Inclusive design of ICT:

The challenge of diversity

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Abstract

Background: Information and communication technologies (ICTs) are currently an integrated part of society. Being able to take part in the information society is a prerequisite for fully being able to take part in society. The goal of "Universal design", "design for all" and similar approaches, collectively referred to as inclusive design approaches (IDAs) in this thesis, is the development of products and services that are accessible and easy to use for as many people as possible, including people with disabilities and the elderly.

Aim: The aim of this work has been to study the challenges related to the inclusive design of ICTs, and in particular, the challenges related to design for diversity. Secondly, it has been to explore two seemingly opposing objectives in inclusive design; namely, the need for flexibility on the one hand, and the need for simplicity on the other hand. A third aim has been to study the practise of inclusive design in light of the knowledge from previous work within user-centred and participatory design.

Method: This work is based upon qualitative research from seven research projects on the universal design of ICT. The methods used in these projects have been focus groups, observation and interviews, personas and technical-accessibility testing. More than 150 participants with a wide range of capabilities have been involved in these research projects.

Contributions: This work has resulted in the following contributions:

1) Based upon examination of the current empirical material and previous and related research, the important elements of inclusive design were identified and discussed.

2) The need for flexibility of inclusively designed ICT solutions is investigated. Several types of flexibility in the empirical research material at hand were examined. Although some types of flexibility may be necessary in inclusive design, it is found that this flexibility might easily lead to complexity. Complexity will in turn be in conflict with the creation of ICT solutions that are simple and easy to use, which is another requirement of inclusive design. Five strategies to reduce the overall complexity of ICT solutions are therefore proposed.

3) A deepened understanding of inclusive design is sought by analysing, comparing and contrasting the various experiences from inclusive design in this research with knowledge from user-centred and participatory design. While it is found that a focus on user involvement is at least as important in inclusive design as in previous approaches, it is underscored that it is necessary to rethink and to be clear about the reasons and purpose behind the user involvement. The focus should be on involving users in inclusive design because it fosters innovation and mutual

learning, it increases the motivation of the development team and because participants can offer important aid in prioritising activities during the design process. Based on this research, some advice with regard to selecting users and the application of methods in an inclusive design context is given.

Conclusions and future work: This research has summarised important elements of inclusive design and deepened our understanding of the challenge of diversity when designing for everybody. It has contributed with some measures to meet these challenges, and pointed out a number of open questions and areas for further work.

Sammendrag

Bakgrunn: Informasjons- og kommunikasjonsteknologi (IKT) er i dag en integrert del av samfunnet. For samfunnet er det derfor viktig at alle kan delta og bidra gjennom bruk av IKT. For den enkelte er det å kunne delta i informasjonssamfunnet viktig for muligheten til likeverdig deltakelse i utdanning, arbeidsliv, organisasjonsliv og hverdagsliv. For å oppnå dette må IKT produkter og tjenester utformes slik at de er enkle å bruke for flest mulig. "Universell utforming", "design for alle" og lignende begreper er eksempler på designretninger og utformingsstrategier som har tilgjengelighet og god brukskvalitet for flest mulig som hovedmål. I denne avhandlingen omtales slike designretninger som inkluderende design.

Målsettinger: Ett av målene med dette arbeidet har vært å studere hvordan man kan ta hensyn til et stort mangfold av brukere i utvikling av inkluderende IKT. Videre har det vært å utforske to tilsynelatende motstridende målsettinger i inkluderende design; nemlig behovet for fleksibilitet på den ene siden, og behovet for enkelhet på den andre siden. Et tredje mål har vært å diskutere inkluderende design i lys av kunnskap fra tidligere IKT-forskning innen brukermedvirkning og brukersentrert utvikling.

Metode: Arbeidet er basert på kvalitativ forskning i syv forskningsprosjekter om universell utforming av IKT. Følgende forskningsmetoder er benyttet i disse prosjektene: fokusgrupper, observasjon, intervjuer, personas og teknisk tilgjengelighetstesting. Mer enn 150 deltakere med et bredt spekter av funksjonsevner har deltatt i disse prosjektene.

Resultater: De viktigste bidragene fra dette arbeidet er:

1) Det gis en oversikt over viktige elementer i inkluderende design. Disse elementene er basert på en grundig gjennomgang av det empiriske materialet, samt en diskusjon og analyse av disse elementene i forhold til kunnskap fra tidligere forskning.

2) Behovet for fleksibilitet i inkluderende IKT løsninger er undersøkt. Flere typer av fleksibilitet i det empiriske forskningsmaterialet er gjennomgått. Selv om noen typer av fleksibilitet kan være nødvendig for å oppnå tilgjengelighet, kan denne fleksibiliteten lett føre til kompleksitet. Dette vil i sin tur gjøre IKT-løsningene vanskeligere å bruke, noe som er i konflikt med inkluderende design. Fem strategier for å redusere kompleksiteten i IKT-løsninger er derfor foreslått.

3) Tidligere forskning innen IKT har vist at brukermedvirkning er avgjørende for å oppnå god brukskvalitet. Det slås fast at dette også gjelder når målet er universell utforming eller inkluderende design, med andre ord når målet er å oppnå god brukskvalitet for alle. Ulike utfordringer med å håndtere mangfoldet av brukere i inkluderende design blir derfor diskutert. Basert på dette gis det noen råd med hensyn til valg av brukere og bruk og tilpassing av metoder.

Konklusjon: Gjennom dette arbeidet er viktige elementer i inkluderende design oppsummert, utfordringene med å ta hensyn til et mangfold av brukere er belyst, og noen tiltak for å møte disse utfordringene er foreslått. Videre er det pekt på flere åpne spørsmål, og noen områder for videre arbeid er foreslått.

Emneord: universell utforming av IKT, inkluderende design, design for alle, brukermedvirkning, brukersentrert design, tilgjengelighet, funksjonsnedsettelser, brukskvalitet, brukervennlighet, digital inkludering, e-inkludering, hverdagsteknologi, etikk

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Tranby, April 2014, Kristin S. Fuglerud

List of papers

This thesis has the form of a paper collection. It consists of two parts. The first part includes the background, an explanation of the relevant concepts and theories and an overall discussion of the papers with a summary of my contributions.

The articles included in this thesis have been published in an anthology (Paper A), journals (Papers B, C and E) and conference proceedings (Papers D and F). These can be found in Part II of the thesis:

A. Fuglerud, K.S. (2009). Universal design in ICT services, in Inclusive buildings, Products and Services: Challenges in Universal Design, T. Vavik, Editor. Trondheim, Norway. pp. 244–267.

B. Fritsch, L., Fuglerud, K. S. & Solheim, I. (2010). Towards inclusive identity management. Identity in the Information Society 3 (3): 515–538. 7 October 2010. URL: http://www.springerlink.com/content/x85883158t117675/.

C. Fuglerud, K. & Dale, O. (2011). Secure and inclusive authentication with a talking mobile one-time-password client. Security & Privacy, IEEE, 9 (2): 27–34. 28 March 2011. URL: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5680893.

D. Fuglerud, K. S. (2009a, 19–24 July). ICT services for every citizen: The challenge of gaps in user knowledge. Proceedings of the 5th International Conference on Universal Access in Human–Computer Interaction. Addressing Diversity. Part I: Held as Part of HCI International 2009, San Diego, CA, USA. Springer-Verlag. pp. 38–47. URL: http://www.springerlink.com/content/j4404j346855r154/.

E. Fuglerud, K. S. & Røssvoll, T. H. (2012). An evaluation of web-based voting usability and accessibility. Universal Access in the Information Society: (4): 359–373. doi: 10.1007/s10209-011-0253-9. URL: http://dx.doi.org/10.1007/s10209-011-0253-9.

F. Fuglerud, K. (2011, 9–14 July). The barriers to and benefits of use of ICT for people with visual impairment. HCI International, Universal Access in Human–Computer Interaction. Design for All and eInclusion, Orlando, Florida, USA. Springer Berlin/Heidelberg. pp. 452–462. URL: http://dx.doi.org/10.1007/978-3-642-21672-5_49.

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Abbreviations

ABD: Ability-based design

AT: Assistive technology

CDE: Countering design exclusion

DfA: Design for all

DTL: the Norwegian Anti-Discrimination and Accessibility Act [Nor: Diskriminerings- og tilgjengelighetsloven].

HCI: Human–computer interaction

ICT: Information and communication technology

IDA: Inclusive design approach

IDM: Identity management

IIDM: Inclusive identity management

NABP: Norwegian Association for the Blind and Partially Sighted

NGO: Non-governmental organisation

PD: Participatory design

STSD: Socio-technical systems development

UCD: User-centred design

UCSD: User-centred system design

UD: Universal design

USID: User-sensitive inclusive design

UU: Universal usability

W3C: World Wide Web Consortium

WCAG: Web content accessibility guidelines

Terms and definitions

Accessibility: Usability of a product, services, environment or facility by people with the widest range of capabilities. Technical accessibility is a precondition for accessibility.

Assistive technology (AT): Any item, piece of equipment, or system, whether acquired commercially, modified, or customised, that is commonly used to increase, maintain or improve the functional capabilities of individuals with disabilities.

Cognitive accessibility: That it is easy to understand both the content and how to use an ICT solution. It is particularly important for people with cognitive disabilities.

Disability occurs when there is a mismatch between the requirements of the environment and the abilities of a person (see section 2.1.1).

Diverse users include people with impairments, elderly people, people with poor ICT skills, people with reading and writing difficulties etc.

Haptic technology is a tactile-feedback technology that takes advantage of the sense of touch by applying forces, vibrations or motions to the user.

Impairment denotes a loss of function that affects the mind or the body.

Inclusive design: In this thesis, it is used as a general label for a design approach that has the goal of making the design accessible and usable for as many people as possible, including elderly and disabled people.

Inclusive design approaches (IDAs): The term is used in this thesis as a label for design approaches with the goal of making the design accessible and usable for as many people as possible, including elderly and disabled people.

Interoperability: The ability of two or more systems or components to exchange information and to use the information that has been exchanged (IEEE Glossary).

ICT solutions: ICT-based systems, products and services that are used to express, create, convert, customise, collect, exchange, store, reproduce and publish information, or otherwise make information usable. To ensure the technical accessibility of ICT solutions, interoperability and compatibility between the solutions and the solutions and AT is necessary.

Technical accessibility: That people with the widest range of capabilities have access to the information and functionality of an ICT solution.

PART I

RESEARCH OVERVIEW

1 Introduction

Information and communication technologies (ICTs) have transformed the way we live, learn and work. They influence people's everyday lives in ways that most of us could not have imagined just decades ago. Many activities in our society depend on access to and on the ability to use ICT-based tools and services. Tasks undertaken at school, at work and in everyday life require access to and the skills in using technology. There has been a rapid increase in the use of self-service technologies among both public and private service providers, where citizens, customers and consumers help themselves by using electronic products and services (Burrell et al. 2000). Examples of such services are paying bills through Internet banks, filling in and submitting tax returns electronically, finding and buying tickets for travel or events either from ticket machines or through the Internet, e-learning, filling in and sending electronic forms, finding and sharing music and films and managing bank accounts and personal finances. People with disabilities feel that the increased use of inaccessible self-service terminals such as kiosks, ticket machines, ATMs and queuing management systems have introduced new barriers into their daily lives (Paper F).

We use ICT for finding and sharing information, to access public and private services, in education, to find and qualify for work, as a means for social communication, for shopping and for entertainment. The proliferation of ICTs in all parts of society and in nearly all types of activities means that it is no longer a realistic possibility to avoid technology altogether. The more reliant society becomes on technology to perform fundamental aspects of everyday living, the more imperative it is that all individuals have access to this technology, and the more costly will be the consequences of a failure to ensure access. Not being able to use the technology makes people dependent on others (Paper F). Not being able to access and use ICT prevents people from full and equal participation in politics, education and various social and organisational activities (Fuglerud & Solheim 2008). Moreover, it is often necessary to use ICT to be able to contribute to society on equal terms to others. In short, access to and the ability to use ICT is necessary to take part fully in society. The opportunity and ability to access and make use of ICT is recognised as an important aspect of a broader question regarding dignity and human rights.

In 2006, the Convention on the Rights of Persons with Disabilities was adopted by the United Nations (UN 2006). This Convention aims to ensure that disabled people can enjoy the full range of human rights: civil, political, economic, social and cultural. This shall be ensured, among other things, through requirements for accessible ICT (Article 2). The issue of accessibility (Article 4) deals with the elimination of obstacles and barriers to enable persons with disabilities to access the environment, transportation, public facilities and services and ICTs. The Convention refers to the concept of universal design (UD) as a means through which to achieve this goal (Article 4).

The integration of all citizens into the information society is often referred to as e-inclusion. This has become an important policy goal internationally. Consequently, several states are extending their laws to ensure equal access to information, products and services for everybody. The Norwegian Anti-discrimination and Accessibility Act (Diskriminerings- og tilgjengelighetsloven 2008) came into force in 2009. The objectives of the Act are to promote equality, ensure equal opportunities and rights and to prevent discrimination based on disability (see more about this legislation in section 2.3). The law is fairly unique in that it introduces UD as a legal term. It contains a duty of general-accessibility accommodation, which is to be achieved through UD.

In the next section, I describe my motivation for working on this subject, and then I briefly describe the concept of UD and similar approaches, and some of the main challenges with these approaches.

1.1 Motivation

My interest in usability, accessibility and UD is based on personal experiences and knowledge related to the use and development of technology. Not least, being married to a person who is virtually blind, gives me inspiration and an urge to work within this field. He encounters, on a daily basis, small and large obstacles in the environment and when interacting with technology. This is a continual reminder of the need for more accessible environments.

I have seen at close hand how accessible technologies can make the difference in terms of being able to be independent, and to participate and contribute on an equal footing with others, or not. Changes that are seen as improvements by many have meant major obstacles for my husband. Often, new solutions have poor accessibility. For example, when our children's school started to send all the parent information by e-mail instead of on paper, it was a major improvement. The e-mail technology was accessible for my husband, and this change made it easy for him to read and follow up on the information and communication from the school. Then, when the school started to use an ICT-based learning management system that was not accessible, it was a major setback for us, since now he could no longer follow up on this kind of information. Again, much more planning and organising was required, since everything had to go through me. Another similar development is the possibility of receiving information electronically from various agencies, such as banks, insurance companies and travel companies etc. This has meant that my husband can read the information by himself; taking care of these issues when it suits him, not needing to wait for me or other people to have the information read out loud to him.

However, the introduction of PDF documents[1] created a new set back, because these documents were not accessible with his equipment. Thus, we were back to the situation where either I had to take care of these things or we had to find common time to read the information through so that he could make notes on what was important. Again, we experienced a “two steps forward and one step back” situation. The technology design directly affected the independence of my husband. It restricted how we could distribute everyday tasks among us, and it required more coordination, organisation and time for us both to be able to solve everyday tasks. These examples may seem small, but taken together, all the things that require special thought and organisation because of poor accessibility have a major impact on how we are able to organise our lives. I am sure that this situation is not unique; it is just an example of how technology affects and changes our lives.

The situation where new technology arrives with new barriers for people with impairments may seem like a paradox, because on the one hand, only our imagination delimits the ways in which we can interact with technology (Paper A). For example, people who are paralyzed from the neck down have fundamentally new possibilities by using technology to control their environment. Another example is people without speech who can speak through synthetic speech technology. On the other hand, the proliferation of everyday technology that is not accessible seems to increase the ICT barriers for people who are not fully able in all respects (Fuglerud & Solheim 2008). Moreover, studies show that even for established technology, such as web pages, there are still major accessibility problems and little, if any indication of improvement over time (Kane et al. 2007; Power et al. 2012). In other words, the accessibility movement is generally unable to keep up with technology development (Miesenberger 2011).

Politicians, legislation and technology developers point to UD and similar approaches as the means to make mainstream technology more usable and accessible. I will use the label *inclusive design approaches* (IDAs) as a collective term for these design directions, and inclusive design as a general term for any of these. In the next section, I will give a short overview of IDAs in general and of UD in particular. I will proceed by describing some of the main challenges of these approaches and then I will point out the direction of this thesis.

1.2 Inclusive design approaches

Various things are associated with IDAs, such as UD or Design for All (DfA) (Harper 2006). It is often placed within the discussion of society at large by referring to socioeconomics, ethics and issues of general discrimination. Others see it as a technological issue and a

[1] While it is possible to create accessible PDF documents, documents in this format had and still often have poor accessibility.

problem to be solved. Many think of IDAs as design for the disabled, although the general intention of these approaches is design for everybody, including the disabled.

The development of assistive technology (AT) – that is, technology specially dedicated to aiding people with a particular disability in performing functions that might otherwise be difficult or impossible – has a longer history than the IDAs. A screen reader[2] (see **Figure 1**) is a typical example of AT used by many visually impaired people.

Figure 1: A laptop PC equipped with assistive technology; i.e., a hardware braille display and screen-reader software.

The development of the typewriter and the transistor are two famous examples of AT from the 19th century. In 1808, Pelligrino developed the typewriter to help his blind friend Countess Carolina Fivizzono to communicate in writing (Jacobs 2002; Magar 2011). Graham Bell was concerned with aiding deaf people to communicate. In 1875, after much research, he came up with a simple receiver that could turn electricity into sound. This research later inspired the invention of the microphone, speaker, telephone, speech recognition, speech synthesis, stereophonic recording and the transistor (Jacobs 2002). An interesting aspect of these early AT achievements is that they laid the foundation for a broad range of current mainstream technology.

The development of ATs and rehabilitation engineering emerged as disciplines in the middle of the 20th century. These came as a response to the need to rehabilitate thousands of disabled veterans from World War II in the 1940s (CUD 2008). The term "assistive technology" was applied to devices for personal use created specifically to enhance the physical, sensory and cognitive abilities of people with disabilities and to help

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[2] A screen reader is an assistive technology often used by blind and visually impaired people that can read Braille. Usually it denotes both hardware and software. The hardware component consists of a Braille display and/or audio output equipment. The software component interprets what is being displayed on the screen, and the content can then be presented either as synthetic speech through the audio equipment or as Braille on the Braille display.

them function more independently in many environments, regardless of their needs (CUD 2008).

As the types of application areas and user groups of computer technology expanded considerably during the 1980s and 1990s, the human–computer interaction (HCI) community became engaged in the issue of how to make this technology available to various groups of disabled people. Design approaches to meet this objective started to emerge within the ICT communities from the middle of the 1980s.

There are now several design approaches that encompass the goal of producing ICT solutions that can be used by broad and diverse populations, including disabled people, elderly people and people with low ICT skills, people with reading and writing difficulties, the poor or otherwise disadvantaged people etc. I use the term IDA to denote a design approach with this goal. Examples of such design approaches are accessible design (EIA&EIF 1996), universal design (CUD 1997), universal usability (Shneiderman 2000; Vanderheiden 2000), universal access (Stephanidis & Savidis 2001), designing for dynamic diversity (Gregor et al. 2002), user-sensitive inclusive design (Newell et al. 2011), inclusive design (Clarkson et al. 2003; Keates, S. & Clarkson, P. J. 2003), DfA (EC 1995-2007; EDeAN ; EIDD ; Stephanidis & Salvendy 1998), e-accessibility (Klironomos et al. 2006), designing for accessibility (Keates 2007) and ability-based design (Wobbrock et al. 2011).

There are also more general design approaches that explicitly refer to the issue of accessibility for the disabled as one of several societal or ethical objectives in design, such as value-sensitive design (Friedman et al. 2006) and the capability approach (Oosterlaken 2010; Oosterlaken 2012).

While there are differences between the various IDAs (see details in section 3.6), the common idea is to make mainstream products and services accessible and usable by as many people as possible, including people with disabilities.

IDAs are seen as complementary to the development of AT, which is technology that is dedicated to people with a special type of impairment.

There are several reasons for the shift in focus from the development of AT to IDAs. Access to ICT is in a continual state of flux. While ATs for enabling disabled users to access ICT products and services are improving, technologies in general are evolving. The fact that we are increasingly surrounded by evolving technology has made it difficult for developers of AT to keep up with the new technologies, and this results in a lag that creates problems and barriers for disabled users (Brown et al. 2012). The idea of the IDA is therefore that it is cheaper and better if the mainstream technologies can be used by disabled people, either alone or with the aid of AT, rather than designing stand-alone ATs for disabled people from scratch (Bühler 2008; Keates, S. & Clarkson, P. J. 2003). Often, the IDAs and the AT meet somewhere in the middle (CUD 2008), where mainstream solutions may be used by disabled people only in combination with certain types of AT. For example, a blind person will (currently) not be able to use the web without a screen reader, and a mobility-impaired person might not be able to use it without his or her input device, be it a special foot mouse, or eye-control technology, which allows for interaction with the ICT by tracking the eye positions of the user.

1.3 Universal design

The empirical work presented in this thesis is conducted in Norway where the term UD is used. The Norwegian interpretation of UD has been based on the definition developed by the Center for Universal Design at North Carolina State University (Brynn 2009 p. 4; SHDIR 2003 p. 12) (see section 3.7.1.1 for various definitions of UD).

During the work with the Norwegian Anti-discrimination and Accessibility Act, the definition of UD was changed to function as a legal term. The current Norwegian definition is as follows:

> “Universal design” shall mean designing or accommodating the main solution with respect to the physical conditions, including information and communications technology (ICT), such that the general function of the undertaking can be used by as many people as possible (ADAA 2013).

While one of the main goals of UD is to make the design usable by people with disabilities, it is important to stress that the purpose is to make the design usable by everybody (or as many people as possible), regardless of their age and (dis)abilities. Ronald Mace, the founder and program director of The Center for Universal Design, demonstrated that when making something more accessible to people with disabilities, it also becomes more accessible to everyone (CUD 2008).

UD expresses a normative goal. Moreover, the interpretation of UD as a concept has two important aspects; that is, it refers to both *a design process* and *the qualities of the resulting design*. Of course, the UD process and the resulting design are closely connected (see more about the concept and definitions in section 3.7.1).

Table 1: The seven principles of universal design

1. **Equitable use**
2. **Flexibility in use**
3. **Simple and intuitive**
4. **Perceptible information**
5. **Tolerance for error**
6. **Low physical effort**
7. **Size and space for approach and use**

The seven principles of UD (**Table 1**) are a central part of the concept (CUD 1997). I have included these principles because they serve well in gaining an understanding of what qualities of products and environments are seen as important and relevant to UD (Wågø et al. 2006 p. 13). The principles can be used to plan and guide the design process as well as to evaluate existing designs (Aslaksen et al. 1997a; SHDIR 2003).

The seven principles of UD do not contain all the criteria for good design. Many other factors are important, such as aesthetics, cost, safety and social conditions. UD should be an integral part of the overall design process, which of course will include a broad range of issues, such as those that have been mentioned.

Since the seven principles of UD were developed in another context – that is, in relation to buildings and architecture – one might ask whether these principles can be applied directly to an ICT environment, or whether some adjustments or precision with regard to the UD of ICT are required. Some properties of ICT may distinguish UD in ICT from UD in other design areas. As the label of ICT implies, these technologies are, by nature, very information and communication intensive. There is usually a substantial amount of information to take on board, and the user's ability to communicate is often more important when interacting with ICT than when interacting with other designed objects or environments. This suggests that the use of ICT is cognitively demanding. To lower the threshold for use, it is particularly important to emphasise UD Principle 3, simple and intuitive use, when aiming at universally designed ICT. Another important precondition for use is that the information is perceptible to the user in the first place (Principle 4). Depending on each individual's abilities, s/he needs to be presented with the information in a way that is perceptible to him or her. Thus, UD in ICT is very much about the flexibility (Principle 2) in presenting the various users with information in a way that they can perceive (Principle 4), and in a way that is easy to understand and interpret (Principle 3). These aspects will be elaborated on further in the next sections.

1.4 Challenges of handling diversity in the inclusive design approaches

The design for diversity is a key objective in all of the IDAs. In the following, different challenges surrounding this objective are discussed.

Shneiderman (2000) has pointed to three main challenges in attaining universal usability: *user diversity*, *gaps in user knowledge* and *technology variety*. Even when considering subgroups of a population, such as the elderly, user diversity is regarded as a fundamental challenge (Dickinson et al. 2011; Gregor et al. 2002).

The challenge of user diversity is about the fact that when trying to target everybody (or as many people as possible), the user population will be extremely heterogeneous. Users have varying physical or cognitive abilities, skills and knowledge, personalities and socio-cultural backgrounds. Harper (2006) has noted that the design for everybody (or as many people as possible) seems to be utopian and in contradiction with common views of design. These views can be illustrated by some rather famous slogans in design, as shown in **Table 2**. The problem is that if you try to design for everybody, you end up not doing very well for anybody, because everybody has different needs.

The challenge of the gaps in user knowledge – that is, the bridging of the gap between what users know and what they need to know – concerns how to present the user with the necessary and sufficient help and information to enable the user to explore and learn to use an interface. Of course, there is a great variety in terms of what users know; thus, this represents another dimension of diversity among users.

Table 2: Design slogans

- **Know thy user!**
- **Design for one person, and be sure that at least that person can use it!**
- **If you design for everybody, you can be sure nobody can use it!**

The challenge of technology variety concerns the design of ICT products and services so that they can run on the various types of operating systems, browsers and devices that the users have. The use of AT together with products and services can also be viewed as an aspect of technology variety.

The rapid development of new types of technology such as mobile technology (e.g. smart phones and tablets) and everyday technology (e.g. self-service machines and smart things[3]) leads to a fourth challenge for IDAs. This is the challenge of designing for various usage situations. It is clear that new user devices, self-service machines and other smart things can be used in varying environments and situations.

Vanderheiden (2000) points out that universal usability is “a function of keeping all of the people and all of the situations in mind, and trying to create a product which is as flexible as commercially practical, so that it can accommodate the different users and usage situations”.

Table 3: Challenges of diversity in IDAs

- **User diversity**
- **Variety in user knowledge**
- **Technology variety**
- **Various usage situations**

In summary, the acknowledgement of user diversity, in contrast to the image of an average user or a typical user without disabilities, is important in IDAs. Knowledge and awareness of the different needs, preferences, abilities, technologies and usage situations of the spectrum of potential users are also central. Moreover, technology trends towards mobile technology and everyday technology makes it necessary to take diversity in usage situations into account as well. **Table 3** summarises these four challenges of diversity.

While the overall motivations, principles and design objectives of IDAs are quite easy to grasp, it is less clear when it comes to the finer details of how to achieve this in practice (Keates, S. & Clarkson, P. J. 2003). Therefore, some say that UD is an elusive and impossible

[3] Smart things refer to many types of things that are connected through a (wireless) network. Often it is associated with smart homes, smart traffic and smart health. An example is a medicine cabinet that communicates when to take what types of medicine to a person, or it can communicate with the owner’s doctor or with a pharmacy to order new medicine when it is empty.

goal, while others argue that there is no problem in interface design that cannot be solved or at least improved (Lazar 2007). To discuss further the challenges of designing for diversity in IDAs, it would be advantageous to have a clearer picture of what the key elements of these design approaches are. This leads to the first research question of this thesis:

RQ1 What are the key elements in IDAs?

The second principle of UD concerns flexibility in use (see **Table 1** on page 8). Vanderheiden (2000) (see quote above) and others (Carbonell 2006; Harper & Chen 2012; Horton & Leventhal 2008; Keates & Varker 2007; Kelly et al. 2008; Shneiderman & Hochheiser 2001; Wobbrock et al. 2011) have also pointed out that inclusive design calls for flexible design. In the next section, I discuss what this may entail in relation to IDAs.

1.5 Diversity calls for flexibility in the design

The need for flexibility in inclusive design may refer to flexibility in the design process itself and in the resulting outcome from that design process. In the following sections, I will present some types of flexibility required in inclusive design of ICT solutions and some research challenges related to this. Then I will present the current challenges of accommodating diversity in the inclusive design process.

1.5.1 Flexibility in inclusive design

One simple example of flexibility in an ICT solution is the possibility of being able to change text sizes and contrast in the user interface. Another kind of flexibility is to let the user interact through different modalities: A blind user needs information presented in audio or as haptics[4] (e.g. braille), while hearing-impaired users need information in a visual or haptic (e.g. vibration) form. In contrast to non-digital objects, the potential for conversion and transformation of information is vast in ICT. Information can be presented in many different ways by using different modalities, such as text, pictures, film, audio and haptic technology (Ellcessor 2010). In addition, the cognitively disabled may be helped by getting the information presented in complementary ways – for example, through written or spoken information in combination with illustrations (Fuglerud 2007). This relates to UD Principle 4 concerning perceptible information (see **Table 1** on page 8).

Being able to utilise different modalities is also necessary when designing for changing contexts and situations. For example, if there is much noise (e.g. in a production room) or where silence is preferred (e.g. during a meeting), a system notification in visual or haptic

[4] Haptic technology is a tactile-feedback technology that takes advantage of the user's sense of touch by applying forces, vibrations, or motions to the user (*Haptic technology* 2013).

form (e.g. a vibrating mobile phone) might be more suitable than an audio alarm. The vast potential of making ICT perceptible for all (UD Principle 4, **Table 1** on page 8) by means of the flexibility that multimodality offers is highlighted by many researchers (Paper A)(Darzentas & Miesenberger 2005; Knudsen & Holone 2012; Obrenovic et al. 2007; Oviatt 2003).

