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Barriers to and Enablers of Usability in Electronic Consumer Product Development: A Multiple Case Study

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This study identified practitioner-reported barriers to and enablers of usability in the development of electronic consumer products. Barriers and enablers are properties, situations, or conditions in the product development process, team, or context that negatively or positively influence the usability of a product. Based on a review of literature on user-centered design and exploratory expert interview, central concepts for studying usability in practice were identified. This was used as input for the case study, which was conducted at 5 product development groups in large multinationals, making (a) portable audio/video players, (b) personal navigation devices, (c) cell phones, (d) laundry care products, and (e) home control products. Data were primarily collected through interviews with

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31 product development practitioners. Based on the data collected, case descriptions were created and more than 1,500 barriers and enablers were identified, categorized, and analyzed. The results of the study are 23 sets of barriers and enablers, of which it is indicated in which of the cases they occur, and accompanied with illustrative quotations from the interviewees. In barriers and enablers, a predominantly "outside–in" relation was observed, from the more external properties of companies (market, company organization) to the more internal (process, team, project). This seems to indicate that the user-centeredness of a product development process is highly influenced by the context in which it is executed. The results also lead to the conclusion that if the goal is to make usable products, one cannot only address activities that are generally considered typical of user-centered design, such as conducting user research and user testing. One also has to take into account how these activities are integrated with and supported by the rest of the product development process, which in turn has to be supported by the product development organization.

CONTENTS

1. INTRODUCTION

The existence of a considerable body of knowledge on usability and user-centered design (UCD) has not prevented the launch of products with limited or even poor usability (Den Ouden, Yuan, Sonnemans, & Brombacher, 2006; Jokela, 2004; Pogue, 2006; Steger, Sprague, & Douthit, 2007, p. 825). This suggests that, in addition to research that generates or adds to new methods for UCD, which has been the focus of much of the research in the human–computer interaction field, it might be valuable to also study practice (Gulliksen, Boivie, & Göransson, 2006; Wixon, 2003). Most studies on usability and UCD in practice have been conducted in the areas of systems and software development, and less attention has been paid to electronic consumer products.

A number of trends make the electronic consumer products sector a worthwhile area to investigate. Due to the increased integration of information technology, electronic consumer products have effectively turned into powerful computers with extensive functionality (Den Ouden, 2006, p. 85; Lindholm, Keinonen, & Kiljander, 2003, p. 12; Norman, 2007) and relatively small dimensions (and thus a small user interface) (Keinonen, 1998), that are often used in networks of products and services (Buxton, 2007; De Visser, 2008, p. 12; Law, Roto, Hassenzahl, Vermeeren, & Kort, 2009). Their decrease in size has also made electronic consumer products more mobile. The increase in the number of environments in which a product is to be used increases the challenge of designing a product that is usable in all situations (van der Bijl-Brouwer & van der Voort, 2009). Although elaborate functionality, small dimensions, and the integration of devices in networks can potentially benefit the user, if

a product scores high on these dimensions it is likely that it will take more effort, knowledge, and skills to create a design that ensures a satisfactory level of usability.

Although increasing product complexity requires more attention to be paid to the UCD of electronic consumer products, the sector suffers from increasing commoditization (Wever, 2009, p. 52), which puts pressure on development time and budgets.

There are indications that developers of electronic consumer products have trouble dealing with this increasingly complicated design challenge. In a survey by the Pew Research Center, 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 teach them how to use it (Horrigan & Jones, 2008). In the past, product returns of electronic consumer products were largely due to technical failures, and the number of returns was decreasing (Den Ouden et al., 2006, p. 3). However, since the late 1990s, the number of product returns has been rising (Brombacher, Sander, Sonnemans, & Rouvroye, 2005), and it was reported that in 48% of the returned products, no technical fault was detected (Den Ouden et al., 2006, p. 825). These "soft problems" (Kim, 2012) are attributed to, for example, people not understanding a product and thus thinking that it does not work (Den Ouden et al., 2006). The cost of product returns in 2007 in the United States alone has been estimated at $13.8 billion, and improving the usability of products is seen as one of the strategies to reduce returns of the "no-fault found" variety (Steger et al., 2007).

1.1. Aim

The aim of the present study was to identify practitioner-reported barriers to and enablers of usability in the development of electronic consumer products. Barriers and enablers are properties, situations, or conditions in the product development process, team, or context (project, company, market) that negatively or positively influence the usability of a product.

In a discussion of research in the medical field, Malterud (2001a) argued that in addition to controlled experiments, the knowledge of experienced practitioners should be studied because that could offer a broader understanding of a phenomenon. A similar argument could be made for research in product development: The design and development of electronic consumer products can be studied and improved by investigating the observations, opinions, and beliefs of practitioners.

The research question in this study was the following:

> RQ1: What variables in product development practice do product development practitioners regard as contributing to or obstructing the usability of electronic consumer products, and how are these factors related?

This study investigated how electronic consumer product development groups try to improve the usability of their products and how they integrate UCD in their product development approach. Although UCD can also improve other product qualities (e.g., product appeal, product attachment, identification with a product), in this case we focused on UCD as a means to achieve usability.

1.2. Outline

Section 2 presents the concept of usability, as defined in the literature, and identifies the relevant properties of electronic consumer products. Section 3 discusses a literature review of the principles and the practice of UCD. This is followed in Section 4 by exploratory interviews with experts on UCD in practice. The literature review and exploratory interviews provide the central concepts (Section 5), which help to set the scope of the case study. In Section 6, the case study method is described, including approaches taken for case selection, data collection, data analysis, categorization, cross-case analysis and verification. Section 7 documents the sets of barriers and enablers that were identified, as well as the relations between the categories of barriers and enablers. This is followed by a discussion of the results and the limitations of this study (Section 8). The article closes with the conclusion (Section 9) and with recommendations for future research and for practitioners (Section 10).

2. USABILITY AND ELECTRONIC CONSUMER PRODUCTS

This section discusses the concept of usability, the relevant properties of electronic consumer products, and how the concept of usability applies to this product category.

2.1. Usability

The construct of usability 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), and they vary in whether emphasis is placed on product usage, product appeal, user performance, user experience, or product ownership.

In this article, we use the definition of usability from the ISO 9241–11 standard (ISO, 1998, p. 2), which is considered the most widely accepted definition (Jokela, Licari, Matero, & Karukka, 2003; Jordan, 1998) and which is also described as "situational usability" (Hertzum, 2010) or as "quality of use in a context" (Bevan & Macleod, 1994):

> 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.

This definition implies that there is no such thing as *the* usability of a product. Usability is a function of the context in which the product is used (Bevan & Macleod, 1994). There are three main dimensions of usability in the ISO standard:

- *Effectiveness:* Accuracy and completeness with which users achieve specified goals.
- *Efficiency*: Resources expended in relation to the accuracy toward the use of the product, for example, required time or mental effort.
- *Satisfaction*: Freedom from discomfort, and positive attitudes toward the use of the product.

These dimensions of usability can be divided into user performance (i.e., effectiveness and efficiency) and subjective elements (i.e., satisfaction; Shackel, 1984), which are also referred to as the user-performance view and the user-oriented view (Bevan, Kirakowski, & Maissel, 1991). These high-level dimensions need to be translated into concrete measures, the suitability of which depends on the context of use (Bevan & Macleod, 1994).

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 (Grudin, 1992; Shackel, 1984). The ISO definition of usability refers to the extent to which users can apply the product to reach their goals. This implies that when evaluating usability, in addition to evaluating how people use the product that is offered, one should also assess whether the product offers the right functionalities. Adding more functionality to a product increases its flexibility (Shackel, 1991), as it can be used to reach a bigger diversity of goals. Thus an increase in functionality *can* have a positive effect on usability, because the chance increases that the product can do what you need it to do. However, it is also claimed that if the functionality of a product increases—all things being equal—the usability of that product, its ease of operation, tends to decrease (Brown & Carpenter, 2000; Keijzers, Den Ouden, & Lu, 2008; Lindholm et al., 2003, p. 31). By creating an appropriate design, however, it is possible to create highly usable products that have extensive functionality (Den Buurman, 1997; Norman, 2007).

2.2. Electronic Consumer Products

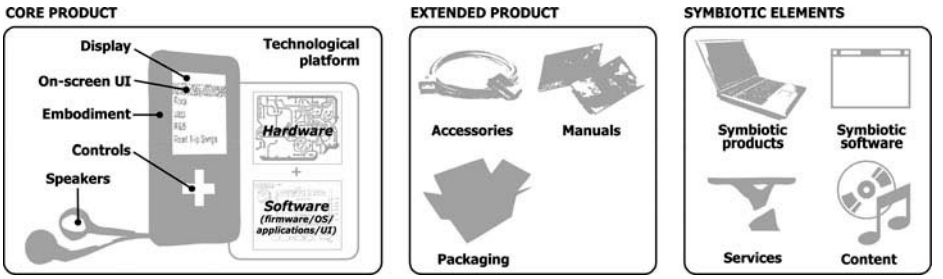
Definition and Properties

In this study, "electronic consumer products" were defined as products that are purchased by individuals for personal use (as opposed to business use), have a physical presence (as opposed to software), and feature integrated information technology that enables them to interact with the user (as opposed to, e.g., chairs and vases). Examples are cell phones, MP3 players, and microwaves.

To offer functionality, in addition to their physical manifestation, electronic consumer products make use of microelectronics and/or information technology. 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, pp. 2–3). In comparison to nonelectronic products, electronic products contain fewer visual clues as to what the products are for and how to operate them (Den Buurman, 1997; Jordan, 1994; Norman, 2002, p. 8).

Electronic consumer products generally consist of a comparable set of components (Figure 1): (a) the core product, with which users primarily interact; (b) the

FIGURE 1. Primary elements of the ecosystem of electronic consumer products, clustered by core product, extended product, and symbiotic elements.



extended product, which facilitates the use of the core product; and (c) the symbiotic elements: the additional products, software, services, and content that allow the core product to function. These elements constitute what is called the product's ecosystem (Buxton, 2007, p. 50).

Product Development Characteristics of Electronic Consumer Products

Along with the increase in functionality, the technological complexity of electronic consumer products has been increasing (Den Ouden et al., 2006; De Visser, 2008). The sector has also witnessed an increase in the pressure on time to market (Brombacher et al., 2005) and shortening adoption cycles, causing companies to have only a limited amount of time to get a return on investment for a certain product category (Minderhoud & 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 & 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; 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 increasing product complexity, new product development requires the collaboration of multidisciplinary teams (Kleinsmann, 2006, p. 20). Product development teams are distributed across the planet (Ketola, 2002, p. 28; Minderhoud & Fraser, 2005), which complicates team communication (Song, Montoya-Weiss, & Schmidt, 1997). Product development groups have been found to increasingly utilize local subcontractors (Den Ouden, 2006, p. 85).

The electronic consumer products market 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). This results in a development process in which time to market is extremely important, and in which the budget is limited.

Comparison with the Digital Domain

Electronic consumer products can be considered a mix of physical products and computers. However, in comparison with domains such as Information and Communication Technology (ICT), software, and web applications, electronic consumer products and their development process have a number of unique qualities, which are discussed next.

Product properties

- *Physical presence*: The embodiment of a product is a part of its user interface, as users may attribute a certain meaning to the appearance of the product, for example, what product category it falls into and how it should thus be operated (Boess & Kanis, 2008). In addition, the embodiment influences how the product can be handled and the physical comfort or discomfort that users experience (Vink, 2005).
- *Device-specific UI*: Electronic consumer products are often equipped with a unique physical user interface (UI; e.g., controls, outputs) and on-screen UI. In the digital domain, it is more common for the UI to consist of standardized controls (e.g., mouse, keyboard, touch screen) and standardized output elements (e.g., audio, screen).
- *Technological platforms*: Purely digital products usually run on more standardized technological platforms (servers, operating systems, motherboards, etc.) than electronic consumer products, for which often custom-built hardware is developed.

Product development properties

- *Freeze during development*: For digital products, the moment when the product design is final or "frozen" is less definitive than for electronic consumer products, for which at a certain point during development preparations have to be made to manufacture hardware and embodiment, and thus investments are made in molds and parts (Ulrich & Eppinger, 2004).
- *Updating after launch*: For digital products, it is common practice to release software updates after a product is launched. Two important enablers of this are that digital products do not freeze after launch and that, because they are connected to the web, it is possible to transfer the data needed for the update. For electronic consumer products, it is of course impossible to change the hardware or embodiment after launch, but the firmware can in some cases be patched, updated, or even completely overhauled if the company has the appropriate infrastructure (Kahney & Gariner, 2008).
- *Development process architecture*: When developing software, it is more common to have design and implementation coincide: The product is designed while being implemented (Buxton, 2007). The hardware freeze makes electronic consumer products as a whole (including software, hardware, and embodiment) less suitable for an Agile development approach (Highsmith & Cockburn, 2001) in which products are

built up in short development cycles, conceiving, designing, and implementing function after function. The software of electronic consumer products, however, *can* be developed in an Agile process.

- *End-users on the team*: A considerable number of studies of UCD in practice have been conducted in the domain of in-house ICT system development. In these projects, development takes place in the organization in which the users work, so in principle face-to-face contact with users, or even including them in a development team, is possible. In organizations that develop electronic consumer products, users are not present within the organization.

