solution that was considered was a mechanical door lock. However, because the moulds to create the mechanical components had already been made, this solution was considered too costly to implement.

13. Resources → 8. Setting requirements & constraints

- To save time, in the hard disk recorder project the team decided to reuse the software of a predecessor product.
- To save costs, a range of recording products – though differing substantially in functionality – shared the same physical remote control design. In a higher end version of the hard disk recorder a more expensive remote control design was used, which proved more usable.

14. Allocated resources → 8. Designing

- The DVD recorder, a low-end product, was not subjected to a summative usability test[32].
- The hard disk recorder and home theatre system, medium and high-end products, were subjected to summative usability tests.

14. Allocated resources → 10. Implementing

- During implementation of the hard disk recorder there was enormous time pressure and the available working hours were mostly directed at dealing with reliability problems. As a consequence, usability problems were not dealt with.
- In the home theatre systems project there was not enough budget to pay the supplier to implement changes that would improve the usability of the on-screen interface.

[32] User testing is considered part of the design activities.

Appendix K Supporting evidence for the model of generating shared knowledge about usability issues (Case Study III)

Representativeness of usage (16) → Data (19)

- The user tests for the DVD and hard disc recorder were conducted on the development site in Asia and the participants in the user tests had to be recruited locally, even though the products were targeted at the American and European market. Locally there were only a limited number of American and European expatriates available, of which it was also doubted whether they were representative for the actual user group, as they had chosen to live abroad and often had spent a considerable amount of time away from their home country.
- To test whether users could fit all cables and connectors in the back of the home theatre system the team made a physical mock-up of the back panel of the product. In the test setup the team could fit all the cables in the bay, however, the cables that were used were thinner than the ones that were eventually used in production. In the final product fitting all the cables and connectors proved to be cumbersome.
- If the language of the DVD recorder was set to Dutch, the list of countries that the user could choose from to indicate his geographical location were not listed alphabetically. This problem did not surface in the user test that was conducted, because in the test language of the device was set to English.

Representativeness (16) → Interpretation (22)

- When the hard disk recorder was subjected to a user test the prototype was not yet completely mature. Delays in response times were attributed to the fact that the device was still in the prototype stage and the problem was not reported. However the final product still was slow, which made interaction cumbersome.
- When the results of the user tests of the DVD recorder were communicated to the development team, they attributed a usability problem that participants had with connecting the cables properly to the fact that the participants were local (Asian) participants who were not familiar with the (European and US) cables.

Data generation (17) → Representativeness of usage (16) → Data (19)

- The use case of programming a recording of a TV show through the electronic programming guide could not be included in the use test of the hard disk recorder, because the test was conducted on the product development site in Asia where the broadcast signal for the electronic programming guide was not available (only in Europe and the US).
- Interviewees indicated that after sales feedback (helpdesk calls, customer satisfaction survey, product returns) had a high representativeness of usage, as the interaction takes place with the real product, by real users, who have real goals, and it takes place in the real context.

- The quality of execution of data generation on product usage was often mentioned to influence the representativeness of knowledge. This referred to for example the tasks that the participants were given, the skills of the test conductor and the questions asked during the test.
- The user tests for the home theatre set were conducted in the consumer-testing lab where the lighting conditions (bright fluorescent lighting) differed significantly from the situation in users' homes when they are watching a movie (dark mood lighting). In one of the user tests (in the lab environment) the display on the main unit was considered not bright enough. The team took action to increase the brightness, only to find that in after sales feedback customers complained that the on-board display was too bright (in their home environment).

Data generation (17) → Data (19) → Analysis (20) → Information (21)

- In the use test of the hard disk recorder participants were asked to setup and install the product, pause live television, conduct a direct recording, program a timed recording, play files from a USB stick and transfer files from the hard disk to DVD. The user test was recorded on video and observed directly by a usability evaluator. The evaluator rated the effort required to perform these use cases and their subtasks per participant, and the participants filled out a questionnaire in which they rated the experienced ease of use and time required to perform a task. The usability evaluator wrote a summary for each task, outlining what problems were encountered, by how many participants, and comments the participants made.
- During the development of the DVD recorder it was subjected to a user interface guidelines benchmark. In the report it was indicated for all of the use cases in the product which ones took longer than the benchmark and which dialogues were not conform to the guidelines. It was indicated which of the product properties were involved.

Data capture (18) → Data (19)

- When user tests were conducted in the consumer experience lab, all tests were recorded on video, so data with a high resolution was available.
- The primary goal of the customer service department was to help people with the problems they had, but the customer service representatives also categorized the questions or complaints that customers have and wrote a short description, which served as a source of information about usability problems. However, the informants indicated that the resolution of this data was too low to make design decisions, determine the cause of the problem, or sometimes even to understand the problem.

Information (21) → Interpretation (22) → Knowledge & understanding (23)

- The report of a user test of the hard disk recorder contained interpretations by the usability evaluator as to what the causes (participant behaviour and assumptions, as well as product properties) for the observed usability problems were.