1.5.2 Flexibility may lead to complexity

A consequence of the flexible and multimodal user interface is that many choices and much functionality are presented to the user (Jameson 2002 p. 5; Pullin 2009). For example, to provide for the possibility of changing text sizes and contrasts, one must add functionality to manipulate these properties. Similarly, adding audio will introduce the need for functionality to control the audio, such as repeat, forward, backward, stop, start, adjusting volume, speech speed etc. (Jameson 2002). This is, in a way, true, even if the transformation of modality is taken care of by AT. In that case, the user needs to operate the AT in addition to operating the application itself. Adding functionality to achieve flexibility may very well be in conflict with the third principle of UD, which is “simple and intuitive in use” (see **Table 1** on page 8).

While experiments show benefits in using multimodality for specific tasks, more research is needed to see how this can be integrated in an overall interface without increasing the cognitive demand (Emery et al. 2003).

Thus, adding flexibility and multimodality often means adding functionality, and this usually adds to the complexity of the user interface. The challenge lies in how to offer this kind of flexibility without making the user interface too complex and difficult to use. **Figure 2** illustrates how accommodating all the different needs through flexibility may lead to complexity in the user interface.

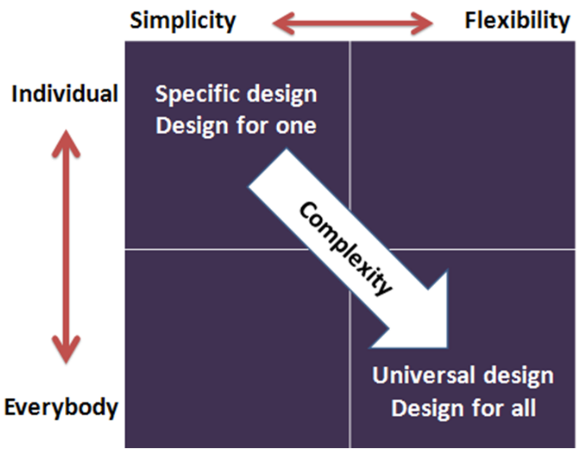

Figure 2: Accommodating everybody with flexibility and multimodality in the interface may lead to complex

There are some approaches to reducing the complexity in UD. Standardisation of certain interaction elements will, for example, reduce the users’ need to learn new ways of doing things both within one application, and across various products and services. Standardisation may therefore reduce the total number of variations in terms of how to do things, and thereby reduce the overall complexity for the user.

Even if a user interface is standardised, the number of choices necessary to accommodate the vast variety of user needs may be huge. Personalised and adaptive user interfaces are proposed as a solution to this challenge (Darzentas & Miesenberger 2005; Hanson & Crayne 2005; Nevile 2005; Savidis & Stephanidis 2004). However, the benefits of adaptive and personalised interfaces are said to be overrated or even counterproductive (Solheim 2009). For example, users have found alterations to the interface to be very disconcerting or confusing (Dickinson et al. 2011; Solheim 2009). It has been pointed out that developments in adaptive systems have mainly focused on some parts or aspects of the adaptation process, such as particular technical issues, and less on the user interface and the usage context (Savidis & Stephanidis 2004).

Thus, research on how flexibility affects users and how to avoid complexity in inclusive design appears to be necessary. This discussion leads to the second research question:

RQ2 What is the relationship between "flexibility in use", complexity and "simple and intuitive to use" in mainstream ICT?

1.5.3 Accommodating diversity in a user-centred design process

While there is broad consensus that it is good practice to follow accessibility guidelines and standards in IDAs, there is an increasing awareness of the fact that this is not enough to achieve accessible and universally designed solutions (Arrue et al. 2007; DRC 2004; Kelly et al. 2009; Power et al. 2012; Theofanos & Redish 2003).

A number of authors stress that this has to be complemented with user-centred design (UCD) and user testing with disabled users (Arrue et al. 2007; Billi et al. 2010; Brajnik 2008; Bühler 2008; Keates 2007; Kelly et al. 2008; Paddison & Englefield 2003; Petrie et al. 2006; Stephanidis 2001; Theofanos & Redish 2003; Wattenberg 2004). (See further details on UCD in chapter 3.4.)

Some researchers point out that the problem in applying a traditional UCD is that the research on the development of mainstream ICTs has been focused on the (non-existent) average user, rather than on the diversity of the users (Darzentas & Miesenberger 2005). Traditionally, these approaches seek to homogenise the user group to more clearly evaluate design decisions (Gregor et al. 2002). This tends, at best, to cause ignorance of the diversity and, at worst, to suppress it. Therefore, they argue, there is a need for more specific knowledge on how to handle the issue of diversity in design (Gregor et al. 2002). The IDAs can be viewed as extending the ICT design disciplines of making good ICTs for a particular user or user group, to making good ICTs for a whole population. However, as Keates and Clarkson (2003) put it, "there is a significant knowledge gap between applying usability for individuals and applying it for populations".

Furthermore, the techniques in UCD need to be modified to be appropriate for more diverse user groups (Gregor et al. 2002; Stephanidis 1999). This is because not all UCD techniques can be applied successfully with all users and there is a need for knowledge about which design techniques are appropriate for which users (Keates, S. & Clarkson, P. J. 2003). Many researchers stress the importance of the involvement of people with impairments in inclusive design processes (Abascal & Azevedo 2007; Czaja & Lee 2007; Gemou & Bekiaris 2009; Keates, S. & Clarkson, P. J. 2003; Kelly et al. 2008; Stephanidis 1999). There are several existing ICT design approaches that deal with user involvement – particularly UCD and participatory design (PD) – and it is therefore relevant for IDAs to draw upon the experiences and knowledge from these design approaches. However, these approaches originated in working-life contexts. Today, we not only use ICT as employees in organisations, but equally or even more often, we use it as citizens in society or as individuals in our homes. In fact, many of our everyday activities depend on access to, and the ability to use various ICT tools and services (Paper A). This means that the context of design has changed quite significantly during the last few decades. The third and last research question is related to what challenges the need to accommodate diversity in IDAs pose in relation to existing knowledge in UCD and PD:

RQ3 What challenges does diversity pose in relation to UCD and PD?

1.6 Research questions summarised

In this section, the research questions presented in the previous sections are repeated. The overall objective of this research is to study the challenge of diversity in design, the very core challenge of the IDAs. I study this challenge from various angles, both with respect to how the design process may take diversity into account, and in relation to the seemingly conflicting properties of a universally designed mainstream solution; namely, “perceivable and flexible” versus “simple and intuitive to use”. The first and the third research questions are mainly about the design process, while the second question is more about the required properties of an inclusive ICT solution.

RQ1 What are the key elements in IDAs?

RQ2 What is the relationship between “flexibility in use”, complexity and “simple and intuitive to use” in mainstream ICT?

RQ3 What challenges does diversity pose in relation to UCD and PD?

1.7 Delimitation

The research questions in this thesis touch upon fundamental challenges of IDAs, namely how to handle diversity when aiming at inclusive design of mainstream ICT. The full answer to these challenges cannot be given through one PhD project. However, I seek to contribute to the answers on these important research challenges with a basis in experiences and with results from several research projects that I have participated in.

These projects, which are described in chapter 4.2, are all about universal design of web-based products and services to be used through PC's and mobile devises. Strengths and weaknesses of the research, and aspects affecting the generalizability and validity of this research are discussed in sections 4.6 and 4.7.

1.8 Outline of the thesis

In this section, I give a short overview of the content of each chapter in the thesis.

Chapter 1 Introduction. The main objective of the first chapter is to frame the research objective of this thesis. I present my motivation for engaging is this research, some central research challenges in the field and the research questions of the thesis.

Chapter 2 Background. In this chapter, I give some background related to the proliferation and use of ICTs among people with impairments, such as the demographic and technological developments and the disability rights movement. I try to show how these factors are related to the current e-inclusion policy, with UD as an important strategy in this policy.

Chapter 3 Previous and related research. In this chapter, I present various research traditions that are related to the research at hand. This chapter is a summary of my literature review in relation to the research objective of this thesis.

Chapter 4 Research approach and methods. The research approach, methodology and methods are presented in this chapter. The projects and the empirical material that this research is based on are also described.

Chapter 5 Research findings and results. The findings from the empirical investigation are described in this chapter.

Chapter 6 Discussion. In this chapter, the findings that have been presented are brought together, analysed and discussed in the light of other research.

Chapter 7 Conclusion and suggestions for further research. The conclusion from the discussion is summarised in this chapter as well as several suggestions for further research that emerged from the discussion.

Chapter 8 References. The publications referred to in Part I of the thesis are listed in this chapter.

2 Background

In this section, I give some background information about the development of the human rights and disability rights movements and the developments regarding e-inclusion. I show how these developments have contributed to the current e-inclusion policies, which have adopted IDAs as a strategy. I also try to show how these ideas have influenced the Norwegian policy in this area. Then I present the current definitions of UD in Norway and discuss the interpretation of this concept in more detail.

2.1 Human rights and disability

In 1964, the American Civil Rights Act was signed. It promised full and equal enjoyment of goods and services. Although it was aimed at racial discrimination, it served as a model for the subsequent disability rights movement (Vavik & Gheerawo 2009).

The United Nations (UN) Convention on the Rights of Persons with Disabilities entered into force in May 2008 (UN 2006). It was ratified by the European Union (EU) in 2010. The Norwegian government was one of the first countries to sign this Convention (AID 2007), and it was ratified by Norway on the 3rd of June 2013 (FN-Sambandet 2013). By December 2013, 158 countries had signed the Convention and 78 countries had ratified it (UN 2013).

During the last decade, legislation to prevent discrimination against people with disabilities has emerged in many countries (Brynn 2009; EDeAN 2009; Lepofsky & Graham 2009; Loiacono & Djamasbi 2012 online first; Thorén 2004). In the following, I briefly describe some ideas that I believe have contributed to this development.

2.1.1 The disability gap model

Traditionally, the terms “handicapped” or “disabled” referred to the loss, damage or deviation in psychological, physiological or biological functions. Disability was seen as a property of the individual; that is, the handicapped or disabled person. Within disability research, there has been a development from a disease and individual-oriented understanding of disability, to a social model. In the social model, the lack of rights and lack of access to different areas of society create disability (Olivier 1990). In this model, disability is not a constant factor, but rather something that may occur in an individual’s meeting with society.

The relational manner of regarding disability has been advocated for in Norway for more than thirty years. It has often been illustrated by the disability gap model.

This model was first published by Ivar Lie[5] in 1989, but it had been used in teaching for at least ten years prior to that (Ness 2011). A simplified version of this model is presented in **Figure 3**.

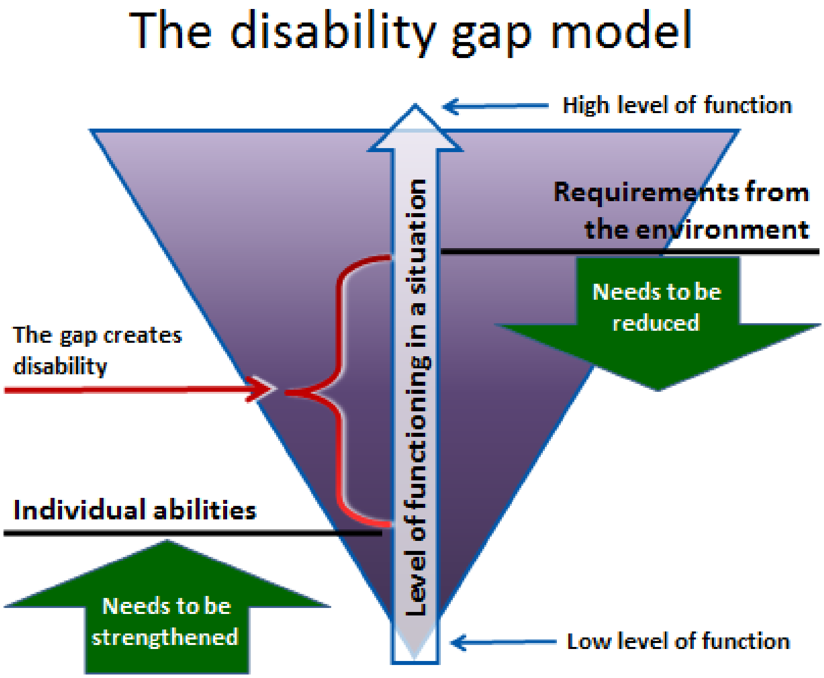

Figure 3: The disability gap model, based on the white paper on Dismantling of Disabling Barriers (St. meld. nr. 40 (2002–2003)).

In accordance with this model, and the definition in the Official Norwegian Report[6] (NOU 2001: 22) entitled: "From user to citizen", a "disability" occurs when people's practical lives are significantly limited because of a gap or mismatch between the person's ability and the demands of the environment or society. This gap, which creates disability, is marked with a red horizontal arrow in **Figure 3**. Moreover, the physical and social conditions that limit participation in the community are referred to as "barriers". This understanding means that disability must be viewed in relation to the environment that surrounds a person. Thus, attention is drawn not only towards the person's function or ability, but also, to a greater extent, to factors that can be changed to decrease requirements or increase

[5] Ivar Lie was Professor at the University of Oslo, Department of Psychology.

[6] The Norwegian government or a ministry may constitute a committee or a working group who report on different aspects of society. A report can be published either as an Official Norwegian Report, i.e., an NOU, or as a regular report. The Norwegian title of this report is *"Fra bruker til borger".*

functioning and thus to reduce disability. In the disability gap model, the emphasis is on the individual's own evaluation of their opportunities based on the experienced gap between their abilities and the requirements from their environment. UD and other IDAs are strategies to reduce the requirements from the environment; that is, strategies to lower the threshold for the use of ICTs. These approaches can therefore be placed at the thick, green down arrow to the right in **Figure 3**. ATs can be regarded as tools to strengthen the abilities of individuals, and can therefore be placed at the thick up arrow in the lower left corner in **Figure 3**. Thus, IDAs and ATs can be used to close the disability gap (illustrated with a red curly bracket) from either side.

In this thesis, I use the term “disability”[7] in accordance with the disability gap model; that is, as something that occurs when there is a mismatch between the requirements of the environment and the abilities of a person. Moreover, in accordance with the gap model, disability is defined by the individual’s own experience of the gap. I will argue that a consequence of this is that the individual should have a say with regard to the evaluation of their opportunities.

2.1.2 The capability approach

One important philosophical theory in the area of human rights and disability is the capability approach, developed by the Indian philosopher and economist Amartya Sen and the American philosopher Martha Nussbaum, Professor of Ethics at the Divinity School, University of Chicago (Nussbaum 2011). This approach focuses on human dignity and respect. Human dignity lays the groundwork for the notion of equal worth and treating people with respect.

The capability approach does not only ask about what a person is able to do, but also about the opportunities that are available to each person. Having equal human value does not mean that each person must be treated equally, but that they should be treated with equal respect and that they should have equal opportunities.

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[7] There is a discourse on the use of terms in this area (Oliver 1996). In the Norwegian white paper no 40 on Dismantling of Disabling Barriers (St. meld. nr. 40 (2002-2003)) there is a differentiation between the concepts of reduced (or limited) functional ability, impairment and disability. The term reduced functional ability or impairment refers to any loss of function that affects the mind or body, while the term disability refers to the experienced gap between the abilities of the individual and the requirements from the environment. The two terms can, for example, be used when describing measures to prevent persons with reduced functional ability from becoming disabled. The term functional impairments can be used synonymously with the term reduced functional ability. In some situations, it is necessary to mention specific groups, such as the hearing impaired, visually impaired, or mobility impaired etc. Some prefer the term “person with visual impairment” rather than “visually impaired” etc., to underscore that it is primarily a matter of a person who happens to have impairment rather than of defining the person by his or her impairment. Although I sympathise with this argumentation, I will not be rigorous in the use of these terms, mainly because the language may become rather stiff and awkward by only adhering to the long form.

However, it must be acknowledged that what is central for people is different, in terms of both quality and quantity. Additionally, the opportunities that each person has not only reside inside the person, but also are a result of the combination of personal abilities and the environment. Therefore, the capability approach talks about both *internal capabilities* and *combined capabilities*, where the internal capabilities reside within the person, and the combined capabilities are the totalities of opportunities a person has for choice and action in his or her specific political, social and economic situation (Nussbaum 2011 p. 21). A society should promote both the internal capabilities (e.g. through education, providing healthcare etc.) and combined capabilities (through developing the society itself). For example, a person can have the internal capability for political thinking, but if the environment is not accommodating, he or she may not have the combined capability of being able to exercise his or her right to vote. According to the capability approach, people with disabilities are equals who need to be taken into account from the start when designing any social scheme (Nussbaum 2011 p. 150).

Overall, the capability approach is focused on choice and freedom, and acknowledges that while everybody has equal rights to dignity, respect and opportunities, it is up to each person to decide what opportunities to choose (for example, choosing not to vote) (Nussbaum 2011).

Several of the thoughts and arguments from the capability approach can be said to be relevant to IDAs. For example, the question of whether equal opportunities with regard to ICT means offering everybody the same interface to treat people equally, or whether a focus on equal opportunities and human dignity may open up other solutions such as alternative interfaces, AT or personalisation. In addition, the idea of including people with disabilities from the beginning when designing any social scheme resonates well with several of the IDAs, which also stress the importance of including users in the design process (see section 3.6).

2.1.3 The universality of disability

The universality of impairments or disability – that experiencing disability is a part of all human lives – is another theme that recurs in the disability movement. Normal adulthood, for example, is only a temporary phase of human life. It is preceded by a period of childhood, during which basic needs for food, comfort, shelter, cognitive development and social interaction must be provided by adult caregivers. In addition, even "normal" adulthood is often followed by a period of increased dependency and reduced abilities, as ageing raises new physical and mental needs (Nussbaum 2011 p. 151).

In the area of biometric authentication, the fact that human beings change over time is acknowledged because it affects the reliability of these systems (Paper B)) (Answers 2011). For example, if a person is ill or injured because of having an eye infection, a hoarse voice or rough fingers from labouring, a retina-recognition system, voice-recognition system or fingerprint scanner, respectively, will have difficulties in identifying a person accurately. Other examples include how the fingerprints of people working in the chemical industries may be affected or how the voice may be changed when a person has the flu or a throat infection. The voice of a person may also change with age, and people with diabetes may have their eyes affected over time. Thus, temporal or permanent impairment due to age, a disease or injury affects all people to one degree or another at some points during their lives, and this must be taken into account when designing ICTs.

Moreover, as pointed out by Vanderheiden (2000), people will frequently find themselves in situations that will constrain some of their functional abilities with regard to them being able to operate ICTs in a similar way as an impairment will do. For example, people wearing a chemical suit or gloves, who have a repetitive stress injury, an arm in a cast, or who are in a bouncing vehicle may have the same difficulties in manually operating an ICT device as a person with physical impairments or dexterity problems. Similarly, people whose eyes are busy (e.g. when driving a car or performing surgery, or who are in darkness) may be equally constrained with regard to operating a graphical user interface as a person with visual impairments. This means that everybody experiences disability from time to time, and this stands in direct opposition to the view that people with disabilities are a discrete minority that is different from “normal” people.

These thoughts, sometimes referred to as the universality of disability (Bickenbach 2010), have begun to receive considerable attention in the human rights movement, the disability research area (Ellcessor 2010) and in the area of inclusive design and multimodal design (Papers A, B) (Knudsen & Holone 2012; Oviatt 2003). People promoting inclusive design are often confronted with the argument that because people with impairments constitute small and special groups, it is too expensive to accommodate them in the design process (Abascal & Azevedo 2007; Dong et al. 2004; Eikhaug et al. 2010). It is therefore important to acknowledge the universality of disability in all its dimensions, and to show that everybody is affected by temporal impairment, situational constraints or permanent impairments at some points during their lives. Otherwise, we risk being stuck in a situation where the interests of disabled people always compete with the interests of people without disabilities (Ellcessor 2010).

2.2 E-inclusion and e-accessibility policies

To include all citizens in the information society is an important policy goal in the EU. This policy, often referred to as the e-inclusion policy, covers many areas, such as e-accessibility, ageing, e-competence, socio-cultural and geographical aspects and e-Government (EC 2011a).

The development of the e-inclusion policy in Europe began in earnest in 2000. At that time, the EU leaders met in Lisbon and set out a new strategy to make Europe more dynamic and competitive. The initiative became known as the “Lisbon Strategy” and it covered a wide range of policy areas. Among the main objectives of the Lisbon Strategy was “The eEurope 2002 Action Plan: An information society for all”. This was followed by the eEurope 2005 Action Plan, the “i2010 Strategy” and the “Digital Agenda” of the current

"Europe 2020 Strategy" (EU Digital Strategy). The overall goal of these strategies is to develop the potential of ICTs to promote innovation, economic growth and progress.

In June 2006, the Ministers of the EU, Member States, and accession and candidate countries, European Free Trade Area countries and other countries adopted a declaration on e-inclusion. This is called the Riga Declaration. It defines e-inclusion as follows:

> "eInclusion" means both inclusive ICT and the use of ICT to achieve wider inclusion objectives. It focuses on participation of all individuals and communities in all aspects of the information society. eInclusion policy, therefore, aims at reducing gaps in ICT usage and promoting the use of ICT to overcome exclusion, and improve economic performance, employment opportunities, quality of life, social participation and cohesion. (EU 2006)

The "European i2010 Initiative on e-Inclusion: To be part of the information society" was proposed in 2007. This initiative comprised of an e-inclusion campaign "e-Inclusion, be part of it!", and a strategic framework for action to implement the Riga Ministerial Declaration. The strategic framework had three main objectives: enabling the conditions for everyone to take part in the information society by bridging the broadband and accessibility gaps, and tackling competence gaps; accelerating effective participation of groups at risk of exclusion and improving quality of life; and integrating e-inclusion actions to maximise lasting impact.

The focus on e-inclusion continues in the Digital Agenda of the Europe 2020 Strategy, where "Enhancing digital literacy, skills and inclusion" is one of seven mentioned actions (EU Digital Agenda).

As I see it, there are two important drivers for the development of the e-inclusion policy in Europe. One concerns the developments within the human rights and disability movements and the acknowledgement of the ideas discussed in the previous sections; that is, human rights and the universality of disability. The other driver in the e-inclusion policy relates to the demographical changes. Populations all over Europe, and, in fact, all over the Western world (EC 2010), are ageing, and there is a need for more efficient ways of taking care of these ageing populations. ICT is seen as an important tool in meeting these challenges.

According to the European Commission (EC 2010), the number of people over 50 years will rise by 35% between 2005 and 2050, and the number of people over 85 will triple by 2050. At the same time, fertility rates are declining. It is estimated that on average in Europe, the ratio between people at work and the remaining population will change from 4 to 1 in 2010 to 2 to 1 by 2050. These changes in demographics will escalate the pressure on Europe's social models and public finances. Important strategies to meet these challenges are, with the help of ICT, increasing the level of elderly in employment and making older persons live at home for longer by facilitating independent living for older persons. Moreover, ICT is considered to be an essential tool in increasing the quality, effectiveness and efficiency of public health and welfare services (EC 2010).

As the population ages, the need for the information society to find ways to accommodate people with age-related impairments increases. Of people over 50 years, 21% have severe hearing, vision or dexterity problems, which makes it difficult or impossible for them to use standard or mainstream ICT solutions (EC 2012b). According to Europe's thematic portal on the information society, "eAccessibility is aimed at ensuring people with disabilities and elderly people access to ICTs on an equal basis with others. This includes removing the barriers encountered when trying to access and use ICT products, services and applications"(EC 2012a).

Thus, by developing applications that are accessible, easy to use and easy to understand, more people will be able to serve themselves. The goal is that mainstream ICTs will be designed to be accessible to as broad a range of users as possible, including older people and people with disabilities. This will allow people to stay independent, active and productive as they grow older. To achieve this, the EC has, from the mid-1990s, funded research within e-inclusion and e-accessibility (EC 2011b). Other important policy areas are market regulation and legislation:

> To develop, implement and maintain Universal Design strategies, incentives should be given to key actors in different sectors of society, public as well as private. With countries organising their social life differently in Europe, both the market and legislation are important arenas and should be addressed by policy makers (CM/Rec 2009).

2.3 Norwegian policy on disability and inclusion

Since the empirical work of this thesis has been conducted in Norway, some background relating to the policy on disability and inclusion in Norway is of relevance. In the next sections, a description of the developments leading to the current policy and anti-discrimination legislation in Norway is presented.

2.3.1 Action plans and reports

The Norwegian government has produced several action plans for disabled people: 1990–1993, 1994–1997 and 1998–2000. In these action plans, disability is defined as a mismatch between individual abilities and environmental demands to function in areas that are essential for the establishment of independence and a social life (St.meld. nr. 34 (1996-97)). In addition to giving concrete measures at various levels, these action plans have also given input to the government's overall policy for the disabled. The action plans point to challenges and strategies in the policy for the disabled. However, they also put forward solutions to some of the key challenges in this area, such as pointing to UD as a strategy.

The publication titled “Universal design – planning and design for all[8]” (Aslaksen et al. 1997b) is the first publication in Norway about UD (SHDIR 2003). It was published by the National Council for Equal Rights for the Disabled in Norway. The report builds on the definition, principles and guidelines about UD developed by the Center for Universal Design at North Carolina State University, and is an attempt to further develop and concretise UD as a concept (Aslaksen et al. 1997b).

The publication illustrates and represents an important shift in the thinking about disability towards the relational model, where a disability is created by a gap between the requirements of the environment and the abilities of the individual (see **Figure 3** in section 2.1.1 “The disability gap model”). Moreover, it prescribes UD as the preferred approach to close this gap, and underscores that the concept of UD is in opposition to unnecessary and stigmatising special solutions. The central themes are equal opportunity, equal treatment and equal human worth. Further, the importance of a holistic approach, were different disciplines collaborate in creating universally designed solutions is emphasised (Aslaksen et al. 1997b). It states that real participation is a necessity to achieve UD. The principles of UD are regarded as part of a quality-assurance process for evaluating the design. See also “The seven principles of universal design” in Annex B.

The Official Norwegian Report “From user to citizen[9]” (NOU 2001: 22), laid an important foundation for the policy development in this area. It recommended using UD as a strategy for participation and equal opportunities, together with a proposal for a law on anti-discrimination, as the two main instruments for improving the lives of people with impairments in Norway.

This report was followed up by a white paper on Dismantling of Disabling Barriers (St.meld. nr. 40 (2002-2003)). It shows a commitment to applying UD to improve accessibility in a number of areas, such as transportation, buildings and outdoor areas, information and communication, and products as well as in culture and leisure. According to this report, the principles of UD should be sought with the help of various measures such as increased information and guidance, research and development as well as through cooperation with the standardisation bodies.

The next Official Norwegian Report in this area, on Equality and Accessibility (NOU 2005:8), laid the foundation for the development of a law to strengthen the legal protection against discrimination on the basis of an impairment. This legislation is described in the next section. The appendix to this report, written by Nicolai V. Skjerdal, has been a particularly important theoretical contribution to the understanding and definition of the term UD (Skjerdal 2005). As the first country in the world to do so, Norway adopted the term “Universell utforming” (translation: universal design) as a legal term. Even though the

[8] The original title in Norwegian is “Universell utforming – planlegging og design for alle”.

[9] The original title in Norwegian is “Fra bruker til borger”.

seven principles of UD (see section 1.3) are not explicitly referred to in the Norwegian legislation, they are central to the understanding of UD (Brynn 2009 p. 4; SHDIR 2003 p. 12; NOU 2005:8 pp. 280-282). As the formulations of the seven principles are rather broad, they should be seen as an expression of ideal goals and as the basis for further discussion (NOU 2005:8 pp. 280-282).

Five years after the Official Norwegian Report "From user to citizen" (NOU 2001: 22), a report titled "Full participation for all? Trends 2001–2006[10]" was published (SHDIR 2006a). This study reported on the development related to inclusion and accessibility during the five-year period from 2001–2006. The report covered important areas of society (SHDIR 2006b) including the ICT area (Fuglerud 2006). The general conclusion was that the situation was largely unchanged. A conclusion related to ICT was that it is especially important to gain more knowledge about ICT and physical accessibility as a barrier to work participation (SHDIR 2006a p. 23). Other important conclusions in the ICT area were that the consequences of not being able to use the technology had increased because of the increased use and proliferation of ICT in all areas of society (Fuglerud 2006) and that the lack of access to information constitutes a democratic problem (Fuglerud 2006; SHDIR 2006a p. 37).

The white paper no. 17 (St.meld. nr. 17 (2006-2007)) laid down further ICT policy in Norway. In this report, inclusion is listed as one of six target areas for Norwegian ICT policy. The other target areas are research and development, ICT and business policy, e-Government, personal privacy and security. According to this document, the Norwegian e-inclusion policy must be based on three main pillars:

- Access to the Internet, equipment and content
- UD
- Digital skills

2.4 Norwegian legislation

In this section, I will comment on two laws that are of special importance with regard to the UD of ICTs in Norway:

- The Norwegian legislation about public procurement (Anskaffelsesloven 2006)
- The Norwegian Anti-discrimination and Accessibility Act, in effect from January 2009 (Diskriminerings- og tilgjengelighetsloven 2008)

[10] The original title in Norwegian is "Full deltakelse for alle? Utviklingstrekk 2001-2006".