Market properties

- *The buyer*: In the case of software for personal use and of electronic consumer products, it can be the case that either a user buys a product for personal use or one user buys a product on behalf of a group of users (i.e., a household, a group of coworkers). In the case of business ICT systems, it is usually the case that the buyer is not the projected user, as purchases are performed by a specialized department.
- *Moment of revenue generation*: In contrast to web and software, one experiences the usability of physical products only after purchasing them (Creusen & Schoormans, 2005; Jokela, 2004; Keinonen, 1998; Nielsen, 2004). The reverse holds for e-commerce websites, such as web stores (e.g., books, real estate) or online content suppliers (e.g., news, streaming video; Donahue, 2001; Mao, Vredenburg, Smith, & Carey, 2005; Nielsen, 2004), as in these cases people need to be able to interact with the website before they can generate revenue for the company that owns the website. In these cases, people are users before they become buyers.

2.3. Electronic Consumer Product Usability

As the definition of usability was developed with the productivity of office workers in mind (Shackel, 1984), the effectiveness and efficiency dimensions were considered very important. Consumer products, however, are used voluntarily with the aim of reaching goals or bringing enjoyment, which caused Jordan et al. (1996b) and Han, Yun, Kwahk, and Hong (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. In contrast to the aforementioned argument by Jordan and Han—namely, 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 achieve the main goal that the product was intended for? The ISO 20282 standard distinguishes between the installation and the 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). However, the definition of usability in the ISO 20282 standard is not fundamentally different from the one in ISO 9241–11.

Although the ISO 9241–11 definition takes into account satisfaction with use, freedom from discomfort, and attitude toward the product, it represents a fairly instrumental view of human–system interaction: The extent to which people are able to reach their goals, at what cost, and how they appreciate the way this happens. It has been argued that when evaluating human–product interaction, more attention should be paid to aspects such as pleasure and hedonics (Hassenzahl, Platz, Burmester, & Lehner, 2000; Jordan, 1995; Kim & Moon, 1998). The basis of this seems to be 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 & Tham, 2003) therefore argue that the definition of usability should be expanded to include hedonic aspects and the user's appraisal of the appearance.

3. STATE OF THE ART

A literature review was conducted of both the principles and the practice of UCD. The principles of UCD were reviewed in order to identify the defining properties of a user-centered approach. The review of literature on UCD practice provided handles on the intricacies of conducting UCD in the real world.

3.1. Principles of User-Centered Design

Following a user- or human-centered design process is seen as a large contributor to creating usable products (ISO, 1999; Preece, Sharp, & Rogers, 2007; Vredenburg, Isensee, & Righi, 2002a). Vredenburg, Isensee & Righi (2002) described traditional product development focusing on technological possibilities and describing product quality in terms of component quality, while in UCD solutions that fit the user are taken as a starting point, and product quality is measured from a user point of view, taking into account needs, wishes, characteristics and abilities of the projected user group.

Next we discuss publications by an author and two groups of authors who identified principles and activities of UCD: Gould, Boies, and Lewis (1991; Gould & Lewis, 1985); Nielsen (1992); and the ISO organization (1999, 2010).

Gould and Lewis (1985) proposed three principles for designing for usability, to which Gould et al. (1991) later added a fourth:

- *Early focus on users*: Understanding user characteristics and tasks through direct contact.
- *Integrated design*: All aspects of the product that influence usability should be developed in parallel and under one management.

- *Early—and continual—user testing*: Collecting empirical data through observation and measurement of user behavior, and collection of feedback.
- *Iteration:* Iteratively modifying a system under development based upon the results of user testing.

Jakob Nielsen (1992) adapted and extended on Gould et al.'s principles in his usability engineering life cycle, which is focused more on activities than on principles. Noteworthy additions in comparison to Gould et al. are analysis of competitor products to explore the solution space and get an indication of their usability; the use of guidelines for creating and evaluating designs; and to not just evaluate products through user testing but also collect feedback from field use. Because Nielsen considered setting goals and checking whether you meet them an essential property of an engineering approach, the usability engineering life cycle explicitly includes the step "setting usability goals," something that Gould and Lewis (1985) included in their explanation of the principles but not as a principle in itself. Finally, Nielsen urged professionals to consider the larger product development context, namely, that their project might be one of a family of products that is developed over generations.

In 1999, the ISO organization published the ISO 13407 standard for human-centered design processes for interactive systems (ISO, 1999), which evolved into the more recent ISO 9241–210 standard (ISO, 2010). In ISO 9241–210, it is stressed that designers should understand not just users and their tasks but also the whole context of use, including the surroundings in which products are used. Of Nielsen's additions, the ISO standard incorporates setting usability goals and using guidelines as activities that can be conducted, whereas feedback from field use is considered to be a part of the principle of empirical user-centered evaluation of designs. Of the three approaches the ISO standard is the only one to state that UCD requires multidisciplinary teams.

3.2. Practice of User-Centered Design

The goal of the second part of the literature review was to identify previously reported barriers to and enablers of usability in practice.

UCD practice can be quite different from UCD principles and theory (Gulliksen et al., 2003; Norman, 1996; Steen, 2008; Wixon, 2003), as real, day-to-day product development is messy (at best). UCD methods that have been proven to be very effective at identifying usability issues, but that are as a consequence also rather time-consuming or require a lot of expertise, might not be applicable in such a context (Wixon, 2003). A number of authors have stressed that in academia there is not enough insight into or appreciation of the practical concerns of UCD practitioners and that to improve usability, product development practice should be studied, for example, through case studies (Grudin, 1991, pp. 435–436; Gulliksen et al., 2006; Wixon, 2003).

A considerable number of usability practitioners have provided descriptions of how their company or department deals with usability and UCD (e.g., Bouwmeester & Stompff, 2006; Hendrick, 2008; Jordan, Thomas, & Weerdmeester, 1996; Lauesen,

1997; Lee & Pan, 2007; Väänänen-Vainio-Mattila & Ruuska, 2000; Wiklund, 1994). These publications provide valuable insights into, and engaging descriptions of, the work and concerns of usability practitioners. However, most cases are not anonymized, which on one hand makes it easier to put the results into context, but as the authors are often employed by the company reported about, the reports might be biased. The authors are, after all, reporting about their own activities and very few companies enjoy publishing their shortcomings and struggles. This may have led to what Lindholm et al. (2003) and Steen (2008) called less critical descriptions in insider accounts of human/UCD practice.

Insider accounts or participatory observation can be an appropriate source of information if the research method used for data collection and analysis is disclosed in sufficient detail to the reader. Otherwise only a limited assessment can be made of the trustworthiness of a qualitative study (Graneheim & Lundman, 2004; Shenton, 2004). Therefore, a selection criterion for including studies in this literature review was whether authors explicitly report the research method for data collection and interpretation.

User Involvement

User involvement, starting in an early stage and continuing throughout the development process, is widely reported to positively influence usability (Boivie, Aborg, Persson, & Lofberg, 2003; Borgholm & Madsen, 1999; Bruno & Dick, 2007; Cajander, Boivie, & Gulliksen, 2008; Clegg et al., 1997; Gulliksen et al., 2006; Høegh, 2008; Poltrock & Grudin, 1994; Rauch & Wilson, 1995). Besides evaluating designs, establishing an understanding of the user (needs and usage context) is pointed out as an important issue (Bekker, 1995; Boivie, Gulliksen, & Goransson, 2006; Cajander et al., 2008; Clegg et al., 1997; Poltrock & Grudin, 1994). Postdeployment information has also been identified as a source of information on product use (Chilana, Ko, Wobbrock, Grossman, & Fitzmaurice, 2011).

The use of appropriate UCD methods is considered to contribute to usability (Boivie et al., 2003; Ji & Yun, 2006; Vredenburg et al., 2002b). Clegg et al. (1997) identified a lack of established methods for user involvement as a barrier to user involvement. Who is involved in conducting an evaluation is mentioned as having a big potential impact on the quality of its outcomes (Poltrock & Grudin, 1994).

From the selected studies, the following aspects emerged that influence the choice of UCD method and the quality of execution:

- Time required to execute a method, as time pressure in development projects is often high (Bekker, 1995; Boivie et al., 2003; Boivie et al., 2006; Bruno & Dick, 2007; Chilana et al., 2011; Clegg et al., 1997; Gould & Lewis, 1985; Gulliksen et al., 2006; Høegh, 2008; Ji & Yun, 2006; Rosenbaum, Rohn, & Humburg, 2000; Vredenburg et al., 2002b);
- Financial costs required to execute a method (Bekker, 1995; Bruno & Dick, 2007; Clegg et al., 1997; Ji & Yun, 2006; Rauch & Wilson, 1995; Vredenburg et al., 2002b);

- Knowledge and experience required to apply a method; presence of staff with required knowledge and experience (Bruno & Dick, 2007; Clegg et al., 1997; Ji & Yun, 2006; Rauch & Wilson, 1995);
- Equipment/facilities required to apply a method (Bekker, 1995; Venturi & Troost, 2004);
- Availability and quality of prototypes (in the case of evaluations; Bekker, 1995; Boivie et al., 2006; Poltrock & Grudin, 1994; Vredenburg et al., 2002b);
- 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, for example, due to sample sizes and/or the availability of video images.

Product Development Process

Product usability is reported to be positively influenced by a development process architecture that allows for user involvement (Clegg et al., 1997; Høegh, 2008) and an iterative approach throughout the process (Bruno & Dick, 2007; Gulliksen et al., 2003). The execution of user involvement activities is reported to be stimulated if a company formally and explicitly includes user involvement (methods) in its development process (Boivie et al., 2006; Cajander et al., 2008; Clegg et al., 1997; Høegh, 2008). However, there is a concern that this may lead to development teams conducting user involvement only because they are required to (Boivie et al., 2006; Clegg et al., 1997).

Having the results of user involvement available only in a later stage is reported to be a barrier to implementing the feedback (Cajander et al., 2008; Gulliksen et al., 2006; Poltrock & Grudin, 1994; Rauch & Wilson, 1995). In addition, the implementation of user involvement outcomes is influenced by whether the development team can grasp the results and has the resources needed for implementation, and the feasibility of the proposed redesign (Høegh, 2008).

In several studies, practitioners indicate that working on a complex product and in a complex development project (large team size, long duration) makes it harder to manage the process, to design a usable product, and to complete the project (Bekker, 1995; Boivie et al., 2003; Gulliksen et al., 2006). The degree to which different elements of a system are developed at different times and in different groups influences whether an integrated approach can be taken (Poltrock & Grudin, 1994).

Product Development Team

A multidisciplinary approach is believed to be essential for effective UCD, as individual disciplines are considered to not have the required expertise to analyze *and* design *and* implement *and* evaluate complex systems (Boivie et al., 2006; Clegg et al., 1997; Gulliksen et al., 2006; Vredenburg et al., 2002b). In addition, domain knowledge (of the product category one is working on) is reported to positively influence usability (Bekker, 1995; Chilana, Wobbrock, & Ko, 2010; Gulliksen et al., 2006).

Whether—and, if so, to what extent—a product development team features members with UCD expertise is widely reported as having an impact on usability (Boivie et al., 2003; Chilana et al., 2011; Clegg et al., 1997; Gulliksen et al., 2006; Rauch & Wilson, 1995; Venturi & Troost, 2004; Vredenburg et al., 2002b). In what stages of product development UCD specialists are involved is reported to be influenced by whether they work from centralized departments or are distributed in product development teams (Borgholm & Madsen, 1999; Madsen, 1999; Rauch & Wilson, 1995; Vredenburg et al., 2002b), and by informal relations of UCD experts with other development roles (Borgholm & Madsen, 1999; Høegh, 2008).

Several explanations are provided for the degree to which UCD specialists are a part of product development teams and the standing they have within them:

- Whether a team has the resources to deal with the outcome of user involvement if these activities were to be performed (Høegh, 2008).
- Education and background of UCD specialists (Borgholm & Madsen, 1999).
- Usability activities being specified in a company's prescribed product development process (Cajander et al., 2008).
- The degree to which UCD is an established discipline and/or department (Gulliksen et al., 2006; Høegh, 2008).
- Whether a UCD specialist is considered to have authority regarding "user issues" (Gulliksen et al., 2006).
- Whether a UCD specialist is considered credible (Chilana et al., 2010).

Within-team communication is considered an important aspect of UCD and is facilitated or obstructed by the use of terminology (Chilana et al., 2010; Venturi & Troost, 2004), the medium used to communicate about the design (e.g., sketches, use cases, prototypes/simulations; Bekker, 1995; Gulliksen et al., 2003; Poltrock & Grudin, 1994; Venturi & Troost, 2004), the way user involvement outcomes are communicated (Chilana et al., 2010; Høegh, 2008; Venturi & Troost, 2004), and the physical and organizational arrangement of the development team (Boivie et al., 2006; Poltrock & Grudin, 1994). The content that is communicated also matters: Communicating too many results from user involvement in one go can lead to the rest of the development team being overwhelmed (Høegh, 2008).

Usability departments "advertising" themselves within the organization—that is, explain how they work and what they can contribute—is reported as a stimulant to

include UCD specialists and departments in teams and processes (Gulliksen et al., 2006; Høegh, 2008).

Company Culture

Awareness of and support for usability within an organization is reported as a very important factor to influence whether a company can effectively conduct UCD (Bekker, 1995; Boivie et al., 2006; Cajander et al., 2008; Rauch & Wilson, 1995; Rosenbaum et al., 2000; Venturi & Troost, 2004).

The attitude of individual development team members toward usability is identified as a major driver for engaging in UCD and the quality of execution (Bekker, 1995; Boivie et al., 2003; Boivie et al., 2006; Bruno & Dick, 2007; Gould & Lewis, 1985; Gulliksen et al., 2003). Product development practitioners are reported to consider usability an ungraspable, fuzzy concept (Cajander et al., 2008; Clegg et al., 1997; Gulliksen et al., 2006), and they can have a large number of reasons and beliefs not to apply the principles of UCD (Gould & Lewis, 1985). The attitude toward UCD/usability is reported to be influenced by whether development team attitude is more technology centered or user centered (Gulliksen et al., 2006).