- Because the usability evaluators worked in a different department than the development team and had not been involved in the development of the project they were considered to be able to provide a fresh and unbiased evaluation, as opposed to development team members who had designed the product themselves and who thus had too much knowledge of the product and were biased because they had designed it themselves.
- In the user test of the DVD recorder it was observed that participants were surprised and annoyed that the device had to be put in standby to be able to record a TV program. The quality manager considered this to be a serious problem that should be solved, as recording a TV program is one of the main purposes of the product. The usability evaluator did not give the problem a high priority to fix, as the number of participants that were unable to complete the use case was low, and they did not seem to very annoyed.
- In the user test of the DVD recorder it was found that the remote control was unresponsive at times, but it was unclear why. In order to find out the cause an extra evaluation was conducted, which revealed that the remote control was not unresponsive, but that the infrared sensor in the main unit was positioned in such a way that it did not have proper signal reception.

Knowledge & understanding (23) → Communication (24) → Shared knowledge & understanding (25)

- The sluggishness of the hard disk recorder during to start up and the accompanying insufficient feedback was a problem that was known before user testing, because it had been discovered in an interaction design guidelines benchmark evaluation. As a consequence of this early knowledge the software development team explored possible improvements to solve the root cause of the problem, which proved to require too much effort. The product manager then brought the software developers to witness the user test. As a consequence the software developers gained a better understanding of the problem, gave it a higher priority to fix and started exploring solutions to improve the feedback during start-up.
- From the user test of the hard disk recorder it was concluded that users had considerable problems to understand and operate the continuous recording function, which was a very important use case. However, as the project was in a late stage of development and improving the problem would require quite some effort to redesign and implement, the team saw little possibility to fix the problem. Because the team would not be allowed to launch the product if it had serious usability problems (stage gate criterion), they feared (even) more delays for their project. The team contested the user test results, but when the usability specialist refused to change the results the team resorted to reducing the importance of the use case, so the product would no longer have a usability problem in an important use case, and could be launched as planned.

- Because the designers worked in a consultancy role they were usually not invited to come and watch user tests, because it was unclear whether the business group or the design department should pay for the presence of the designers. As a consequence, designers did not have the opportunity to see the consequences of their design choices for product use.
- Usability problems were communicated by the customer service department to the business group mostly in quantitative form, indicating how often questions were asked in a certain category, accompanied by very concise and ambiguous descriptions of individual consumer complaints. Therefore after sales feedback was considered more of a red flag that a problem was present than as valuable input for design decisions.

Resources (26) → Data generation (16) → Representativeness (17)
- Conducting user tests in the target market (abroad) with participants that were representative for the actual user group was considered too expensive.

Resources (26) → Data capture (18)
- The user testing group had a user testing laboratory for conducting observational studies, equipped with video recording and storage equipment, which allowed them to record all user tests on video.

Resources (26) → Communication (24)
- The user testing group did not have the appropriate facilities (computers) to edit the videos of the user tests and creating the video clips was considered too time consuming. As a consequence no video clips were used when communicating user test results.

Timing (27) → Data generation (16) → Shared knowledge & understanding (25)
- Early in the projects AV@home did very little user testing, because no product samples were available, which were considered needed to perform a user test with reliable results.

Timing (27) → Communication (24) → Shared knowledge & understanding (25)
- If a product was a follow-up to a similar predecessor (high representativeness of stimulus material), the knowledge about usability problems gained in the previous project through user testing and after sales feedback could serve as early knowledge on usability problems in the successor project.

Summary

Problem statement: Even though there is a large amount of methods for user-centred design, the usability of electronic consumer products (e.g., portable music players, washing machines and mobile phones) is under pressure. Usability is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. That the usability of electronic consumer products is under pressure is attributed to an increase in the functionality they offer, a decrease in size, their usage in networks, and the large variety of contexts of use. Furthermore, the development of these products has become increasingly challenging due to their increasing complexity, pressure on time to market, globally distributed product development teams, and the commoditization of electronic consumer products.

Research goal: It was suspected that the cause for the usability of electronic consumer products being under pressure may lie in practice. However, as current literature on usability in product development practice does not take an integrated approach, contains few case studies, and only a limited amount of studies investigate electronic consumer products specifically, the insight into how usability is dealt with in development of electronic consumer products is limited. Therefore the goal of this thesis was to obtain this insight as well as to identify variables in product development practice that contribute to or obstruct the usability of electronic consumer products, and to investigate how these variables are related.

Conceptual framework: Before conducting empirical studies, the primary concepts for studying usability in product development practice were identified by reviewing existing research as well as through exploratory interviews with experts on usability from academia and industry. Based on this a conceptual framework was created that provides an overview of concepts that may influence user-centred product development and usability, as well as a description of the (expected) relations between them. This included an analysis of the dependent variables of this research: interaction, user experience and usability.

Three case studies: In total three case studies were conducted. In each of the case studies an integrated approach was taken, focusing on the whole product development process (as opposed to just design) and including six roles that were considered to have the most influence on usability: the product manager, marketing specialist, industrial designer, interaction designer, usability specialist and development engineer.