2.4.1 Public procurement

In 2004, the EU adopted a new directive on public procurement (EC 2004). According to this directive, "Contracting authorities should, whenever possible, lay down technical specifications so as to take into account accessibility criteria for people with disabilities or design for all users". Following this directive, the Norwegian Law on Public Procurement was amended and included a clause about UD from 2007. One may interpret the Norwegian legislation to go somewhat further than the EU directive because it omits a "whenever possible" phrase, and requires that UD is taken into account from the planning stage of a public procurement. According to Paragraph 6 of this law, all public bodies shall take into account the life cycle cost, UD and environmental impact of the acquisition when planning each acquisition (Anskaffelsesloven 2006).

2.4.2 Anti-discrimination and accessibility

The purpose of the Anti-discrimination and Accessibility Act is to promote equality and ensure equal opportunities for and rights to social participation for all persons regardless of disabilities, and to prevent discrimination based on disability. The Act shall help to dismantle disabling barriers created by society and to prevent new ones from being created. The Act applies to all areas of society with the exception of family life and other relationships of a personal nature. In the following, I summarise some important aspects of the law[11]. The law contains the following definition of UD:

> "Universal design" shall mean designing or accommodating the main solution with respect to the physical conditions, including information and communications technology (ICT), such that the general function of the undertaking can be used by as many people as possible (ADAA 2013).

Paragraph 3 is about the duty to make active efforts towards UD and to report on such activity. It states that public authorities shall make active, targeted and systematic efforts to promote the purpose of the Act. Employers in the public sector and employers in the private sector with more than 50 employees have an obligation to actively plan and work towards UD through their own undertaking. The undertaking shall give an account of the measures that have been implemented and measures that are planned for future implementation to fulfil the legal requirements.

Paragraph 9 of this law concerns the obligation to ensure general accommodation (UD). It states that public undertakings shall make active, targeted efforts to promote UD within the undertaking. The same applies to private undertakings that offer goods or services to the general public. Public and private undertakings that offer goods or services to the

[11] The summary is based on an unofficial translation of the Norwegian Anti-discrimination and Accessibility Act collected by the Law Library, University of Oslo: http://www.ub.uio.no/ujur/ulovdata/lov-20080620-042-eng.pdf

general public are obliged to ensure the UD of the undertaking's normal function, provided that this does not entail an undue burden for the undertaking. When assessing whether the design or accommodation entails an undue burden, particular emphasis is placed on the effect of the accommodation with regard to the dismantling of disabling barriers, the necessary costs associated with the accommodation, the undertaking's resources, whether the normal function of the undertaking is of a public nature, and its safety and cultural heritage.

Paragraph 11 concerns the UD of ICTs and deadlines for providing universally designed ICTs. Here, ICT refers to technology and technology systems that are used to express, create, convert, exchange, store, duplicate or publish information, or which in some other way make information usable. New ICT solutions that support the undertaking's normal functions and which is the main solution aimed at, or those that are made available to the general public are to be universally designed as from 1 July 2014. For existing ICT solutions, the obligation applies as from 1 January 2021. The obligation does not apply to ICT solutions whose design is regulated by other legislation, such as ICTs in the area of transport, working life and education (areas that have their own legislation).

2.5 Summary

In summary, e-inclusion and e-accessibility are important policy areas in the EU, and in other parts of the world as well (Thorén 2004). In the first part of this century, disability grew out of a medical perspective, denoting an individual with some kind of defect. Later, a more relational view on disability developed. The human rights and disability movement has grown out of social and philosophical ideas and how we perceive and look upon the world. Disability denotes a socially constructed category, and social and cultural values are very important in how we interpret and perceive this category. Social phenomena or constructs are reproduced and negotiated over time. Thus, how we regard a person who is disabled and who is regarded as disabled or non-disabled varies across cultures and time.

The developments within ethics and the human rights movement have influenced the development of policy in this area and the development of the IDAs in several ways:

- A shift in how we regard human life and its value. It is the being, and not the doing or thinking that gives humans a value.
- The fact that all humans have an equal human value implies that all human beings have equal rights to opportunities, choice and freedom.
- A relational view on human capabilities; the capabilities of a person do not only reside within the person, but are a result of the combination of personal abilities and the environment.
- The universality of disability or impairments means that disability will more or less affect everybody.

Considering this background and because of the demographic changes (i.e. ageing populations), the e-inclusion and e-accessibility policies have become important policy areas in the EU (EC 2005; EC 2007), and in the USA (Section 508 2007).

An increasing number of countries are introducing clauses in their legislation to promote the inclusive design of ICTs to prevent discrimination and exclusion from the information society (EDeAN 2009). Central themes are equality, taking a holistic and interdisciplinary approach, real participation and using principles of UD or DfA in a quality-assurance process, from project inception to the final result.

Since the concept of UD was introduced in Norway in 1997, the field has evolved. Several important steps have been taken through policy documents, through a number of action plans concerning UD and through new legislation. UD has become a chosen strategy for promoting equal opportunity and equal rights, participation and democracy, and is as such interlinked with political and social perspectives on disability and disability policy.

3 Previous and related research

This thesis concerns the challenge of diversity in IDAs and of how to deal with it. In this chapter, I present relevant fields of research and try to highlight aspects and findings of particular relevance to the research at hand. This is done with a historical perspective in mind to highlight the parallels and differences of the previous research in relation to the current context of research within inclusive design. The most important traditions or fields related to this work are:

- Human–computer interaction (HCI)
- Socio-technical systems development (STSD)
- The Scandinavian school of systems development
- User-centred design (UCD)
- Inclusive design approaches (IDAs)

The last four categories can be regarded as branches of the first, HCI. These research fields are presented in the following sub-sections.

3.1 Human–computer interaction

The field of HCI had its origins in a branch of applied psychology, human factors and ergonomics (Baecker et al. 1995 p. 41). This branch focused on enhancing the quality of use of artefacts through investigations on how to improve the design of equipment and tools. This can be traced back to Frederick Tailor's time-and-motion studies of industrial workers. Before World War II, the focus was mainly on letting humans adapt to the machines, while during and after World War II, attention was drawn to the design of machines that could fit with humans (Shaver 2009). One reason for this shift in perspective was the realisation that simple design flaws caused disastrous outcomes and unnecessary deaths during the war (Grudin 2005; Shaver 2009).

Much of the early human-factor research concentrated on interfaces for use in control rooms and in the monitoring of manufacturing processes. Many laboratory experiments measuring psycho-physiological reactions (such as blood pressure, pulse etc.) were conducted. The early human-factor research resulted in many guidelines and checklists for creating effective user interfaces in these environments.

During the 1960s and 1970s, information technology was spreading fast. Around the same time, developers began to take advantage of psychological research in the design of computer systems. In this period, the focus was on the psychology of programmers, because most people who used computer systems at that time were programmers (Baecker et al. 1995 p. 41).

In the 1970s, there was a gradual building of the awareness that there was a need for effective human–machine interfaces for non-programmers. The personal computer was emerging as a tool for workers – primarily for office workers. The work at IBM and Xerox Palo Alto Research Center in this period was crucial, especially regarding the concept of the “personal workstation” (Baecker et al. 1995 pp. 42-43).

In the late ‘70s and early ‘80s, communities focusing on improving human factors in computer systems expanded rapidly. Laboratory experiments were conducted to improve performance. The focus was on optimising displays and commands, reducing the number of required keystrokes and shortening execution times (Rosson & Carroll 2001). The development of computer systems at this time built on a mechanistic world view, were the focus was on rationalisation, efficiency and control (Bansler 1989). Organisations were considered as machinery and the people who worked there were considered as “system components”. This view on systems development eventually got much of the same criticism as Taylorism and “scientific management”. It became clear that the optimisation of human performance and reliance on formal laboratory experiments was too narrow an objective, and that this would not necessarily produce interfaces that were easy or satisfying to use (Rosson & Carroll 2001). Moreover, the skills and competencies of the workers were not valued in the Tayloristic world view (Bansler 1989).

During the ‘80s, socio-technical ideas therefore received more attention within the research on systems development, and new research fields emerged, such as STSD (Mumford 2000; Mumford 2006) and PD (Bjerknes & Bratteteig 1995; Ehn 1993). In this period, the focus of HCI shifted towards a more explicit focus on the user and the usage context (Karat & Karat 2003), and the concepts of usability and UCD were developed (Constantine & Lockwood 2000; Norman 1983; Svanæs & Gulliksen 2008).

The HCI field was influenced by the socio-technical and PD communities, and these ideas started to appear in the HCI literature and conferences in the early ‘90s (Karat & Karat 2003). From mainly focusing on individuals in laboratory experiments, the focus shifted to groups of individuals in a work context, and the HCI researchers moved out of the lab and into organisations. Ethnographic methods became more common in the HCI field, and the field of computer support for cooperative work (CSCW) emerged (Bannon 1991; Karat & Karat 2003).

With the rapid developments within ICT, the increased access to the Internet and the broad availability of various types of devices and mobile technology, ICT solutions are increasingly used in our everyday lives, both at home and in public spheres. The technology development has changed from mainly industrial and commercial applications to everyday technology and applications for leisure and entertainment. ICT solutions are not necessarily regarded as tools, but can often be regarded as a social arena, a service or just as a part of our environment. This has meant a dramatic change in usage contexts. The HCI researchers’ focus has broadened to consider a range of additional factors that can contribute to the value of an ICT solution or artefact, such as our social life, culture, emotions, fun and aesthetics (Bødker 2006; Karat & Karat 2003). The more recent term, user experience (UX) design, has emerged as a response to these changes. This is a broad concept that encompasses all aspects of the user's interaction with a company and its products and services (Nielsen & Norman). However, the proliferation of technology in all areas of society are only reinforcing the need to make technologies accessible for more diverse user groups in multiple and diverse usage situations and for a variety of ICT equipment. These design challenges coincide with the design challenges of the IDAs.

Many researchers recommend, as mentioned in section 1.5.3, that inclusive design should be based on a UCD process involving people with impairments. The experiences that have arisen from design traditions that focus on user participation, such as STSD and PD, are therefore relevant to IDAs, as well as experiences from the UCD approach itself. In the following, I will give a more detailed background on these branches of HCI and then I will present the characteristics of various IDAs.

3.2 Socio-technical systems development

Socio-technical ideas were interlinked with action research ideas and can be traced to work at the Tavistock Institute during the '50s (Mumford 2006). Action researchers believed that the best way to study complex social systems, such as an organisation, would be to study them as a whole entity. The study of parts or single variables would not give satisfactory answers. As complex social systems consist of dynamic processes, action researchers contend that a fruitful way to study this is to introduce changes and then observe the effects of the changes (Baskerville 1999). The Tavistock pioneers believed that their research projects should not only be attempts at increasing knowledge, but that they should also embrace the idea of improving work situations that were unsatisfactory in human terms (Mumford 2006). This approach and methodology was called "socio-technical". The main idea was that the human aspects and the technical aspects were equally important in a socio-technical system.

When ICT researchers started to be concerned about job quality and satisfaction, they turned to these socio-technical ideas. One of the pioneers of STSD was Enid Mumford. She stated that if one does not explicitly design a system according to goals of job satisfaction, the effect of the system will be arbitrary and unpredictable (Mumford 1996). The result can be that the system produces undesirable human consequences, such as routine work and low-skilled jobs. While many HCI methods have focused on the individual, STSD focused on organisations and groups within organisations (Baxter & Sommerville 2011).

STSD also had an important democratic component; namely, that employees who used the new systems should be involved in determining the required quality of working-life improvements. However, the PD traditions in Scandinavia that emerged in the same period had an even more explicit emphasis on democracy. This will be described in the next section.

3.3 Scandinavian and participatory design

Even if the socio-technical principles became widely recognised among both managers and system developers, an objection was that these ideas had little impact on how systems were designed in practice (Bansler 1989). The socio-technical thinking was therefore criticised. The main critique was that the importance of economic, political and social forces behind technological development was underestimated. The socio-technical approach was built on the assumption that there is a harmonious relationship between workers and management, and that they mainly have common interests (Bratteteig 2003). Moreover, the socio-technical approach did not necessarily support democracy in the workplace. The introduction of semi-autonomous groups at Volvo Kalmar was described as an example of a socio-technical solution that did not change the power balance in the organisation. On the contrary, the vertical power structures and division of work was only further reinforced (Ehn 1993). It was concluded, therefore, that the socio-technical theory did not have enough impact. In practice, it did not have any democratisation effect, and it could even be manipulative (Bjerknes & Bratteteig 1995).

These were the main reasons why researchers in Scandinavia in the late ‘60s and early ‘70s developed an alternative approach to STSD; that is, a worker-oriented approach. This approach is denoted as the critical tradition, the collective resource approach or the Scandinavian design tradition (Bansler 1989; Bjerknes & Bratteteig 1995; Bratteteig 2003 p. 17; Ehn 1993; Kyng 1994). The advocates for the alternative approach did not criticise the socio-technical principles in themselves, but criticised the way in which they were advocated for (Grønvall & Kyng 2011). Scandinavian researchers argued that the importance of power and resources had been greatly underestimated in previous approaches. Therefore, the political aspects of technological development were emphasised, as well as structural rights to participation and democracy (Bansler 1989).

In parallel with the introduction of information systems in working life during the ‘60s and ‘70s, Scandinavian researchers therefore initiated systems development projects involving the trade unions (Grønvall & Kyng 2011). At the same time, the trade unions began to recognise the need to participate in systems development processes to be able to influence future systems (Berntsen et al. 2002). The collaboration between the national Labour Organisation in Norway, the LO (Landsorganisasjonen), the National Employers’ Federation, the NAF (Norsk Hovedorganisasjon), and researchers from the Norwegian Work Research Institute, the AFI (Arbeidsforskningsinstituttet) and the Tavistock Institute is an example of efforts towards working-life democracy and industrial productivity (Bratteteig 2003).

Researchers at Norwegian Computing Center (NR)[12] were, at that time, involved in several projects related to the development of better methods for systems development

[12] In Norwegian: Norsk Regnesentral (NR).

and training (Berntsen et al. 2002 p. 151). The Norwegian Union of Iron and Metal Workers (NFJM)[13] decided at their annual meeting in 1970 to collaborate with researchers at the NR on methods and strategies for planning, management and the handling of data, and they applied for funding to the Research Council of Norway (Berntsen et al. 2002). Through the NFJM project, a new strategy was developed: the "collective resource" approach (Grønvall & Kyng 2011). This built on the assumption that there is an inherent conflict in the relationship between capital and labour. In this approach, the unions played a central role, and researchers had the role of supporting the local unions. It became clear that in the struggle for democracy, it was necessary to strengthen the workers through strengthening their knowledge. The NFJM project and other union projects contributed to building the unions' expertise in these matters and helped them to make use of the new law, the Data Agreement, about participation in systems development. The Data Agreement came in 1975, and it regulated the rights for employees to participate and have some influence when new computer systems were introduced (Berntsen et al. 2002; Grønvall & Kyng 2011). Thus, principles of participation in systems development in a work context are enshrined in legislation and agreements.

The Nordic research project, UTOPIA, is often referred to as an example demonstrating that it is possible to find a solution that avoids deskilling when it is one of the objectives of the project (Ehn 1993; Garson 1995 p. 22). This project had a tool perspective. The focus was on how to develop a system that could function as a tool for its users. Moreover, it was an explicit goal to design tools that would increase the workers' skills. At a time and in an industry where other studies showed a tendency towards deskilling of groups of workers (e.g. typographers), the UTOPIA project managed to create solutions that strengthened these groups. The empowerment of the workers was seen as a key to democratisation in the workplace, and at the same time, it would contribute to high-quality results (Bjerknes & Bratteteig 1995; Ehn 1993).

> The democratic ideal is a beautiful human intervention: Every human should have the right to participate equally in decisions concerning his or her life. (Ehn 1993 p. 42)

The degree of actual influence and power varies in the Scandinavian traditions from this period. While the main objective of many researchers in Norway was first and foremost the democratisation of the workplace, researchers in Sweden placed a greater emphasis on job satisfaction and productivity (Ehn 1993). However, a common feature in all the Scandinavian traditions is the strong emphasis on user participation and influence during system development. Scandinavian design is a set of perspectives and practices for increasing the role of users as active participants in the process of designing computer artefacts so that they have a positive impact on the users' lives (both in and out of the workplace).

[13] In Norwegian: Norsk forbund for jern og metallarbeidere (NFJM).

Later, research on user participation in system development shifted from a focus on democracy to a greater focus on the system developer's ethical obligation to make good systems (Bjerknes & Bratteteig 1995). Democracy is seldom an explicit goal in PD projects today, where the focus is mostly on user participation and the resulting design (Kyng 2010).

The forms and degree of user involvement varied in the Scandinavian traditions, from representative users, to consultants, to collaborators (Bjerknes & Bratteteig 1995). The main thought was that the users of future system(s) were experts in their own work, and that their knowledge was needed in systems design. Moreover, involving users would contribute to the knowledge upon which the systems were built, would enable people to develop realistic expectations, and thus would reduce resistance to change (Bratteteig 2003).

3.4 User-centred design

User-orientation in system design is not a new idea, and can be traced to at least the mid-‘60s. In what Gould (1995) describes as an experimental paper from 1966 about empirical methods in system design, Gloria L. Grace observes that *"*User-oriented design has become an increasingly important feature for modern computer-based systems” (Grace 1966).

The term “user-centred design” (UCD) appeared in the early ‘80s (Baecker et al. 1995) and became widely used after the publication of the book entitled: “User-Centred System Design: New Perspectives on Human–Computer Interaction” (Norman & Draper 1986). Norman built further on the UCD concept in the widely known book “The Psychology of Everyday Things” (Norman 1988). Norman emphasised the importance of exploring the needs and desires of the users and the intended uses of the product.

Gould and Lewis (1985) are famous for introducing the three main principles of a user-centred approach (Sharp et al. 2006 p. 425), which are:

1. An early focus on users and tasks
2. Empirical measurement
3. Iterative design

With the first principle, to focus on users and tasks early on, Gould and Lewis (1985) emphasised that developers should understand users, rather than just identify them. This meant that they should have direct contact with users prior to designing the system. The second principle is a recommendation to make the intended or potential users use prototypes or simulations of the system to carry out real tasks, and to measure their performance and reactions. This user testing should be done as early as possible, and the system should then be redesigned to mitigate the identified usability problems. The cyclic process of prototyping, user testing and redesigning, should be repeated as many times as necessary. This is what is meant by principle three: iterative design. According to Gould and Lewis (1985), iteration is necessary because the design will never be right the first time. More recent texts also recommend incremental development in the iterations, allowing for refinements based on empirical evaluations with users (Gulliksen & Lantz 2000; Sharp et al. 2006 p. 428), and during the 1990s, most new development methods were iterative and incremental, acknowledging the instability of initial user requirements (Bygstad et al. 2008).

Along with increasing demands for usable ICT solutions, there was also an increasing demand for defining the concept of usability and developing usability measurement methods (Karat & Karat 2003). Various frameworks and models were suggested (Eason 1984; Madan & Dubey 2012; Shackel 2009), and usability was placed in a broader context of system acceptability; that is, whether the system is socially and practically acceptable (Nielsen 1993 pp. 24-25). Later, the definition of usability provided in ISO 9241-11:1998 by the International Organization of Standardization (ISO 9241-11 1998) was generally accepted and is frequently referred to (Alsos & Dahl 2008; Følstad et al. 2010; Gulliksen et al. 2003; Karat & Karat 2003; Keinonen 2008; Stephanidis et al. 1998; Svanæs & Gulliksen 2008). This definition reads as follows:

> Usability is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use. (ISO 9241-11 1998)

Usability assessment emerged as a discipline during the ‘80s, with dedicated conferences (Dumas & Salzman 2006). Empirical methods to evaluate and measure usability, such as usability testing, interviews and surveys were introduced in this period. Usability inspection has been a popular alternative to user testing because it is regarded as less resource intensive. Usability inspection is usually performed by one or more usability professionals inspecting the ICT solution with the aim of finding usability problems, often with the aid of guidelines and checklists (Nielsen 1994). During the last two or three decades, the usability measurement methods have been evaluated, refined and adjusted to be more efficient, cost-effective, manageable and reliable. Several studies to compare usability testing with inspection methods have also been conducted (Dumas & Salzman 2006; Fernandez et al. 2012; Følstad et al. 2010; Hwang & Salvendy 2010). Although these studies have revealed weaknesses regarding the validity of both usability testing and inspection, empirical usability testing is still regarded as the gold standard in usability evaluation (Dumas & Salzman 2006). However, it has been pointed out that usability testing does not uncover all usability problems and that this must be taken into account when comparing the two approaches (Dumas & Salzman 2006; Følstad et al. 2010; Hwang & Salvendy 2010). Researchers also recommend combining user testing with inspection methods because these methods are regarded as complementary (Hwang & Salvendy 2010; Nielsen 1994).

The need to involve actual users, often in the environment in which they would use the product being designed, was, according to Baecher et al. (1995), a natural evolution in the field of UCD. Early proponents of user involvement included both system developers and human-factor specialists (Grudin 1991). The motivation for involving users in the development process was mainly to increase usability and user acceptance.

A further development of these ideas is found in user-centred system design (UCSD) (Gulliksen et al. 2003). UCDS is user-centred and focuses on usability through the entire development process. Gulliksen et al. provide a quite elaborate description of UCSD, summarised as a set of principles. These are based on empirical research. According to Gulliksen et al. (2003), the key principles of UCSD are:

1. User focus: The goals of the activity, the work domain or context of use, the users' goals, tasks and needs should guide the development at an early stage.
2. Active user involvement: Representative users should actively participate, early on, and continuously throughout the entire development process and throughout the system lifecycle.
3. Evolutionary systems development: The systems development should be both iterative and incremental.
4. Simple design representations: The design must be represented in such ways that it can be easily understood by users and all other stakeholders.
5. Prototyping: Early on and continuously, prototypes should be used to visualise and evaluate ideas and design solutions in cooperation with the end users.
6. Evaluate use in context: Baselined usability goals and design criteria should control the development.
7. Explicit and conscious design activities: The development process should contain dedicated design activities.
8. A professional attitude: The development process should be performed by effective multidisciplinary teams.
9. Usability champion: Usability experts should be involved early on and continuously throughout the development lifecycle.
10. Holistic design: All aspects that influence the future use situation should be developed in parallel.
11. Processes customisation: The UCSD process must be specified, adapted and/or implemented locally in each organisation.
12. A user-centred attitude should always be established.

A central standard of UCD is ISO 9241-210:2010 Ergonomics of Human–system Interaction, Part 210: Human-centred design for interactive systems (ISO 9241-210 2010). In this standard, the term *human* is used instead of *user* to emphasise that it addresses a number of stakeholders, not just those typically considered as direct users of a system.

According to this standard, a human-centred approach should follow the following principles:

- The design is based upon an explicit understanding of users, tasks and environments
- Users are involved throughout design and development
- The design is driven and refined by user-centred evaluation
- The process is iterative
- The design addresses the whole user experience
- The design team includes multidisciplinary skills and perspectives

The human-centred design process is illustrated as a circular process (see Figure 4 below).

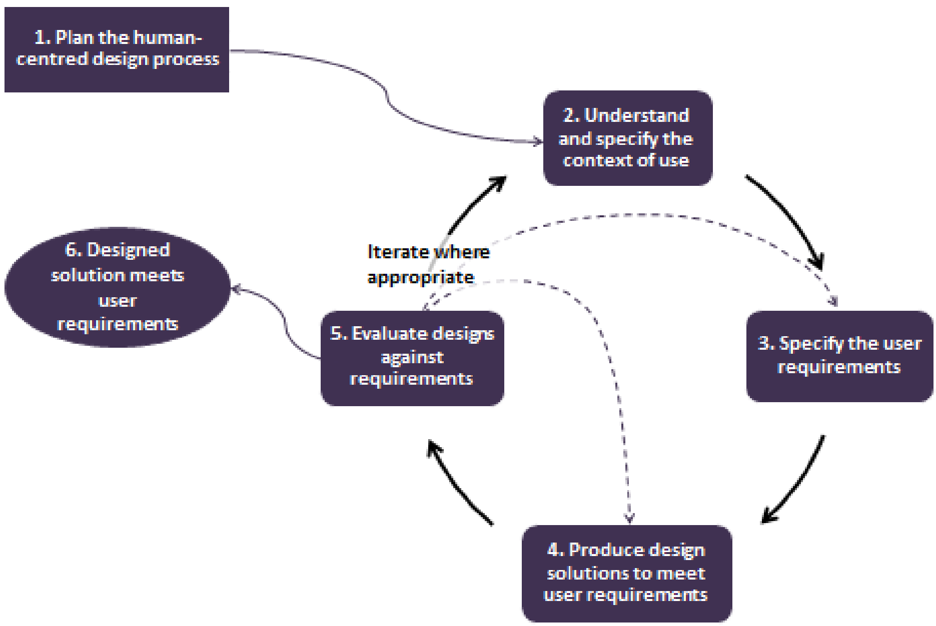

Figure 4: The human-centred design process (ISO 9241-210:2010).

The process has six main activities, and these are:

1. Plan the human-centred design process
2. Understand and specify the context of use
3. Specify user and organisational requirements
4. Produce design solutions
5. Evaluate design against requirements
6. ICT solution that meets user requirements

Activity numbers two to five are to be repeated as many times as necessary until the ICT solution has the appropriate quality and meets the user requirements.

UCD emphasises empirical evaluation with users. The development of prototypes, that is, an early version or sample of the solution that can be evaluated or tested by users, is therefore central to UCD. Prototypes can be characterised by their maturity level; that is, from low to high fidelity. A low-fidelity (lo-fi) prototype is quick, easy and cheap to make. The main purpose of lo-fi prototypes is to demonstrate design suggestions rapidly through tangible and testable artefacts. It is also an advantage that non-programmers can take part in the development of lo-fi prototypes (Egger 2000). Paper-based design sketches are commonly used as lo-fi prototypes in the early design phases.

High-fidelity (hi-fi) prototypes are at the other extreme. They are characterised by being hi-tech working prototypes with partial to full functionality. The advantage with hi-fi prototypes is that users can truly interact with them. However, they are more costly and time consuming to develop, and competence in programming is required. There is a continuum from lo-fi to hi-fi prototypes (Egger 2000). During a development process, the solution often evolves from being a lo-fi prototype, towards being an increasingly more hi-fi prototype, until it is a fully developed and final solution. It is advisable to use lo-fi prototypes to explore design alternatives and high-level design directions, whereas hi-fi prototypes are better for more detailed design decisions (Memmel et al. 2007).

3.5 User involvement

In the Scandinavian design projects, the development was conducted in a work-environment context, where the users were known from the outset of the project. Grudin (1991) characterises this as in-house development. He points out that the situation is different in the case of competitive bids for contract development, and for product development. In contract development based on competitive bids, the development is often done based on systems specifications and users are typically not a part of the development process, although they may have been involved in the systems specification phase. In product development, the actual users often remain unknown until the product is sold (Grudin 1991). Thus, the conditions under which to engage users will differ depending on the development context.

With the increased use of interactive systems and off-the-shelf products, the competitive pressure for usability and creating a great user experience has increased. The necessity of involving users in the development of interactive systems is now widely acknowledged (Boivie et al. 2006; Gould & Lewis 1985; Göransson 2004; Kujala & Kauppinen 2004; Kyng 1994; Rasmussen et al. 2011). It is recognised that *early* user involvement is most efficient and influential as the costs involved in making changes increase as the development continues (Abras et al. 2004; Kujala 2008). However, user involvement is practised to varying degrees. Users can be treated as anything from passive objects of study to fully empowered decision makers (Göransson 2004).

User involvement may be categorised in various ways. It can be characterised according to the influence that the users have on the design, and the responsibilities they are given in a development process (Stålbrôst 2008). One way of characterising user involvement is to place it on a continuous scale from *informative*, through *consultative* to *participatory* (Kujala 2008). On the informative end, users only provide information, while on the participatory end, they may participate actively in the development process and have a say in the decisions that are made. Users play a consultative role when they can comment on the design and make suggestion for improvements.

A common piece of advice in the literature is to involve *representative users* in the development process. However, there are several different interpretations of what this means and of what aspects are important when selecting and involving users (Kujala & Kauppinen 2004; Muller et al. 2001; Rasmussen et al. 2011).

One important distinction can be made according to whom the user participant is representing. User participants who only represent themselves participate at an *individual level*, while users who represent an organisation or a group of users participate at a *system level* (FFO 2000; NS 11040 2013). If a user has difficulties in participating and expressing his or her opinions (e.g. because of dementia), a relative or other caring person can sometimes represent this person on an individual level. A user representative at the system level is expected to have knowledge about the needs of the whole group that he or she represents. A system-level user participant should bring forward viewpoints from the group she or he represents, and provide feedback to the group. It is important that all parties are aware of the role of the user participants in this respect (NS 11040 2013). This means that whom the user is representing (himself or herself or a group) should be explicit, although this is often not the case. In the HCI literature, the term “representative users” often implicitly refers to users who participate at an individual level. In the PD literature, the term is often used about users who participate on a system level.