To create support for usability among colleagues, "educating other disciplines" about what usability and UCD is, and explaining their value, is a commonly cited strategy (Boivie et al., 2006; Borgholm & Madsen, 1999; Bruno & Dick, 2007; Clegg et al., 1997; Gulliksen et al., 2006; Rauch & Wilson, 1995; Rosenbaum et al., 2000; Venturi & Troost, 2004).

Upper management supporting and understanding usability and UCD is mentioned in a large number of publications as a factor (Bekker, 1995; Boivie et al., 2006; Borgholm & Madsen, 1999; Clegg et al., 1997; Gulliksen et al., 2006; Høegh, 2008; Ji & Yun, 2006; Rauch & Wilson, 1995; Rosenbaum et al., 2000; Venturi & Troost, 2004; Vredenburg et al., 2002b), both for creating a user-centered company culture and for providing the required facilities for conducting UCD.

Prioritization of Usability in Projects

During product development, a large number of decisions have to be taken, and in these decisions usability can be overlooked (Boivie et al., 2003) or not given priority by the team as a whole, even if UCD specialists consider the issue critical (Boivie et al., 2006; Høegh, 2008).

The following issues were identified as influencing the prioritization of usability in projects:

- Explicitly setting goals for the level of usability (Bruno & Dick, 2007; Clegg et al., 1997).
- Usability being a complex, less tangible concept and its future advantages are uncertain, whereas development teams are more likely to give priority to concrete, measurable goals (Gulliksen et al., 2006).

- Presence of a person in the team with considerable authority who finds usability important (Gulliksen et al., 2006; Gulliksen et al., 2003).
- Attitude of teams toward users and usability (Gulliksen et al., 2003).
- Whether the team is focused on making a usable product or on adhering to set specifications (Gulliksen et al., 2003).
- What product properties the team considers important (Cajander et al., 2008).
- Personal preferences of team members (Høegh, 2008).

4. EXPLORATORY INTERVIEWS

In parallel to the literature review, exploratory interviews were conducted with experts on usability in practice, from both academia and industry.

4.1. Method

Interview Setup

The interviews had an open and exploratory character. The interviewer probed informants for their views on the biggest obstacles to and stimulants for usability in practice. Each session took 1.5–2 hr and was captured through note taking and in a postinterview write-up.

Participants

The interviewees had the following profiles:

- Founding partner of a human-centered 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.
- Academic researcher of ergonomics and business administration.

4.2. Results

An analysis of the interviews resulted in an overview of obstacles to and enablers of usability during product developments, which then were clustered into relevant topics for usability in product development (Figure 2).

5. CENTRAL CONCEPTS

The collection of concepts that emerged from the literature and interviews (Figure 3) suggests that when investigating barriers to and enablers of UCD practice, the scope should be broader than just the usability department and its activities. The

FIGURE 2. Topics Relevant to Studying Usability in Practice, Identified Through Exploratory Expert Interviews.

Concept	Subjects It 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 UCD is formalized.
Methods for user involvement	• The collection of UCD 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 toward usability.
Development group organization	• Organizational structure (e.g., by product category, discipline, matrix organization). • Whether and, if so, 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.

FIGURE 2. (Continued).

Concept	Subjects It Covers
Product portfolio	• The type of products a company sells (e.g., consumer electronics, bathroom furniture, office equipment). • The number 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.

product development process, the team that executes it, as well as the organization within which product development takes place are reported to influence a company's proficiency in user-centered product development. Thus the identification of central concepts helped to determine the focus of the case study.

6. METHOD

6.1. Case Study

The problem at hand called for a qualitative research approach, as this 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" (Miles & Huberman, 1994, p. 10). The selected research method is the case study; suitable for explanatory studies into "a contemporary set of events over which the investigator has little or no control" (Yin, 2009, p. 13).

6.2. Case Selection

We opted to study multiple product development groups, because a multiple case design reduces the risk of results turning out to be not transferable to other projects or groups (Yin, 2009, p. 61). In addition, a case study with multiple cases is often considered more compelling, and more robust (Herriott & Firestone, as cited in Yin, 2009, p. 53). Multiple case studies offer researchers a deeper understanding of outcomes and causal relationships, because by comparing the results from several cases it can be observed whether—and, if so, under what circumstances—a certain phenomenon will occur (Miles & Huberman, 1994, pp. 26, 29).

FIGURE 3. Comparison of Similarities and Differences Between the Concepts Identified Through the Literature Review and the Exploratory Interviews.

Central concept	Definition	Literature Review		Exploratory Interviews
		Principles & Activities	*Practice*	
User involvement	Seeking information directly or indirectly from users in order to create or evaluate a design.	√	√	√
Product development process	Characteristics of the process of conceiving, developing, and introducing new products.	√	√	√
Product development team	The roles that are assigned to execute the product development process, subdivisions in the team, and how the roles relate to and communicate with each other.	√	√	√
Development group organization	How the product development group or company is subdivided into organizational units, how these are related, and how responsibilities are divided.			√
Position of usability specialists / usability department	How UCD specialists are organized, how they interact with development teams, and their background, approach, and resources.		√	√
Management approach	The mechanisms that are used to control the direction and quality of development group activities.			√
Company culture	The extent to which and how usability/UCD is part of the way of working, attitudes, experiences, beliefs, and values within the product development group.	√	√	√
Prioritization of usability in projects	The extent to which and how usability plays a role in decision-making in projects.	√	√	
Product portfolio	The type and range of products that a development group develops and markets.			√
Market	Sales channels, competitors, and target group properties.			√

FIGURE 4. The Case Selection Criteria.

Selection Criteria	Details
Complex products for personal use	Companies that develop electronic consumer products
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 segmentation of roles among the development team members
Conducts in-house product development.	Not purchasing products from suppliers "as is"

Selection Criteria

The case selection was based on a comparable case sampling strategy, meaning that the intention was to select development groups that have comparable relevant characteristics (Miles & Huberman, 1994, p. 28). In such a sampling strategy, the choice is made on conceptual grounds, not on representative grounds; the researcher is following a replication logic, aims to select those cases in which the phenomenon to be studied is considered likely to occur, not those cases that are representative of the entire population (Miles & Huberman, 1994, p. 29). To select appropriate and comparable cases for studying barriers to and enablers of usability in practice, case selection criteria were established based on the literature review and exploratory interviews (Figure 4).

We wanted to study companies that are actively trying to improve the level of usability of their products. If this effort is not made, it can hardly be called surprising if products turn out to be unusable. In addition, companies that try to develop usable products are a potential source of best practices. That a company exhibited an effort to make usable products was operationalized as a company featuring usability-related roles and activities.

Case Descriptions

Based on these criteria, five development groups (four in Europe and one in Asia) were selected (Figure 5). The group descriptions are anonymized, the promise of which ensured their willingness to also share negative observations and agree to publication of the results. An overview is provided in the supplementary materials (1. Case properties) of the characteristics of the five product development groups, including how they were organized, their culture, their products, the market they operated in, the process development process (including user involvement), and team properties.

AV2go—Portable Media Players

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

FIGURE 5. Overview of the Participating Product Development Groups.

Case	Product Category	Location	Usability Department / Activities
AV2go	Portable media players (audio/video)	Asia	Present
EnRoute	Personal navigation (primarily in-car)	Europe	Present
WashCare	Laundry care	Europe	Present
D-Phone	Cellphones	Europe	Present
HomeControl	Controls for home automation systems	Europe	Activities present, departments external

about 50 people dedicated to working on personal media players. AV2go had its own product strategy and management, as well as market intelligence groups, whereas 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

Enroute—Personal Navigation Devices (Primarily In-Car)

The company was originally 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 was carried out in Asia by third-party contractors.

D-Phone—Cellphones

Europe-based product development group of cell phones, which at the time had between 5000 and 10,000 employees. It was commercially quite successful, and the organization was growing and organizational changes were frequent. The product innovation organization was divided into two large units, supplemented by a global sales and marketing network. The whole product development organization was located in one city but not in the same building. The global corporate offices, as well as the marketing and sales organization, were located in a 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 taking photos.

Washcare—Home Appliances

Product development group of a European multinational with more than 15,000 employees worldwide. The company was a matrix organization: The departments were organized 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 its staff had a lot of experience and domain knowledge.

Homecontrol—Home Automation

Europe-based product development group, part of a division that develops components for home and office automation systems (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. In this case, the focus was on a specific development project: A new type of thermostat in which an external industrial design agency and human-centered design consultant were involved.

6.3. Data Collection: Interviews With Product Developers

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

Interviewee Selection

The goal was that in each company we would obtain information from the roles identified as relevant for usability through the literature review and exploratory interviews (Figure 6).

Thus, the interviewees (Figure 7) were a sample from the development group, the sampling parameter (Miles & Huberman, 1994, p. 30) being their role in the product development process. The role definitions were used to discuss with the primary contact of each company the people who should be interviewed. More background

FIGURE 6. Development Team Roles Identified as Relevant for Studying Usability in Product Development.

Job Title	Role Description	Also Known as
Product manager	Coordinates product development, sets the priorities for the product	Project manager, customer-marketing manager, product-marketing manager, product planner
Marketing specialist	Collects market information, defines marketing strategies	Marketing manager, market intelligence manager, market research 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, user experience or 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

FIGURE 7. Overview of the Interviewees per Company (Top Row) and the Extent to Which They Related to Roles the Researchers Intended to Interview (Left Column).

Case	AV2go	D-phone	EnRoute	WashCare	HomeControl
Product manager	Product planner Product manager	Product planner	Product manager Requirements manager	Project manager	Product manager
Marketing specialist	Market intelligence	Marketing manager	Market intelligence manager	Marketing manager	Sales manager
Industrial designer	Product designer	Industrial designer	[Partly via Hardware development manager]	Industrial designer	Industrial designer (external consultant)
Interaction designer	Interaction designer	UI designer	User Experience Manager	Interaction designer	
Usability specialist	User test manager	Usability specialist	[Partly via Requirements manager]	User testing specialist	Usability specialist (external consultant)
Development engineer	Software development manager	Software developer	Hardware development manager Software development manager Software test manager	Software development manager	Development engineer

information on the interviewees can be found in the supplementary materials (2. Interviewee properties).

Interview Setup

The interviews were performed using a general interview guide to ensure that the same basic lines of inquiry were explored with all interviewees (Patton, 1990, p. 343). The interview guide consisted of the following main subjects (a complete interview guide is provided in supplementary materials, 3. Interview guide):

- 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 toward, usability.
- Role-specific questions: activities, responsibilities, and concerns.
- Critical incidents regarding usability (products that had good or poor usability, probing for underlying causes).
- Probing for properties, situations, or conditions that positively or negatively influence usability.
- Personal data and background.

Data Recording

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

6.4. Data Analysis: From Interviews to Barriers and Enablers

This section describes how the barriers to and enablers of usability, as well as the descriptions of the product development groups, were derived from the interview data.

Creating Jointly Told Tales

The interviews were transcribed literally and analyzed using the qualitative data analysis program Atlas.ti. As a first step, we identified meaning units, which are words, sentences, or paragraphs that contain aspects related to each other through their content and context (Graneheim & 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 & Lundman, 2004). The combination of meaning unit and condensed meaning unit is

similar to "jointly told tales" (van Maanen, 1988, p. 95), which communicate both the viewpoint of the informant and the interpretation of the informant's statement by the researcher (Roth & Kleiner, 2000, p. 190; see Figure 8, second and third columns).

As the goal was to identify factors that contribute to or obstruct usability in practice, the next step was to derive barriers and enablers from the condensed meaning unit (Figure 8, fourth column). Analogous to Kleinsmann's barriers to and enablers of shared understanding (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.

Identifying Barriers and Enablers: Is There Influence?

Barriers and enablers are factors; they are thought to have an effect. This suggests the presence of causal or explanatory relationships. We labeled something a barrier or an enabler if interviewees indicated that a situation, condition, or property had a positive or a negative influence on usability, that is, if the interviewee explicitly stated that something had an effect on usability, or more implicitly if the interviewee said that it should no longer be done like that (or should be done more often).

A second method we applied to determine whether there was influence was counterfactual reasoning (Goodman, 1991; Mackie, 1974). In counterfactual reasoning, it is argued on the basis of existing knowledge (e.g., from literature and experience) how the end result of a situation might have been changed by hypothetically removing a condition from the situation (Weegels, 1996). So we also considered something a barrier or an enabler if hypothetically removing or altering it would have influenced a product's usability.

Determining the Kind of Influence: Positive or Negative?

Whether to label a factor as a positive or negative influence was determined by the original wording of 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 led to the barrier "not doing user testing." As these examples demonstrate, a large number of barriers in a case does not necessarily mean that everything was going wrong in this company but does point out that the interviewees phrased the influence negatively.

Determining Relations Between Barriers and Enablers

We found that barriers and enablers are often related. They can exert their influence through a chain of events or conditions. We refer to a chain of barriers or enablers that influence each other as a "mechanism." In addition to the influence of the barrier or enabler, the direction of that influence should be indicated. We 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

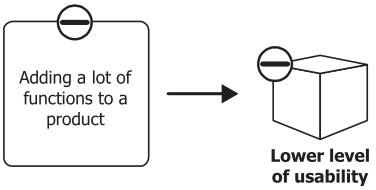
FIGURE 8. Example of How Barriers and Enablers Were Derived From the Interviews.