Case Study I: In this study the goal was to explore how usability is dealt with in four sectors adjacent to the electronic consumer products market: high-end automotive, professional printers and copiers, office coffee makers and fast moving consumer goods. This study had a pilot-like character and served as an opportunity to test and refine the research method. The study had a multiple case design with holistic cases. A maximum variation case sampling strategy was used, with product complexity and business versus

consumer products as the dimensions along which the cases varied. Using a topics guide, interviews with 19 product development practitioners were conducted, focusing on three topics: 1) the product development process, 2) multidisciplinary teamwork, and 3) attitude towards usability. Based on the interviews, context descriptions of the companies were created and barriers and enablers for usability were identified. A barrier is a property, situation or condition in the product development process, team or context that negatively influences the usability of a product. An enabler is the positive equivalent of this. To verify the findings and to discuss remaining issues a workshop was held in which the primary contact from each company participated. The results of this case study indicated that different product characteristics lead to differences in the attitude towards usability in the companies making these products, as well as to different methods for user-centred design being possible and relevant. What methods for user-centred design were used was also influenced by the attitude towards usability, which in addition influenced team composition. Finally, a number of implications for the method to be used in the next case study were identified.

Case Study II: In this study the goal was to learn how usability is dealt with in the development of electronic consumer products and to identify barriers and enablers for usability, and to study how these are related. The study had a multiple case design with holistic cases. The cases were selected based on a comparable case sampling strategy in which product type, efforts to improve usability, segmentation of roles, and whether product development was conducted in-house were the dimensions. The participating cases were five product development groups of major international companies, which created portable audio/video players, personal navigation devices, mobile phones, home controls and laundry care products. The primary data source was interviews with 31 product development practitioners fulfilling the roles that were identified earlier as relevant for usability. Based on the interviews, context descriptions of the cases were written and 'jointly told tales' were constructed, consisting of interview quotes, the researcher's interpretations and the barriers/enablers. The 1700+ barriers and enablers thus identified were categorized using a categorization scheme that was based on the conceptual framework and that was developed further through open coding. The scheme formed the basis for the development of the Trace tool, which is an interactive software application that provides a categorized, interactive, browsable overview of the barriers and enablers. With the help of the Trace tool a cross-case analysis of mechanisms of barriers and enablers for usability was conducted. To verify the findings the primary contact of each company was asked to provide feedback on the context description and the description of mechanisms of barriers and enablers identified at his/her company. They were also given access to an online version of Trace so they could explore the barriers and enablers themselves. A final workshop was held in which the findings were presented, verified and in which emerging issues were discussed. The study provided insight into how usability is dealt with by product development groups in the electronic consumer products market. Secondly, mechanisms of barriers and enablers were identified, in the following categories: (1a) Process / creating usable products, (1b) Process / evaluating usability (2) Knowledge, (3) Team, (4) Project, (5) Company and (6) Market.

Case Study III: In the aforementioned study barriers and enablers were identified based upon interviews and at times it was only said *that* they influenced usability and it remained unclear *how*. Therefore the goal of the third and final case study was to trace the origins in product development of usability issues. This was done by investigating the development history of three electronic consumer products developed by one product development group, which makes this a single embedded case with three embedded units of analysis. For each of the products usability issues were identified based on usability tests and after sales feedback. Through a combination of the focused and semi-structured interview approach it was discussed with the product development team members (19 in total) that were involved in creating the products, how 35 of these usability issues had come into being and had been solved. Based on the interviews a context description of the development group and the projects was created, as well as a description of how the product development group dealt with usability. Secondly, based on the interviews causal networks per usability issue were created that indicated origins of usability issues and what caused them to be solved (or not). Based on the 35 causal networks two causal models of usability in product development practice were induced. The first model - the usability issue lifecycle - aims to explain what variables in product development influence usability issues. The second model shows what variables play a role in the generation of shared knowledge about usability issues. To verify the findings they were presented and discussed during workshops at the product development group where the study was conducted as well as at other organizational units of the parent company of the product development group.

Conclusions: The main conclusion of this thesis is that to be able to develop usable electronic consumer products, companies cannot suffice with adapting their process, but should make changes to their organization as well. Especially because the trends that cause the usability of electronic consumer products to be under pressure are expected to continue and even strengthen. Four primary drivers in product development for usability were identified: (1) User-centred design proficiency: the ability to execute a user-centred product development process; (2) Shared knowledge within the product development team (about users, design solutions and potential usability issues); (3) Design freedom: the extent to which a development team is able to make the most appropriate design, determined by design mutability and available resources; (4) Prioritization of usability: the extent to which usability is prioritized during product development and within the product development organization. For each of these drivers related mechanisms of barriers and enablers specific for the electronic consumer products sector are presented.

Recommendations for industry: Based on the insights gained through the case studies as well as existing research, 25 recommendations for industry were developed that describe how the author would organize a product development group if the goal is to make usable products. The recommendations were 'user tested' and iterated by putting them on the weblog that the author kept while working on this research. The recommendations were published as a card set alongside this thesis.

Samenvatting

Probleemstelling: Ondanks dat er een grote hoeveelheid methoden voor gebruiksgericht ontwerpen beschikbaar is, staat het gebruiksgemak van elektronische consumentenproducten (bijvoorbeeld draagbare muziekspelers, wasmachines en mobiele telefoons) onder druk. Gebruiksgemak is de mate waarin een product gebruikt kan worden door gespecificeerde gebruikers om gespecificeerde doelen te bereiken met effectiviteit, efficiëntie en naar tevredenheid in een gespecificeerde gebruikscontext. Dat het gebruiksgemak van elektronische consumentenproducten onder druk staat wordt toegeschreven aan een toename in functionaliteit in deze producten, miniaturisering, dat ze gebruikt worden in netwerken en de grote variëteit aan gebruikscontexten. Daarnaast is het ontwikkelen van dergelijke producten uitdagender geworden door de grote tijdsdruk, productontwikkelingsteams die verspreid over de wereld werken en het feit dat productdifferentiatie afneemt en er steeds meer geconcurreerd wordt op prijs.