When developing ICT solutions for broad user groups, it will, in practice, not be possible to recruit a truly cross-sectional representative sample of users (Keates 2006; Kujala & Kauppinen 2004). Keates (2006) illustrates the difficulty of recruiting a sample of impaired users that reflects the variations in types and degrees in the real world by drawing on an example. In this example, he makes the assumption that for three categories of capabilities involved in an interaction (vision, hearing and dexterity), one might say that ten degrees of impairment and variations could be sufficient as a representative sample. Then, if five users are required for each degree of impairment, and taking into account interaction effects between the three types of disabilities and the 10 degrees of impairment, the number increases exponentially ($5*10^3$), and around 5000 users would be necessary. The conclusion is that it is not possible to recruit anything near a representative sample (Keates 2006).

While Kujala and Kauppinen (2004) suggest a process for identifying and selecting representative users, Rasmussen et al. (2011) argue that it is particularly important to have user participants who are able to advocate for the needs of the whole group that they represent. They appreciate the fact that usually it will not be possible to involve a truly representative sample of users. Therefore, the role of a user representative is as much about empathy as about knowledge. Without considerable empathy, it will not be possible for a user representative to advocate convincingly for needs that differ from their own needs.

Another categorisation of representative users is provided by Muller et al. (2001). They identify and compare six different interpretations:

- Statistical average user: One stands for all. In this interpretation, the representative user is selected so that the important user characteristics, and possibly usage settings, are average in terms of the target user population of the ICT solution in question.
- Statistical stratified sample: Range of users. In this interpretation, the target population is divided into subpopulations (stratums) according to a range of important user characteristics. User participants are selected to cover this range, and the size of the sample from each subpopulation reflects its relative proportion to the whole target population.
- Grounded theory: Sampling for diversity. In this interpretation, the sampling of users continues across multiple persons in the target population until the researcher is satisfied that the important sources of heterogeneity are exhausted and thus that the important user characteristics are represented and covered.
- Participatory design: Political delegation. In this interpretation, the user representative is chosen by other users to represent their interests in the design process.
- Persona. In this approach, one or more personas are produced to serve as the representative users. Personas are in-depth descriptions of fictive, but typical users. The personas are often created through a process that utilises various types of knowledge about the user population in question, e.g. from observations, previous encounters, interviews and surveys.
- Extreme characters. In this approach, fictive descriptions of untypical users that may challenge the design are developed.

In the first four of these interpretations, actual people are selected to represent users in one way or another, while the last two interpretations refer to fictive user descriptions.

Another aspect of user involvement that should be considered is to what extent each user is involved. In a study of user involvement in UCD (Lai et al. 2010), it was found that quantity with regard to user involvement is not necessarily linked with quality of the design outcome; that is, it is not necessarily the case that the more the user contact, the better. The way in which users are involved also matters. The findings indicate that it may be better to have a user participant for a longer time and to get feedback through several development iterations of a solution from the same user, than to have new participants all the time (Lai et al. 2010). Others have also found a very limited effect from short-term participation (Rasmussen et al. 2011). However, involving users on a full-time basis in a project may turn them into domain experts rather than representative users, and therefore it is important to involve users on a temporary basis as well as on a long-term basis (Gulliksen et al. 2003).

To what extent users are involved will be determined by the applied theory and advice, and not least by the practical considerations and constraints in each case. This will be discussed in the next section. Studies of practices in industry suggest that user involvement is more of an ideal than the reality (Bygstad et al. 2008).

3.6 Barriers to user-centred design and user involvement

Despite much research within the area of UCD and quite detailed guidelines, such as the UCSD principles and the mentioned, standard human-centred design process (see section 3.4), many new ICT systems and web services are delivered with major usability flaws. The UCD methods and techniques are often not properly applied (Bygstad et al. 2008; Svanæs & Gulliksen 2008). A reason for this may be that there are a lack of usability experts and that the principles of UCD are not fully understood (Boivie et al. 2006).

Another reason might be that the principles of UCD can be difficult to implement in organisations. For example, Cajander (2011) found that the concept of iterative development is not always fully understood. In addition, it can be difficult to incorporate an iterative process into a development organisation if it does not fit well with the organisation's project management methods or business plans. Therefore, it is an essential task to establish and enmesh a user-centred process into the general development process. Moreover, it has been found that management support and commitment among the stakeholders are necessary preconditions for being able to conduct a user-centred process (Gulliksen & Lantz 2000).

Various challenges in relation to user involvement have also been documented, not least when developing mainstream ICT solutions for the general market (Bak et al. 2008; Bygstad et al. 2008; Grudin 1991; Kujala 2008). As mentioned, the type of development, whether it is in-house, contract development or product development, influences the possibility of involving users (Grudin 1991). Tight delivery deadlines may be another important obstacle (Bygstad et al. 2008). Additionally, when the target user group is very inhomogeneous, there is a need for more guidance on how to treat representativeness, for example, what characteristics are important when selecting users (Baxter & Sommerville 2011; Kujala & Kauppinen 2004; Rasmussen et al. 2011).

In general, there is a range of issues surrounding a project that can influence the possibility of carrying out UCD. Svanæs and Gulliksen (2008) propose using the concept of "context of design" to denote such boundary conditions that may constrain the development process. They suggest analysing the context of design to enable the better tailoring of UCD activities into the development process.

In summary, although there are different interpretations of what UCD means, such as which users, and to what extent the users should be involved in the development process, the principles of UCD originally provided by Gould and Lewis and further developed, detailed and visualised in ISO 9241-210-(2010), are generally accepted as the best practice for the development of interactive systems. In spite of this, it seems that UCD is seldom applied according to this best practice in industry.

3.7 Inclusive design approaches

In section 1.2, I list several terms and design approaches that I have gathered under the label of inclusive design approaches (IDAs). While these approaches have a common goal of designing for diverse user groups, they may have varying perspectives and emphasize somewhat different aspects. In this section, I will give some background on some of these terms and approaches, and try to highlight some of their specifics.

The term “universal design” (UD) had its origin in the USA, while the term “Design for all“ (DfA) is widespread in Europe. “Inclusive design” is frequently used in Britain and Ireland (Darzentas & Miesenberger 2005; Keates et al. 2004). Countering design exclusion, user-sensitive inclusive design and ABD are newer approaches with their origins in the UK.

3.7.1 Universal design

UD has been briefly introduced in section 1.3 because the empirical work of this thesis has been performed in Norway where this term is used.

The term UD was introduced in 1985 in an article by Ronald Mace (Vavik & Gheerawo 2009). Mace’s pioneering work within accessibility and what he termed UD formed much of the basis for legislation that prohibits discrimination against persons with disabilities, such as the Fair Housing Amendment of 1988 and the Americans with Disabilities Act of 1990 (Center for Universal Design 2010). In 1989, Mace established the Center for Accessible Housing, currently known as the Center for Universal Design, in the School of Design at North Carolina State University in Raleigh (Center for Universal Design 2010).

3.7.1.1 Definitions of universal design

The definition of UD developed by the architect Ronald Mace at the North Carolina State University Mace is widely known and adopted in many fields, including, more recently, in the design of ICT:

> Universal design is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. (CUD 1997; MD 2007)

The definition is normative and provides a framework for specifying the qualities of products and environments, such that these may be used by all members of society on an equal footing.

In the Norwegian legal definition (see section 2.4), the requirements can be interpreted as having been reduced somewhat from being “usable for all people, to the greatest extent possible” to “can be used by as many as possible”.

In UD, a holistic view is taken (MD 2007), meaning that an individual UD solution is assessed in an overall context (e.g. corresponding to the individual’s meeting with society in the disability gap model described in section 2.1.1 and to the concept of combined capabilities in the capability approach in section 2.1.2). It is stated that the concept of UD incorporates a stronger focus on equality than is implied in the concept of “accessibility for persons with reduced functionality”:

> While it is possible to obtain accessibility for persons with disabilities by means of specially-targeted solutions, the universal design principle stipulates that the primary solution must be designed to anticipate the needs of all users. (MD 2007)

The definition of UD in the Convention on the Rights of Persons with Disabilities is similar to the original definition (CUD 1997), except that it includes a sentence about assistive devices:

> “Universal design” means the design of products, environments, programmes and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design. “Universal design” shall not exclude assistive devices for particular groups of persons with disabilities where this is needed. (UN 2006)

The inclusion of assistive devices in this definition acknowledges that it may be necessary (at least in the current situation), to combine UD and ATs to close the disability gap (see the disability gap model in section 2.1.1).

The seven principles of UD developed by a group of architects, product designers, engineers and environmental design researchers at the North Carolina State University is a central part of UD as a concept. (A full and detailed version of the principles can be found in Annex B). These principles represent the main qualities that a universally designed solution should fulfil. They are generic, and they are adopted within a wide range of design disciplines, from architecture and product design to the design of ICT products and services.

The definitions of UD have a strong focus on equitable solutions before special solutions, and on usability for all people. This is also reflected in the seven principles of UD (see also section 1.3.), where Principle 1 is about equitable use, and Principles 2–7 can be seen as different aspects of usability, although Principles 6 and 7 are more directed towards the physical properties of a solution.

3.7.1.2 *Universal design as a process*

In a concept-clarification document from the Norwegian Ministry of the Environment (MD 2007), it is underscored that UD is a strategic approach. It is an approach and a strategy to design products and services in such a way that they can be used ideally by all people, regardless of their age, training and (dis)abilities. UD involves the planning and the process of designing products and environments. The overall goal is to achieve an inclusive society that ensures full equality and participation for all. The document establishes the importance of user participation in the development process and encourages the involvement of a wide array of users from various types of user groups. Moreover, it is stated that relevant special-interest organisations should be key partners in the development processes, and a democratic decision-making process is advocated for:

> The universal design strategy necessitates cross-disciplinarity in planning, follow-up, implementation, and assessment activities. Appropriate processes for participation are needed to encourage the involvement of a wide array of users, and such processes play a fundamental role in promoting democratic decision-making. Universal design thinking does not necessarily entail the establishment of new work procedures, but requires broad participation from NGOs and various types of user groups. Insight from persons with disabilities is of central importance, and relevant special interest organisations thus comprise a key partner in development processes and quality control of solutions. (MD 2007)

3.7.1.3 *Universal design and democracy*

In the discussion and development of the UD concept, there is also a clarification of the principle of equality (Aslaksen et al. 1997b). The principle of equality is expressed in the goal whereby all physical products and the environment in the broadest sense should be usable by all people. This is based on the requirement that all people should have the same opportunities to participate in various areas of life, relating to, for example, education, work and leisure (Aslaksen et al. 1997b). It is emphasised that it is not satisfactory to refer specific groups to special solutions, making it explicit that UD is highly preferred to ATs. Equality implies that everybody should be entitled to access the same services.

Aslaksen et al. (1997b) point out that the development of the UD concept in many ways is a further development of democracy, with a strong emphasis on the rights of the disabled. They maintain that there are clear parallels to the work on gender equality and the work on equality between people of different ethnic backgrounds (Aslaksen et al. 1997b).

For UD to be a strategy to strengthen democracy, it should build upon a relational model of disability, where both environmental and individual factors are included. Lid (2012) argues that it is important to take into account the complex interplay of political, social, environmental and individual factors that contribute to disability and discrimination. As an analytical tool to analyse this complex phenomenon, she suggests that it can be useful to differentiate between the micro, meso and macro level (see **Table 4** below).

The individual experience; that is, to what extent a solution is accessible and usable for a particular person, can be analysed at a micro level. Project-related issues, such as what technical standards and approaches to follow, can be analysed at the meso level, while politics, legislation and social justice is influenced at a macro level (Lid 2012). Different factors come into play on the different levels, and using these levels in the analysis may help to encompass the complexity of UD as an approach to achieve equality and democracy.

Table 4: Analysing universal design according to various societal levels, adapted from Lid (2012)

Macro level	Societal level: concepts of humans, politics, legislation and social justice
Meso level	Project level: the development process, context of design and technical standards
Micro level	Individual experience: usability and accessibility

When it comes to the UD of ICTs, there are also clear parallels to the Scandinavian systems development tradition, where democracy and user involvement are important elements. With this approach, user participation and knowledge are regarded as essential for improving working-life democracy and for producing products of higher quality (Bjerknes & Bratteteig 1995; Ehn 1993). Similarities and differences in this approach are discussed further in the next section.

3.7.1.4 Parallels in participatory design and in universal design

The PD research in information systems originated in studies carried out primarily in Scandinavia and Britain, and later on in the United States. The European PD approaches can be divided into two main traditions: the collective resource approach or the Scandinavian design approach adopted in Scandinavia, with an emphasis on union and worker empowerment (see section 3.2 Socio-technical systems development), and the socio-technical approach in Britain (see section 3.2 Socio-technical systems development). The latter focused on autonomy in workgroup organisations through power sharing, joint responsibility and multiple leadership (Byrne & Alexander 2006).

In very much the same way as in the early PD traditions, “participation” in UD is viewed both pragmatically and ideologically; that is, as something that helps efficiency, satisfaction and progress, but also as something which is morally right (Byrne & Alexander 2006). Thus, UD can be said to help efficiency in society at large, but is also the morally correct thing to do. In the early work on defining and clarifying UD, the democratic ideals and human rights perspectives were important. Moreover, the process view is underscored by pointing to the importance of user participation and of continually evaluating the solution against the seven principles of UD, from project inception to the final result (Aslaksen et al. 1997b).

One argument that is often mentioned in relation to UD is that there may be conflicting interests between different groups of the disabled. Actually, this does not only apply to people with different types of impairments, but between various groups in general. When planning solutions for the entire population, the considerations of the disabled are central, but not sufficient (Aslaksen et al. 1997b). These considerations must also be seen in relation to the needs and desires of the rest of the population, whether they are children, the elderly, women or men, or people with different ethnic backgrounds and traditions. Therefore, one must be aware that there may be different interests and conflicts in UD regarding the environment (Aslaksen et al. 1997b). PD has paid particular attention to the aspect of how to handle conflicting and different interests in the design process. The lessons learned in PD may therefore be of particular interest for UD. While there has been a focus on guidelines in accessibility research, it seems that more and more researchers are realising that this is too simplistic; thus, the emphasis on UCD. Some go further and use the same type of argumentation as can be seen in the PD literature:

> Accessibility is a property of the relation between the user and the resource in the context of how that is mediated; not a property of the resource. Accessibility must be situated within a real-world context, and acknowledge the unequal power structures that constitute disability and accessibility. (Cooper et al. 2012)

UD challenges are related to how to get disabled people represented and how to get the most vulnerable groups to speak. There are also ethical (and validity) questions with regard to letting one person or even a few persons represent a group. How participants are included in the research (i.e. whether they are self-selected or whether they are elected, or appointed by an organisation or otherwise) is important in terms of both the ethical considerations and in terms of how we can regard and interpret the outcomes. These issues have been discussed previously (Kraft & Bansler 1994; Svanæs & Gulliksen 2008).

There are important differences between UD and PD as well. One such difference is the fact that much of the early PD work was related to developing technology within organisations and in a work context. There are not so many examples of the PD of ICTs outside of the work context (Byrne & Alexander 2006). Another difference is the focus on involving disabled people.

Therefore, a particular challenge of applying PD in a UD context is that many of the tools referred to and used in previous PD research (and in UCD research for that matter), will work best for people without impairments. For example, low-fidelity prototypes such as paper mock-ups would typically not work very well with visually impaired people. However, the recommendation of Pelle Ehn is still valid:

> To make real user participation, a design language-game must be set up in such a way that it has a family resemblance to language-games the users have participated in before. (Ehn 1993 p. 74)

This could mean that since the language of visually impaired people (as an example) is largely based on audio or tactile communication, design activities involving them should be based on these communication means.

3.7.2 Design for all and inclusive design

Design for all (DfA) is, according to the European Design for All and e-Accessibility Network (EDeAN), a European term that promotes inclusion, equality and socially sustainable development. The purpose of DfA is to support access to the environment, the usability of products and access to services. It refers to a process of ensuring that products and environments address users, irrespective of their age or ability, and to a process that has a focus on user involvement. The EDeAN was initiated by the EC in 2002, in accordance with one of the specific goals of the eEurope 2002 Action Plan (EDeAN).

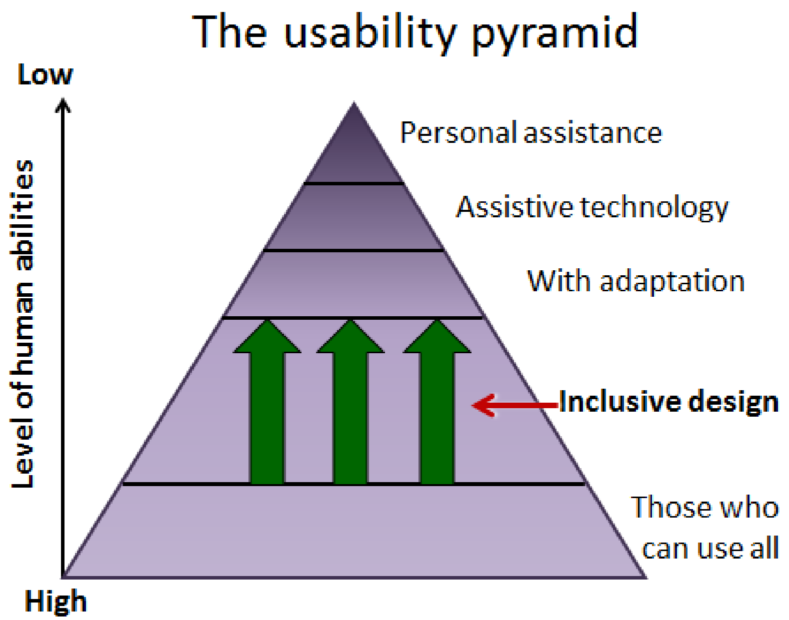

Figure 5: The usability pyramid based on Nordby (2003).

The role of this network, which organises more than 160 organisations in the EU, is to increase awareness about DfA, to facilitate idea sharing between scholars and to provide DfA teaching and academic resources (EDeAN). DfA is regarded as a graded concept that allows for adaptation and usage of ATs (Darzentas & Miesenberger 2005). Darzentas and Miesenberger point to the usability pyramid (see **Figure 5)** to illustrate this point. Knut Nordby, a deceased Norwegian psychologist who contributed greatly to European standards within the DfA area, has been credited with this model (Nordby 2003; Nordby 2004).The usability pyramid illustrates access levels in relation to ICT solutions, and the whole pyramid represents all people. When moving from the base of the pyramid to the top of the pyramid, the ability level changes from very high to very low. The wide area at the base of the pyramid represents people who can use ICT solutions that are designed without any special thought regarding diversity. The next level, above the base level, represents people who can use ICT solutions that are inclusively designed.

The green upward arrows in this area illustrate that the aim of inclusive design is to include as many people as possible while moving upwards in the pyramid. The next level illustrates those individuals who need to adapt to the technology to be able to use it, such as getting up very close to read a display, memorising a sequence of actions, or using notes or other aids in memorising passwords. The next level represents people who cannot use mainstream technology without some form of AT, and the final top level represents those individuals who cannot use ICT solutions without assistance from other people.

I have intentionally included a pyramid (upside down) in the disability gap model (see **Figure 3** on page 17) to show the parallels between the disability gap model and the usability pyramid. Both models are discussed by Nordby (2004), and I believe that Nordby based the usability pyramid on the ideas in the disability gap model. He argued that as the product complexity increases and the user specialisation diminishes, we witness a widening usability gap. This usability gap creates disability because people will not be able to use basic tools and services without usability. With the name of his model (i.e. the usability pyramid), Nordby emphasised the role of usability in inclusive design, and thus its role in closing the disability gap.

3.7.3 Universal usability

Usability is also emphasised by Shneiderman (2000), who calls for *universal usability* (UU). The focus of UU is to design products so that they are usable by the widest range of people operating in the widest range of situations as is commercially practical (Vanderheiden 2000). Vanderheiden (2000) demonstrated that there is a connection between UU and the design for various situations, and that for every type of disability, there is a situation with constraints that would produce similar requirements. I have elaborated on this in Paper A.

More than ten years ago, Vanderheiden (2000) identified 200–300 resources and strategies for making products more accessible. The number of such resources has only increased since this work was carried out. This is overwhelming for designers. They have to prioritise both from among sets of guidelines and from among the guidelines within each set. Vanderheiden (2000) therefore outlined an approach for helping designers to prioritise features in a product from among the various dimensions of accessibility and usability issues. This important work has become the basis for better guidelines in terms of priority levels, such as in the web content accessibility guidelines (WCAG).

Moreover, Vanderheiden (2000) points out that because of the multi-dimensional nature of disability and the vast number of guidelines, it is essential to be able to prioritise between the different requirements and features. He therefore puts forward a framework to guide such prioritising activities. This framework is divided into several dimensions:

- Accessibility and usability: To what extent are the features usable or not for certain user groups or in some situations?
- Independence vs. co-dependency: To what extent does the user need assistance to be able to use a certain feature?
- Efficiency and urgency: How often will it be necessary to use the feature and how urgent is it to be able to use it?
- Effect of features vs. cost of implementation: To what extent are the costs of implementing a feature offset by its benefit to the market?

Vanderheiden (2000) characterises cognitive constraints as a unique dimension from the dimensions above. The reason is that while it is possible to make most products usable for individuals with no vision, hearing or even with no physical abilities, there are very few products, if any, which are usable by individuals with no cognitive abilities. The strategies to increase cognitive access will therefore be characterised by facilitating access in different ways. Each technique that can facilitate cognitive access may push a few more people over the threshold and into the category of individuals who are able to use a product. Cognitive accessibility is therefore a more graded concept than accessibility for the sensory or physically impaired.

3.7.4 The relationship between usability and accessibility

Sometimes accessibility is divided into two aspects: technical accessibility and usable accessibility (Paddison & Englefield 2003). Technical accessibility can be achieved by conformance to accessibility guidelines and various standards. This can, to a certain extent, be tested through accessibility tools; that is, by software tools that check for conformance to such standards and guidelines (see more about this in sections 3.7.5 and 3.7.6). The main goal of technical accessibility is to ensure that it is possible for people with disabilities to access and perceive the information in an interface.

Usable accessibility ensures that the solution is usable for people with disabilities. It can be achieved by applying good usability principles, such as applying usability guidelines and UCD. An important element in UCD is evaluation with users. Therefore, a number of researchers advise complementing the application of accessibility guidelines and standards with user testing involving disabled users (Arrue et al. 2007; Billi et al. 2010; Petrie et al. 2006; Rømen & Svanæs 2011; Theofanos & Redish 2003).

Rømen et al. (2011) point out that the definitions of accessibility in the world wide web (W3C) web content accessibility guidelines (WCAG) version 2.0 (W3C WCAG 2.0 2008) and in the International Standardisation Organisation standard no. 9241-171 (2008) are different. According to WCAG, a website is accessible ‘‘when people with disabilities can use the Web”. According to the mentioned ISO standard, accessibility is usability for people with the widest range of capabilities. One difference between the definitions is that while the WCAG only requires the possibility for disabled people to be able to use the Web (i.e. “can be used”), ISO explicitly requires usability for people with the widest range of capabilities. This definition is also similar to the definition of UD. (See also the definition of usability in section 3.4.) However, WCAG continues by saying that “More specifically, Web accessibility means that people with disabilities can perceive, understand, navigate, and interact with the Web, and that they can contribute to the Web”. Being able to perceive, understand, navigate and interact are, in fact, important elements of usability. The problem is that the WCAG 2.0 guidelines per se do not put any weight on methods to achieve usability, although the benefits of involving users are actually described on the W3C Web pages (W3C WAI Users 2005).

3.7.5 Accessibility

According to “Guidelines for standardization to address the needs of older persons and people with disabilities” (ISO/IEC Guide 71 2001), accessible design may be achieved in three ways,

1. By designing products, services and environments that are readily usable by most users without any modification;
2. By making products or services adaptable to different users (adapting user interfaces); and
3. By having standardised interfaces that are compatible with special products for persons with disabilities (such as ATs).

Some people with disabilities are dependent on using specialised software, called AT, along with mainstream ICT solutions to benefit from these. A typical example is a blind person using a braille display (see **Figure 1**). Another example is text-to-speech software for dyslexics. The various definitions of accessibility and UD often lead to a discussion about where the boundaries are between universal or inclusive design, accessible design and AT.

Accessible design is a subset of UD (ISO/IEC Guide 71 2001). While the emphasis of accessible design is on enabling access for the elderly and people with disabilities, UD has a more pronounced emphasis on designing products and environments to be usable by all people without the need for adaptation or specialised design. The distinction can be interpreted as UD having an ideal of equality, where the ultimate goal is to make the main solution accessible to all users, while accessibility is more pragmatic, and can be achieved in various ways, through DfA, adaptation or specific solutions.

However, a mainstream solution that is accessible for a user only if used together with certain types of AT, such as a screen reader, is often accepted as being universally or inclusively designed. Thus, since it is accepted that UD does not exclude the use of AT when needed (see the UN definition in section 3.7.1.1 above), the concepts are rather overlapping in practice.

Interoperability between system components, such as operating systems, browsers, software and hardware, ensures that these components can work together. If one aims at accessibility by means of a combination of a mainstream solution and AT, interoperability between components of ICT solutions and AT is critical. Some even regard the lack of such interoperability as the biggest accessibility barrier (E-Access Bulletin 2011). Interoperability is achieved by using open standards, formats and protocols, which allow the various components to work together.

Although the role of accessibility standards and guidelines (see the next section) has been rather prominent within the accessibility literature, and particularly in the web accessibility literature, several authors point to the need for more holistic approaches (Hailpern et al. 2009; Kelly et al. 2009; Leahy & Broin 2009; Milne et al. 2005; Sloan et al. 2006).

3.7.6 Standards and guidelines

Adherence to standards and guidelines is a frequently mentioned approach in IDAs. Guidelines from W3C's WAI are frequently referred to. The most widely accepted standard in this area is the W3C WCAG, adopted as an ISO/IEC International Standard (ISO/IEC 40500:2012) in October 2012. The W3C authoring tool accessibility guidelines (ATAG) and the user agent accessibility guidelines (UAAG) are examples of other important guidelines from WAI (E-Access Bulletin 2011). Other important international standards are CEN/CENELEC Guide 6: Guidelines for standards developers to address the needs of older persons and persons with disabilities. This is identical to the ISO/IEC Guide 71.

Several standards in the ISO 9241 series have high relevance, such as Part 20: Accessibility guidelines for information/communication technology and Part 171: Guidance on software accessibility. These standards cover issues associated with designing accessible web applications and software for people with physical, sensory and cognitive disabilities. Following accessibility guidelines, for example, to ensure that "alt" tags are labelled appropriately and that text size is relative rather than fixed, can be regarded as good software-engineering practice because it usually results in more robust ICT solutions (Paddison & Englefield 2003).

However, a number of authors have noted that following standards and guidelines is not enough to achieve accessible and universally designed solutions (Arrue et al. 2007; Billi et al. 2010; Petrie et al. 2006; Rømen & Svanæs 2011). There are a number of possible reasons for this. First, accessibility guidelines tend to provide general principles rather than contextual and specific instructions. Second, designers who are required to follow specific accessibility standards or guidelines may not understand the underlying accessibility issues. Trying to follow accessibility guidelines without understanding why is both frustrating and ineffective. A third problem is that accessibility guidelines and standards often have poor usability with regard to their intended audience; namely, the system designers (Law et al. 2008). Fourth, the designers face the challenge of prioritising between a large and growing number of standards and guidelines (see section 3.7.3).

One can also use accessibility evaluation tools to check whether web pages conform to the WCAG guidelines. These tools are software programs or online services that can be used to determine whether certain guidelines have been fulfilled. A list of such tools can be found at the W3C web site[14]. Today, these tools can automatically determine conformance to parts of the WCAG 2.0 guidelines. Thus, they offer a quick way to identify potential accessibility flaws, but there are still a number of manual checks that must be performed as well.

One problem is that the results of manual conformance evaluations differ considerably, even with experienced evaluators. In a study with 25 experienced accessibility evaluators and 27 novices, it was found that two experienced evaluators would only agree on average to slightly more than half of the WCAG 2.0 success criteria (Brajnik et al. 2012). They also found that untrained designers, developers or software quality auditors missed many accessibility barriers and the ones that were found were highly inaccurate. Therefore, Brajnik et al. (2012) assert that untrained professionals cannot reliably determine whether pages are conformant to WCAG 2.0 or not. This result indicates that there are similar problems with reliability in accessibility inspection using WCAG 2.0, as have been found with various usability inspection methods (see section 3.4 User-centred design). The divergent results from these evaluations are problematic when legislation requires WCAG 2.0 conformance.

Another problem with relying on standards and guidelines is that a solution that conforms to the accessibility guidelines, to the extent that such conformance can be established, may be technically or “theoretically” accessible, but at the same time, the solution may be so difficult to use for certain user groups that it is hard or even impossible to use in practice (Gunderson 2009; Theofanos & Redish 2003). Guidelines and standards are helpful in removing many accessibility barriers, but they need to be complemented with other methods (Arrue et al. 2007). Therefore, many researchers have arrived at the conclusion that in addition to conformance with accessibility guidelines, inclusive design needs to be based on principles of UCD (Arrue et al. 2007; Kelly et al. 2009; Paddison & Englefield 2003).