Interviewee	Meaning Unit	Condensed Meaning Unit	Barriers/Enablers	Merged Barriers/ Enablers per Actor	Overview of Barriers/Enabler per Case
User test manager	*"Well 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 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.	B: Poor analysis of customer service logs. (2x) B: Slow communication of customer service logs. B: Customer service logs not accessible. B: Development team not knowing what product aspects customers complain about (2x).	B: Poor analysis of customer service logs. (2x) B: Slow communication of customer service logs. B: Customer service logs not accessible.
	"I think it's the . . . just too massive the data, it just so much that once you see it you're just scared away by all this data, and you know someone should really be able to jump in and help to really make use of the data right."	The data in the customer service center report is too massive. There is so much information that the reader gets scared away. The method of analysis and presentation could be improved.	B: Poor analysis of customer service logs. B: Customer service logs not accessible. B: Development team not knowing what product aspects customers complain about.		B: Development team not knowing what product aspects customers complain about (2x). E: Knowing about usability problems in a product. B: Knowledge on usability problems only available when product is already on the market.

Product planner	*"Actually, I have considerable doubts about this type of research, because for us it is not so . . . What we get the most out of, we do beta tests, right before product launch, and at that time we can still change some things, and what we can't change is transferred to the next generation."*	The results of the after-sales satisfaction survey are in too late to be able to change the products. The interviewee finds the results from beta testing more useful, because at that time the product is still under development, and there is still a possibility to change the products. Things that can't be changed in the current product will be solved in the next range.	E: Knowing about usability problems in a product. B: Knowledge on usability problems only available when product is already on the market. E: Being able to make changes to a product before launch. B: Not being able to make changes to the product before launch. E: Transferring knowledge on usability issues to a follow-up project.	E: Knowing about usability problems in a product. B: Knowledge on usability problems only available when product is already on the market. E: Being able to make changes to a product before launch. B: Not being able to make changes to the product before launch. E: Transferring knowledge on usability issues to a follow-up project.	E: Being able to make changes to a product before launch. B: Not being able to make changes to the product before launch. E: Transferring knowledge on usability issues to a follow-up project.

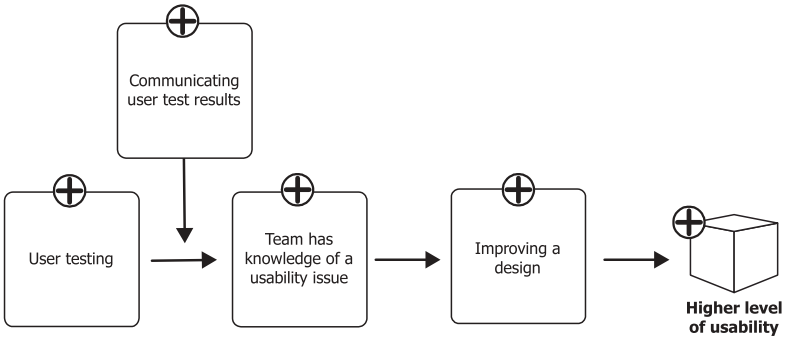
Note. For each interviewee (first column) quotes from the transcript (meaning unit, second column) were accompanied by an interpretation by the researcher (condensed meaning unit, third column), which together form "jointly told tales." Based on these, the barriers and enablers were identified (fourth column). The fifth column shows how barriers/enablers that were mentioned multiple times by a single interviewee, in this case "poor analysis of customer service logs" and "development team not knowing what product aspects customers complain about," were merged and how it was marked that the issue was mentioned two times. In the final step (final column) a listing was made of the barriers and for one case.

FIGURE 9. Example mechanism.



Note. **According to interviewees, adding a lot of functions to a product negatively influences the level of usability of a product.**

FIGURE 10. Example mechanism of enablers that are both needed to exert their influence.



Note. **User testing does not influence the usability of the product if the results are not communicated to the development team and if no action is taken.**

(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 a reinforcing nature. If a barrier is related to an enabler (— → +), this barrier can prevent or negatively influence the occurrence of the enabler. If an enabler influences a barrier (+→ —),something positive has a mitigating or even neutralizing influence on a negative situation or event.

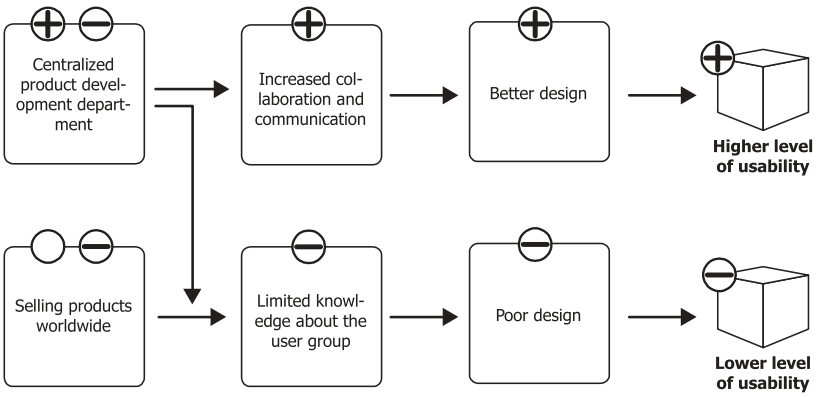
Some barriers or enablers influence usability in a fairly direct way, as in the example mechanism in Figure 9.

However, in quite a number of cases, barriers and enablers exert their influence on the usability of products through a chain and combination of events and circumstances (Figure 10).

Also, combinations of barriers and enablers that individually seem to have no influence can have an effect on usability, as visualized in Figure 11.

It is also possible that one barrier/enabler influences multiple other barriers/enablers. And what is a barrier in one "chain" can turn into an enabler in the next. The barrier "centralized product development department" from the preceding

FIGURE 11. Example mechanism of how a neutral property can be turned into a barrier by a mitigating factor.



Note. **A single central product development location (top left) was mentioned as beneficial for team communication and collaboration, which is considered especially important with an intangible product property such as usability. On the other hand, a central product development location was mentioned as a mitigating barrier. If a company sells its products worldwide (bottom left) this means that the product developers are not in direct contact with users, which limits their knowledge about them.**

example is actually quite beneficial for the communication of usability test results. This means that the barriers and enablers should be regarded in their context.

Eliminating Multiple Instances per Interviewee

To prevent there being multiple instances of an identical barrier or enabler in the database, due to it being mentioned several times by an interviewee, we grouped identical barriers and enablers. Barriers and enablers were considered identical 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 more than once, we indicated the number of mentions in brackets behind the title of the barrier/enabler. Mentions of a barrier or enabler by different interviewees from one development group were not merged into one mention, as this would eliminate the possibility to analyze the differences and similarities in barriers and enablers mentioned by different roles.

Verification

During data analysis of the first two development groups, a 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 two researchers discussed only jointly told tales that the first researcher thought

might contain problematic interpretations. The first researcher studied the last two cases independently.

6.5. Categorizing and Visualizing Barriers and Enablers

The previously described steps resulted in the identification of just over 1,500 barriers and enablers. The 1,500 barriers and enablers include similar barriers and enablers that were mentioned by different interviewees, so they do not describe 1,500 *different* ways in which usability can be influenced. Because of the sheer amount of data, a digestible overview had to be created. In addition, the interrelated nature of barriers and enablers called for a way to explore the relations between them.

Structuring the Data: Product Development Categorization Scheme

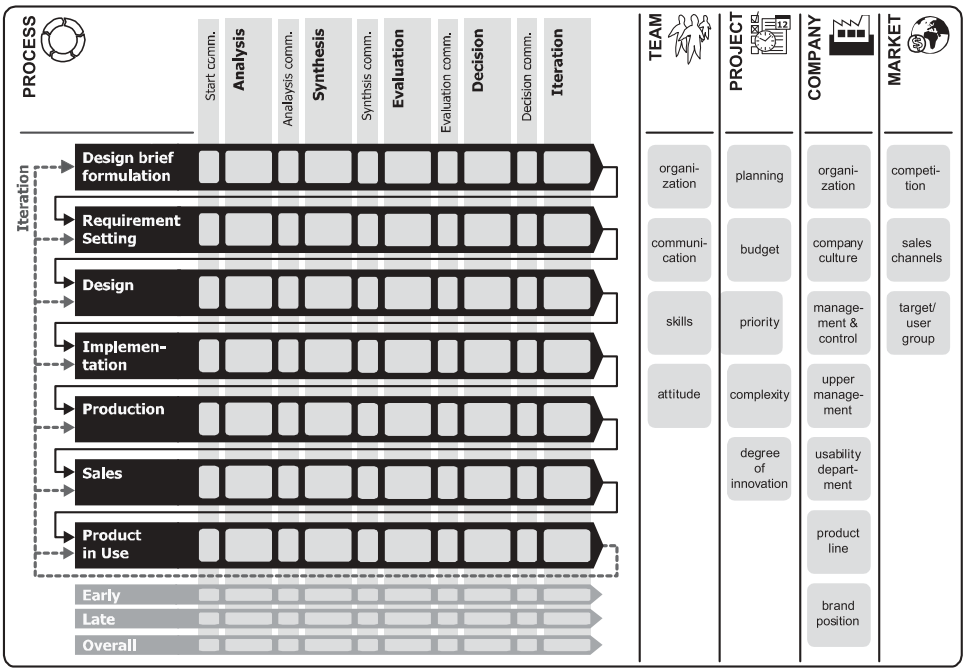
To facilitate further analysis of the large number of barriers and enablers, we wanted to categorize them, as grouping objects with similar patterns and characteristics and subsequently conceptualizing them allows for a better understanding of a phenomenon (Miles & Huberman, 1994, p. 249). Because large amounts of data in a purely textual or tabular form are hard to analyze (Faust, 1982), we developed a categorization scheme, which allows for structuring and data reduction. Miles and Huberman (1994) advocated 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.

Based on the central concepts identified through the literature review and exploratory interviews, an initial coding scheme was created, which we then modified through open coding (Strauss & Corbin, as cited in Malterud, 2001b). This resulted in a detailed coding scheme of about 250 codes that we then categorized and merged into a final categorization scheme (Graneheim & Lundman, 2004) that bears similarity to a conceptually clustered matrix data display (Miles & Huberman, 1994, p. 127). The resulting categorization scheme (Figure 12) consists of five main categories. These are (from left to right) process (matrix in the left square area), team, project, company, and market (area on the right).

The process category matrix consist on the vertical axis of phases of the product development process (adapted from Buijs, 2003), whereas the horizontal axis is based on the activities of the basic design cycle (Roozenburg & Eekels, 1995, p. 88). Between the steps of the basic design cycle, we added a "communication" subcategory (narrow columns, labeled "comm.") to indicate the transfer of information between the activities of the basic design cycle.

The main category "Team" contains barriers and enablers that refer to properties of the people who conduct the activities that form the process. "Project" refers to properties of a product development project, such as planning and budget. The

FIGURE 12. The categorization scheme for clustering the barriers and enablers, containing (from left to right) the main categories: process, team, project, company, and market.



"Company" category contains barriers and enablers that refer to properties of a product development group or its parent company. "Market" contains references to the area, country, or section of the population that the development group is targeting.

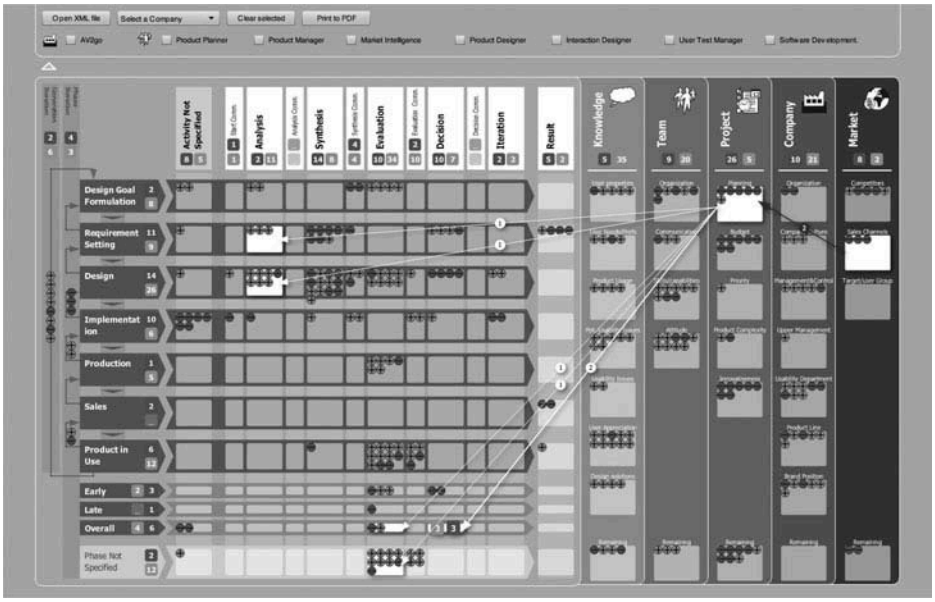
Analysis of Barriers and Enablers per Company

The database of categorized barriers and enablers was analyzed using a custom-built interactive data visualization tool called Trace (Figure 13). This allowed us to view the distribution of barriers and enablers across different categories, explore the relations between categories of barriers and enablers, and get an overview of barriers and enablers within a category. It also allowed for the interactive exploration of the relations between categories of barriers and enablers. Using this tool, we analyzed the barriers and enablers and the relations between them for each of the companies. For each case, we identified sets of related barriers and enablers that were mentioned by multiple interviewees—as this indicated agreement—as well as unique barriers and enablers, as we considered these to be possible sources of new insights.

6.6. Generating Case Context Descriptions

For each of the development groups a context description was written to outline how the group was organized, how it conducted product development,

FIGURE 13. The data visualization tool, used to map barriers and enablers on the product development process.



communicated, and so on. The context descriptions were based on the interviews, information from the primary contacts, and on-site observations and informal interviews. Very concise descriptions of the cases are presented in Section 6.2, and a more elaborate, itemized version of the case context descriptions is presented in Appendix A.