Het onderzoeksdoel: Het vermoeden was dat de oorzaak voor het gebrek aan gebruiksgemak in elektronische consumentenproducten in de productontwikkelingspraktijk zou kunnen liggen. Echter, omdat de bestaande literatuur weinig onderzoeken naar gebruiksgemak in de productontwikkelingspraktijk bevat die een integrale aanpak volgen, die gevalsstudies rapporteren en die zich specifiek richten op elektronische consumentenproducten, is er momenteel beperkt inzicht in hoe men met gebruiksgemak omgaat tijdens productontwikkeling. Daarom was het doel van dit onderzoek om dit inzicht te verkrijgen, alsmede om factoren in productontwikkeling te identificeren die een bijdrage leveren of een beperking opleveren voor het gebruiksgemak van elektronische consumentenproducten en hoe deze factoren gerelateerd zijn.

Conceptueel raamwerk: Voorafgaand aan het empirische onderzoek zijn de belangrijkste concepten voor het onderzoek doen naar gebruiksgemak in productontwikkeling geïdentificeerd door middel van literatuuronderzoek en verkennende interviews met experts uit de praktijk en onderzoekswereld op het gebied van gebruiksgemak. Op basis hiervan is een conceptueel raamwerk gecreëerd dat een overzicht biedt van concepten die mogelijk invloed hebben op gebruikersgerichte productontwikkeling en gebruiksgemak, alsmede de (verwachte) relaties tussen deze concepten. Hieronder viel ook een analyse van de afhankelijke variabelen van dit onderzoek: interactie, gebruikersbeleving en gebruiksgemak.

Drie gevalsstudies: In totaal zijn er drie gevalsstudies uitgevoerd. In elk van de studies is een integrale aanpak gevolgd, waarbij aandacht wordt besteed aan het productontwikkelingsproces als geheel (in tegenstelling tot alleen de ontwerpstap) en de zes rollen in productontwikkeling waarvan werd verondersteld dat deze de meeste invloed hebben op gebruiksgemak: de productmanager, marketingspecialist, industrieel ontwerper, interactie ontwerper, gebruiksgemakspecialist en de ontwikkelingsingenieur.

Gevalsstudie I: Het doel van deze studie was om te verkennen hoe er wordt omgegaan met gebruiksgemak in vier aan elektronische consumentenproducten aanpalende sectoren: hoogwaardige automobielen, professionele kopieer- en printproducten, koffieautomaten voor kantoor en schoonmaakproducten voor de consumentenmarkt. Deze studie had een verkennend karakter en diende als mogelijkheid om de onderzoeksmethode te testen en verfijnen. Meerdere gevallen waren betrokken bij het onderzoek, waarbij elk van de gevallen als holistisch werd beschouwd. Om de gevallen te selecteren is een selectiestrategie toegepast waarbij gestreefd werd naar een maximale variatie, waarbij productcomplexiteit en professionele versus consumentenproducten de variërende dimensies waren. Aan de hand van een onderwerpenlijst zijn interviews uitgevoerd met 19 productontwikkelingsprofesionals waarbij de focus lag op drie onderwerpen: 1) het productontwikkelingsproces, 2) multidisciplinaire productontwikkeling en 3) de houding ten opzichte van gebruiksgemak. Op basis van de interviews zijn beschrijvingen van de bedrijfscontext van elk van de gevallen beschreven en zijn obstructies en katalysatoren voor gebruiksgemak geïdentificeerd. Een obstructie is een eigenschap, situatie of conditie in het productontwikkelingsproces, -team of -context die een negatieve invloed heeft op het gebruiksgemak van het product. Een katalysator is het positieve equivalent hiervan. Om de bevindingen te toetsen en resterende onderwerpen de bespreken is een workshop gehouden waaraan de primaire contactpersoon van elk bedrijf deelnam. De resultaten van deze gevalsstudie geven aan dat het type product dat een bedrijf ontwikkelt invloed heeft op de houding ten opzichte van gebruiksgemak alsmede op welke methoden voor gebruiksgericht ontwerpen mogelijk en relevant zijn. Welke methoden voor gebruiksgericht ontwerpen werden toegepast werd ook beïnvloed door de houding ten opzichte van gebruiksgemak, wat ook invloed had op teamsamenstelling. Tenslotte heeft deze studie een aantal implicaties voor de in de volgende gevalsstudie te volgende onderzoeksmethode opgeleverd.