However, as pointed out in section 1.5.3, it is not straightforward to accommodate the vast diversity of users in UCD. The current UCD methods therefore need to be extended to support the development of inclusive technology (Gregor et al. 2002; Stephanidis 1999). Areas that need to be extended and further developed include incorporating social context in the analysis, facilitating the involvement of users with disabilities, supporting requirement engineering methods that can facilitate the elicitation of requirements in

[14] http://www.w3.org/WAI/RC/tools/

novel contexts of use and with different user groups and investigating multimodality (Stephanidis 1999). The Norwegian process-oriented standard for universal design and user participation (NS 11040 2013) address the need for involving users with disabilities. This standard is based on the UCD process described in ISO 9241-210 (ISO 9241-210 2010).

UCD does not assume a particular development process and it does not describe how to ensure effective systems design (ISO 9241-210 2010). A broad range of development methods are used in the industry and UCD can be integrated into different development processes, although this can also be challenging (see section 3.4). Design for accessibility can also be integrated into various design processes. Zimmerman and Vanderheiden (2007) describe a way to include design for accessibility into a general development process. The main idea is to introduce accessibility checkpoints into the overall development process by relating specific accessibility guidelines to existing tools, such as use cases, scenarios and personas. They also recommend complementing this with expert reviews and user testing. This is therefore an example of extending an existing development process by integrating ideas from UCD and accessibility. In the next three sections, IDAs that can be said to be extensions of UCD are described. These are countering the design exclusion (see section 3.7.7), user-sensitive inclusive design (see section 3.7.8) and ability-based design (see section 3.7.9).

3.7.7 Countering design exclusion

The aim of countering the design-exclusion (CDE) approach by Simeon Keates and John Clarkson is to design more inclusive products and services. A central theme in this approach is to raise the designer’s awareness of barriers to a product to avoid exclusion that is due to subconscious biases and assumptions about users’ capabilities.

This approach is an extension of traditional UCD (Keates, S. & Clarkson, P. J. 2003). However, the traditional UCD approaches rarely address the functional capabilities (physical, sensory, cognitive) of their users explicitly. The basic assumption in CDE is that products exclude users because their features do not match user capabilities. Keates and Clarkson (2003 p. 69) suggest the following definition of inclusive design: An inclusively designed product should only exclude the users that the product requirements exclude.

In other words, if the product requirements do not exclude specific user groups, the actual design should not do so either.

To be able to estimate the level of exclusion of a product, it is necessary to assess what capability demands are placed upon the users by the various features of the product. By combining the capability demands of a product with functional-capability data about the target population, one can estimate the numbers of people excluded by that product in relation to the intended target population.

This approach means that designers must be provided with detailed information about the functional capabilities and the spread of those capabilities throughout the general population. Such information can generally be obtained from survey data about the prevalence of disabilities and there are several sources of such data. The appendix in Keates and Clarkson's book, "Countering design exclusion, an introduction to inclusive design", contains a comprehensive set of capability data based on a survey about disabilities in the UK.

It is also necessary to be specific about what is meant by the target population of a product. The WINIT population scale (see **Figure 6**) is a tool to help designers to be clear about what the intended target population of their product is, so that they will be able to estimate the level of inclusion or exclusion in a product. The population definitions in the WINIT scale are:

- Whole population – everyone;
- Ideal population – the maximum achievable, i.e. the theoretical best possible product;
- Negotiable maximum population – everyone included by the specification. It is negotiable because the specification may change during the development process;
- Included population – those who can actually use the product. This can be assessed as soon as prototypes exist of the product; and
- Target population – those who were intended to use the product. This can be particular socioeconomic groups based on marketing strategies.

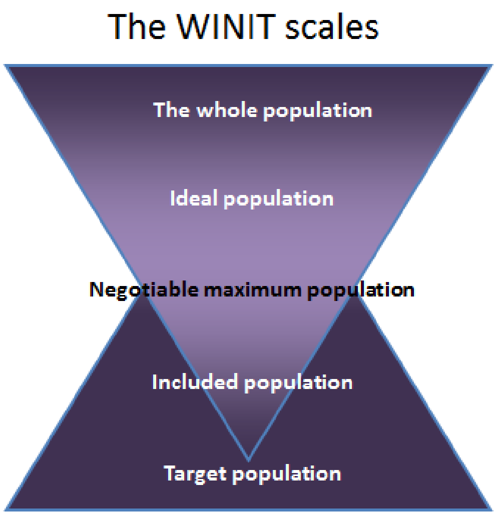

Figure 6: The WINIT scales (Keates, S. & Clarkson, P. J. 2003).

The exclusion estimates based on functional-capability data in the population can provide a basis for correcting the features that cause exclusion of the highest numbers of users. However, addressing the requirements of one particular user group can introduce problems for other user groups. If there are conflicting requirements, estimates of exclusion with regard to various user groups can aid designers in making the necessary trade-offs (Keates, S. & Clarkson, J. 2003 p. 48).

Keates and Clarkson also present an inclusive design knowledge loop (Keates, S. & Clarkson, P. J. 2003). This is an iterative UCD loop, similar to the human-centred design process presented in **Figure 4** on page 37. An important extension to UCD is that inclusive design knowledge must be acquired throughout the loop. This means that the developers must acquire functional-capability data about the end users and about the available inclusive design methods and techniques. This information is used when deciding upon a target population and specifying the product. Then information and methods are applied while generating a product (prototype). The product should be verified against the specification, to ensure that the product meets the functional user requirements. However, to validate the product, it is necessary to test it with end users. If the product is not successfully verified or validated, the process is repeated.

To be able to optimise the overall inclusive design practices with respect to the cost of applying them, one should be clear about the aim with regard to inclusion from the very outset of the process, and a holistic view of the design process is also necessary (Keates, S. & Clarkson, P. J. 2003).

3.7.8 User-sensitive inclusive design

Gregor et al. (2002) state that a new design paradigm is needed to design interfaces that are suitable for older people. This paradigm has to address a much greater variety of users than UCD has done. It has to handle the recruitment of "representative users", handle conflicts of interest between user groups (including able-bodied users), it needs to specify the characteristics and functionality of the user group exactly, have tailored, personalised and adaptive interfaces and include provisioning for accessibility by offering interoperability with AT (Gregor et al. 2002). A new methodology, which they term user-sensitive inclusive design (USID), is suggested. This methodology is further described by Newell et al. (2011), who point out some challenges that that occur when people with disabilities are part of a formal user group within a product development environment. These include:

- It may be difficult to get informed consent from some users.
- The users may not be able to communicate their thoughts, or may even be ''incompetent'' in a legal sense.
- The user may not be the purchaser of the final product.
- Payments may conflict with benefit rules.
- Users with disabilities may have very specialised and little known requirements.
- Different user groups may have very conflicting requirements for a product.

Gregor et al. (2002) argue that a traditional UCD approach is not adequate to address these issues. It is necessary to seek out diversity in a much more systematic fashion. Newell et al. (2011) argue that the developers need greater empathy with users, and that this must be reflected in research, development and in the design methods.

By using the term user-sensitive as opposed to user-centred, they want to communicate the lack of a truly representative user group, the difficulties in communication with users, ethical issues and the importance of the attitude of the designers (Newell et al. 2011). Professional theatre is one method that can be used instead of direct user participation, for example when this is difficult because of ethical and practical issues, as with particularly frail people, or with people who cannot give informed consent (Newell et al. 2011).

Some similar thoughts can be found in the article "Spark innovation through empathic design" by Leonard and Rayport (1997). Here it is argued that successful design requires a high degree of empathy with the target population, and they explain how techniques of empathic design can be used to understand consumer needs, even when the consumers themselves do not recognise that they have needs, for example, in areas where technology does not yet exist (Leonard & Rayport 1997). Ethnographic methods such as observation of customers are an important part of the empathic design approach. Brainstorming for solutions and the development of prototypes are other important elements. These are also important elements of PD. PD has also been regarded as an appropriate starting point for emphatic design for people with dementia (Lindsay et al. 2012a).

3.7.9 Ability-based design

The emphasis of ability-based design (ABD) is to base the design on what abilities people have rather than on what disabilities they have (Wobbrock et al. 2011). The focus should be on what a person can do. Further, the focus should be on making the ICT solution flexible enough to fit the abilities of the person using it. Instead of making people dependent on AT, the ABD suggests making the mainstream technology flexible enough to meet the needs of people with diverse abilities. This can be done by adaptability or adaptivity.

Adaptability denotes to what extent an ICT solution can be customised to fit the users' needs. The customisation can be done either by the user or by other people, such as an expert or caregiver. Adaptivity refers to the extent to which the ICT solution can change itself to suit a particular user. To achieve ABD, Wobbrock et al. (2011) introduce seven principles (**Table 5:** The seven principles of ability-based design).

The first two principles are required in ABD and have to do with the designer's attitude or stance; that is, the designers must refocus from disability to ability, and the burden of change must be placed on the designers, not on the users. Principles 3 to 6 are recommended while Principle 7 is encouraged, recognising that some ABDs may require special hardware or software.

Principles 3 and 4 are concerned with the interface. The aim of Principle 3 concerns removing the need for the user to adapt to the system. This includes removing the need for expensive add-ons, such as AT. This can be done by adaptive systems (i.e. systems that automatically adapt to the user) or by providing customisation options so that the user can adapt the system. Principle 4 is about giving the users control over any adaptation mechanism, so that they have the opportunity to override and adjust the mechanism.

Principles 5 to 7 relate to the system. Principles 5 and 6 will support adaptation through the awareness and monitoring of users' actions and the context in which the system is used. Principle 7 encourages designers to make use of readily available off-the-shelf hardware and software to lower the economic and practical barriers to use.

Table 5: The seven principles of ability-based design

Stance	**1. Ability**	Designers will focus on ability not disability, striving to leverage all that users *can* do.	Required
	2. Accountability	Designers will respond to poor performance by changing systems, not users, leaving users as they are.	Required
Interface	**3. Adaptation**	Interfaces may be self-adaptive or user-adaptable to provide the best possible match to users' abilities.	Recom-mended
	4. Transparency	Interfaces may give users awareness of adaptations and the means to inspect, override, discard, revert, store, retrieve, preview and test those adaptations.	Recom-mended
System	**5. Performance**	Systems may regard users' performance, and may monitor, measure, model or predict that performance.	Recom-mended
	6. Context	Systems may proactively sense context and anticipate its effects on users' abilities.	Recom-mended
	7. Commodity	Systems may comprise low-cost, inexpensive and readily available commodity hardware and software.	Encour-aged

Adaption is a core idea in ABD, and is the opposite of the one-size-fits-all approach. Rather, it supports the idea of the universal application of "design-for-one". An ABD process is one that focuses on abilities throughout the design process, and it should be based on iterative design (see section 3.4). Although Wobbrock et al. (2011) provide several good examples of projects were the principles of ABD are applied, they are not very specific on the design process.

3.7.10 Personalisation and adaptation

As pointed out in section 1.4, the main goal of the IDAs, namely, the design for diversity, seems to be the main challenge of these approaches. The problem is, according to Harper (2006), that to create DfA, you have to make generalisations about the users. However, it is these very generalisations that have led to the development of technology that is impossible to use for many people (Harper 2006). One recommended approach to deal with this challenge is to provide personalisation and adaptation. This has been put forward as a major research challenge (Stephanidis 2001). This is also a central idea in the ABD approach.

To be able to personalise or adapt to a particular user, some information about the user, his or her device or context is necessary. Parts of this information may be retrieved automatically, for instance what type of device the user has (e.g. whether the user has a mobile device), but usually this is not enough information to achieve the required level of personalisation. In general, the user must be identified and she or he has to provide some initial information about his or her preferences. This information is collected into user profiles that hold information about the user, for example, about what modalities and interaction mechanisms best suit the user.

However, collecting these user preferences is a challenge. If the ICT solution is seldom used, the user will not bother with the extra work. Besides, research indicates that those who would gain most from effective customisation or personalisation, for example, novices or people with disabilities, are seldom able to customise effectively on their own (Bunt et al. 2004). They need assistance with the personalisation process itself. Another pitfall is that personalisation becomes a substitute for good user-interface design (Newell 2011; Nielsen 1998; Raskin 2000).

There is also a need for methods that allow for the detection of both generalisable design principles as well as the instances where the design must allow for substantial customisation to be able to meet the specific needs of individuals. McGrenere et al. (2003) suggest a participatory approach to achieve this. They use informal interviews, brainstorming among interdisciplinary researchers and iterative design, beginning with low-fidelity paper prototypes. They start by testing concrete design suggestions with two or three individuals. In each stage, they try to identify both general improvements and user needs that should be incorporated by customisation or adaptation. It is important to notice to what degree the specific needs and requirements vary among the participants. The design suggestions, one per participant, are expected to stabilise after a few iterations. Then these prototypes are presented to two or three new participants (McGrenere et al. 2003). Among the lessons learned is that it is difficult to have people with cognitive disabilities evaluate low-fidelity prototypes, and therefore that prototypes with higher fidelity are better (McGrenere et al. 2003).

3.7.11 Barriers to inclusive design

The number of barriers faced by impaired people (e.g. documented in Paper F) suggests that there are major barriers to inclusive design. User evaluations with people with impairments are seldom carried out (Arrue et al. 2007). In a study of current design practices in industry, several discrepancies between established design theories and current design practices were identified (Dong et al. 2003). Common reasons for not carrying out inclusive design in the industry include insufficient time and financial resources, inadequate access to users, inexperience in dealing directly with users, and, most frequently, a lack of demand from the commissioners of the designs. It is also found that designers worry that they may inadvertently offend people with impairments because of a lack of experience in interacting with them (Dong et al. 2003).

A major obstacle to user involvement in inclusive design is that designers rarely have any formal access to users with impairments (Dong et al. 2003). Moreover, even if it is possible to get access to users with impairments, there is a need to consider the issue of representativeness (see also the discussion about the interpretation of representative users in section 3.5).

Pullin and Newell (2007) propose considering a number of “outriders”, or so-called extra-ordinary users in depth as individual people rather than as representatives of an age group and/or disability. The extra-ordinary users are older users with multiple minor disabilities and users with major disabilities, but who are otherwise in the target population of the ICT solution in question. Users should be selected to illustrate characteristics which are important (Newell et al. 2007). A similar approach is to select "edge cases"; that is, people who are on the borderline of being able to use a product, but who would commonly be expected to be able to use it (Keates 2007). While it may be easier to recruit users with varying degrees of impairments because there are more individuals to recruit from than when recruiting edge cases, involving edge cases can be more effective. The reason for this being that when the design can accommodate someone with a high degree of a particular impairment, the chances of including those with a lesser degree of that particular impairment are quite high (Keates, S. & Clarkson, J. 2003). Similarly, Eikhaug et al. (2010) suggest including "lead users", who are users that place greater demands on a product or system and therefore challenge it in ways beyond that of the average mainstream user. The lead users can be older people, people with disabilities, children or people with diverse cultural backgrounds.

Obstacles to inclusive design can be divided into the following categories of barriers (Dong et al. 2004):

- Perception barriers: The perception that inclusive design is unrealistic, complex, niche marked, more time consuming or that it is more expensive.
- Technical barriers: That there is a lack of resources, knowledge, regulations or methods and tools.
- Organisational barriers: That inclusive design does not fit into the business culture or business strategy, or that there is a lack of risk-taking or willingness to invest in new practices.

Dong et al. (2004) found perception barriers to be the most significant barriers. These included "lack of business case", "perceived sacrifice of aesthetics", a "perception that inclusive design is more expensive" and a "perception that it can be complex to design inclusively".

I believe that the extent of these barriers is a major reason as to why the existing literature often devotes a great deal of space to arguing why IDA is important (Eikhaug et al. 2010; Fuglerud 2009; Keates, S. & Clarkson, J. 2003; Keates 2007; Lazar 2007; Paddison & Englefield 2003), and to identifying and correcting prejudices and preconceptions about inclusive design. For example, Eikhaug et al. (2010) have identified ten such prejudices: expensive, boring, only about physical objects, only about accessibility and disability, only about AT, not for me (as a designer), not concerned with aesthetics, for niche markets such as older people, just another buzzword and only about public services.

3.8 Summary

In the field of HCI, we have seen the development from a focus on specialist users, such as operators or programmers, to a focus on how technology impacts us all. Although researchers in HCI became aware early on of the importance of context in the design of a computer system, the scope of the context has only been extended through the influence of traditions such as socio-technical design and PD. Today, most HCI researchers see the user as part of a complex social system in which ICT plays an increasingly important role.

Usability and UCD are central concepts within the HCI field, and they are defined in accepted ISO standards. Along with these concepts come a set of techniques and methods, such as usability guidelines and various design and evaluation techniques and methods. The key elements of UCD can be derived from ISO 9241-210:2010. UCSD provides an even more elaborate set of principles for user-centred systems design.

The necessity of involving users in the development of interactive systems is now widely acknowledged. However, the extent to which users are involved and how they are involved varies. Users can be treated as anything from passive objects of study to decision makers.

A number of approaches to develop accessible and inclusive ICT solutions have emerged since the mid-eighties, such as accessibility (ACC), universal design (UD), universal usability (UU), design for all (DfA), countering design exclusion (CDE), user-sensitive inclusive design (USID), and ability-based design (ABD). These approaches share the common goal of making technology accessible to as many people as possible, including people with disabilities. To get an overview, I have collected these design directions under the umbrella of IDAs. It is, however, also important to study the peculiarities of each approach because they emphasise, explore and discuss different aspects that are relevant to this field. While there is broad consensus that it is good practice to follow accessibility standards and guidelines to achieve inclusive design, there is an increasing awareness of the fact that this is not enough to achieve inclusive ICT solutions.

Some researchers make a distinction between *technical accessibility* and *usable accessibility*. For an ICT solution to be inclusive, it needs to be both technically accessible and have usable accessibility. An ICT solution is technically accessible if it provides access to content and functionality for people with impairments. This can largely be achieved by meeting technical criteria in the ICT solution, and many such criteria can be found in guidelines and standards. An ICT solution has usable accessibility if it is usable by people with impairments, and this can be achieved by applying UCD and usability techniques to people with impairments. However, these techniques need to be adapted for people with impairments. In addition, user involvement is one of the major barriers to both UCD and IDAs.

Although there are several suggestions as to how to extend UCD with measures to increase accessibility, it is still a great challenge to handle diversity and to create solutions that can be used by everyone. Personalisation and adaptivity as a possible solution seems to have gained increasing attention.

To summarise, from among the IDAs, the following elements are regarded as important:

- Based on a user-centred development process (DfA, CDE, USID)
- The approach being holistic (UD, ACC, CDE)
- The approach being interdisciplinary (UD)
- A focus on the variety of users and usage contexts (all)
- Involving users with impairments, and in particular conduction empirical evaluations with impaired people (DfA, CDE, USID)
- Handling conflicting requirements between user groups (CDE, USID)
- Using accessibility standards and guidelines and ensuring interoperability with AT (ACC, DfA, UU)
- A focus on a combination of accessibility and usability from the beginning (DfA, UU)
- Using personalisation and adaptation to achieve flexibility (UD, DfA, UU, USID, ABD)
- A focus on equitable use before special solutions (UD, ABD)
- A focus on user abilities and what users can do (ABD)
- Utilising a framework to prioritise requirements and features (UU)
- Acquiring knowledge about user capabilities across populations (CDE)
- Considering ethical issues and paying special attention to certain categories of disabled people, such as frail older people and those who are cognitively impaired (UU, USID)

The abbreviations in parenthesis after each item indicate in what IDAs I judge that specific element to emerge most clearly.

4 Research approach and methods

This chapter covers the research approach, research methods and data analysis applied in the work of this thesis. I describe my perspective and point of departure. The research approach has been mainly interpretive, while one can argue that there are also aspects of a critical and emancipatory approach. Several research methods have been used: focus groups, interviews, participant observation, personas and automatic-accessibility testing tools. I also discuss ethical issues and describe how the empirical material has been collected and analysed. Lastly, I discuss the strengths and weaknesses of the selected research approach.

4.1 Philosophical perspective and outlook on technology

This research is qualitative, and has been performed within an interpretive paradigm. I share the view of ICT solutions as social systems, whose behaviour is heavily influenced by the goals, values and beliefs of individuals and groups, as well as by the properties of the technology (Cornford & Smithson 1996 p. 9). In particular, it will be influenced by the perspectives of those involved in the development and implementation of technology in a specific environment. Although one may use technology in many different ways, I believe that the design of technology will have a major impact on how we use it and understand it.

Before starting this PhD work, I was aware of various aspects and challenges of the technology for disabled people, particularly for visually impaired people, and I knew that the situation was quite complex. It has been important for me to understand the aspects of use and of acquiring the technology, its meaning for people with disabilities, the dependencies involved as well as the aspects related to development.

Parts of this work can also be categorised as being within a more critical or emancipatory paradigm. This is because it touches upon policy issues, and possibly sensitive issues of potentially vulnerable groups, which I – because of my personal situation in being married to a disabled person who works in the area of disability policy – am aware of, am affected by and may possibly influence. Walsham (2005) argues that interpretive research can also be critical, although critical research tends to focus more heavily on issues such as asymmetries of power, alienation, disadvantaged groups or structural inequity.

I see my research as my small contribution to the work for the rights of the disabled and vulnerable groups, and my work is certainly affected by a wish to influence decision makers in a direction towards more inclusive ICT. This has, to a certain extent, influenced the way in which I have carried out the research and how the research results have been framed and presented. Thus, I would label this research as mainly interpretative, with a critical flavour.

One concrete example of this was the summary and presentation of the project results for the study on the barriers for the visually impaired (see Paper F). On the one hand, I was overwhelmed and slightly aggravated because of the sheer number and seriousness of the barriers revealed through the observations and interviews in this study. I thought that these barriers, in the form of delays, time spent, hassle and exclusion were quite extensive and I thought that no “able-bodied” person in Norway would have accepted such conditions. On the other hand, many of the participants seemed to tackle the obstacles and accept the barriers with stoic calm and patience. The project was carried out in collaboration with the Norwegian Organisation for the Blind and Partially Sighted (NABP), where my husband works, although he did not participate in the project. For many years, his main field of responsibility has been to influence politicians to create better conditions for the visually impaired. We had discussed aspects of his work many times, from his experiences; I knew that the way in which problems are framed and presented is of importance with regard to the possibility for change. If the decision makers get the impression that the problem is too difficult or requires a lot of work and resources, they may think that the situation is hopeless, and might be reluctant to do anything. Therefore, it is important to balance the presentation of results to instil some hope and optimism with regard to what can be done to improve the situation and in such a way as not to scare employers off from hiring visually impaired people. I was quite conscious of this aspect while writing the report on this project and in the subsequent presentation of the results, both in relation to politicians and to developers and usability experts. It was important not only to present the problems and obstacles, but also to balance this with notes on resources and strengths among the participants, and possibilities in terms of what could and should be done.

4.2 Projects

During the last decade, I have been involved in many projects where the main theme has been the UD of ICT and e-accessibility. I was admitted as a PhD student to the Department of Media and Communication at the University of Oslo from June 2008.

I have been involved in defining the projects through my work with the project proposals. I have been the project leader in four of the projects and I have participated in another three projects. Therefore, I have had an influence on the formulation of the research questions and the direction of the research in all of the mentioned projects. This has given me the chance to work within my overall research interest of the UD of ICT in all the projects in a way that has been meaningful. The research questions and the issues in the projects have been related, and the overall research theme of this thesis has emerged through my work in various projects within this area. One may say that the projects have paved the way for this thesis. Six of the projects that I have been involved in are selected to shed light on the research theme, and they are listed in **Table 6** below. More details on the projects are provided in the next sub-sections.

Table 6: Overview of projects included in this thesis

Project number	Project	My role	Development or evaluation	Period	Duration
P1	ICT – working life	Project leader	Evaluation of existing ICT solutions	April 2005– Oct. 2005	½ year
P2	Diadem	Task leader: user investigations	Development and evaluation of prototypes	Sept. 2006– Aug. 2009	3 years
P3	Unimod	Project participant	Development and evaluation of prototypes	Jan. 2007– Aug. 2009	2.5 years
P4	ICT barriers of the visually impaired	Project leader	Evaluation of existing ICT solutions	Dec. 2006– Dec. 2007	1 year
P5	uu-Authentication	Project leader	Development and evaluation of prototypes	June 2008– Dec. 2008	½ year
P6	e-Vote	Project leader	Evaluation of prototypes	Aug. 2009– Dec. 2009	½ year
P7	e-Me	Project participant	Development of prototypes	May 2010– Dec. 2013	3 years

4.2.1 ICT working life

The background of the ICT working-life project was the strong and increasing trend towards introducing ICT tools in nearly all types of occupations. The new ICT tools require increased ICT literacy, and reading and writing skills. At the same time, statistics showed that a higher share of the workers in practical occupations than in theoretical occupations had dyslexia or reading and writing challenges. I wanted to find ways to help these employees to master the new ICT tools. In particular, I wanted to study how to improve the design of the ICT tools to make them easy to use and easy to learn for all types of workers, including workers with lower levels of ICT skills and reading and writing skills. An e-learning system and a system for workflow and document management related to purchasing and invoicing were chosen as cases. Fifteen employees involved in practical work (26–61 years old) with low education levels and low levels of ICT skills were interviewed and observed while they used one of the two software systems. Data was collected through notes from observations and from a semi-structured interview about the system in question and technology usage in general. The project results are described in a Norwegian project report (Fuglerud 2005).

4.2.2 Diadem

In the Diadem project, the focus was on the design of an expert system that would help elderly people with low ICT literacy and age-related cognitive decline to be able to use ICT services. Two electronic forms, one travel-reimbursement form and one form to apply for a safety alarm were used as examples. The project developed a prototype system that would monitor the behaviour of the user while filling in the form. The user's behaviour was stored in a user profile, and based on that, the user interface would adapt automatically and dynamically to the particular user. The interface would change and the user would get personalised help based on the monitored behaviour. The development was carried out in an iterative fashion. Participants were involved in three stages. In the first stage, the requirements-elicitation stage, a focus group was formed. This was audio recorded and transcribed. Then people of 55+ years were interviewed and then observed while solving a specific task in which they had to fill out an existing electronic form (i.e. ask for a travel reimbursement or apply for a safety alarm). In the second and third stages, participants were interviewed and then observed while using the first and then the second (and last) version of the prototype system when filling in forms. In the last iteration, participants were aged 67+, and only the safety alarm form was used. Data was collected through notes from observations, structured background information and semi-structured interviews about technology usage.

4.2.3 ICT barriers of the visually impaired

The objective of this project was to study the possibilities for and barriers to the use of ICT for blind and partially sighted people, as well as to propose measures to remove the identified barriers. At the start of the project, a focus group was in place to shed light on the problem area and to give input to the field study. The questions in the focus group were broad to ensure that the important areas were covered and to help select example tasks for further observation. Then, a study of 28 blind and visually impaired participants was conducted. We would visit the participants at home, at work or at their place of study, and they were observed while doing common ICT tasks. They could select from among ten different tasks, such as buying a railway ticket, finding information on the home page of their municipality, checking cultural events in their local community or filling in web-based forms. Dependent on the selected task and their speed, they would attempt to solve from one to three tasks during the allotted time. The participants were interviewed after the task-solving activity. They were also asked questions about their experiences when using everyday technology, such as mobile phones, ticket machines, ATMs and queuing machines, although these technologies were not observed in use. Data was collected through notes and audio records from observations and the semi-structured interviews. The project results are described in a Norwegian report (Fuglerud & Solheim 2008).

4.2.4 Unimod

The main goal of the Unimod project was to create knowledge about multimodal, personalised user interfaces and to improve the accessibility of electronic services. The project's solutions addressed different users with various forms of cognitive disabilities. The basic assumption was that by simplifying user interfaces for these users, we would make the solutions easier to use for all users, and thereby contribute to increasing the data quality and efficiency of electronic services. The sub-goals of the project were to develop middleware, knowledge and guidelines to make it possible for the different service providers to improve the user interfaces in existing electronic services, and to develop new and accessible services in alternative channels such as traditional web services and mobile services. Two different service areas were used as examples; namely, maps and geographical information, and electronic forms, reporting and dialogue. Prototypes were developed within these service areas. The persona method together with participant observation and interviews were used for requirement elicitation and evaluation. Data was collected through notes from observations and semi-structured interviews.

4.2.5 uu-Authentication

The goal of the uu-Authentication project was to identify research challenges and needs related to UD, accessibility, security and privacy in common solutions for authentication and registration. Various registration and authentication methods were studied with regard to accessibility. A short literature review was performed, interviews with the help desk of a large Norwegian public service were carried out and an analysis of help-desk calls and interviews was undertaken. Moreover, an authentication prototype with audio output was developed. Observations and interviews were conducted with five visually impaired participants and five participants with dyslexia while using authentication solutions. They would use the authentication prototype, and they would try to log in to a large Norwegian e-government service. One other public-authentication service was analysed by an accessibility expert. Data was collected through notes and audio recordings from observations and interviews, and the project results were reported in a Norwegian report (Fuglerud et al. 2009b).

4.2.6 e-Vote

In this project, the usability and accessibility of e-voting prototypes from five different vendors were evaluated. The accessibility and usability of the prototypes were evaluated in different and complementary ways. The activities included expert evaluation using personas, user testing and testing of conformance to accessibility guidelines using (semi)automatic tools. The prototypes were evaluated with 24 users across two iterations. Users from various user groups were recruited, such as the elderly and people with visual, audio, cognitive and motor impairments. Several of the user evaluations were conducted in the field and with users using ATs, for example, text-to-speech software, screen reading and magnification software, braille displays, alternative keyboards and pointing devices. Data from user evaluations was collected through notes, audio records and interviews, and the results from the project are documented in a report (Fuglerud et al. 2009a).