6.7. Cross-Case Analysis of Barriers and Enablers

In the cross-case analysis, we compared the sets of related barriers and enablers and context descriptions across development groups. The goal was to see which sets of barriers and enablers occurred in which groups, and possibly find out why. As with the individual analyses of the cases, the goal was to identify both common and unique barriers and enablers. The identified sets of connected barriers and enablers were then captured in a narrative, in which it was indicated in which of the development groups a certain mechanism occurred or did not occur.

6.8. Verification of Results

To verify the sets of connected barriers and enablers (per company as well as cross-case), a feedback workshop was held with the primary contacts of four of the companies. Feedback from the fifth company was obtained through telephone conferences.

In the week leading up to the workshop, the participants could view the barriers and enablers for their company in an online version of the Trace tool. They were given a short explanation of the categorization scheme and directions for use and were encouraged to explore the barriers and enablers identified in their company. The goal of this was to familiarize them with the tool and give them an opportunity to explore the content on their own without being directed by our findings.

In the workshop itself, we gave the participants the narrative of the barriers and enablers in their company, and with that as a reading guide they went through the barriers and enablers in the Trace tool. They subsequently had had an opportunity to explore the analysis and the data, and they provided feedback on whether they considered the analysis to be an accurate description of issues in their company. Finally, we presented the cross-case analysis and offered the participants an opportunity to respond to our conclusions.

Three researchers were present during the workshop: one workshop leader to present the results and moderate the discussion, and two to observe and take notes. The workshop was recorded on video, and relevant parts were transcribed.

After the workshop, each participant was sent the case context description of their development group and was asked to indicate whether the description was accurate, whether important issues had been overlooked, and whether parts of the description should be changed or removed for reasons of confidentiality. Based on the participants' input, the overview of barriers and enablers per company and the context descriptions were changed and extended, and a summary was written of their reactions.

7. RESULTS: BARRIERS AND ENABLERS

This section provides a cross-case analysis of the sets of connected barriers and enablers that were identified per main category and an indication of the relations between the main categories of barriers and enablers.

The sets of barriers and enablers discussed next are those that surfaced in a multiple cases, those that seemed typical of the sector, and those that were atypical or counterintuitive, because these could be starting points for new ways of working or further research.

The description is structured according to the five main categories of the product development categorization scheme (Figure 12), namely, Process (subdivided into Creating and User involvement), Team, Project, Company, and Market. Bracketed numbers in the narrative indicate in which of the product development groups the mechanism was found (e.g., [1] = AV2go, [2] = EnRoute). Provided at the bottom of each page is a legend, linking the numbers to the cases. In addition, the narratives are illustrated with quotations from the informants.

7.1. Process/Creating

Identifying the Right Functionality

Creating products with too much and not the right functionality was one of most frequently mentioned barriers and was reported as being one of the most harmful barriers to creating usable products [1,2,3,4,5].

> Products that are very simple to use, even though they may be lacking features generally do better than products really trying to shut everything in, because they can be quite complex for the consumers.
>
> Market intelligence manager (AV2go)

Too much non-user-centered functionality was considered to be influenced by a desire to keep up with the functionality in competitor products [1,2,4], and by retail channels and sales departments that demand non-user-centered requirements [4].

> We don't implement all features that others have, but we do pick those of which we think: "Hey, that looks good, that should be in." Yes, that's partly the reasoning.
>
> Software test manager (EnRoute)

Although it was widely believed that going for more elaborate functionality is likely to lead to less usable products (assuming the development effort stays the same), it was also believed that products with limited functionality are harder to sell [2,3,4,5].

> Marketing always wants to see a lot of washing programs, because the machine may be on display in <big consumer electronics outlets> and there will be nobody there to describe how to operate the washing machine. And then consumers say: "Oh look, this one has only six programs, and this <brand> has 12 programs and it is cheaper than the one from WashCare. That's a better choice." That is our problem a little bit.
>
> Industrial designer (WashCare)

> But it's also commercial. It depends a bit on what business you are in, but we have to come out every year or every half year with something new—and it has to be new stuff, because otherwise people are very disappointed.
>
> Primary contact (EnRoute)

Informants often pointed out 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 [1,2,3,5].

> I think that we—my colleagues and I—are generally on the technology-side, which holds the danger of wanting to implement all possible options and stuff, which are not interesting at all for the end-user.
>
> Development engineer (HomeControl)

Setting user-centered requirements was considered to be positively influenced by knowledge of and a feel for the user group [1,2,3,4,5], and by knowledge of usability problems [4].

> Then we do The Voice of the Customer, to identify what the user would expect. We translate a lot of what we call "critical-to qualities," which are actually how you translate what users say into technical terms.
>
> Software developer (AV2go)

Methods mentioned for evaluating proposed functionality were user testing of concepts [2,5], conjoint analysis of user requirements [5], and expert reviews of user requirements [2,4]. If a product development team has access to logs of product use, the team can learn about the most frequently used functions, which helps to select and prioritize functions [2].

> That's something we can measure on the server. Where we can see how many people subscribe for a service out of all devices we sell, and then what percentage of people actually use it or not. And how, a little.
>
> Software development engineer (EnRoute)

Styling versus Usability

In most cases, instances were mentioned of styling being prioritized over usability, which would negatively influence usability [1,2,3,4]. As a reason for prioritizing styling over usability, it was mentioned that styling was considered to increase buyer appeal [3]. In the majority of the cases, the physical user interface (buttons, knobs, etc.) was created not by interaction designers but by product designers [1,2,3,4], who were considered less inclined to prioritize usability.

> There are sometimes conflicts that the industrial designer wants to make a more clean and reduced look and feel, and doesn't want any knobs and keys at all. And for me, as an interface designer, it is very critical to make it easy to use for a large range of people.
>
> Interaction designer (WashCare)

> Sometimes what you see is this for example: we cannot put too many buttons on it, so we need to make it very clean in terms of the look. But at the same time, because we don't have many buttons, if we want to do different things like—we

> have music playback, radio, recordings, different functions—and we need to. . . . I need to think about how can I match those buttons with those functions.
>
> UI designer (AV2go)

Creating a Usable Design: Everything but Design

When discussing what design strategies were employed to make products that are easy to use, most informants referred to things that *facilitated* making a usable design, such as designing from the user perspective [1,2,3], having enough time [1,2,3,4], and evaluating the design [1,2,3,4,5], and hardly referred to techniques or methods that influence the act of designing itself.

> Researcher: "How do you design a product that is easy to use?"
>
> Informant: "I'll do some tests, I'll make a prototype after I have the design concept and I'll try to use it, I'll ask my colleagues to use it . . ."
>
> Interaction designer (AV2go)

Iterations

Early usability evaluation of designs was considered important, because in the later stages of product development there is very limited possibility to implement the results of usability evaluations [1,2,4].

> Sometimes the usability test has been done very late in the process. Even when we have the new UI running in the handsets. And we have some time to do minor corrections and stuff like that.
>
> Software engineer (D-Phone)

We identified three ways in which iterations take place in the product development process: activity iterations, phase iterations, and generation iterations.

An activity iteration is an iteration that takes place within one phase of the development process [1,2,3,4,5], for example, when making changes to requirements while in the requirements phase, or improving the design while in the design phase. We label this an "activity iteration" because these iterations refer to switching between the types of activities of the basic design cycle (see p. 30).

> The original concept [which was changed, ed.] was to have buttons on both sides. We brought in UI specialists and we asked them: "Are these the locations to have them in"? And their finding was: "If you position them symmetrically, on the top and bottom of the device, same keys on opposite sides, then we might run into the problem that when users try to push one button they might push both.
>
> Product designer (AV2go)

A phase iteration is an iteration that jumps from the current product development phase to a previous one [1,2,3,4,5]. For example, problems during implementation or production can trigger a phase iteration back to the design phase.

> While coding they always discover problems or issues we haven't thought of, so I always need to update the specification as we go along. . . . So, there is always feedback, which is usually quite intense, when they start coding for real.
>
> UI designer (D-Phone)

A special type of phase iteration are so-called running changes to a current product based on information collected after product launch [2,3]. Whether companies did this was said to depend on how long the product would remain on the market [1,3] and on the company's ability to update the product remotely (i.e., via the Internet) [2].

> We do a customer satisfaction survey after the product has been launched, then we ask the consumers about their experience with the product and we find out what the problems are. And then work, not only kind of for the existing product but also say like, iterations, where you do first versions and second versions.
>
> Market intelligence manager (AV2go)

Generation iterations—using the knowledge gained from a product to improve a next generation—were considered an important alternative to running changes [1,2,3,4,5].

> Based upon that feedback, they request that certain things be relooked at by the test team or certain issues are just fixed straight away or in some cases they may be feeding in new feature requests for future revision of the software.
>
> Requirements manager (EnRoute)

> So, maybe it doesn't change the current product, but it should be some kind of input to future products.
>
> Marketing manager (D-phone)

Design Freedom

The design of a usable UI was considered to be hindered if designers are confronted with limited design freedom [1,2,3,4]. Suggested causes were interaction designers who may only design the on-screen UI and not the physical controls [1,2,4], as well as limitations of the technological platform [1,2,3,4].

> Sometimes we do have technical limitations, so not 100% of my concept can be implemented. But sometimes I also work closer to the software engineer and I will tell them my concept and we develop the concept together. Because they know

> very much of what the limitations are, but sometimes I do not, so I need to tell them and they will tell me what can be done, what cannot.
>
> Interaction designer (AV2go)

Limitations of the technological platform were reported to be due to the use of third-party platforms [1] or components [2] and too early and isolated design (from people with UCD knowledge) of the technological platform [1,3,4].

> When we purchase a product from a supplier, because the UI is already built in, we are not able to have the same standards in terms of the buttons we would use, and layout or battery life.
>
> Market intelligence manager (AV2go)

> When we built the platform, we didn't really thought [*sic*] this through what exactly the consumer really needs. And so, whenever there was some new thing that we wanted to add in, then we had to change the whole thing, and that would end up causing more side issues.
>
> User test manager (AV2go)

7.2. Process/User Involvement

Early Usability Evaluation

Early usability evaluation was regarded as being very important [1,2,4], because in the early phases of the product development process it was considered still possible to improve the design [1], whereas when testing is conducted late [1,2,4] the implementation of changes is less likely [1,2,4], as late iteration requires a lot of time and effort.

> The challenge is whether or not we do that testing early enough, to be able to really make a change as a result of what we hear.
>
> Marketing manager (D-Phone)

> Often it's also done too late and then you don't have any time left to adjust things.
>
> Software tester (EnRoute)

However, informants did point out that evaluating a design—especially through user testing—requires stimulus material [1,2,4], for example, mock-ups, simulations, prototypes, or samples, which are often not available in the early stages of development [1,2,3,4].

> We won't have a prototype at the time we have the ideas, so you can't say it's good or its bad. That's a problem.
>
> Project manager (WashCare)

> Sometimes you will just have the possibility to test something, to do usability research by the time you've already made something. And only then will you see whether something is good enough, yes or no.
>
> Software tester (EnRoute)

Selecting User-Centered Evaluation Methods

The methods said to be used most 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].

> And then, maybe the ergonomic tests, I ask the smallest man I know in the . . . first in the design department or if he is not small enough, I ask for the engineers, just use the new product. Then I ask a big man or a big woman whether they can operate it and I ask them what they think of it.
>
> Industrial designer (WashCare)

Only in a single case was the use of usability inspection methods reported [4]. This was also the case with early user testing of UIs with, for example, paper prototypes [3].

Whether and how user testing is conducted was reported to depend on the available time [1,2,3,4,5], budget [1,3,4,5] and staff [1,2,3,5].

> Yeah, it could be difficult. Sometimes we introduce new functions, that, we, er, we don't have time to do usability tests.
>
> Software developer (D-phone)

> In general you only have limited resources to conduct these studies and they cost a lot of time, a lot of resources.
>
> Software tester (EnRoute)

Often-mentioned concerns with regard to the setup of user testing were the representativeness of test participants for the projected user group [1,3,4,5] and of the stimulus material [1,3,4].

> Sometimes just really small scale, by recruiting people within the company, or family or friends of colleagues. If I really want to do it solidly we design a test and call a recruitment agency and they provide the participants.
>
> UX manager (EnRoute)

> In the last stage we have the real interactions on a prototype that really looks like the later machine. It is much more comfortable if they have a real machine and it

> is not such an abstract view on the interface as if you had only a touch screen for example where we have a simulation of the interface.
>
> Interaction designer (WashCare)

Communicating User Involvement

When communicating user test results, it was considered important that the development team members are exposed to rich information [1,3,4,5] of "real" people [5] using the design. Informants said they achieved this by showing team members video clips of user tests [1,3,4,5], or by having the product development team visit user tests [1,3,4,5] or by team members conducting user tests themselves [3].

> By having them watch the user test and see what happens—which is also what you do by showing videos—you can create an incredible empathy with the end-user, which can also be a different kind of user than they imagined.
>
> Usability consultant (HomeControl)

> Researcher: "Why do you go to the test?"
>
> Informant: "Because, you cannot . . . sometimes the reported information is not as good as the observed information."
>
> Product designer (D-Phone)

After-Sales Feedback: Useful, but Underused

Informants reported a great variety of possible sources of information on the performance and reception of a product on the market. It was reported to be possible to collect information about usability problems, product usage, and user appreciation [1,2,3,4,5] from customer service [1,2,3,4,5], customer satisfaction questionnaires [1,2,4], forums and consumer review websites [2], reviews in the press [1,2,4], monitoring service and product use [2], feedback from marketing and sales [3,5], and longitudinal field testing [4].