Gevalsstudie II: Het doel van deze studie was om te leren hoe er tijdens de ontwikkeling van elektronische consumentenproducten wordt omgegaan met gebruiksgemak, alsmede het identificeren van obstructies en katalysatoren voor gebruiksgemak en de relaties hiertussen. De studie bevatte meerdere gevallen welke werden beschouwd als holistisch. Het uitgangspunt van de gevalsselectie was om de gevallen zoveel mogelijk vergelijkbaar te laten zijn. De selectieparameters waren producttype, inspanningen om gebruiksgemak te verbeteren, segmentatie van rollen in de teams en of productontwikkeling door de eigen organisatie werd uitgevoerd. De onderzochte gevallen waren vijf productontwikkelingsgroepen van grote internationale ondernemingen; ontwikkelaars van draagbare audio/video, persoonlijke navigatiesystemen, mobiele telefoons, thuisthermostaten, en was- en droogapparatuur. De primaire informatiebron bestond uit vraaggesprekken met 31 productontwikkelingsprofessionals die de rollen vervulden die eerder waren aangemerkt als relevant voor gebruiksgemak. Op basis van deze interviews zijn beschrijvingen gemaakt van de bedrijfscontext van elk geval en zijn er 'gezamenlijk vertelde verhalen' geconstrueerd, welke bestaan uit interviewcitaten, de interpretatie van de onderzoeker en een obstructie of katalysator. De meer dan 1700 obstructies en katalysatoren die op deze wijze geïdentificeerd zijn, zijn vervolgens gecategoriseerd door middel van een categorisatieschema dat gebaseerd was op het conceptuele raamwerk en dat verder is uitgewerkt door middel van open coderen. Dit schema vormde de basis voor de ontwikkeling van 'Trace', wat een interactieve software applicatie is die een doorsnuffelbaar, interactief overzicht biedt van obstructies en katalysatoren. Met behulp van Trace is een vergelijkende analyse uitgevoerd tussen de gevallen van de mechanismes van obstructies en katalysatoren. Om de bevindingen te toetsen is het primaire contact van elk bedrijf gevraagd om terugkoppeling te geven over de beschrijving van de bedrijfscontext en van de obstructies en katalysatoren. Ze kregen ook toegang tot een online versie van Trace opdat ze de obstructies en katalysatoren zelf zouden kunnen verkennen. Tenslotte is er een afsluitende workshop gehouden waar de bevindingen werden geverifieerd en resterende onderwerpen werden bediscussieerd. Deze studie resulteerde in een beschrijving van hoe productontwikkelingsgroepen van elektronische consumentenproducten omgaan met gebruiksgemak. Ten tweede zijn er mechanismen van obstructies en katalysatoren voor gebruiksgemak geïdentificeerd in de volgende categorieën: (1a) Proces / creatie van gebruiksvriendelijke producten, (1b) Proces / testen van gebruiksgemak, (2) Kennis, (3) Team, (4) Project, (5) Bedrijf, and (6) Markt.

Gevalsstudie III: In de voorgaande studie werden obstructies en katalysatoren geïdentificeerd, gebaseerd op interviews en in sommige gevallen werd alleen gezegd *dat* iets invloed had op gebruiksgemak en niet *hoe*. Daarom was het doel van de derde en laatste gevalsstudie om te achterhalen waar in productontwikkeling de oorsprong van gebruiksproblemen lag. Dit is gedaan door onderzoek te doen naar de productontwikkelingshistorie van drie elektronische consumentenproducten, ontwikkeld binnen één productontwikkelingsgroep. Daardoor betrof deze studie één geval, met daarin drie ingebedde eenheden van analyse. Voor elk van de producten werden gebruiksproblemen geïdentificeerd op basis van gebruikstests en terugkoppeling van kopers. Aan de hand van een combinatie van de gerichte en de semi-gestructureerde interviewmethode is er met de leden (19 in totaal) van de productontwikkelingsteams van de betreffende producten bediscussieerd hoe 35 van de geïdentificeerde gebruiksproblemen ontstaan en (mogelijk) opgelost waren. Op basis van de interviews is een contextbeschrijving van de productontwikkelingsgroep gecreëerd en een beschrijving van hoe de groep omging met gebruiksproblemen. Daarnaast zijn er op basis van de interviews 35 causale netwerken gemaakt die een overzicht geven van factoren die invloed hebben gehad op het ontstaan en oplossen van een gebruiksprobleem. Deze causale netwerken vormden de basis voor de inductie van twee causale modellen van gebruiksgemak in de productontwikkelingspraktijk. Het eerste model – de levenscyclus van gebruiksproblemen – heeft tot doel uit te leggen welke variabelen in productontwikkeling invloed hebben op gebruiksproblemen. Het tweede model laat zien welke variabelen een rol spelen in de generatie van gedeelde kennis over gebruiksproblemen. Om de bevindingen te toetsen zijn ze bediscussieerd tijdens workshops bij de productontwikkelingsgroep waar het onderzoek uit is gevoerd, alsmede bij andere organisatorische eenheden binnen het moederbedrijf van de productontwikkelingsgroep.