4.2.7 e-Me

The primary objective of the e-Me project was to provide new knowledge about usability and accessibility of identity management (IDM) systems and authentication mechanisms.

The IDM systems were studied in the context of today's information society with widespread use of social networks in nearly all types of undertakings. The use of social networks was rapidly changing from mainly being a means for informal communication between individuals towards being a means for communication in public and commercial service production. Secure and trusted IDM that can be used in these new contexts is therefore required. The goal of the project was to contribute to significantly improving the accessibility of IDM systems without compromising privacy, security and legal frameworks. Demonstrators in two application areas; namely, banking and public services were developed in the e-Me project. While empirical evaluation were part of the work in the e-Me project, I was not fully involved in this work because I was in Scotland when this was going on. I have therefore not included the user sessions in e-Me in the empirical material of this thesis. However, much of the theoretical work of this thesis has been carried out within the e-Me project.

4.3 Research approach

In this section, I describe my research approach, the user groups that have been in focus and how participants were recruited for the research activities.

4.3.1 Qualitative case studies

A qualitative research approach has been applied in all the projects. The aim when utilising a qualitative research approach is to gain a deep understanding of the subject matter at hand. In interpretive and qualitative research, the matter under investigation is usually studied in its natural setting. The researcher attempts to make sense of, or interpret a phenomenon in terms of the meaning people bring to it (Denzin & Lincoln 1994 p. 2).

A *case study* is a detailed study of an example of a phenomenon (Flyvbjerg 2006). It is often appropriate to use case study as a research approach when the research questions are exploratory and explanatory (2013 pp. 10-11). This is the type of research questions posed in this thesis: "What are the key elements...", "In which ways..." and "How can we...". A case study is often used "to investigate a contemporary phenomenon in depth and within its real-world context" (Yin 2013 p. 16) and when the focus is on activities as they occur in the real world (Lazar et al. 2010). Case studies may also be useful when a holistic approach is needed (Yin 2013 p. 24) and previous research within inclusive design has called for a holistic approach (see section 3.8).

Table 7: Overview of cases and empirical material

P. no	Project name	ICT solution /case	Methods and data collection (number)	Description of participants
1	ICT working life	- Software for workflow and document management related to purchasing and invoicing - An e-learning security course	- Interviews (14) - Observations (14)	- Employees undertaking practical work (26–61 years old), low education levels and low levels of ICT skills, 2 female and 13 male. The mean age was 41 years, and two participants were older than 45 years.
2	Diadem	Two types of electronic forms: - Travel reimbursement - Application for safety alarm	- Focus group (1) - Interviews (67) - Observations (67) - Audio records - Personas	- One focus group with 7 participants. - The elderly and people with cognitive difficulties and workers with low education (cleaners at a hospital). - Three iterations with interviews and observations with, respectively, 21 (15 female and 6 male), 13 and 30 (17 female and 13 male) participants. In the first two iterations, participants were older than 55 years. In the last iteration, all the participants were 70 years and older and the mean age was 76 years.
3	ICT barriers for the visually impaired	- Common ICT tasks in ten different ICT solutions, such as buy a ticket, find information on a web page and fill in an electronic form	- Focus group (1) - Interviews (28) - Audio records - Observations (28)	- One focus group with 12 participants. - Interviews and observations of 28 visually impaired participants (17–60 years old). This included 12 males and 16 females. Fourteen participants were blind, and 14 were partially sighted. Seven participants were students, 11 participants had a job and 10 participants did not work or study.
4	Unimod	- Job application form - Mobile workflow - Multimodal help (Screencasts)	- Interviews (13) - Observations (13) - Personas	- Interviews and observations of 5 participants with cognitive difficulties and 8 elderly and hearing-impaired participants.
5	UU-Authentication	- Mobile authentication application	- Interviews (10) - Observations (10) - Audio records	- All participants were experienced PC and mobile phone users, aged from 16–60 years, 7 females and 3 men, of whom 5 were dyslexic and 5 were visually impaired.
6	e-Voting 2009	- Comparing five e-voting prototypes	- Interviews (24) - Observations (24) - Video records - Personas - Accessibility tools	- Interviews and observations were performed in two iterations, with 9 participants, 5 male and 4 female in the first iteration, and 15 participants, 8 male and 7 female in the second iteration. - Participants were from various user groups: cognitively impaired (4), hearing impaired (6), physically impaired (3), visually impaired (10), first-time voter (1).
7	e-Me	- Authentication mechanisms - Payshare	- Literature review	

In the projects the focus has been on UD of one or more ICT solutions. The common contemporary phenomena of interest across the projects are issues related to the ICT solutions in question, both the UD process and the properties of each ICT solution. I regard the study of each ICT solution as a case. A requirement of a case study is that the "case" can be limited in time and space (Crang & Cook 2007; Stake 2005). The cases are limited in time and space within each project. A description of the ICT solutions (i.e. the cases) in each project is given in **Table 7** on page 69.

Case study research can cover multiple cases and then draw a single set of "cross-case" conclusions (Yin 2013 p. 18). Cases can be assembled in *a multiple case study*, or in what Stake (2005) calls a collective case study, because they affect the main research theme in different ways. In all the projects, participants from different user groups have been studied while they have used the ICT solutions in question. (The user groups in focus and the recruitment strategies are described in subsequent sections.)

As the types of ICT solutions vary and the user groups included in the studies vary, the case studies in this thesis are not *literal replications*, but rather *theoretical replications* (Yin 2013 pp. 56-63). These variations must be taken into account when discussing and contrasting the findings from the different cases.

The ICT solutions in the projects can be said to be what Stake (2005) calls *intrinsic* case studies, in contrast to *instrumental* case studies. In intrinsic case studies, the main purpose is to understand the issues at hand. If a particular case is examined to illuminate some general or abstract phenomenon, or something other than the understanding of a particular situation, or something that goes beyond the case at hand, it is instrumental. Case studies can be both intrinsic and instrumental (Lazar et al. 2010 p. 156). When including the ICT solutions in the projects in this thesis, they become instrumental because they are chosen to illustrate a theme of this thesis, which is slightly outside the theme of each project. Including multiple cases provides a better basis for generalisations from case studies (Lazar et al. 2010 pp. 156-160).

I interpret Stake (2005) to mean that it is an advantage that each case is first and foremost intrinsic, because over-emphasising generalisation across different cases can lead to attention being drawn away from matters that are important in each case. The ability to give a rich and detailed picture of the world is also the purpose and the strength of qualitative research.

In summary, one can say that this thesis is based on several qualitative projects including the study of one or more ICT solutions, which may be regarded as intrinsic case studies. However, when taken together in the context of this thesis, the cases become instrumental and constitute a multiple case study.

4.3.2 User groups

In all the projects, the focus has been on developing ICT solutions that are more inclusive for people with impairments. Although inclusive design is about including everybody, there has been a particular focus on certain categories of users in each project, except for the e-voting project, where the focus was on people with all types of impairments.

The user groups in focus in each particular project (**Table 8)** have been the basis for the recruitment of volunteer participants for the project. This means that participants have been recruited from the user group in focus (see more about the recruitment strategy in the next section).

Table 8: User group in focus per project

User group\Project	P1. ICT working life	P2 .Diadem	P3. ICT barriers of the visually impaired	P4. Unimod	P5. uu-Authentication	P6. e-Vote	P7. e-Me
People with low levels of ICT skills	X	X				X	
People with reading and writing difficulties/dyslexia	X				X	X	X
People with cognitive difficulties/impairments		X		X		X	
The elderly		X		X		X	X
Visually impaired			X		X	X	X
Hearing impaired				X		X	
Physically impaired						X	

Within the user group in focus, other characteristics have varied, such as gender, education level, occupational status, degree of impairment etc. A description of the empirical material collected in the various projects, in terms of how many participants, types of impairments, gender and ages are given in **Table 7**.

4.3.3 Recruitment strategy and access to participants with impairments

The discussion in this section is related to describing the sample of participants in the research that has been carried out, and how they were recruited. I will come back to a discussion of what this research has taught me about access to users and how to include users in UD projects in general in section 6.3.2.

There are two main categories of sampling strategies: *probability* and *non-probability* strategies (Blomberg et al. 2003). Probability sampling is typically used to calculate statistical characteristics of populations. Non-probability sampling is most commonly used in ethnographic and qualitative methods. Blomberg et al. (2003) list four types of non-probability sampling strategies: quota, purposive, convenience and snowball. In quota sampling, the aim is to cover the possible variation in certain parameters across a population. The population is categorised into user groups, and then a number of participants from each user group is recruited. This approach is only possible when it is easy to identify and recruit participants from these user groups.

The main sampling strategy in the projects has been purposive (Blomberg et al. 2003). This is a variant of quota sampling, where the number of participants in each user group is not strictly specified, but is dependent on what is possible within the available constraints, such as time and access to users. Blomberg et al. (2003) state that non-probability sampling is often more than adequate to achieve the desired research objectives in ethnographic studies and HCI projects. Even when participants are not chosen through the probability strategy, one can get reliable results from 4–5 participants if they are chosen carefully, according to Blomberg et al. (2003).

In our projects, we have recruited users through non-governmental organisations (NGOs) for the disabled, private networks, information meetings and sometimes through the snowball effect; that is, where participants tell other people about the project, and they have contacted us because they want to participate as well. Some potential participants have been asked directly, while others have contacted us based on information and invitations from meetings, in e-mails and on the NGO's Facebook pages.

The most common categorisation of impairments are along the sensory, physical and cognitive dimensions, and these can be divided more specifically into visual, auditory, physical and cognitive impairments (Henry 2007 p. 115). In the e-Vote project, we recruited from among these four categories of impairments. The following user groups were selected: partially sighed, blind, hard of hearing, deaf, various types and degrees of physical impairment and various types and degrees of cognitive impairment. The user groups in the other case studies have been more restricted (see **Table 8** and **Table 7**). To the extent that we could choose among participants within a user group, the general strategy has been to aim at diversity with regard to sex, age (except for when the user group was elderly), degrees of impairment, ICT experience, education, occupational status and experience related to the ICT solution in question.

Many of the participants have been recruited through NGOs for the disabled, and this has been an advantage because they have contact with many more potential participants than we do as researchers. Moreover, based on their knowledge about their members, the NGOs have helped in searching for a balanced sample with regard to the mentioned background variables. In spite of this, it has often been time consuming and difficult to get participants, and hence we have had to settle for purposive sampling rather than quota sampling. Generally, we have managed to recruit the planned number of people within each main category of impairment, while the degree of impairment has been more arbitrary. People with minor impairments tend not to look upon themselves as disabled, and are therefore not as likely to be members of a NGO for the disabled. However, although it has not been possible to recruit people exactly according to a predefined distribution along various variables, the resulting samples have been quite diverse.

The degree of impairment of the participants with sensory and physical impairments has ranged from significant to high, whereas the participants with cognitive impairments had relatively low degrees of impairments. Determination of the degree of impairment of participants with sensory and physical impairments has been based on observation and self-reporting. Being blind, deaf and lame from the neck down was the highest degree of sensory and physical impairment among the participants. Determining the degree of cognitive impairment was more challenging, and is discussed further in section 4.5.2. In general, the participants had only one type of impairment. Elderly people tend to have several types of mild impairments and this was also the case for some of our elderly participants. However, having several types of impairments was not registered as a separate category.

To summarise, the sampling strategy in this research does not fit directly into any one of the six types of sampling strategies proposed by Muller et al. (2001) (see section 3.5). While the focus was on covering the main types of impairments, we also tried to vary other variables, such as age, sex, education and experience. We tried to cover a range within each impairment group. However, the number of participants from each impairment group was not selected according to the relative prevalence in the population, but rather because users' characteristics might affect the experience of the ICT solution's usability and accessibility in different ways. In this way, the sampling strategy resembles the first step in the grounded theory – a sampling for diversity approach. This is because we purposefully recruited participants from predefined user groups with a focus on important sources of heterogeneity with regard to use of ICT. However, the overall sampling approach is not in accordance with grounded theory because this would require subsequent sampling dependent on the initial analysis (Birks & Mills 2011 pp. 69-73).

To put the information from observations and interviews into context, we used background information about the participants, such as age, sex, education, occupation, attitudes, ICT knowledge, type of impairment and type of AT during the analysis.

4.4 Methods

As in each of the projects, the overall approach in this thesis is qualitative. Qualitative research involves the use and collection of a variety of empirical materials, such as through interviews, artefacts, observations and texts from case studies, but also of knowledge from personal life stories, experiences and introspection (Denzin & Lincoln 1994 p. 3). This may include project reports, minutes from meetings, transcriptions of focus groups and interviews, but also experiences, thoughts and introspection. These are both valid and important contributions in a qualitative and interpretative practice. These materials represent meanings in different contexts and shed light on the subject matter from different angles. Therefore, it is advised that more than one interpretative practice is employed in any qualitative study (Denzin & Lincoln 1994 p. 4).

Six papers are included in this thesis, and **Table 9** provides an overview of how the papers relate to the projects. These papers report on selected results from the projects. The underlying empirical materials have also been used directly in the work with this thesis.

Table 9: Overview of papers and what projects they are based upon

Paper\Project	P1. ICT working life	P2 .Diadem	P3. ICT barriers of the visually impaired	P4. Unimod	P5. uu-Authentication	P6. e-Vote	P7. e-Me
A. Universal design in ICT services	X	X	X				
B. Towards inclusive identity management			X	X	X		X
C. Secure and inclusive authentication with a talking mobile one-time-password client					X		
D. ICT services for every citizen: The challenge of gaps in user knowledge	X	X	X	X			
E. An evaluation of web-based voting usability and accessibility						X	
F. The barriers to and benefits of use of ICT for people with visual impairment			X				

This thesis is based on my experiences from actively participating in the projects. In addition to the empirical material collected in the case studies, as described in section 4.3.1, I have had access to much other related material, such as project internal communications, reports, meeting minutes, conference presentations and informal communication with other researchers and actors in this field, such as NGOs. Moreover, my personal life story of being married to a visually impaired person has undoubtedly affected my views and interpretations. All these materials and experiences have shed light on the subject matter from different angles.

An important question is whether someone else would arrive at the same conclusions as I have, based on these materials. At least the reader should be able to understand how the methods were applied, how I have worked through the material and how I arrived at my conclusions (Crang & Cook 2007 pp. 146-147). Therefore, it is essential that the qualitative and interpretative researcher is able to describe the process of gathering information, analysing and concluding in as detailed and transparent a manner as possible. In the remainder of this chapter, I try to give both an overview and details about how the research has been conducted, and about how the empirical material has been collected. The methods used are focus groups, interviews, observation, personas and automated accessibility tools.

Table 7 on page 69 gives an overview of the types and amounts of empirical materials that have been collected in the various projects, and what methods have been used in each project. A more detailed account of the actual procedures and how the methods have been applied is given in the subsequent sections.

The degree of user involvement in this research can be characterised as consultative, on a scale from informative, through consultative to participatory (see section 3.5). The users and stakeholders have been consulted through focus groups and interviews. They have been encouraged to provide general comments and suggestions, to comment on and criticise prototypes and ICT solutions and to provide suggestions for improvements in these solutions. Although some stakeholders have participated in reference groups and steering groups, the users in general have not participated in decisions related to the projects or the development processes. The user participants in the interview and observation sessions participated on an individual level, while the participants in the focus and steering groups participated on a system level (see section 3.5).

4.4.1 Focus groups

In two of the projects, Diadem and ICT barriers for the visually impaired, an initial focus-group meeting was held to provide input about the topic of research. The focus groups had 7 and 12 participants, respectively, including the researchers (see **Table 10**). In both cases, people with different experiences and backgrounds related to the topic were put together to come up with various perspectives and issues. An interview guide was provided in advance, indicating the themes (respectively, 5 and 6 themes) to be discussed at the focus-group meeting.

Table 10: Focus groups

	Project	
	Diadem	**ICT barriers for the visually impaired**
No. of participants	7	12
Duration	1.5 hours	2 hours
Material	Interview guide	Interview guide
Information gathering	Notes and audio	Notes and audio
Analysis	Thematic analysis of transcribed audio recording	Thematic analysis of transcribed audio recording

The focus-group meetings were led by a researcher (me in both cases), who had the task of ensuring that all of the topics in the interview guide were covered during the allotted time, which was one and a half and two hours, respectively. Crang et al. (2007 p. 93) suggest that one and a half hours is about right, while two hours may be tiring for all those involved. However, given that there were 12 participants in the focus group for the ICT barriers for the visually impaired project, two hours seemed to be necessary to give all of the participants the opportunity to comment on each topic. The focus-group meetings were held in an informal style, allowing for a quite free conversation among the participants. In both cases, the focus-group meetings were audio recorded and transcribed.

Focus groups are useful for identifying response categories and themes that the researchers might not otherwise have considered. In both cases, new aspects and viewpoints concerning accessibility and barriers to ICT usage were revealed. Focus groups can make questionnaires, interview guides and other evaluation methods more relevant and language sensitive, because new themes and vocabulary used by the users can be discerned. In both cases, important themes, requirements for prototypes and questions to be aware of when doing user research were identified. The results of the focus groups were incorporated into the subsequent material, such as interview guides and the preparation of tasks for user tests and evaluations. This is described in the next section.

4.4.2 Interviews and observations

Interviews and observations have been central methods in all the projects. The overall procedure has been fairly similar across the projects. This is an advantage when comparing investigations of multiple cases because it increases reliability (Lazar et al. 2010 p. 166). A combined observation and interview session was conducted with all the participants. A session with a participant typically consisted of six steps (see **Table 11**). Each step is described in the following.

Table 11: Observation and interview sessions

Step	Description
1	Information and consent
2	Registering of background information
3	Observation of task solving (thinking aloud)
4	Semi-structured interview
5	Writing minutes
6	Analysis

1. Information and consent

At the start of each test session, the researcher would ensure that the participant had been informed about the test procedure and their rights, especially that s/he could withdraw at any point. The researcher would offer to read the information letter to the participant, and would offer to accommodate any particular concerns that they might have.

Participants were asked to sign an informed-consent form, acknowledging that the participation was voluntary, and that they could withdraw at any time without having to give any reason. Further, the participants were assured that their privacy and identity would be safeguarded.

In projects 2–5, there was an option to allow the session to be voice recorded. This was usually accepted. In project 6, there was an option to allow the session to be video recorded. Participants were more reluctant to be video recorded than voice recorded.

2. Registering of background information

The background information about each participant was noted, such as sex, age, ICT training and experience, knowledge and experience about the application domain or type of application in question, type and degree of impairment and type and version of any AT used.

3. Observation of task solving

In all the projects, the participants were asked to use some kind of software, either an existing product or service (projects 1, 3, and in the first iteration of project 2) or a prototype (in the second and third iteration of project 3, and in projects 4, 5 and 6). In each project, concrete ICT tasks related to the software in question were developed. During all of the task-solving sessions, except for the last Diadem evaluation, participants were asked to think aloud. (For details on thinking aloud, see section 4.4.3.) The reason for not using thinking aloud in the last evaluation of the Diadem project was that this evaluation was designed as an experiment comparing the user performance of the form-filling task with the aid of the Diadem system with the user performance of the same task without the Diadem system. Quantitate measures – such as the time to finish a task and the number of errors – were compared with and without the Diadem system. As thinking aloud may have influenced the performance, it was omitted in this evaluation. Instead, participants were encouraged to discuss their experiences after the task-solving activity. With very few exceptions, users agreed to be audio recorded during the sessions, and about half of the participants in project 6 agreed to be video recorded.

For tasks requiring input, dummy information was offered, so that the participant did not feel obliged to use his or her own data or to come up with something on the spot. During the task-solving phase, the researcher took notes on all types of difficulties, obstacles and (mis)interpretations. Sometimes the participants would become stuck when using the system. If they seemed not to be able to continue on their own, they would get a hint from the researcher on how to continue. This was also noted.

4. Semi-structured interview

After observing the task-solving activity, a semi-structured interview was conducted. Semi-structured interviews can be used to deepen and enrich our understanding of the issue at hand (Lazar et al. 2010 pp. 189-197). The questions were open ended and covered themes related to the accessibility and usability of the ICT solutions in question. The interviews were performed in a conversational style and the participants were encouraged to elaborate on the questions, and on various thoughts and experiences related to this. During the semi-structured interviews, the participants were encouraged to tell stories that provided information beyond the current situation or timeframe. In each project, a set of questions was prepared. The interviewer would also follow up on particular comments and ask about further clarification from the participant to gain additional insight and understanding. While letting the participant talk quite freely, we also tried to make sure that all the questions in the interview guide were covered.

5. Writing minutes from each observation and interview session

Notes and recordings were used when writing minutes from each observation and interview session. While very few sessions were transcribed from beginning to end, some parts from several of the sessions were transcribed. In particular, this was the case where participants had formulations that seemed to be particularly illustrating. A fairly detailed set of minutes from each session was written.

4.4.3 Thinking aloud

The "thinking-aloud" method is commonly used in usability testing to capture the users´ experiences (Baecker et al. 1995 p. 950; Constantine & Lockwood 2000; Nielsen 1993). The participants are instructed to say aloud what they are doing, thinking and feeling while they perform a task. It is important to make the participants feel at ease, and therefore one should stress that it is the ICT solution that is tested, not the participant. Rather, the participant's role is to contribute by exposing the application's shortcomings and weaknesses. The researcher or observer will sit next to the participant, observe her actions and listen to verbalisations of her thoughts. This will give insights into the participant's intentions and about possible misinterpretations and misconceptions about the user interface. If the participant grows silent, the observer prompts the participant to think aloud again. The strengths of this method are that it may give very detailed information about what parts of the user interface cause problems and why the problems occur, with relatively few participants and without the need for special equipment. In addition, the informal atmosphere often leads to many spontaneous comments and suggestions. The main weaknesses of the method are that people may be reluctant or unable to verbalise while they are working, they may work differently when they are verbalising their thoughts and, in particular, thinking aloud affects the performance measures such as time to completion and possibly also error rates. During the task-solving phase, the researcher notes as much as possible about the participant's comments and actions and also notes these afterwards in a post-session interview (see also Paper C).

4.4.4 Analysis

In each of the projects, a thematic analysis was carried out based on the minutes from the observation and interview sessions. The general approach was based on an open-code process (Crang & Cook 2007 p. 137). This is often used in qualitative analysis and is typical of the first steps in an approach based on "grounded theory" (Birks & Mills 2011 p. 95).

In general, two phases of analysis were performed: a *vertical* and a *horizontal* analysis. In the vertical phase, all the text in each of the minutes was scrutinised and marked with tags; that is, descriptive keywords. As the aim was to analyse the data openly, the themes were not decided on before the vertical analysis, but since the interviews were based on an interview guide, the themes from the interview guide would often reappear, particularly at the start of the process.

The practical way in which it was done was usually by writing the tags in the margin of each of the printed minutes. The minutes with tags were read again to regroup and find more fine-grained or precise themes. Often, I used coloured pens to aid in this process (see **Figure 7**). From the tags and phrases, themes and sub-themes were formed.

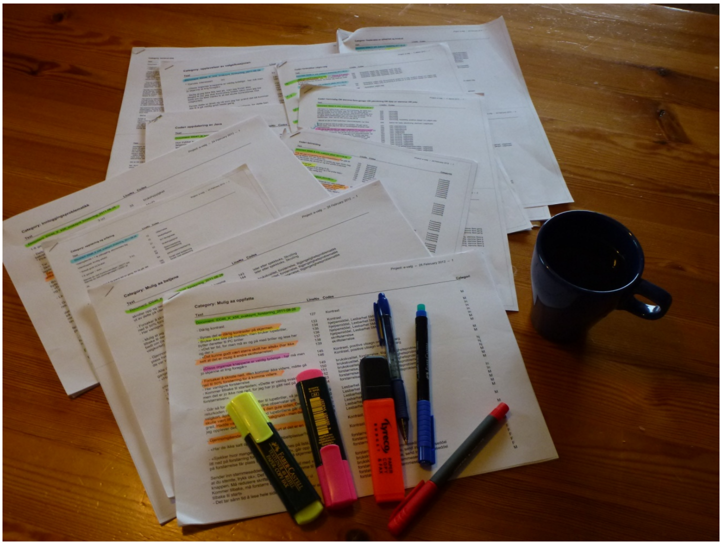

Figure 7: Tagging sentences and sections in minutes with colours and key words.

The *horizontal* analysis was carried out by collecting the data associated with the identified themes across all the interviews in a case study. This was done to be able to see the patterns more clearly when analysing the material across all the sessions. While the overall approach was the same in all the projects, the concrete processing of data was carried out in slightly different ways.

Various tools were used to collect and organise the data. In the ICT working-life project, the ICT barriers of the visually impaired project and the uu-Authentication project, the themes were entered into an excel sheet together with background information such as demographic data, years of data experience, types of tools and AT etc., and then scrutinised further.

In the Diadem project, a mind-mapping tool (Freemind) was used to organise the themes and sub-themes based on the minutes. Then the themes and sub-themes were entered as section headings in a word document with a table below each heading. Sentences or descriptive sections from the minutes were then copied into the tables under the relevant headings along with a number indicating how many of the 30 participants had experienced the issue in question. An example of horizontal data analysis in the Diadem project is given in **Table 12**.

In the e-Voting project, the various sentences and sections were copied into a table. There were columns for the type of operating system, browser and version, participant number (indicating type of impairment), screenshot number, error severity, error type and prototype name as well as the descriptive data (sentences or sections) from the individual minutes. To ease the analysis, the table was sorted in different ways and the themes could then be split into further sub-themes. For example, we could look at the data sorted by prototype name, theme or type of impairment. The table was attached to the usability and accessibility report delivered to the project owners (Fuglerud et al. 2009a). In the second evaluation of the e-Voting software, an analysis software, Open Code 3.6 (Umeå University 2009), was used to aid the tagging and organising of the material into themes.

Table 12: Horizontal data analysis in Diadem, themes and sub-themes

Theme title: Profile form	
Sub-theme title: Preferences	
Sub-theme description: Problems with instructions on page and understanding how to complete the preferences	
Sub-theme comments/examples and frequency count (number of users)	
	Total
Font used earlier in the form was not indicated. Researcher had to explain which font had been used so far. User commented that this was confusing.	3
User tried to select a larger text, but the text size did not seem to be changed.	1
User thought she had used font size 18 (instead of 15) as no font size was prefilled in the Preference form.	1
The user wanted a description/explanation of what kinds of sounds were connected to each of the sound-effect check boxes.	1
Users wanted to remove the dinging sounds and clicked to remove sound effects. However, the sound did not disappear.	14
When clicking advanced-opportunities options for Diadem, style and maximal number of sections per... appeared without further explanation. Number of users who clicked this option.	1
When deleting the tick for simple sound effects, the choice for advanced sound effects disappeared on this page. However, advanced sound effects were still ticked on the Control page.	1

4.4.5 Personas

A *persona* is a hypothetical archetype of a user described in great detail and refined by his or her goals and needs, rather than being based merely on pure demographic data (Lindgren et al. 2007). When based on and combined with user research, the use of personas can be a technique to bring in new perspectives and highlight the diverse characteristics of the users. It is suggested that personas are created on the basis of quantitative and qualitative materials, such as market research materials, field studies, focus groups and interviews (Pruitt & Grudin 2003; Schulz & Fuglerud 2012). Although the persona method can be used alone, it can be more powerful if used to complement, not replace, other methods (Pruitt & Grudin 2003; Schulz & Fuglerud 2012). As personas are reductive in the sense that some user characteristics are reduced into a persona, they cannot replace the deep knowledge and insight gained from involving users directly in design activities (Massanari 2010).

The description of each persona includes their experience, types of impairment, attitudes, usage environment and any AT that they needed. (See Schulz and Fuglerud (2012) for a discussion of experiences in creating and using personas with disabilities.) The use of personas may bring up important aspects concerning individual differences, not only with respect to demographics, but also with respect to personalities, goals and abilities. To be able to use personas effectively, it is necessary that the users of the personas, such as designers and developers, feel that they know the personas well, and achieving this is one of the main challenges with the method (Pruitt & Grudin 2003).

In the Unimod project, several personas with different cognitive profiles were developed. One of these persona descriptions, a person with dyslexia, is included in **Figure 8** as an example (translated from Norwegian to English by me). These personas were developed in a workshop with stakeholders, such as developers, designers and people with ample experience with the user group in question (Schulz & Fuglerud 2012). The users were not involved in this workshop. As various aspects of the user group were discussed during the persona-creation process, participants in the workshop could fill in the details with related real-life stories. Such stories could come up to illustrate typical traits, needs, attitudes and habits of people in the user groups. The personas were used in subsequent discussions among the researchers and developers, and sometimes the stories from the persona-creation process were told again and these stories were useful for keeping the personas alive.

In the e-Vote evaluation project, six personas were developed (an elderly person, an immigrant, a vision-impaired, a hearing-impaired, a physically impaired and a cognitively impaired individual). In this case, the personas were developed by a group of researchers with ample experience of interacting with various user groups, particularly with people with impairments. The aim when developing the personas was to try to cover the diversity of the population, not only with regard to impairments, but also with regard to age, interests, social background and occupational status.