> The reason we looked at this [started dealing with the issue, ed.] was the dramatically poor uptake of the traffic information service—so people apparently were not subscribing to it—and a lot of reports at Customer Support of people who could not set up the required data connection or whatever. Lots and lots of questions."
>
> Manager UX Group (EnRoute)

> We have a Customer Service Centre here, that people can call with questions and remarks about thermostats or our other products. And we register the complaints

> and deal with them. And if something got out of hand, they come to [colleague] or me.
>
> Product manager (HomeControl)

A reason that after-sales feedback was considered valuable was that it originates from real-world users [1,4].

> We send out a questionnaire to customers who registered online. We ask them what they think about the product now they have used it. That helps us to understand the real actual experience of customers after they bought the product.
>
> User test manager (AV2go)

However, the "resolution" or richness of the information was said to be quite low, which can make it hard to draw conclusions about the cause of an issue [1].

> All the data gets lumped into one category. Or people provide no reason; they just don't like it. And how to analyze the data, there's basically no way to do that. Which makes it very hard for us to deal with that.
>
> Software developer (AV2go)

After-sales feedback was reported to be mostly communicated to project or product managers [2,3,4], and not to the rest of the development team (so including designers, usability specialists, and engineers).

> Customer support sends its feedback directly to product management and we are . . . we were not at the time in the loop, so for me it was: "I have no idea."
>
> User experience manager (EnRoute)

> Researcher: "What information do you get, once the products are on the market?"
>
> Informant: "Nothing."
>
> Researcher: "Nothing?"
>
> Informant: "I have no contact with the market. It's up to me to go out there and find out what people think, customers and dealers. But it was my own idea to do that."
>
> User test manager (WashCare)

7.3. Team

UCD Specialists on Team

Whether a team has a user-centered attitude and the skill to see the user perspective was reported to be influenced by the presence of usability and interaction design specialists on the team [2,3,4,5]. However, it was often said that these disciplines only join the team in later stages and/or for a limited time [1,2,3,4,5].

> Researcher: "And what should I not do if I want to make usable products?"
>
> Interviewee: "You should not get one usability specialist to look things over before you release it at the end. Usability can't be just fixing stuff at the end."
>
> Usability specialist (D-phone)

> I really prefer to be involved as soon as possible. When there is really not even a concept yet, but some inkling of "we're going to make this for those people." We should be involved at that stage already to collect our own information, and that should continue till the end, when it's been launched and we collect information about how the device was received in the market. That's the ideal process.
>
> Manager UX Group (EnRoute)

In none of the companies were the usability specialists an integral part of the product development team, though in one case [2] the user experience department used the interaction designer as their "liaison" on the team.

> People don't have to ask us on board; we invite ourselves. Normally, what you have is a designer who is a part of the project team, and all the other people from user experience are sort of satellites around the designer. They help out when it's needed. . . . Testing is often requested by the designer. Or organized.
>
> Manager UX Group (EnRoute)

Seeing the User Perspective

The most important skill that a team needs to create usable products, according to the informants, is "seeing the user perspective:" The ability to understand what is important to users and anticipate how they would use the product [1,2,3].

> You need to look at each feature from a customer perspective. If I were using this product, how would I expect to create a plan or a route? And how would I expect to start browsing the map? And how would I expect to download traffic?
>
> Requirements manager (EnRoute)

However, a certain degree of "home blindness" (not seeing the particularities of a design because one is so familiar with it) [2,3,4] was mentioned to occur, because team members have too much knowledge of their product [2,4].

> Often you get, er, "home-blind"; you don't see the same problems that normal users see. Developers see different problems, because we are using the phone differently.
>
> Software developer (D-phone)

Team members are often more advanced users than average [3,4], possibly due to their technological background [2,3] and team members "fall in love with their design" [1,2,3], both of which were reported to limit the ability to see the user perspective.

> From that technical thinking, that was how this was built. It was not created from the user perspective.
>
> Software tester (EnRoute)

> Researcher: "What made it so hard to convince them?"
>
> Interviewee: "Well, it sounds like a really elegant idea, very natural almost. But they, er, they had just fallen in love with the idea. That was it, really. And I was the spoilsport who came to shoot the idea down."
>
> User experience manager (EnRoute)

Team Member Experience

More experienced team members were reported to develop what was described as a "feel" for the user and for what is good in terms of usability [1,2,3].

> It takes a long time, though, to really have an image of "OK, who are the users and how are they using it."
>
> Primary contact (AV2go)

Having experienced team members was considered to make it easier to create usable products [1,2,3,5], as experienced people have a lot of domain knowledge and carry with them knowledge from previous projects.

> I think the experience is important. Often new colleagues could maybe sometimes try to rush into things and do changes that seem very small, but could have very large consequences. Due to historical reasons they don't know.
>
> Software engineer (D-phone)

Attitude Toward Usability

The attitude toward and prioritization of usability by team members was reported to have an effect throughout the product development process, 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] and design [1,2,4,5] phases (see Figure 12).

> . . . product planners who are really interested in usability and listen to data and to good arguments. Or even phone us up and say "Look, you know, I've got this product, I have to remove this button, what shall I do?" So there are individuals for whom it's very important. In which case it's easy to, er, make a change.
>
> Usability specialist (D-phone)

> Personally changing the design, as a designer—I mean being passionate about a certain design—of course I don't like it. But at the end of the day the user has to validate whether it is good design based on the very experience of the product, so no matter how good it might look, if the user experience is poor I don't think that is a successful design."
>
> Product designer (AV2go)

Attitude toward and prioritization of usability were reported to depend on the perceived benefits of usability (e.g., 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].

> We're claiming to be the easy smart navigator. So we have to be usable.
>
> Market intelligence manager (EnRoute)

> And this company still has certain roots that make it quite technology-driven. It's still differentiating one product from the next generation by adding functionality. And it means our products ARE overly complex.
>
> Usability specialist (D-phone)

Usability was reported to be 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 the brand position includes usability-related claims [1,2].

> Easy to use. That is something that should be the basis of what we do. If, so to say, my parents would not be able to use it. . . . There's a board member that always says: "If my wife can't use it, it's not good enough."
>
> Product manager (EnRoute)

> For a company to produce products that are easy to use it has to have usability, for the end-user, as the absolute top priority for its products, which requires an organization that is absolutely passionate about usability. This might be achieved by

> having very passionate people responsible for usability, that can instill this passion onto [*sic*] the organization.
>
> Marketing manager (D-phone)

The degree to which team members are in direct contact with users or participants (i.e., through field studies or user testing) was also seen as a contributor to a more user-centered attitude [2,3,4,5].

> . . . but for developers to actually have an interface to people that use their products. . . . I think it gives them some inspiration rather than . . . they don't get concrete ideas from it, but it gives you such a more tangible way of identifying with the people you're making this product for.
>
> Requirements manager (EnRoute)

> They were surprised about the test results. But also positively. They understood that it is good to discuss with customers, with end-users whether this was the right way to do it. And they were satisfied about the possibility to have this conversation.
>
> User testing specialist (WashCare)

7.4. Project

Planning and Budget Dominant Considerations

Time pressure on a project was described as having a large impact throughout the product development process [4,5]. It influences whether—and, if so, how—teams conduct user research [1,2] and user testing [1,2,3,4,5], the creation of designs [1,2,3,4], designs being compromised or not [1,3,4], and whether a design and changes that improve usability are implemented [1,2,3,4].

> Well, we try to regularly run user tests, but they're quite demanding in terms of man hours. It can easily take two weeks to prepare and run a test and we just don't have that time right now.
>
> UX manager (EnRoute)

> And implementing solutions just takes a lot, a lot of time. We gave the first signals about a year and a half ago, when we tested it the first time. Well, didn't get through because of time pressure, and now it's still not fixed!
>
> Software tester (EnRoute)

Informants in companies that had short product development cycles [1,2] and very distinct seasonal sales peaks [1,2], such as the Christmas and summer holidays, reported that they suffered from higher time pressure than informants in companies with longer cycles [3,5] and less strict sales deadlines [5].

> AV2go sells a lot during Christmas—this goes for the whole industry. You need to sell then, because it is up to 40 or 50 percent of your sales volume. In essence, you're always under time pressure and do things, launch products, that if you really would have wanted to do it right, should have been launched the year after.
>
> Product planner (AV2go)

Similar to planning, budgetary concerns are reported to 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 design of the UI, product and platform [1,3], whether the design can be implemented as intended [1], what kind of simulations (to apply in user tests) can be made [1,3,4,5], and on how concept and design evaluations are conducted [1,3,4,5].

The available budget seems to be influenced by how important a project is to the development group [4], and by the product positioning [1,3]; companies with high-end products seem likely to have a higher budget.

> Sometimes it is business-driven. Then they say: "We need to sell a very low-cost product, we know the volume is high." And then cost becomes more dominant. If it is a new concept product with maybe some fancy features that you want to bring out, then the product manager may have more say.
>
> Software developer (AV2go)

Formalizing User Involvement

Formally including UCD activities (e.g., user research, interaction design, user testing) in the product development process was mentioned as an enabler of planning and executing user involvement in development projects [3,4,5].

> The interface design step should be integrated, should have a defined place in the development process of your products.
>
> Interaction designer (WashCare)

> Our organization works according to a system in which the voice of the customer is really important. It's a way of quality control, to continuously keep an eye out.
>
> Usability consultant (HomeControl)

However, it was also mentioned that formalizing user involvement might backfire: Teams may start exhibiting a "checklist mentality"—performing the required steps, but not thoroughly or not acting upon the outcomes [1,2].

> The risk of really formally including usability into your process and describe it as: "Milestone X: You have to do activities A, B, C, D," is the fact that people will

> just look at the checklist, focus, and go: "Tick, tick, tick. We're done." It's almost backfiring.
>
> Primary contact (AV2go)

Degree of Innovation

It was mentioned that introducing a new product, platform, UI, or content increases the risk of usability problems [1,2,4,5], because it decreases the knowledge of design solutions [1,2] and of potential usability problems [1,4].

> When I want to introduce a totally new behavior or functionality in the camera and I am not sure how people would respond to this.
>
> UI designer (D-phone)

> If you do something new every year, you run into new problems every year, and I don't think you can make good products that way. A revolutionary change every time is too risky and makes you forget or not properly do stuff.
>
> Product planner (AV2go)

Informants in most cases reported that developing a product over generations [2,3,4,5] and/or having a UI paradigm [2,3,4] are ways to prevent having to create a (UI) design from scratch for each product [2,4]. In addition a UI paradigm increases usability because users are familiar with the UI from other or predecessor products [3].

> Building up a new UI for each phone is way too much work. We actually have a couple of different UI platforms. It takes time to carefully develop a new UI.
>
> Product planner (D-phone)

Being able to effectively apply a UI paradigm throughout a product line was reported to require both within-generation consistency (products within a generation are similar enough to share a UI concept) [3,4] and between-generation consistency (similarity between the different generations of a product) [4,5].

Control Over the Ecosystem

Having control over the ecosystem (the network of products and services that enable a product to function) was considered beneficial in a number of development groups [1,2,4], because this enables a company to design for the whole usage cycle [1,2,4].

> We have control over some parts, our own hardware, etc. But Windows Media Player, that comes from Microsoft. Accessories might be ours, might not be. And

> that's where the room for improvement is, that we don't have control over all elements. I am convinced that our hardware is good, but the link to the software is . . . can be painful, because we don't control that. The same goes for content.
>
> Product planner (AV2go)

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.

7.5. Company

Disconnect Between Hardware/Software and Design/Development

The hardware and software development processes were often reported as being quite separated [2,3,4,5], even to the point where the software and hardware department were located in different countries [2]. This separation was suggested to negatively influence communication about the limitations of the technological platform [1], and whether—and, if so, to what extent—the usability department could provide feedback on the usability of, for example, the physical controls of the product [2,4].

> Because Hardware Development [which includes the embodiment, ed.] is in the UK, you can't just walk upstairs and say: "Hey, well, this is really not a good solution" and of course they are contesting our knowledge of hardware.
>
> Manager UX group (EnRoute)

In all of the companies, the design department was a separate organizational unit from the rest of the product development organization, which was reported to negatively influence communication and cooperation between the designers and the rest of the product development team [1,2,3,4,5].

> The physical part of the UI, like the buttons you have on them, sliders, etc., er, well, we of course have preferences on them. And well, it is not really our responsibility. We can have, er, wishes, erm . . . There are real requirements, basically, and when we [UI department, ed.] come into the process, these requirements are always set, I mean for the hardware. Erm, on that particular issue, we are trying to improve, so we will get into the process earlier, so we still have a chance at perfecting, for example, keys or slider or the industrial design.
>
> UI designer (D-phone)

In a number of cases, product designers and interaction designers were reported to cooperate only to a limited or very limited extent [2,3,4].

> We have people doing industrial design and they're very competent and they know a lot about usability, but at the same time, when we get their products in our hands, we can say "Damn, you know, if someone just talked to us for five minutes . . . so I'd seen this sketch earlier I wouldn't have been able to say: 'Look, people will press this accidently.' Maybe we could have explored it some other way."
>
> Usability specialist (D-phone)

Organizational Complexity

In one case, a large and complex development organization [1] was mentioned to be more likely to have more steps and stakeholders in the product development process, which in turn may lead to product concepts being compromised [1], whereas in smaller, less complex organizations [2] fewer people are involved.

> We are extremely user-focused, but between getting the message from the user and translating that into something that the user can use, there are so many people and so many steps in between—because AV2go is such a big company—so things change by the time it reaches the end.
>
> Product manager (AV2go)

Usability Department

In several development groups, the usability department was reported to be understaffed [1,2,3] or not present [5], even though usability was said to be considered important within the company [1,2,5] and was a part of the brand proposition [1,2] or a unique selling point [5]. This lack of staff was reported as a barrier to the involvement of usability specialists in projects [2], the ability of the usability specialists to learn about and explore new methods [1], and the time it took the usability department to provide development teams with feedback about their products [3].