Conclusies: De belangrijkste conclusie van dit proefschrift is dat om in staat te zijn om gebruiksvriendelijke elektronische consumentenproducten te ontwikkelen, bedrijven niet kunnen volstaan met het aanpassen van het productontwikkelingsproces, maar ook aandacht moeten besteden aan de inrichting van hun organisatie. Vooral omdat verwacht kan worden dat de trends die het gebruiksgemak van elektronische consumentproducten negatief beïnvloeden zich zullen voortzetten en wellicht nog sterker zullen worden. Tijdens dit onderzoek zijn vier primaire drijfveren voor gebruiksgemak geïdentificeerd: (1) Vaardigheid in gebruiksgericht ontwerpen, (2) Gedeelde kennis binnen het productontwikkelingsteam (over gebruikers, ontwerpoplossingen en mogelijke gebruiksproblemen), (3) Ontwerpvrijheid: de mate waarin een productontwikkelingsteam vrij is om het meest passende ontwerp te maken/kiezen, wat wordt bepaald door de veranderbaarheid van het ontwerp en de beschikbare middelen; (4) Prioriteren van gebruiksgemak: de mate waarin gebruiksgemak voorop wordt gesteld gedurende productontwikkeling en in de productontwikkelingsorganisatie. Vervolgens worden per drijver aan deze drijver gerelateerde mechanismen gepresenteerd van obstructies en katalysatoren specifiek voor de sector van elektronische consumentenproducten.

Aanbevelingen voor de industrie: Tenslotte, op basis van inzichten die via de gevalsstudies en bestaand onderzoek zijn verkregen, zijn er 25 aanbevelingen voor de industrie ontwikkeld die beschrijven hoe de auteur van dit proefschrift een productontwikkelingsgroep zou inrichten als het doel is om gebruiksvriendelijke elektronische consumentenproducten te maken. De aanbevelingen zijn onderworpen aan een 'gebruikerstest' en verbeterd door ze op het weblog te plaatsen dat de auteur schreef gedurende het uitvoeren van dit onderzoek. De aanbevelingen zijn gepubliceerd in de vorm van een kaartenset.

Publications resulting from this work

Academic

Van Kuijk, J.I., M. Mak, P.H. den Ouden (submitted) "Selling Simplicity: The Functionality-Usability Dilemma; A case study of the definition, development and introduction of Philips Easy Line."

Van Kuijk, J.I., E. Preijde, E. Toet and H. Kanis (2009) Expected versus experienced usability: what you see is not always what you get. IEA2009, 17th World Congress on Ergonomics, Beijing, China.

Wever, R., J. van Kuijk and C. Boks (2008) "User-centred design for sustainable behaviour." International Journal of Sustainable Engineering 1 (1): 9 - 20.

Van Kuijk, J.I. (2008) Make it Easy on Yourself; How to purchase an easy to use product in eight steps (In Dutch, original title: Maak het jezelf makkelijk: in 8 stappen naar een gebruiksvriendelijk product) Tijdschrift voor Ergonomie Jaargang 33, 2008 : Number 1, February.

Van Kuijk, J.I., H.C.C.M. Christiaans, H. Kanis and D.J. van Eijk (2007) Usability in Product Development Practice: After Sales Information As Feedback. Conference of the International Association of Societies of Design Research: Emerging Trends in Design Research. Hong Kong, China.

Van Kuijk, J.I., H.C.C.M. Christiaans, H. Kanis and D.J. van Eijk (2007) Usability in Product Development; A Conceptual Framework. Concemporary Ergonomics 2007, Proceedings of the English Ergonomics Society Annual Conference 2007, Nottingham, UK, Taylor & Francis.

Van Kuijk, J.I., H.C.C.M. Christiaans, H. Kanis and D.J. van Eijk (2006) Usability in the Development of Consumer Electronics: Issues and Actors. IEA 2006, 16th world congres on ergonomics, Maastricht, The Netherlands.

Other

(Contribution to) William Lidwell, Gerry Manacsa (2009) Deconstructing Product Design: Exploring the Form, Function, and Usability of 100 Amazing Products. Rockport Publishers, Beverly, MA, USA. ISBN: 9781592533459

(Contribution to) Consumentenbond (2009) Why make it hard? Focus on usability Why make it hard? Focus on usability. Digitaalgids January/Februari 2009, Consumentenbond, Den Haag, The Netherlands.

Van Kuijk, Jasper (2007) Why Doesn't it just Work? Usability in the Product Development Process (In Dutch, original title: Waarom Werkt het niet Gewoon? Gebruiksgemak in het Productontwikkelingsproces) Product Magazine, Media Business Press, Rotterdam

Interviews

Interview with Quest Magazine: P. Fontani (2008) Drowning in Versatility (In Dutch, original title: Verzopen in Veelzijdigheid). September 2008, G+J uitgevers, The Netherlands

Interview with Kassa Radio, Radio 1, about usability in consumer products (November 11, 2009)

Interview with Radio Wereldomroep, about usability in consumer products (November 12, 2009)

Interview with Nederlands Dagblad: Maarten Vermeulen (2005) The device rules (In Dutch, original title: Het apparaat de baas) Nederlands Dagblad: July 30, 2005

Online

Uselog.com | the product usability weblog (www.uselog.com, 2005-2010)

Acknowledgements

Welcome to what is probably the most-read page of any thesis. And that is not me being cynical, I think it deserves to be just that. There is only one name on the cover of this thesis, but as the adage goes: never judge a book by its cover. Many people contributed, helped, supported, read, (re)wrote, criticized, loved, fed and - at times - were the subject of me being euphoric, unreasonable, happy, angry, or curious. So this is going to be a long list.

First of all, all the practitioners I interviewed, observed, harassed, interviewed again, and asked to review and to comment: thank you. I hope you will continue to be as cooperative and open as you have been with me, because I think it is a very symbiotic and worthwhile way of cooperating.