In the e-Voting project, we used a technique which we call persona walkthrough (Schulz & Fuglerud 2012) when evaluating the e-Voting software. This is similar to cognitive walkthrough, as described in Shneiderman (1998 p. 126), where an expert simulates or play-acts the persona while carrying out typical tasks.

Whereas walkthrough methods are often performed by a group (Constantine & Lockwood 2000; Dumas & Salzman 2006), in our case they were performed privately by each expert (i.e. researcher) in this project. Instead of having the researcher trying to behave as any user while doing the walkthrough, he or she would carry out the tasks according to the usability and accessibility evaluation plan while play-acting a particular persona.

Thomas (28 years) – profile D

Occupation: Driver.

Education: Has completed primary school. Drop-out, good in practical and oral subjects. He has no certificate because he is unable to understand theory.

Social status: Is living with his parents.

Personality: Open and social, “a happy boy”.

Interests: Computer games, films, friends.

Cognitive challenges / characteristics:

- Reading and writing difficulties
- Prefer images/icons
- Avoids “writing situations”
- Avoids reading longer texts

Thomas has chosen the transport sector because this enables him to get a job directly. He did not want to attend a “normal school” anymore with lots of academic subjects. He has tried many other career choices, but failed and gave up. However, he'd really like to have a profession and a job, and is now starting with a new momentum. He wants to be able to take care of himself, and does not want to be dependent on the welfare system. He wants to be ready to take a job quickly.

Job description; typical goals, tasks and situations: Thomas sits in the passenger seat, and is training for his class B driving license. He is alert in relation to the tasks, and has a lot of opinions, ideas and suggestions for improvements. (This can sometimes be a bit much for the driver who actually has a driving licence). Each week he works 3 days and attends classes with theory training for 2 days.

Needs, frustrations, attitudes and values:

- He shows up at work.
- He feels that he can handle this better than the driver can, and is impatient.
- He writes many text messages, and uses this to communicate with work and friends alike.
- He understands the system, but struggles to read the text on the driver list. He does not take notes, but remembers most things by heart.

Quotes:

“I’ll have a job at NorCargo.”

“Computers are mostly for games!”

“I hate keyboards!”

“Mac and MultiTouch is the best!”

Figure 8: Example persona description from the Unimod project.

The six personas were distributed among three researchers so that each researcher did the persona walkthrough twice with two different personas (see Paper E). The personas were distributed according to the researcher's experience with different user groups, so that the researcher with the most experience of dyslexics play-acted the dyslectic persona, the researcher with the most experience of people with physical impairments play-acted the persona with physical impairments and so on. This is an important point, because ample experience related to how people with a certain type of impairment use technology is necessary for realistic play-acting performances. The persona walkthroughs served several purposes; namely, testing for technology diversity, acquainting the researchers with the ICT solution and as preparation for the user evaluations.

Personas were used as pre-pilots and led to some adjustments of the usability and accessibility evaluation plan. For example, the number of task scenarios was reduced from three to two because the persona walkthrough revealed that it would be too time consuming to do three scenarios with all the prototypes. We also did some adjustments to how we would present the necessary materials, such as the log-on information and the materials to aid in the process of discussing and ranking the prototypes.

The persona-creation process in these two projects was quite informal. This could have been a weakness if the persona method was meant to be a substitute for user involvement and user evaluations. However, in both projects, personas were used as a complementary method to user involvement. In the Unimod project, it worked as a learning and communication tool. In the e-Voting project, it worked as a tool for expert usability and accessibility inspection and as a tool for preparing for user evaluations. I do not think that a more formal approach would have significantly enhanced the outcomes when used in these ways.

4.4.6 Accessibility evaluation tools

Accessibility evaluation tools are software programs or online services that can be used to determine whether an ICT solution meets specific accessibility guidelines. A list of such tools can be found on the W3C web site[15]. While accessibility evaluation tools cannot automatically determine the usability and accessibility of an ICT solution, they offer a quick way of identifying potential accessibility flaws. It is therefore recommended that such tools be used before any user evaluation to correct and eliminate issues that can be detected automatically, and that are known to cause accessibility problems frequently. In the e-Voting project, the A-Checker[16] tool was used along with other manual and (semi-) automatic checks of conformance to guidelines and standards (see Paper E).

[15] http://www.w3.org/WAI/RC/tools/

[16] http://achecker.ca/checker/index.php

4.5 Ethics

Respecting human dignity, beneficence (i.e. to maximise benefit) and nonmaleficence (i.e. to minimise harm) are fundamental ethical obligations in research. To achieve this one should consider various ethical issues and follow ethical principles and guidelines. It is the responsibility of the researcher to understand implications of his or her research and to protect the rights and wellbeing of participants regardless of the nature of the research. The following ethical principles have been considered in this research: To respect human dignity and autonomy, to obtain free and informed consent, to be sensitive to vulnerabilities, to minimize the risk of harm, to protect privacy, confidentiality and anonymity, and to consider justice and inclusiveness. These issues are discussed in more detail below.

4.5.1 Human dignity and autonomy

Respecting autonomy is about acknowledging the individual's right to determine their own course of actions without having any obligation to explain or justify these actions. While individuals have been invited to participate in the various projects, either directly or through NGOs, it has been important that this should not be done in a coercive manner. See also discussion about compensation in section 4.6.3 . The content of the information letter and the informed consent form were explained orally to the potential participants and they also received it in writing. Appointments have been followed up with an e-mail confirmation with contact information for further questions, and to make it easy to change or cancel the appointment.

Truthfulness and avoidance of deception are central to obtaining informed consent. When participants know that they are participating in security research, they may involuntarily be more aware of security issues than they are normally. One may therefore be tempted to conceal the security aspects of the research to get more realistic data from user evaluations. Such issues were discussed in relation to the e-Me project, but participants were always fully informed about the nature and purpose of the research. This has also been the case in the other projects.

4.5.2 Sensitivity to vulnerabilities

Ethical guidelines emphasise the need for special safeguards to protect vulnerable persons against abuse, discrimination, deception or exploitation. Most of the participants in this research had impairments, but was otherwise healthy, and they were all able to give informed consent. The participants were therefore not considered to be particularly vulnerable or frail. Information about the type and nature of their impairment has been recorded, but no other personally sensitive data (such as sexual lifestyle, ethnicity or political opinion) were registered.

People with impairments can often be disregarded and underestimated. For example, when I am out together with my husband, people will sometimes communicate with me about him as if he is not there or cannot speak for himself. In shops or restaurants, I have been asked about what he prefers, or the exchange has been given to me in cases in which he has made the payment. Therefore, treating participants with dignity also implies to treat participants in a natural way, directly, with respect and equality, as is common practice, and to show interest in their opinions.

We categorised reading- and writing difficulties as a cognitive impairment, and approached Dyslexia Norway, and other relevant organisations. In the e-voting project we recruited people with many types of impairments in parallel. It was undoubtedly most difficult to recruit people with cognitive impairments. Difficulties with recruiting people with cognitive impairments have been reported by other researchers as well (McGrenere et al. 2006). One reason might be that having a cognitive impairment is still, to a greater extent than for physical and sensory impairments, associated with stigma.

Another sensitive issue was the determination of the degree of impairment. People with sensory or physical impairments often give some explanation of the degree of their impairment in terms of a percentage of function or the capacity to perform work. In the Diadem project, participants' cognitive skills were measured with the Mini Mental State Examination[17] (MMSE). This is a 30-point questionnaire commonly used in medicine to screen for cognitive impairment and dementia. The decision to use this test was made by the project coordinator, and was approved by the ethics committees of the three countries were user evaluations were conducted, namely in Norway, the UK and Italy.

The challenge with using this test, however, is that it is very rough, and cannot reliably reveal mild cognitive impairments. According to Gjerstad (2001), the MMSE is not particularly accurate, except for possibly in capturing obvious dementia cases. However, people with dementia and people who are not able to give informed consent were not in the target group for Diadem, nor for any of the other projects.

Twenty-four participants aged 70 years and older were tested with the MMSE during the observation and interview sessions. None of these participants could be characterised as cognitively impaired according to the MMSE; that is, they did not score below the threshold indicating cognitive impairment. However, because we know that ageing normally results in a deterioration of cognitive functions, we would expect somewhat reduced cognitive functions among the elderly participants compared to younger people. Although it did not seem as if the participants felt offended by the test, it was unnecessary, since it to a very limited extent could capture any differences between our participants.

[17] A number of different mental abilities, such as memory, attention and language are tested by the MMSE. The top score is 30 points and scores above 27 indicate normal cognition. Scores from 25–27 are inconclusive and must be further examined. Scores from 21–24 indicate mild, 10–20 points indicate moderate, and scores of less than 9 points indicate severe cognitive impairment.

In other projects where we included people with cognitive impairments, Unimod, e-Me and the e-Vote project, we did not use any objective measurements of the participants' cognitive abilities. The only indications we had regarding their cognitive abilities were based on knowledge about what organisation they were recruited from, self-reporting and observation.

Ten participants in Diadem were recruited from the Sunnaas Rehabilitation Hospital, a unit for rehabilitation of the cognitively impaired and persons with acquired brain damage. These ten participants had some specific diagnoses within the category of cognitive deficiency, based on thorough examinations by medical personnel at the hospital. We did not have access to these participants' particular diagnoses; we only knew that they had a cognitive-deficiency diagnosis. Professionals at the Sunnaas Hospital recommended us not to use the MMSE test on these participants. It was argued that because these people had already received a specific cognitive-deficiency diagnosis, it would be ethically dubious to test again with the much less accurate MMSE. In addition, our contact at Sunnaas did not think that this test would reveal any cognitive impairment for these participants, even if they had a cognitive-deficiency diagnosis. Therefore we did not use the MMSE on these participants.

Based on experiences in the projects, we have concluded that diagnoses are in general not particularly useful to guide the design, and that it is better to focus on the actual abilities of the users in relation to the use of ICT. A specific functional or cognitive impairment may have various causes, but pose similar requirements to an ICT solution.

4.5.3 Privacy, confidentiality and anonymity

To make sure that all personal data were handled in accordance to the Norwegian Personal Data Act (Personal Data Act 2001) and guidelines for use of personal information in research (Datatilsynet 2005a; Datatilsynet 2005b), we developed and documented a procedure for retention of consent forms, recorded material (audio and video), data records, notes and minutes. We used dummy data so that participants should not need to reveal their own data (see also section 4.6.2). It should be noted that information relating to disability is health information and therefore considered to be sensitive personal data, and must be treated accordingly (Fuglerud 2010; Personal Data Act 2001). During the period of this research, NR has become a member of the Privacy Ombudsman Services of the Norwegian Social Science Data Services (NSD). This is a resource centre that assists researchers with regard to data gathering, data analysis, and issues of methodology, privacy and research ethics.

When anonymity is required it is important that a person cannot be indirectly identifiable through background information such as place of residence combined with data on age, gender, AT, etc.. As a rule of thumb, we have required that the data must be generalised in such a way that each person-record can apply for at least five individuals. The use of a particular type of AT might be quite rare and one should therefore take care in relation to anonymity. This information in combination with e.g. sex, age and municipality could sometimes easily identify a person.

Besides procedures for data retention, there is a need to consider what type of information that is relevant and reasonable to discuss during meetings with participants. Sometimes participants in this research could be quite personal and talk about private matters. It can be difficult to judge the relevance and to steer such conversations. In some cases I felt it would be rude to cut off the conversation, since the participant would try to illustrate some relevant point by the story. Sometimes people may need somebody to talk to and the researcher needs to balance between being empathic, respectful and interested, and keeping to the theme at hand.

4.5.4 Minimising the risk of harm

In research with people with reduced physical or cognitive capabilities, it is necessary to be sensitive to the wellbeing of the participants and to accommodate the process to the participants needs (Culén & Velden 2013). To lessen the strain and pressure for the participants, we always emphasized that it was the ICT solution and not the performance of the participant that were under scrutiny. Nevertheless, some participants seemed to find it quite stressful to be observed, and they could become tired or feel embarrassed if they could not figure out how to do things. The degree of strain each participant felt would probably depend upon many things, such as the researcher and his or her ability to make the participant feel at ease, the place, the equipment, the ICT solution, the type of impairment and their abilities and their personality. Therefore the researcher needed to be sensitive and flexible in relation to each particular participant. The fact that we visited many of the participants in their homes meant that the participant could not leave, and the researcher had to be extra sensitive to when to stop. Sometimes we would skip parts of the tasks or questions in the interview guide to finish within the agreed timeframe, or because the participant seemed to be tired. As a form of debriefing and to uncover any unforeseen misconceptions or negative effects, we would end the user session by asking the participant about how they felt about the participation and whether they had any questions.

4.5.5 Justice and inclusiveness

Justice and inclusiveness is about fairness and equity in selecting participants and stakeholders in the research (Bailey et al. 2013). This includes access for participants to the research process such access to meeting rooms and facilities and access to information and materials. Moreover, there benefits from research should be fairly distributed, and no group should be unfairly burdened with harms of research. Accessibility to the physical environment and to information was considered during this research. While the goal of this research was universal design, we have not included all types of impairment groups or otherwise disadvantaged groups. It is therefore important to be aware that there are many groups and aspects that are not covered.

4.6 Strengths and weaknesses of the research approach

In this section, issues related to the strengths and weaknesses of the research approach are discussed. I discuss the strengths and weaknesses of the observations and interviews in the field, potential consequences of using dummy data and the potential consequences of using compensation for the participants. Further, I discuss the use of and not use of formal accessibility conformance checks, and I then move on to discuss issues concerning the research methods, and the way in which they have been applied.

4.6.1 Observations and interviews in the field

According to Vavik (2010), the methodological approaches in inclusive design (Vavik used the term UD) were originally mostly based on natural sciences. However, during the last two decades, as UD as a discipline has developed, it has become more focused on cognitive accessibility. Topics such as human behaviour, social patterns, lifestyles, experience design, tacit knowledge, empathy and the understanding of new emergent behaviours are brought together with ergonomic and functional requirements. There has been a shift towards applying more qualitative methods inspired by the social sciences. Thus, UD has moved from mainly the natural sciences domain to a combination of natural sciences and social sciences (Vavik & Keitsch 2010) and has become more interdisciplinary in nature (Dalcher 2006). Additionally, in the usability field, practitioners are encouraged to make field methods an integral part of their work practice (Dumas & Salzman 2006). I think this is a consequence of ICT being used in increasingly different contexts by increasingly diverse user groups, as opposed to the early applications that were mostly used in work and often in office environments.

In all the projects, we chose to visit the participants in their own environments. We let the participants decide at what location they preferred to meet for the interview and observation session, for example, in their home, workplace, at a senior centre or another suitable location. The participants were encouraged to use their own equipment.

Evaluating the use of an ICT solution in the field will usually bring up a wider range of issues than a laboratory test, which has long been viewed as a gold standard within the usability field (Hollingsed & Novick 2007). However, especially when it comes to involving participants who use ATs, observing use in the field may be a preferable approach. First, there are a seemingly endless number of combinations of types and versions of computers and setups with ATs, and each type of AT and its equipment often has many possible settings and configuration options that have to be optimised according to the needs of each particular user. It is generally very time consuming to achieve the same settings on lab equipment as on the participants' own equipment. Often, the participant does not know or remember what settings they are actually using, and then one has to attempt to achieve approximately the correct settings on the lab equipment. Thus, making the participant use lab equipment often requires adaptation – thus diverting attention away from the ICT task in question. In some cases, it is not possible for the participant to use unfamiliar equipment and to participate in unfamiliar settings. By visiting the participants, one is not limited to the setups that are available in the lab. Moreover, participants may be reluctant to bring their own machines to a test lab, especially for those who mainly use stationary equipment. Additionally, travelling to a laboratory may be perceived as a barrier in itself for many people, for example for some people with mobility impairments or for people who are less resourceful.

In summary, it is easier to have meaningful observations with a wide range of users by having the opportunity to visit the participants. Moreover, this is in line with the view that an individual UD solution should be assessed in an overall context, as stated in the Norwegian concept-clarification document (MD 2007)(see section 3.7.1.2).

The uncontrolled environment of the field studies that constitutes the empirical data of this thesis has its weaknesses too. In the first submission of Paper C (Fuglerud & Dale 2011), some of the evaluators deemed the work as totally unscientific and worthless. The main critiques were the uncontrolled environment, lack of a control group and lack of detail in the presentation of the results. This was an important lesson that challenged us to be much clearer about what the aim of the study was, how the data was collected and how the results were interpreted. For example, in the first submission of the paper, we had not included how many participants (out of the 10) had experienced one or another of the problems. Since the sample of participants was so small, and by no means could be said to be statistically representative, we considered the numbers as irrelevant. However, as a means for making the data and the analysis more transparent, it may be of value to present such information.

Thus, the most obvious limitations of these studies is that they do not give quantitative answers, such as how large a proportion of the overall population would experience a particular problem. Another aspect of the uncontrolled environments of these studies is the difficulty in pinpointing the exact cause of any problem or obstacle that occurred. As the users used a variety of technical equipment, which we as researchers did not know in detail, it could be difficult to judge what caused the problem. For example, it could sometimes be difficult to judge whether a problem that seemed to be of a technical nature was caused by particular elements in the configurations of the AT equipment, the operation system, the browser, the software under study or a lack of interoperability between these elements. Thus, although the realism in the studies is high, in the sense that we, to a large extent, observed real-life problems, we were not always able to explain the cause of the problems in detail. This is also related to the discussion concerning a lack of formal assessment regarding conformance to accessibility guidelines in section 4.6.2 and breadth vs. depth in section 4.6.4.

4.6.2 The use of dummy data during task-solving activities

In some of the projects, we provided dummy data that the participants could use to complete the task. The reason for this was partly due to privacy and partly due to convenience. Particularly for authentication and the form-filling tasks, we provided dummy data so that participants did not reveal their own user names, passwords and personal data. In addition, in the e-Voting project, we suggested a political party to vote for, based on a random procedure, to protect privacy. The use of dummy data made the tasks more "mechanical". To a certain extent, it helped the participants to understand the task, or sometimes they could complete the task even if they did not understand everything, as long as they understood what data to put in where. In some cases, participants chose to use their own data, and in these cases, more questions about the expected types of input data occurred. Thus, providing dummy data may hide some potential usability problems. We probably would have identified more problems related to unclear language, formulations and explanations without the dummy data.

4.6.3 Compensation to participants

Participatory approaches to research may raise the expectations of the participants in terms of them being rewarded in some way (Byrne & Alexander 2006). At the very least, they hope that the research will result in future systems that are more accessible and usable for them. On this ground, participants may accept not being paid for their time and contribution. However, usually, the researchers cannot guarantee the outcome of the research or that it actually will benefit the participants.

It seems that the practice of paying for participation is becoming increasingly common in several research fields (Head 2009). I have received feedback from NGOs, such as the NABP, that they get an increasing number of requests to recruit participants for various types of projects. Not just scientists want to get hold of informants, but also marketing agencies, and various types of businesses and commercial projects. Social scientists have noted that this may lead to an "overfishing" of informants (Ekern 2009), which in turn makes it more difficult to get participants for research.

Payments during research projects can have an important function in terms of gaining access to participants and in encouraging participation (Head 2009). On the other hand, payment may influence the attitude of the participants. Some NGOs, such as the NABP, recommend giving compensation to participants in various types of projects. This can be financial compensation, such as the reimbursement of travel costs and time, but other forms of compensation, such as a gift voucher are also common.

Giving compensation is a way of showing that the effort of the participant is valued and recognised. This is especially important when the research aims at developing a commercial result in the end, as is often the case in ICT research projects. Therefore, the NABP thinks it is reasonable for participants to receive compensation.

My husband, who works for the NABP, has facilitated contact with relevant persons in the organisation through introductions and practical information about who to talk to, phone numbers and e-mail addresses. Beyond this, he has not been involved in the projects. Neither he nor the organisation has received financial compensation for participating in the projects.

Another aspect related to compensation is the status of the participant, and the power relations between the researcher and the participants. Since the researchers are likely compensated for their time in the project through salaries and other external rewards, it has been noted that it seems natural that participants should also be compensated for their time (Head 2009).

However, it is also pointed out that compensation may constitute a methodological problem that can affect the quality of the research because it might lead to a biased sample. The participants may feel that they should give something back to the researcher. In this way, compensation may be regarded as a form of gift exchange, which would be ethically problematic (Ekern 2009). On the other hand, it is claimed that payments can contribute to a more representative sample, since it may be easier to recruit participants, and especially to get participants from vulnerable groups who otherwise have a tendency not to be represented. It is also important to consider what options the researchers have for payment or compensation. The alternative may be fewer participants, and thus less information and greater uncertainty in relation to research results.

Participants in all the cases in this thesis were given either monetary compensation or a gift voucher (value: NOK 500, about 60 Euro). This is a common level of compensation for this type of activity in Norway. The amount given was below the threshold for tax liability for individual work performances outside of employment. Thereby, we could avoid registration of the participant in the payroll system, which would have been a problem in relation to participants who preferred anonymity as well as a lot of extra administrative work.

It has been important not to connect the performance of the participant to the compensation. It was stressed that receiving the compensation did not affect the participant's right to withdraw at any point during the research session or afterwards. A concern has been raised that compensating participants might mean that they say what they believe that the researchers want to hear, rather than giving an 'authentic' account of their experiences, views and attitudes (Head 2009). Another reaction may be that the participants force a response where they otherwise would have been indifferent.

It was important to recruit a wide variety of participants to the projects, and, in particular, not only people who were confident and technologically competent. I am of the opinion that it is better to use compensation than not in this kind of research. Although I do not think that the compensation were large enough in itself to entice participation, I am convinced that we would have had significantly fewer participants without the compensation. The participants may have been more positive towards the prototypes and software presented than they would have been without any incentive to participate. This must be taken into account when interpreting the data.

The fact that all the participants were observed while doing tasks may to a certain extent balance out potential biases due to the compensation involved. As described previously (in section 4.1), I was somewhat surprised about the generally positive attitudes of the participants in the ICT barriers of the visually impaired study because we did not think this harmonised with the observed level of barriers and obstacles (Paper F). In an article about empathic design, Leonard & Rayport (1997) note that “Sometimes customers are so accustomed to current conditions that they don't think to ask for a new solution, even if they have real needs that could be addressed”. I think, to a large extent, participants in this study were so accustomed to their current conditions, such as frequent data breakdowns, that they did not give it very much attention. The compensation, together with getting attention as a group, may also have contributed to a positive atmosphere. In addition, in the Diadem project, we found that the participants were reluctant to criticise the solution presented to them and that they tended to blame any difficulties with the solution on themselves. Other researchers have also observed this tendency, particularly among older participants (Eisma et al. 2004; Newell 2011 p. 124).

To summarise, the self-recruitment strategy and the decision to use incentives when recruiting participants may have resulted in a sample of participants with a slightly more positive attitude to the ICT solutions in question than without the incentive and with a statistically representative sample. The fact that the interviews were always accompanied by observations has, to a certain extent, contributed to levelling out this bias in the overall analysis.

4.6.4 Conformance checks of accessibility guidelines

Only in the e-Voting project was a formal check for conformance to accessibility standards and guidelines performed. Despite the fact that conformance to such standards was among the basic requirements of the e-Voting prototypes, this evaluation revealed that the prototypes did not, in fact, conform fully to these guidelines (see Paper E). Conformance to such guidelines was also a requirement of the Diadem prototypes (see section 3.7.6 for an overview of the relevant standards and guidelines). It would have been an advantage if a formal conformance check had been done in all the cases. Then one could, with much greater certainty, have established whether or not a lack of conformance to such guidelines was in fact the main cause for some of the observed problems.

4.6.5 Depth vs. breadth

A weakness of the analysis may be that the observations and interviews were not fully transcribed. Thus, it may be the case that the material was coloured by the language and interpretations of the researchers too rapidly. Interpretive research is about how individuals and groups perceive the world “out there” and the issue of representation is central (McIntyre-Mills 2010).

During the task-solving activities, many things usually happened at the same time. Participants had varying experiences with using the mouse, keyboard, buttons and ATs, and sometimes, strange things could happen because users did unforeseen things. This would happen at the same time as the participants were thinking aloud and commenting, and sometimes there were technical problems and bugs in the system. Although the researchers tried to register and note everything that they observed, it was often not possible to register all the details because several things happened at the same time. While many of the sessions in the e-Voting project were video recorded, most of the other material was audio recorded. Although the audio records were helpful in writing the minutes, particularly for the participants' audible comments, they do not show their actions. Therefore, it was not always possible to describe everything that happened in detail. As both registrations and writing up the minutes are influenced by what the researcher is looking for, and as there were so many different issues, the researchers involved may have prioritised certain things according to their own preconceptions. The researchers (my colleagues and I) may also have missed deeper issues that might have emerged through an even more thorough approach.

The question of breadth vs. depth is also a question of prioritising within the available time and resources. It would not have been possible to do a complete transcription of both interviews and observations with the same number of participants within the available time. To do that, we would have had to have reduced the number of participants in the various studies significantly. I believe that the main consequence of our choice is that we may have missed out some issues and also that we were not always able to fully understand why certain problems occurred. On the other hand, there is an aspect of quantity to this research that would not have been possible with fewer but deeper analyses of each session. This is not to say that the research is quantitative, but this choice has meant that I have had the opportunity to conduct relatively many user observations and interviews with quite diverse users. As one of the main challenges of inclusive design is diversity, I think it is an important experience. Thus, in relation to the focus of this research, the choice of allowing a certain breadth at the cost of depth has positive aspects too. It has given an overview, a broad experience and the possibility of seeing patterns that might not have been possible with a smaller number of participants.

4.6.6 Reflexivity, transparency and personal biases

The term reflexivity is used about the practice of making explicit the research process and researcher's potential underlying motives and biases (Smith 1996; King 1996). By making this explicit, the process may become more transparent, or at least the reader is encouraged to bear in mind that the processes of research and analysis may be coloured by the biases of the researcher.

Reflexivity is most commonly discussed in relation to phenomenological or interpretative research approaches, but, in their book about grounded theory, Birks and Mills (2011 p. 55) argue that a reflexive practice is important both in a interpretative research tradition and in a positivistic research tradition. In the interpretative research tradition, the researcher should be transparent and open about their reasons and motivations for the actions, decisions and conclusion. In a positivistic tradition, where the idea is to maintain an objective separation from the object under study, a mechanism to separate one's own behaviour, feelings and thoughts from the objective truth is necessary. Journal writing or memo writing is recommended as a reflexive practice, particularly in relation to a grounded theory approach (Birks & Mills 2011 pp. 52-55).

In my research, I have tried to make my biases and motives explicit through describing my personal life experiences and relationships in relation to my research interests. Particularly, I have been open about my relationship with the NABP. This relationship has given me easier access to visually impaired participants in the projects, and it has probably coloured my presentation of the findings (see also section 4.1). Although one could say that many of the challenges of impaired people are in principle similar, the NGOs for different groups of disabled people do not necessarily share the same strategies for solving these challenges. The relatively close relationship with the NABP has made me more aware of their opinions in many cases.

I have also reflected on my practice during the research projects, mostly in connection with developing the observation and interview guides, and when analysing data and writing up the reports. In connection with listening to audio recordings and watching the videos from the observations and interviews, I have had the opportunity to evaluate my own interview technique. This has been educational, because although I had the intention of asking open questions, it can be quite revealing when listening carefully to how the questions were formulated. Unfortunately, I have not engaged in a systematic and regular practice of reflexive journal or memo writing. I clearly see the value of more regular and systematic practices, both because writing is a way of clarifying and developing one's thoughts and ideas, and because it may increase the transparency and quality of the research (Birks & Mills 2011).

The fact that other researchers have been involved in the data collection and analysis in all the projects, except for the ICT working-life project, has probably contributed to a richer picture than if I had been the only researcher involved. To a certain extent, this have contributed to levelling out my biases as far as the cases go, but not so much in relation to the further interpretations and deductions made in this thesis.

4.6.7 Strengths and weaknesses summarised

The empirical material in this thesis is based on 7 projects (see **Table 6**) and includes 25 different ICT solutions (see **Table 7**). In four of the projects (P2, P3, P5 and P7) the development process was based on a full UCD process with prototype development and evaluations. The remaining three projects included only the prototype evaluation stage of the UCD process. Although we have studied several ICT solutions within the projects, the development process has been approximately the same for the ICT solutions developed and evaluated within one project. The discussions of aspects of the design process, i.e. research question one and three is therefore based on four to six[18] cases dependent on

[18] I did not include the evaluation phase of the e-Me project

what part of the process that is in focus. When it comes to research question two, and specifically regarding the relationship between flexibility and complexity of the resulting designs, the various ICT solutions can be regarded as different cases, although the two ICT-solutions in the Diadem project were quite similar, and the five prototypes in the e-Vote project were quite similar.

The interview and observation sessions with 156 participants have mainly been conducted in the field. The participants have been quite diverse in terms of capabilities (see **Table 8**). This has contributed to high realism with regard to the types of problems experienced by diverse users when using mainstream ICT solutions. The self-recruitment strategy and the decision to use incentives in the projects have probably contributed to a sample of participants with a more positive attitude to the projects and the ICT solutions presented to them than a probability sample would have done. The fact that the interviews were always accompanied by observations has, to a certain extent, contributed to levelling out this bias in the overall analysis.