> I need to take the time for setting up a proper test, and because I work alone and have no colleagues, I don't have that time. I have quite a lot on my desk, and I simply have to do it all in sequential order, so I would prefer if someone would assist me, so we could run the tests faster.
>
> User testing specialist (WashCare)

Management and Control

In one case, it was suggested that usability should be a part of the staff's key performance indicators [1].

> Researcher: "If I am a company making consumer electronics, and I want to make them as usable as possible, what do I do?"

Interviewee: "First of all you put usability in everybody's bonus sheet. If you want to know what people do, look at what's on their bonus sheet, because that's how they'll behave."

Product planner (AV2go)

That company also wanted to measure or quantify the usability of a product [1], which seemed to be influenced by usability being a part of the brand proposition [1].

Especially because the whole <slogan> brand campaign we have defined things to be more measureable. And we measure usability with measureable parameters.

Product planner (AV2go)

Upper Management

Informants said that if upper management is actively involved in decision making for product development projects, it has the power to stimulate the implementation of a design that improves usability [2,3,4].

Interviewee: "But that was really a tough cookie to get that across this time."
Researcher: "So why did you succeed in the end?"
Interviewee: "Well, probably because we could convince the CTO and CEO that it really was cumbersome to operate."

Manager UX group (EnRoute)

7.6. Market

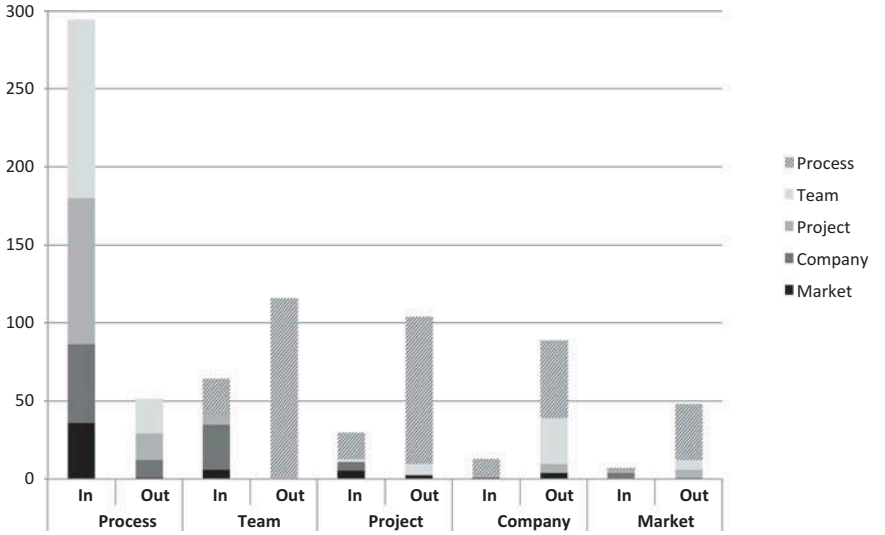
Centralized Product Development for a Global Market

Respondents said that when a company conducts its product development activities at a centralized location but sells its products worldwide [3,4], this leads to team members having less direct contact with the user group (as they do not live among them) [3,4] and makes it harder for team members to observe user tests (if these are conducted in the target market) [3,4] or means that the user tests have to be conducted with unrepresentative participants [3]. This lack of contact with the user group was considered to reduce the knowledge of user group properties [3,4], needs and preferences [3], product usage [4], and usability problems [3].

At the moment we don't do user testing or focus groups on an international basis. We are just working with people here in <countryA> and if we want to gain real knowledge about end-user needs, we would have to do it internationally, because at the moment I think about 70% of our market is not in <countryA>.

Interaction designer (WashCare)

FIGURE 14. The incoming and outgoing relations for five main categories of barriers and enablers (from top to bottom: process, team, project, company, market).



7.7. Relations Between Main Categories

As pointed out in Section 6.4, the identified barriers and enablers were often interrelated. We analyzed the relations between five of the main categories of barriers and enablers, namely, process, team, project, company, and market (see the categorization scheme in Figure 12). In Figure 14 the incoming and outgoing relations between each of these main categories are aggregated and visualized, which gives an indication of the direction of influence between the categories of barriers and enablers, that is, whether, for example, barriers and enablers in the process category were more influenced *by* barriers and enablers from the team category, or whether barriers and enablers in the process category were more often found to have an influence *on* those in the team category.

Figure 14 shows that the process category is mainly influenced *by* barriers and enablers in other categories (almost 300 incoming vs. 50 outgoing relations). This suggests that how a product development process is executed is influenced to a large degree by the context in which it is executed: by the team that executes it, how the development project is set up, the company it is executed by, and the market the company operates in. An example of such a mechanism is the following: A sector has distinct seasonal sales peaks (market) and thus rapid development cycles (company), which results in high time pressure on development projects (project), which results in user tests not being conducted (process) or the results of user tests not being dealt with (process).

In general there seems to be an "outside–in" pattern of relations between barriers and enablers: There are more relations from market to company (outside–in) than from company to market (inside–out), more from company to project (outside–in)

than from project to company (inside–out), and more from team to process (outside–in) than from process to team (inside–out). This seems to indicate that if the goal is to make usable products, one cannot just focus on the right process: By whom and the context in which that process is executed needs to be taken into account.

7.8. Verification: Practitioner Responses to the Barriers and Enablers

Overall, from the feedback from informants collected for verification of the results (see Section 6.8 for the verification method), it can be concluded that most barriers and enablers accurately reflect the situation of the development groups at the time of research.

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

EnRoute1: "Well, I think it was . . . it is a pretty accurate reflection of how it was at the time. Er, over time things change, fortunately, as well. I think I can agree with most of the observations."

WashCare: "All in all it fits very well, it still does for the large part."

In the HomeControl case, the interviews focused on one particular (rather successful) project, and a very experienced (external) user-involvement consultant was interviewed. This may have skewed the barriers and enablers toward 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 kinds 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) "Hmm, hmm."

8. DISCUSSION

This section relates a number of the results to existing literature and discusses potential implications.

8.1. The Value of User Involvement is in the Follow-Up

We found many instances where barriers were mentioned regarding the follow-up of user involvement. There were many factors that limited the extent to which the design of the product was actually changed—for example, time pressure, budget limitations, or other team members—other than the usability specialist not understanding or not prioritizing an issue.

Integrating insights from user involvement through an iterative approach is considered a principle of UCD (Gould et al., 1991; Gulliksen et al., 2003; ISO, 2010; Nielsen, 1992) and has been reported as an enabler in practice (Bruno & Dick, 2007; Gulliksen et al., 2003). However, not implementing the results of user involvement has also been identified as a barrier in previous studies and is usually attributed to the late availability of the results (Cajander et al., 2008; Gulliksen et al., 2006; Poltrock & Grudin, 1994; Rauch & Wilson, 1995) or problems getting the results across (Chilana et al., 2010). From our study, it can be concluded that design freedom is an important underlying factor that determines whether user involvement can be followed up on: Can changes be implemented? Is there enough time and budget, does the team have the necessary skills, and is the team allowed to make changes to the whole product? In consumer electronics, design freedom can be severely limited due to role restrictions (interaction designers only do "on-screen"), limitations of a frozen or third-party technological platform, and the passing of certain process "gates" after which production investments have been made or parts have been ordered. A positive effect that we observed is that due to the cyclic nature of the development of electronic consumer products, in which a new product has to be released every 6 or 12 months, if design freedom is too limited in one project, there is a chance to include these improvements in the next generation.

Thus, late user-centered evaluations are not barriers in themselves: They are barriers because it is too late to implement the results, because in a late stage of product development design freedom becomes limited, due to a lack of resources. There might be design and development strategies that can help keep design freedom at a higher level in the later phases.

A second issue that seems to have considerable impact on whether the results of user involvement are implemented, is the attitude of team members or the team as a whole toward usability, and whether they prioritize usability in decision making, an issue that was also identified in previous studies (Boivie et al., 2006; Cajander et al., 2008; Gulliksen et al., 2006; Gulliksen et al., 2003; Høegh, 2008). Changing the priorities that team members set is influenced by many factors, many of which are beyond the realm of influence of the product development process or of UCD practitioners.

8.2. The Holistic, Integrated Approach: Not There Yet

A coordinated design of the overall product is mentioned by all authors of UCD principles as having a positive effect on usability (Gould et al., 1991; ISO, 2010; Nielsen, 1992). So is having multidisciplinary teams (ISO, 2010). However, in

the product development groups we investigated, the usability specialist was hardly ever a full-time member of a development team, nor were the product designer and interaction designer. Furthermore, there was often a separation between software and hardware development, and between interaction and product design. Second, control over the ecosystem—and thus over the whole user experience—was often lacking. It seems that in electronic consumer products, a holistic, integrated approach is not yet the norm.

8.3. Usability: A Fuzzy, Ungraspable Construct

Informants pointed out that within their organizations there was usually not an explicit, shared definition of usability, but they did consider a shared definition or understanding of usability an enabler. Previous studies indicated product development practitioners often consider usability an ungraspable, fuzzy concept (Cajander et al., 2008; Clegg et al., 1997; Gulliksen et al., 2006).

Interaction is something that comes into existence only as people start using products and services. Although interaction is observable as it happens, the user experience takes place inside someone's head, with some expressions finding their way to bodily posture and facial expression. Usability, which has both user performance (interaction) and user experience dimensions, is also invisible. In addition, is it also a nonquantifiable product quality (Guldbrandsen, 2006): It is something that is quite difficult to put a number on, in contrast to quantifiable product qualities such as the number of pixels on a screen, bandwidth, or rotations per minute of an engine.

The ungraspable nature of usability seems to be a reason why communicating the results of user involvement is reported to be a challenge by our informants as well as in literature (Chilana et al., 2010; Høegh, 2008; Venturi & Troost, 2004).

8.4. Being User-Centered: Beyond the Process Description

In literature, formally including user-centered activities in the product development process is mentioned as one of the primary safeguards for usability (Boivie et al., 2006; Cajander et al., 2008; Clegg et al., 1997; Høegh, 2008), and in this study many interviewees said that they believe that a company's "official" development process should facilitate or even prescribe the application of UCD methods. However, in literature (Boivie et al., 2006; Clegg et al., 1997), as well as among our informants, we encountered concerns about mandatory user involvement. Bødker et al. (1998, p. 109) suggested that a way of working should not be cast in stone, as methods are made by working in specific contexts and designers use their experience to adapt rules, procedures, and methods to actual situations. Some interviewees argued that a company culture could provide a "pull" for user involvement: Product development teams should *want* to apply UCD methods because they see the value of it. These interviewees argued that being user-centered also refers to the people who execute the process, not just to the process itself. In support of this notion, Löwgren and Stolterman (1999) argued that 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." Gulliksen et al. (2006) argued that focusing solely on process is undesirable; these authors consider qualifications and skills, as well as knowledge and experience, inseparable from the individual.

8.5. Electronic Consumer Products Have a Double Development Cycle

In most of the companies we investigated, the development process of electronic consumer products actually consists of two separate development cycles: The development of the technological platform (hardware, firmware, mechanical), followed by the development of specific products based on that platform. For ICT and the web, the platform is usually a given or at least standardized. The varying nature of the technological platform of electronic consumer products seems to lead to a desire among UCD professionals to know more about the possibilities and limitations of the platform, as well as to a desire to influence decisions being made about it in an early stage (when they were usually not involved).

8.6. Time Pressure Related to Strict Retail Deadlines

Many studies of usability in practice indicate that a pragmatic consideration as time is dominant, because time pressure in projects is often high (Bekker, 1995; Boivie et al., 2003; Boivie et al., 2006; Bruno & Dick, 2007; Chilana et al., 2011; Clegg et al., 1997; Gould & Lewis, 1985; Gulliksen et al., 2006; Høegh, 2008; Ji & Yun, 2006; Rosenbaum et al., 2000; Vredenburg et al., 2002b). Time pressure also played a dominant role in this study of the electronic consumer products market. It was attributed to very strict launch deadlines. Electronic consumer products are announced in advanced and promised to retailers. For some product categories, the "must launch" moments are Christmas and the summer holidays. If product development companies fail to meet launch deadlines, there is a fair chance they will not be included in the following year's "shelf plan."

8.7. "It Depends": Effect of Functionality, Networked Products, and Innovation

In this study, three issues surfaced that were mostly considered to be barriers by the informants but that also have the potential to improve usability.

First, putting too many functions in a product was often mentioned as a barrier, because it makes it harder for users to find a function, makes it harder to design a usable interface, and on the whole makes the product development process more complex. However, it can also be argued that to achieve the goal of carrying around as few products as needed, it is preferable to have one single product with a lot of functions (that you would actually use) than to have multiple products. It seems that the interviewees were referring to an "all things being equal" situation: All things being

equal, it is harder to make a usable product if it has more functions. However, if it is possible to manage the development process properly and come up with the right interface, a product with more functions can be more usable than one with fewer.

"We don't have control over the ecosystem" was mentioned as a barrier. Electronic consumer products, and particularly home audio and video, are increasingly connected to networks. In theory, this can greatly enhance usability, as for example, this allows a person to use only one remote instead of four to operate the TV, home cinema, set-top box, and hard-disk recorder. In practice, however, development groups often do not have control over the whole ecosystem, but have to deal with crucial elements of the ecosystem being developed by other development groups within the same company, or by other companies entirely. In those cases, the increasingly networked nature of electronic consumer products becomes detrimental to usability.