Case I: Liesbeth van Driel, you have moved mountains during your work on the first case study; you made a great contribution to this thesis. My gratitude also goes out to the representatives from the participating companies: Karin, Wouter, Henk and Lilian, Tanya and Heidi. Thank you for your hospitality, openness, patience, and enthusiasm. Kaj Morel, thank you for your constructive and critical views.

Case II: My thanks and appreciation goes out to all the interviewees, and especially the primary contacts in the participating development groups. Wietske, Eve, Rory, Ingrid, Magda, Markus, David, Kristoffer, Eugene and Lilian: a big thanks for your input, efforts, help, insights, and patience. Arjen Klinkenberg, thank you for your great work on the Trace tool. Elke, thank you for believing this study was 'something that should be done' and getting me out there.

Case III: I am indebted to Cynthia van den Eijnde who put great effort and thought into studying the home theatre system project and whose thoughtful comments helped shape the study. Thanks also to the students of the UTaR course who conducted usability evaluations of the three products. Finally, this study would not have been possible without Jeroen from AV@home, who was always willing to help to find the right documents and people, who created support for this research project within AV@home, and supplied me with invaluable moments of reflection and empathic criticism. I very much enjoyed working with you.

To Meike Mak. Because the length of my thesis had already gotten somewhat out of hand I could not include the very inspiring and insightful case study you did on Philips Easy Line in it. But it was a great pleasure to watch you work and I have the feeling the results of your work will make their way out there in some other form.

Thank you to all the product development practitioners and researchers who took the time and effort to comment on the recommendations for industry: Jim Drew, Bas van Elk, Rich Gunther, Dave Gustafson, Lilian Henze, Samantha Hosea, Frederik Hoolhorst, Janne

Kaasalainen, William Lidwell, Meike Mak, Alex, Tim Selders, Froukje Sleeswijk Visser, Marieke Smets, Brian Tidball, Esther Toet, and Onno van der Veen.

Thanks to René van Meurs for your help on the uselog.com redesign and Marieke de Roo for lending me your expertise on graphic design.

I am grateful to the warm and welcoming people at Northwestern University's Segal Design Institute and MMM program where I spent a thoroughly inspiring two months. Don and Liz, thank you for the opportunity you gave me, and for involving me in so many inspiring activities and for the great discussions we had.

I have a wonderful supervisory team to thank, for this thesis as well as for 'my further scientific education' (which to my amazement was the only official task I had according to my contract). I hope we will continue to have those kitchen table discussions in which we discussed anything; as the evening progressed the subject would move from my thesis, to the field, to the faculty, to science and then of course 'the world'.

To Daan van Eijk. Thank you so much for believing in me from the start. Thank you for the freedom and support you gave me. I admire your positive attitude and your passion for the field and the faculty. Thank you for guarding the structure and focus of my project. Thanks for putting my feet back on the ground now and then, as well as lifting my spirits when I needed it. And as for your questions when I for example proposed to transcribe every sigh, pause and sneeze of the interviewees - "Isn't this a little too much detail?" - Ehm, yes, it may have been.

To Heimrich Kanis. You taught me the value of things that do not come naturally to me. Of doubt, of postponing judgement, of the smallest details, and that the greatest thing that can happen to a scientist is getting stuck. You told me to look for the things that do not fit my ideas, instead of for what confirms them. You read everything I wrote with great attention, sometimes to my despair. Thank you for teaching me a new way of looking and for caring.

To Henri Christiaans. You supplied me with numerous important handles to get a grip on my work. On the other hand, when I would be up in my methodological fortress, guarded by Yin, Miles and Huberman, you would at times talk me down. I learned from you that science is rigor, but also pragmatism. You never forget to look at the bigger picture: how everything would fit together.

I experienced being a PhD candidate at Industrial Design Engineering as 'being raised by the village'. Because of the great variety in disciplines in our faculty I got advice from a multitude of perspectives – both solicited and unsolicited – which I think is of great value for someone doing research in the multidisciplinary field that product development is. I feel a strong connection to IDE, am proud of its heritage and present position, and greatly value the luxury of being under one roof with so many knowledgeable and passionate people. Thank you for having me.

To my StudioLab colleagues who made life so much more enjoyable, are never out of ideas, and can provide solid advice and criticism: Aadjan (dear papa StudioLab), Brian (or Brain, sorry for distracting you so much), Beatriz, Carlita, Carolien (I admire your thoughtful ways), Corrie, Daniel (keep building), Erdem, Froukje (for your energy), Geke (the details are not the details and thanks for talking me down one floor), Gelma (Tivoli, some time again soon?), Gert (I've found out you are much less cynical than you seem), Juan, Nazli, Onno, Remco, Rob, sNynke (your passion is inspiring), Steven, Tommes (you are a great sparring partner both for academic and humorous purposes), PJ (always up for a (academic) discussion), Wei and Walter (because you know things about stuff).

My AED colleagues: I left the third floor too soon; you are great company. I hope to see more of you in the near future.

The same goes for Sonja (Buzink), Andre, and Renee: I really enjoyed your company.

To my fellow project members of the Design for Usability project: Thank you for your feedback and our lively discussions and Sinterklaas session. Sonja (van Grinsven-Evers), thank you for the cups of tea and encouragements.

To Tim Selders: Thank you for getting me interested in design management, thinking visually, strategy and structuring data.

To Nicky: You were only here a short while, but I really enjoyed having you around with all your energy and with you mustering more enthusiasm for Holland than I have at times.

To Maaike: Apart from having learned from your research I learned from you. You pioneered a path I took a bit later than you. And I am grateful for that. As I am for the many lunches, teas, walks and talks.

Miguel. Slow cooker. Never stressed. It's been a great pleasure and privilege to go through the whole thing in parallel and in many cases 'together'. Loved those summer evening train rides back from work (but speak up!). I will not hold Spain winning the world cup against you. I am proud to have you as a paranimf.

To Wietske: With me from our days in the Piet Heinstraat. You know how I can let things get out of hand (think: Compaq computer and a UI design assignment) and you tell me if I do. Your experiences in product development practice inspired me to study it. Apart from that you are a great, great friend. Having you as a paranimf gives me great pleasure and confidence.

To Henk, my father: Thank you for always believing in me, and for instilling me with the belief that anything is possible. I would not have started this endeavour without that. And my passion for (the English) language, my guess is I got that from you.

To Stina, Mam: Thank you for your interest, support, care, and concern. I would not have finished this endeavour without it. My passion for coffee, my guess is I got that from you.

Lieve Marieke, je hebt me erdoor gesleept als het te groot werd, enthousiast gekregen als ik chagrijnig was en bent kritisch geweest als ik groter dan mezelf werd. "Het antwoord is ja: jij zou me vinden."

To anyone I forgot: it was not on purpose. Let's have coffee.

About the author

Jasper van Kuijk (1976) was born in The Hague (The Netherlands) and obtained a master's degree in Industrial Design Engineering from TU Delft (The Netherlands), where he specialized in human-product interaction of electronic consumer products. He interned at the usability group of Ericsson Mobile Communications (Lund, Sweden). His graduation project took place at Philips Research's Media Interaction Group (Eindhoven, The Netherlands), in the Ambient Intelligent Lighting (AIL) project. In this project he developed the InfoLight, a device intended to unobtrusively show information through light, movement and sound. Based on his work in the AIL project he was awarded co-authorship of two patents.

After his graduation in 2002 Jasper worked as a communications advisor at IDE, developing the faculty's external communication strategy and material. He then joined *PARK advanced design management*, a design management consultancy that advises on design process innovation, design department organization and design strategy.

In 2005 he started as a PhD candidate on a project initially called 'modelling on usability engineering'. In 2006 he was co-author of the proposal for the IOP program for the funding of applied research, which resulted in the Design for Usability project of which his research project became a part.

During his PhD project he started 'the product usability weblog' (www.uselog.com) where he wrote about consumer product usability: examples of products with good and poor usability, usability studies, interesting papers, and news and events. By the end the weblog had almost 10.000 hits per month. He also wrote columns for the TU Delft newspaper 'Delta' and for the IO-News magazine for external contacts of IDE.

In 2009 he spent two months as a pre-doctoral research fellow at Northwestern University's Segal Design Institute and MMM-program.

Besides his research he is a professional speaker for the Speakers Academy on the subject of human-centred innovation and product development, and facilitates workshops, on e.g., user-centred product development and presentation skills for design(ers).

He is currently a PostDoc at the Faculty of Industrial Design Engineering at TU Delft where he works in the ID-StudioLab, a hotbed of design researchers, research designers, design educators and a lot of other hybrids.

Besides being a researcher Jasper is a 'cabaretier' and took part in the Leids Cabaretfestival (2009) and the Cameretten festival (2010).

Why is the usability of mobile phones so poor? Why am I not able to do something as simple as hooking up my DVD recorder? Why do they make these products so hard to use? And are they doing it on purpose?

The usability of electronic consumer products - portable music players, washing machines, mobile phones - is under pressure. This is attributed to these products being equipped with more and more functions, becoming smaller, and being used in networks and in a large variety of usage contexts. To further complicate things development of these products takes place under enormous time pressure, at low budgets, and by globally distributed teams.

In the past years many methodologies and methods for user-centred product development have been developed, but consumers are still confronted with scores of unusable electronic consumer products. So what is going on? The problem seems to lie in product development practice. However, current literature on usability in product development practice does not study the product development process as a whole, contains few case studies, and only limited research is available on the electronic consumer products sector specifically.

To increase the insight into usability in the development of electronic consumer products three case studies were conducted. In each of the case studies an integrated approach was taken: the focus was on the product development process as a whole (as opposed to design only), and not just on the usability specialist and interaction designer, but on six roles that were considered to have most influence on usability: the product manager, marketing specialist, industrial designer, interaction designer, usability specialist and development engineer. Interviews were conducted with 69 product developers across 10 product development groups.

The results provide a description of how usability is dealt with in product development of electronic consumer products, an overview of mechanisms of barriers and enablers for usability, and two causal models of usability in product development. Finally, 25 recommendations for industry were written that suggest how to organize product development if the goal is to make usable electronic consumer products.

TU Delft
Delft University of Technology

DESIGN for USABILITY
www.designforusability.org

NL Agency
Ministry of Economic Affairs