"Innovation is bad for usability," multiple informants said. This is surprising, as we usually see the word innovation in a positive context. However, our informants pointed out that as soon as you start doing something new, you risk ending up at the bottom of the learning curve. Introducing a new product, interface, content, etc., may create new usage issues. In analogy to the innovator's dilemma (Christensen, 1997), though in time innovating the UI or a product may produce a superior user experience, the initial product may not be as usable as its predecessor.

8.8. Limitations of the Study

Interview-Based

As mentioned, we followed Malterud's (2001a) adage that studying the knowledge of experienced practitioners can offer a broader understanding of a phenomenon. To do so in product development practice, we used interviews. By conducting an interview-based case study we were able to cover a lot of ground: We investigated quite a few development groups, and within each group we interviewed people from various disciplines in the limited time that was available (Eisenhardt & Graebner, 2007). Second, interviews have the benefit of being very insightful, as the interviewees provide their perceived causal inferences (Yin, 2009, p. 102). However, apart from the known disadvantages of interviews, such as bias or poor recollection, using interviews as the primary data source may have influenced the results in other ways. We noticed that the interviewees were rarely very critical of themselves. Deliberately or not, they did not often remark that they lacked a certain skill or had executed a project poorly. They more often pointed to external factors that limited or enabled them, which also included other actors. We believe that these effects were at least partly mitigated by interviewing informants with diverse roles in the development team, as this offers multiple perspectives of the same subject and prevents retrospective sense-making of a sensitive issue by a single informant (Eisenhardt & Graebner, 2007).

Scope: Design Brief to Market Introduction

Although this study took the process phases preceding the design brief into account, we paid more attention to how the product was developed than to 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 or not easy to use? Nonetheless, 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 information would have been found had we put more focus on design brief formulation and the preceding phases.

Transferability

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 to the term "external validity" or "generalizability" (Shenton, 2004). We next discuss which issues should be considered when transferring the results of this case study to other contexts.

The results of this study were produced by investigating the product development groups of medium-sized or large corporations, with a stage gate or waterfall product development process, in which there is some to strong separation of disciplines that work on products that have a highly interactive character as well as a physical presence and that are sold to consumers. We think that many of the barriers and enablers can differ when studying companies that outsource design and development (e.g., working with external design and engineering consultants), in a business-to-business sector, and if an Agile development architecture is applied (Highsmith & Cockburn, 2001). A second issue regarding the development process architecture is that the companies we investigated had very distinct and well-established design phases, whereas this is less common in, for example, software development (Buxton, 2007).

To enable practitioners and fellow researchers to consider whether—and, if so, to what extent—the results of this study are applicable to their context, we have provided an itemized case context description in Appendix A.

9. CONCLUSION

We identified many interrelated factors instead of the one, all-influencing variable that determines whether a company can adhere to the principles of UCD. This may be a reason why, even though there is a considerable body of knowledge on UCD, many products with shortcomings in terms of usability enter the market, and there are only a few companies worldwide that are considered truly user-centered.

The results of this study suggest that for a company to be able to conduct user-centered product development of electronic consumer products, an integrated and organizational approach is required. How a development process is executed seems to be influenced to a large extent by the team that executes it, the project setup, how a company is organized, and the market it operates in. This means that only setting up a user-centered product development process is not sufficient, because the existing organization might not be able to support and facilitate it.

This study also showed that if the goal is to create usable products, it is not sufficient to introduce activities that only are typically regarded as "user-centered," such as user research and user testing. It has to be taken into account how these activities are integrated with and supported by the rest of the product development process. For example, the value of a usability evaluation lies not in the evaluation itself or in its outcome but in the follow-up: What a product development team is willing and able to do with the information. User-centered *design* is not enough: It is about user-centered innovation, from the fuzzy front-end through to products being used.

The goal of this study was to identify barriers to and enablers of usability in the development of electronic consumer products and to investigate how they are related. We identified the barriers and enablers in a number of categories that, as previously mentioned, extend beyond the process, namely, the properties of the development process (creating and user involvement), the team, the project setup, the company organization, and the market a company operates in. Figure 15 provides an overview of the primary sets of barriers and enablers we identified. When investigating the relations between the main categories of barriers and enablers, we found a direction that was predominantly outside–in (Figure 14, p. 46), meaning that how the design and development process is executed seems to be influenced considerably by the context in which it is executed (Figure 16).

10. RECOMMENDATIONS

10.1. For Future Research

Practitioners Need Practice-Centered UCD Methods

When developing and testing UC or development methods, design researchers should bear in mind that the 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 many resources to execute. Developers of UCD methods and approaches need to take into account the context in which these will be applied. We learned from this study that if UCD methods are to be used in practice, they should not just be effective at assessing the fit between a design and the context of use but should do so using limited resources, and practitioners should like applying them. In other words: We should assess the usability of UCD methods in practice; we should strive for practice-centered methods. Our findings and literature on UCD practice suggest that due to their efficient setup, approaches like Guerilla HCI (Nielsen, 1994) and Lean UX (Gothelf & Seiden, 2012) can greatly benefit practitioners.

UCD Cycle as the Unit of Analysis

In literature on methods for UCD and human–computer interaction, much emphasis is put on how to evaluate usability and user experience. However, these evaluations are valuable only if they are acted upon, if a product gets improved. And, as

FIGURE 15. Sets of Related Barriers and Enablers Identified in this Case Study, Clustered According to the Main Categories of the Categorization Scheme: Process, Team, Project, Company, Market, with References the Pages of the Results Section in Which This Mechanism Is Discussed.

Mechanism	Explanation	Page
Process: creating		
Identifying the right functionality	Offering the right functionality is a part of usability. Practitioners found it relatively easy to identify new functions, but hard to select the ones that actually are of value to users.	30
Styling versus usability	Practitioners often mentioned a conflict between styling and usability during design. In practice it seems to be considered a trade-off, "or-or."	32
Creating usable designs, everything but design	When asked how they created usable products, few references were made to synthesis activities, compared to what facilitated making a usable design (e.g., attitude, resources, knowledge).	32
Iterations	Whether iterations are performed has a large influence on product usability. We identified three types of iterations: activity iterations (within a phase), phase iterations (across phase), and generation iterations (across product generations).	33
Design freedom	Practitioners pointed out that the biggest barrier was often not a lack of knowledge of usability issues or of a better design, but limitations in the implementing of the improvements. Suggested causes of limited design freedom were limited involvement of UCD specialists in the design of the physical elements of the UI and to limitations of the technological platform.	33
Process: user involvement		
Early user-centered evaluation	Important enabler because as in an early phase, degree of design freedom is still relatively large, yet often not performed, because of the lack of what informants considered an appropriate simulation.	33
Considerations for applying user-centered evaluation methods	User testing was reported as the most applied user-centered evaluation method, whereas usability inspection methods and user testing with low fidelity prototypes were hardly reported. This is remarkable, considering that the most often mentioned concerns for selecting methods were resource related: available time, budget, and staff.	35
Communicating user involvement	In order to communicate the results of user involvement effectively, it was considered important that team members are exposed to rich information about "real people" using the design.	35
After-sales feedback: useful but underused	A large number of possibilities were reported for after-sales feedback as a form of user-centered evaluation. Considered valuable, as this information originates from real-world product use.	35
Team		
UCD specialists on the team	The user-centered attitude and skill of a team was considered to depend to a large extent on the presence of UCD specialists, who often only join the team in a late stage and for a limited time.	37

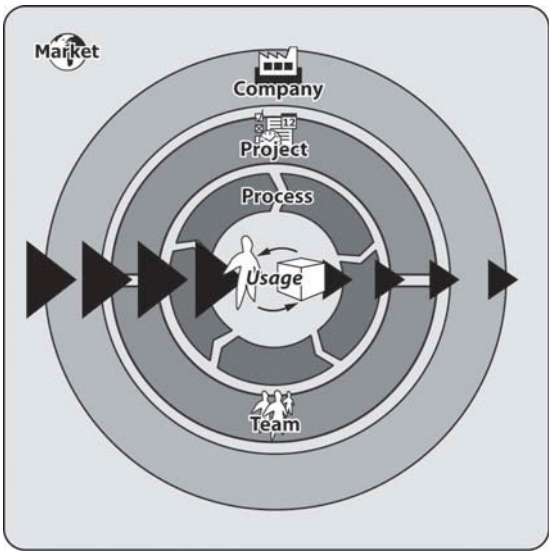
(*Continued*)

FIGURE 14. (Continued).

Mechanism	Explanation	Page
Seeing the user perspective	Informants considered "seeing the user perspective" the most important skill needed to be able to create usable products. Barriers to this skill can be disciplinary background, and having too much knowledge about a product category and about your own design.	37
Team member experience	More experienced team members were said to develop a "feel for the user" and have more domain knowledge, both considered an enabler for designing and developing usable products.	39
Attitude toward usability	Team member attitude toward usability was considered to influence the entire product development process. Attitude was reportedly affected by perceived benefits, brand position, strategy and culture, as well as by team members being exposed to the results of user testing.	39
Project		
Planning & budget dominant considerations	Time and budgetary concerns were reported to be very dominant considerations both for user involvement and for design/development. Companies with short development cycles and distinct seasonal sales peaks seem to suffer more from time pressure in development projects.	40
Formalizing user involvement	Formally including user-centered activities (user involvement, interaction design) in the development process was mentioned as an enabler. However, it was also pointed out that formalization may backfire: Teams may start exhibiting a "checklist mentality."	42
Degree of innovation	Informants mentioned that introducing a new product, technological platform, UI, or content is a barrier to usability because in those cases there is a decrease in the knowledge of appropriate design solutions and of potential usability problems. Developing a product over generations and/or having a UI paradigm was seen as an enabler, because it avoids having to design from scratch and users are familiar with the UI concept.	42
Control over the ecosystem	Having control over the ecosystem of a product was considered beneficial, because it increases design freedom and allows for designing for all stages of product use.	43
Company		
Disconnect between hardware/software and design/development	The development process of the hardware and that of the software were often reported as being quite separated. Secondly, in all cases product design departments were separate organizational units from the product development organization. Both were suggested to be barriers to designing usable products and communicating about the context of use and usability issues.	43
Organizational complexity	One of the cases was very large and complex development organization, which the informants pointed out as a barrier as this leads to more development steps and stakeholders, whereas another organization, which was smaller and much simpler, seemed not to suffer from this issue.	44

Usability department	In several cases, the usability department was reported to be understaffed and unable to perform all the activities required or requested. In these cases, the company valued usability and it was even a part of the brand position or unique selling point.	44
Management and control mechanisms	In one case, it was suggested that usability should be a part of staff's performance indicators, as this might be an incentive for them to prioritize usability during product development.	45
Upper management	It was reported that if upper management is involved in decision making in product development projects, this could be a powerful stimulation for implementing usable solutions.	45
Market		
Centralized product development for a global market	In two cases, it was considered a barrier that product development was performed at one central location, whereas the product was sold worldwide. This limited the knowledge of the development team about users as well as the possibility to perform appropriate user-centered evaluations.	45

FIGURE 16. Visualization of the relations between the main categories of barriers enablers identified through this case study, and how more "outside–in" (larger arrows, left) relations were found between barriers and enablers than "inside–out" (smaller arrows, right). Adapted with permission from van Kuijk (2011).



Legend:

1 = AV2go,

2 = EnRoute,

3 = WashCare,

4 = D-phone,

5 = HomeControl

Wixon (2003) pointed out, in practice the goal is not to detect usability issues but to fix them. This depends not only on the accuracy and reliability of the evaluation method but also on whether the results are actionable, communicated effectively, and incorporated in a redesign. To reflect this, research that is aimed at improving the field of UCD should—in addition to investigating evaluation methods—also study, for example, how the outcomes of user tests and front-end user research influence design, and effective synthesis strategies for creating usable designs. The overarching research question for researchers studying UCD should be "What makes products more usable?" not just "How do we consistently identify the largest possible number of usability issues?"

"Live" Case Study

For future research that aims to identify the causes of usability issues, it seems a worthwhile strategy to investigate a product development project in real time. This would make the researchers less reliant on the recollections and interpretations of interviewees, enable access to project documentation, and provide a more detailed insight. A critical issue would be to choose the appropriate project to study. The results of this research should facilitate the identification of projects in which serious usability problems are likely to occur and which aspects to focus on during a live study. A special topic of interest in such a study could be how development teams deal with usability during the synthesis phase, during the actual creation of designs, as this proved very hard to assess through retrospective interviews.

10.2. For Practitioners

Take Both a Boardroom and a Grassroots Approach

Although it seems there is no silver bullet for UCD and development, a lot of ammunition is available. There are many "entry points" if you want to improve the UCD capability of your organization. One can imagine a top-down, more strategic, and organizational approach, as well as a bottom-up approach, more focused on the development activities. It is, however, of the essence to realize that for a company to become truly user-centered, an organizational, integrated approach is required. There is much more than just process, and without changing organizational aspects and without buy-in from upper management, running a user-centered product development process can be a rather frustrating exercise. However, by making your process and your team more user-centered, you are very likely to improve the usability of the product you are working on, as well as providing the examples and leverage that practitioners need to make the more strategic changes. The same goes for a well-documented usability disaster.

You Are Working on Something Invisible, Intangible, and Long Term

When trying to improve usability, you are aiming for an invisible, nonquantifiable goal the effects of which are long term. That is the kind of product property that easily drops off the radar of a product development team or that is simply ignored. This is why issues concerning usage and usability, be it within a development team or across an organization, may take extra effort to communicate effectively. Use examples, visualizations, bring them to user tests, let people experience the issues at hand.

NOTES

Background. This article is based on one of the studies from the Ph.D. thesis of the first author.

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