The decision to opt for a certain level of breadth at the expense of depth in terms of reports from each individual user session have meant that we may have overlooked some issues, and not fully uncovered the underlying reasons for all of the issues that were identified. This is particularly true when it comes to technical details of the accessibility problems experienced by participants. A more extensive use of formal accessibility conformance testing would have been useful to help determine the cause of the technical problems. The use of dummy data may also have hidden some usability issues, and there may have been social or cultural nuances that have not been captured.

The research includes a combination of several methods, particularly interviews and observation, but also two focus groups, the use of the personas method in three projects and use of formal accessibility evaluation in one project. This has illuminated the issue at hand from various angels, made it possible to a draw a rich picture and contributed to a nuanced understanding of aspects that influence the challenge of diversity in inclusive design.

4.7 Generalisability and validity

The quality of research can be judged according to its contributions to the body of knowledge. It is important to address the question of generalisation when evaluating research (Cajander 2011). According to Walsham (1995), there are four different types of generalisation that can be drawn from interpretive case studies – the development of concepts, the generation of theory, the drawing of specific implications and the contribution of rich insight – or a combination of these. The generalisations might be valuable in other settings, although they are not necessarily wholly predictive for future situations.

The contribution of this research to the area of HCI and inclusive design is mainly rich insight and the drawing of specific implications based on the cases. These contributions are relevant for participants in inclusive design projects, such as researchers, practitioners and users. Although the phenomena in the cases studies are interwoven with the particular context and social structures in those cases, the insights and implications can prove useful for related work in other contexts and situations. The usefulness depends on whether the described insights and implications are relevant, and whether the descriptions of the surrounding circumstances are detailed enough so that various similarities and differences may be compared and contrasted to other contexts and situations. For example, the types of ICT solutions that have been studied, the user groups that have been involved as well as the social and cultural context are factors of significance in relation to the analysis and the results.

5 Research findings and results

In this chapter, the research findings and results from the papers are presented. In the following, I give a summary of each paper. This summary includes publication details and a short abstract. Then the summary and findings are presented in a tabular format. The summary is presented in the left column, and the corresponding findings are distilled into lessons learned and the recommendations, presented in the right column. The lessons and recommendations are numbered for easier reference, and I have indicated which of the research questions presented in section 1.6 that each particular lesson or recommendation relates most closely to.

5.1 Summary of papers

5.1.1 Paper A: Universal design in ICT services

Fuglerud, K.S. (2009). Universal design in ICT services, in Inclusive buildings, products & services: Challenges in universal design, T. Vavik, Editor. Trondheim, Norway. pp. 244–267.

This paper is included in an anthology on inclusive buildings, products and services. The main theme of the paper is how to develop inclusive ICT services. I present arguments for UD as an approach, discuss the benefits of UD for the individual, society and for the service providers, discuss the connection between UD, the design for various usage situations and multimodality, and provide recommendations for incorporating UD into the design process.

5.1.1.1 Relation to the research questions

Summary of Paper A	**Lessons learned/ recommendations**
Since many of the ICT products and services developed today are mainstream services that are potentially directed towards all users, to be used with various devices and in various situations, I argue that UD is a particularly relevant and appropriate approach for the development of such services. I show that there are overlapping requirements in developing technology for various usage situations and for people with disabilities. The need for multimodality in both cases is highlighted. This is related to the need for	A1: Focus on a variety of users, devices and usage situations (RQ1) A2: The design for various usage situations and the design for people with disabilities require considerations regarding flexibility and multimodality (RQ1) (RQ2).

Summary of Paper A	Lessons learned/ recommendations
flexibility, i.e. that the user interface should allow the users to select the most appropriate mode of interaction according to their abilities, situation, preferences and devices.	
I point out that accessibility is usability for people with the widest range of capabilities. Therefore, I recommend incorporating UD activities into a user-centred and iterative development process, such as identifying and applying relevant accessibility standards and carrying out user research and evaluations with users with disabilities. Due to the close relationship between usability and accessibility, it is necessary to focus on both usability and accessibility when conducting user research and user evaluations.	A3: Usability and accessibility are closely connected (RQ1) A4: Integrate UD in UCD (RQ1) A5: Identify accessibility standards and guidelines (RQ1)
I stress the importance of commitment towards and knowledge about UD among managers and the development team, and to actively seeking out the perspectives and viewpoint of different stakeholders during the design process.	A6: Organisational commitment towards and knowledge about UD is necessary (RQ1) A7: Seek out the viewpoints of the different stakeholders (RQ1)
Diverse users should be involved early on and throughout the development process. Results from user research, tests and evaluations must be frequently communicated and discussed within the development team. This will lead to a deeper understanding and the need to adjust, change and re-order priorities during the process. Therefore, it is important to consider who should be involved in and how to handle the process of prioritising and changing the requirements.	A8: Involve diverse users early on and throughout the development process (RQ1) A9: Facilitate communication between user and developer (RQ1) A10: Handle the process of prioritising and changing the requirements (RQ1)
Several methods for carrying out user research and evaluations are discussed, such as personas, heuristic evaluation and think aloud, and some suggestions are made regarding meeting the challenge of diversity. I recommend combining several methods and perspectives. As a point of departure, I suggest analysing the ICT solution with regard to various types of constraining situations and corresponding impairments (i.e. impaired	A11: Method triangulation: The challenge of diversity requires the use of various perspectives and several methods when doing user research and evaluations (RQ1)(RQ3)

Summary of Paper A	Lessons learned/ recommendations
vision, hearing, dexterity, cognition, reading and writing abilities). An example is presented as a table in the paper. While acknowledging that it is not possible to recruit people so that they cover all types and combinations of situations and disabilities, I recommend focusing on diversity when involving users in the development process.	A12: Analyse solutions with regard to constraining situations and corresponding impairments (RQ2)(RQ3)

5.1.2 Paper B: Towards inclusive identity management

Fritsch, L.; Fuglerud, K. S. & Solheim, I. (2010). Towards inclusive identity management. Identity in the Information Society 3 (3): 515–538. October 07, 2010. URL: http://www.springerlink.com/content/x85883158t117675/

In this paper, we argue for a shift of perspective in identity management (IDM) systems research and development. We show that current IDM systems are difficult and even impossible to use for many people. At the same time, many ICT solutions and e-services require some kind of identification. Therefore, to include all citizens in the information society, the IDM methods must be accessible for all citizens. We introduce the term inclusive identity management (IIDM) to mean a systematic approach towards integrating usability and accessibility concerns in the design and development of IDM systems. In this approach, a broad range of users with different skills, ages and various (dis)abilities – with different cultural backgrounds and utilising different devices – must be considered. Several widespread IDM methods and techniques are described, analysed and discussed from the perspective of inclusive design. Important challenges are identified and some ideas for solutions addressing the challenges are proposed and discussed.

5.1.2.1 Relation to the research questions

Summary of Paper B	Lessons learned/recommendations
It can be argued that IIDM is a special area of inclusive design. IIDM may be particularly challenging because of the divergent goals of inclusive design approaches (IDAs) and security design, where the goal of IDA is to make access easy for everybody and the goal of security design is to control and restrict access. However, as argued in the paper, most ICT solutions have some form of IDM, and thus the key elements of designing IIDM are important in IDA. We emphasise the following elements as of particular importance to IIDM: an interdisciplinary and	B1: Inclusive identity management is necessary because most solutions have some kind of identity management (RQ1) B2: Interdisciplinary and context driven (RQ1) B3: Based on UCD (Iterative development, empirical evaluation with users) (RQ1) B4: Method triangulation (RQ1)

Summary of Paper B	Lessons learned/recommendations
context-driven approach, mutual learning, iterative development, empirical evaluation of ICT solutions with users (including people with disabilities), other stakeholders and method triangulation.	
An overview and taxonomy of authentication methods with respect to accessibility and usability is presented, and several current challenges of IDM systems are identified (both in terms of usability and accessibility, but also in terms of security and privacy). It is asserted that there is no single authentication method that can be used by all users, and that alternative methods are needed to include various user groups with different skills, ages and (dis)abilities.	B5: No single authentication method is accessible to everybody and alternatives are necessary (RQ2)
The diversity of users is highlighted as a challenge to the design of IDM systems in this paper. IIDM systems are analysed across various user groups, and a rough indication of how accessible the various mechanisms are for various user groups is given. The actual usability and accessibility of such systems will be dependent on the specific implementation. Methods to evaluate security levels as well as usability and accessibility levels of such systems are called for.	B6: A tabular analysis gives indications of challenges for various user groups, but methods to evaluate actual usability and accessibility as well as security levels are needed (RQ3)
We also emphasise that IIDM is central to inclusive design because it provides possibilities for adaptation and customisation through profiling, which can again be a means to achieve inclusively designed ICT solutions. Several ways in which profiling may contribute to usability and accessibility are discussed, such as adaptation to individual needs by filtering out irrelevant information, choosing a form of delivery that suits each particular user and providing contextualised help. However, as pointed out in the paper, these approaches raise new challenges in terms of privacy and security.	B7: Inclusive identity management is essential to achieve adaptation and personalisation (RQ1) (RQ2) B8: Profiling may contribute to usability and accessibility, but introduces new privacy and security challenges (RQ1) (RQ2)

5.1.3 Paper C: Secure and inclusive authentication with a talking mobile one-time-password client

Fuglerud, K. & Dale, O. (2011). Secure and inclusive authentication with a talking mobile one-time-password client. Security & Privacy, IEEE, 9 (2): 27–34. 28 March 2011.

This paper describes an exploratory and qualitative study with the aim of evaluating whether introducing a new modality, namely audio, into a security design would make the solution more inclusive. The study included two different groups of the disabled: visually impaired and dyslexic people. The process of redesigning and evaluating an existing authentication mechanism to make it more inclusive is described. Based on experiences from redesign and evaluation processes, advice on issues to consider when including audio in the development of an inclusive mobile security application are given.

5.1.3.1 Relation to the research questions

Summary of Paper C	Lessons learned/ recommendations
The paper touches upon RQ1 because it gives advice on inclusive design, based on experiences from the case of designing an inclusive authentication mechanism. The advice includes utilising an iterative and user-centred process, involving diverse users early on, and allowing them to evaluate the design in several iterations, ensuring interoperability with ATs, and making use of multimodality – especially if the use of ATs would conflict with other requirements.	C1: Based on UCD (iterations, empirical evaluation) (RQ1) C2: Involve diverse users early (RQ1) C3: Ensure interoperability with AT (RQ1) (RQ2) C4: Consider multimodality (RQ1) (RQ2)
The results indicated that the new modality was attractive to both user groups. However, several issues in the prototype design were confusing to the users, and thus one might say that the prototype had a certain degree of complexity. Most of the confusion was related to the use of two different devices (namely, a PC and a mobile phone) and to when to do what on which device. The need for two devices was not a UD requirement, but rather a security requirement (for two-factor authentication). Thus, the study confirms that security functionality may create complexity.	C5: Introducing a new modality, namely audio, was attractive to two different user groups (RQ1)(RQ2) C6: Complexity may be related to a combination of devices (RQ2) C7: Combining two devices in a two-factor authentication process contributed to complexity (RQ2)
The introduction of audio in the application did not seem to contribute directly to the experienced confusion, but it brought forward new questions in terms of how to present the audio. The users had different preferences concerning this, such as with regard to the grouping of digits and the pace. Some	C8: Introduction of audio created a need for flexibility in audio presentation (RQ2)

Summary of Paper C	Lessons learned/ recommendations
ways of providing flexibility by accommodating different user preferences regarding the audio presentation are discussed, including the possibility of providing different versions of the solution, or by providing a personalisation procedure during installation and set-up.	C9: Flexibility may be achieved by providing different versions of the solution or by personalisation (RQ2) (RQ3)
The issue of diversity is touched upon in the paper, although the study only included two user groups: visually impaired and dyslexic users. By including two different groups of disabled people in the study, we could ensure that the efforts of including one user group would not exclude or introduce obstacles to another group. A quite detailed description of the low-cost usability method, "thinking aloud", was included. This was included to provide increased transparency on how the study was conducted. It is also an example of a usability and accessibility evaluation including people with disabilities that can give much valuable input to the design. This method is neither very difficult nor extremely costly.	C10: By including several different user groups, one can sort out potential conflicting needs (RQ1) C11: Find methods that work well with diverse user groups (RQ3)

5.1.4 Paper D. ICT services for every citizen: The challenge of gaps in user knowledge

Fuglerud, K. S. (2009a, 19–24 July). ICT services for every citizen: The challenge of gaps in user knowledge. Proceedings of the 5th International Conference on Universal Access in Human–Computer Interaction. Addressing Diversity. Part I: Held as Part of HCI International 2009, San Diego, CA, USA. Springer-Verlag. pp. 38–47.

The paper describes the results of an analysis of usability and accessibility issues across four case studies (all of which are included in this thesis) with diverse users using mainstream ICT solutions. There was user diversity across many background variables, such as type of disability, age, education level and whether in education, work or neither. The goal was to see whether there were special patterns, similarities or differences between the problems experienced by the various user groups when using the ICT solutions.

5.1.4.1 Relation to the research questions

Summary of Paper D	Lessons learned/recommendations
One main finding was that there were no obvious patterns with regard to problems faced by particular user groups, other than technical-accessibility issues for visually impaired people.	D1: Many usability problems occur across diverse user groups (RQ1)(RQ2) (RQ3)

Summary of Paper D	Lessons learned/recommendations
Apart from the mentioned issues faced by visually impaired people, I was not able to find any other obvious patterns with regard to problems faced by particular user groups. On the contrary, many of the problems seemed to occur across all user groups.	D2: The visually impaired experienced special problems due to poor technical accessibility (RQ2)
Another main finding was that there were mismatches between the ICT skills required to be able to use the case applications and the participants' ICT skills and knowledge. This mismatch occurred across all user groups and applications. Due to the vast number of various interaction methods and possible combinations of them, the applications appeared complex to many of the participants. Moreover, the participants did not look for or utilise help functions.	D3: The vast number of interaction methods and possible combinations of them contribute to experienced complexity for the users and is in itself a challenge (RQ2) D4: Users needed training, but rarely utilise help functions (RQ2)
The problems that many of the participants experienced were not related to accessibility (except for some technical-accessibility problems that affected the visually impaired participants), but rather to the plethora of interaction methods, many of which they did not necessarily know. The requirement of the third UD principle, to design ICT solutions in such a way that anyone can use them, regardless of previous knowledge, experience or training is problematised. The study shows that *gaps in user knowledge* is an important dimension of user diversity. This challenge needs to be addressed explicitly and systematically. It is also necessary to be clearer about what types of flexibility are wanted and necessary in IDAs.	D5: Problems were related to unknown functionality (RQ2) D6: Gaps in user knowledge are an important dimension in user diversity, and must be explicitly addressed (RQ2)
Some strategies for closing the gap between what users know and what users need to know to use mainstream ICTs are suggested, such as more focus on accessibility and usability, better help functions, reducing complexity by using layered interfaces, scaffolding and personalisation. However, these approaches need to be extended with frameworks and methods to define the basic layer and to prioritise functionality for scaffolds. I suggest that defining a basic set of usable and accessible ICT features could be used as a basis for novice training and development of a basic layer in applications.	D7: Strategies to reduce complexity are needed (RQ2)

5.1.5 Paper E. An evaluation of web-based voting usability and accessibility

Fuglerud, K. S. & Røssvoll, T. H. (2012). An evaluation of web-based voting usability and accessibility. Universal Access in the Information Society: (4): 359–373. doi: 10.1007/s10209-011-0253-9. URL: http://dx.doi.org/10.1007/s10209-011-0253-9.

This paper reports on a study evaluating accessibility and usability of several Internet voting prototypes. The paper provides a concrete example of how one may perform a thorough usability and accessibility evaluation of ICT solutions. We show how various methods can be combined in such an evaluation; namely, technical testing, the persona method and user testing. People with a wide range of disabilities, such as those who are visually impaired, hearing impaired, physically impaired and people with dyslexia participated in the usability and accessibility testing. Through the findings of this study, factors that are important to consider in the development and testing of web-based voting systems are highlighted.

5.1.5.1 Relation to the research questions

Summary of Paper E	**Lessons learned/recommendations**
We describe how various methods can be combined in an evaluation of the usability and accessibility of web-based ICT applications. The methods used were automatic and manual accessibility inspections with respect to standards and guidelines, expert testing with the persona method (i.e. persona walkthroughs) and evaluation with users in the field. The persona method was adapted to the process at hand, and we argue that knowledge and experience of how disabled users use ATs is necessary.	E1: Use method triangulation when evaluating usability and accessibility with diverse users (RQ1) (RQ3) E2: Knowledge about how disabled users use ATs is necessary
The prototypes that had one particular form of flexibility (i.e. providing several alternative ways to navigate within the application) were considered more complicated than the prototype that did not have this form of flexibility. This type of flexibility was, however, not necessary for technical accessibility. What was not evaluated, because it was not implemented, was multimodality, such as audio, pictures or video. Several participants requested this kind of supporting material.	E2: Flexibility in terms of several alternative ways to navigate within the application seemed to increase the complexity and did not contribute to accessibility (RQ2) E3: Multimodal learning materials were requested by participants (RQ1)

Summary of Paper E	**Lessons learned/recommendations**
A particularly interesting finding was that one particular prototype was preferred by the participants from all the user groups, except for people with dyslexia. They preferred another prototype with party symbols, while the winning prototype was rated as number two by them. Thus, although the participants in the study were quite diverse, the results of the user testing were not so divergent. This suggests that conflicting requirements from different user groups need not necessarily be a major obstacle to UD. Several common types of problems are summarised, and it is worth noting that nearly all participants, regardless of disability, had problems with the sequence of actions, page structure and navigation. In general, too many options seemed to be a problem to the users across all types of disabilities.	E4: Participants across all user groups experienced usability problems and problems with too many options (RQ2)
Despite the clear usability and accessibility requirements, all the prototypes had significant usability and accessibility flaws, whereof several could have been revealed through expert accessibility inspection and conformance testing with respect to standards and guidelines. Therefore, we argue that developers of such systems are lacking in knowledge concerning IDAs or that this does not have enough priority.	E5: Accessibility inspection and conformance testing can probably reduce the number of accessibility flaws in mainstream applications (RQ1)
Finally, we argue that it is important to study various aspects, such as social, technical, security, privacy, trust and usability when designing an e-voting solution.	E6: It is important to explore a variety of contextual aspects and issues from different disciplines when designing solutions for web-based voting (RQ1)

5.1.6 Paper F: The barriers to and benefits of use of ICT for people with visual impairment

Fuglerud, K. (2011, 9–14 July). The barriers to and benefits of use of ICT for people with visual impairment. HCI International, Universal Access in Human–Computer Interaction. Design for All and eInclusion, Orlando, Florida, USA. Springer Berlin/Heidelberg. pp. 452–462.

This paper concerns a study that aimed to identify the benefits of and barriers to the use of ICT for visually impaired people and to propose measures to remove those barriers. Visually impaired users' encounters with technology were investigated through a focus-group interview, a field study of 28 visually impaired persons with observations of task-solving activities and semi-structured interviews. Their experiences with Internet services, mobile phones, kiosks, ticket machines, ATMs and queuing management systems were studied.

5.1.6.1 Relation to the research questions

Summary of Paper F	**Lessons learned/recommendations**
The study showed that the visually impaired experienced major challenges in using ICTs in their daily life. Many ICT products and services, mobile phones, kiosks, ticket machines, ATMs and queuing management systems have poor accessibility. Inaccessible mechanisms for registration and authentication were a major barrier to the use of various Internet services. The proliferation of self-service terminals and queuing management systems constituted another major barrier for the visually impaired.	F1: Many everyday technologies have poor accessibility for the visually impaired (RQ2)
Unstable systems, often because of poor interoperability with ATs, are an underestimated problem for visually impaired people. It is evident from the paper that the necessary flexibility caused by the need for interoperability with ATs often leads to an increased demand for learning and problem-solving capacities on the part of the user. This is because the user needs to learn both to handle the ICT solution in question and the AT, and these two in combination. Moreover, the visually impaired user has to handle new updates both of the ICT solution and the AT, and the combination, clearly leading to a complex and demanding situation.	F2: Using AT together with mainstream technology increases flexibility, but contributes to a complex situation for the AT user (RQ2)

Summary of Paper F	Lessons learned/recommendations
Thus, the challenges of using AT together with mainstream solutions are not only related to poor interoperability, but also to contextual factors such as the possibility of getting support, the dependence on people that could give the support, and the need for more frequent and extensive training when using AT together with mainstream technology. Based on the findings, some suggestions for further development and research priorities are suggested, such as accessibility tools that can be used by developers, accessible registration and authentication mechanisms, learning materials, web 2.0 and social media, mobile web and everyday technology.	F3: Using AT together with mainstream technology may lead to an increased need for training and support (RQ2) F4: Further research is needed in accessibility, accessible registration and authentication mechanisms, learning materials, web 2.0 and social media, mobile web and everyday technology
The main conclusions of the paper are somewhat related to the issue of the development process. While one conclusion is that a major challenge is interoperability and the robustness of mainstream technology working together with ATs, I also emphasise that technical accessibility and compliance with standards and guidelines is not enough to obviate the barriers for visually impaired people. Therefore, there is also a need for a shift from a one-sided focus on conformance to accessibility standards and guidelines, to a combination of approaches, and to combine considerations of technical accessibility and usability. Moreover, organisational and contextual issues such as set-up, training and support need to be considered by stakeholders in the development cycle.	F5: Achieving interoperability and robustness of mainstream solutions working together with AT is a major challenge F5: It is necessary to consider the combination of accessibility and usability in context (RQ1) F6: Organisational and contextual issues such as set-up, training and support need to be considered in inclusive design (RQ1) (RQ3)

6 Discussion

In the previous chapter, the main findings of the research papers were pointed out. In this chapter, these findings are categorised, structured and discussed. I also bring in experiences and findings from the projects presented in section 4.2. The organising principle of this chapter is the research questions.

6.1 RQ1: The key elements in inclusive design

Various lessons learned and recommendations from the papers were presented in the previous chapter. By sorting and structuring these lessons and recommendations, I have identified thirteen elements of inclusive design (see **Figure 7**: Identified elements of inclusive design). In the following, I will discuss these elements in light of the empirical findings, the experiences from the projects and related research. The sub-sections below correspond to the thirteen identified elements.

6.1.1 Based on a user-centred process

Many researchers assert that inclusive design must be based on a user-centred design (UCD) process. While there are different interpretations of UCD (see section 3.4), there seems to be general agreement about the three main principles of UCD; namely, 1) an early focus on users and tasks, 2) empirical measurement with users, and 3) iterative design. Research in inclusive design would probably benefit from more specific and explicit descriptions of what is meant by basing it on UCD.

In all the cases included in this thesis, there has been an empirical evaluation of some kind of software. In four of the seven projects (i.e. P2, P3, P5 and P7 in **Table 6** on page 65), the development process corresponded to the human-centred design process (see **Figure 4** on page 37). In the three other projects (P1, P4 and P6), the ICT solutions under scrutiny have either been existing ICT solutions or prototypes developed by others.

The three-year project, Diadem, is an example of an iterative development project with prototyping and empirical evaluation. It focussed on the elderly and people with cognitive impairments. To get user input early on (i.e. before anything was developed), a focus group was conducted, and participants were recruited to evaluate existing ICT solutions that were similar and relevant to the software to be developed (i.e. electronic forms). This gave a good starting point for the requirements' specification.

The project proceeded with the development of a prototype, which was evaluated through a user trial. Based on the results from the user trial, a new and updated prototype was developed and evaluated in a second user trial.

Figure 7: Identified elements of inclusive design

The two user trials took place after many months of development (nearly a year in each iteration), with 16 and 30 participants, respectively. Although some expert evaluations were performed during the prototype development, many quite serious usability and accessibility problems were uncovered in each user trial.

The problems were so severe that they had a negative effect on the user experience as a whole, and prohibited feedback on many other aspects of the design. It would have been a great advantage to uncover these difficulties earlier in the prototype-development period. It confirmed that a focus on evaluations as early as possible is extremely important.

The duration of the uu-Authentication project was only half a year and included one development and evaluation cycle; that is, one iteration. The prototype that was developed was evaluated with ten users, and many usability and accessibility issues were uncovered. The Unimod and e-Me project were more exploratory with several smaller prototypes, mainly evaluated by experts, and with user evaluations towards the end. I believe it would have been desirable to include users earlier in these projects as well. However, the aim of these research projects was not to develop commercial solutions, but to generate knowledge and to show possible concepts through prototypes. Thus, several more iterations would have been necessary to arrive at production-ready solutions.

These experiences have led me to conclude that shorter development periods including empirical evaluations with fewer participants would have been more beneficial than having a large user trial with up to 30 participants after a relatively long development period. While it is certainly desirable to have early user involvement and empirical evaluation, it is also my experience that this is challenging to achieve in practice, even in research projects that have inclusive design as one of their main goals. Limited resources, and the time and the amount of work associated with finding and recruiting participants and coordinating user evaluations into the overall development process have been among the main obstacles for shorter, but more frequent iterations.

6.1.2 Organisational commitment towards and knowledge about inclusive design is necessary

The usability and accessibility evaluations of five e-voting prototypes (Paper E) demonstrated many shortcomings in all the prototypes in spite of clear usability and accessibility requirements from the procurer. We assert that this might be due to lack of knowledge, priority or commitment in the development organisations (Paper E).

In Paper A, I put forward arguments for why inclusive design is important, and state that organisational commitment and support from the management in the development organisation is important for inclusive design. Further, I state that it is necessary to educate the service provider, the project owner, the management and the development team about inclusive design. This is because there are many perception barriers to inclusive design (see section 3.7.11).

In addition to having inclusive design as a high-level goal in the development organisation, it is necessary to have the commitment from team members and team leaders (Paper A). The projects in this thesis have been undertaken in the context of e-inclusion as a research area. I have been the leader of the e-inclusion group and have been the project leader for several of the projects (see **Table 6**, page 65). I argue that e-inclusion as a research context and my personal commitment to UD have been crucial for the start-up and implementation of the projects.

Commitment from the management is shown to be a critical success factor in UCD to get the necessary resources and support to undertake user-centred activities (Boivie et al. 2006; Gulliksen & Lantz 2000). In a study conducted by the National Council on Disability in the USA, leadership was found to be the most important factor for the various agencies' attitudes towards and success in achieving accessibility (NCD 2001). The leadership had taken different forms in the different agencies. However, in all the cases, a person's leadership and engagement seemed to have sprung out of some kind of life experience or personal commitment, and this evolved into sustained efforts in the workplace. In another study across three sectors, organisational motivation for implementing web accessibility was explored. Two motivational factors for accessibility could be derived from across all three of the sectors. These were that of having a key personality with engagement in accessibility and a high level of social commitment in the organisation (Leitner & Strauss 2010).

Having a *usability champion* has been reported to be an important factor for succeeding in usability design (Gulliksen et al. 2003; Mrazek & Rafeld 1992). It seems to be important that this person has a clear role and mandate to decide on usability matters (Boivie et al. 2006; Bygstad et al. 2008; Gulliksen et al. 2003). Researchers in UCD advise pointing out somebody in the project organisation who will be responsible for the user perspective of the services (Følstad & Skjetne 2007). Having a *user advocate* in ICT development is important, whether this person is a user or not (Rasmussen et al. 2011). This is because needs that have advocates tend to become requirements and considerable effort is made to implement them, while needs without advocates often do not become requirements and remain unimplemented (Rasmussen et al. 2011).

My experiences clearly support these findings from UCD. I argue that the project-establishing phase is the best opportunity to create a unified understanding of what one wants to achieve, why and how. Therefore, it is important to establish organisational commitment for inclusive design during the project-establishing phase. In research projects, the project-establishing phase is typically during the proposal-writing stage, while in industry, this phase starts during the procurement and sales process, or when formulating and responding to tenders. Likewise, I infer from UCD research and experiences from the projects that having an "*inclusive design advocate"* is important, and that this person needs the competence and knowledge to contribute to the practical work as well as being personally engaged.

6.1.3 The approach must be holistic, interdisciplinary and context driven

The need for interdisciplinary work in the development of inclusive ICT is highlighted in several of the papers. In Paper E about e-voting, it is recognised that several aspects, such as social, technical, security, privacy, trust, usability and accessibility may influence voting behaviour and may thus influence web-based voting as a phenomenon in contrast to traditional voting. Various competences are therefore needed in the development of e-voting solutions.

In Paper B, we argue that there is a need for inclusive identity management (IIDM) because many ICT solutions require that the user is identified and authenticated. The development of IIDM requires interdisciplinary competence within fields such as inclusive design, privacy, legal issues and usability (Paper B). Different fields use different approaches and methods, and devotion to interdisciplinary learning and collaboration is necessary. It must be recognised that knowledge is socially distributed and therefore an interdisciplinary approach must focus on collaboration and dialogue between all of the actors involved. We recommend applying a context-driven approach, where problems are formulated and evaluated in the context of the application (Paper B).

The risk of adverse consequences might be regarded as particularly consequential when dealing with voting applications. However, most technologies developed today are to be used in highly complex environments, by large and diverse user groups, in different usage contexts, with various types of technologies involved. The users may therefore be affected by a number of factors. This underpins the importance of interdisciplinary teams (Paper B), utilising different perspectives in design (Paper A) and of studying various aspects that can affect use in an empirical context (Papers B and E).

Dalcher (2006) argues that both the constructive nature of design in general, and its focus on the creation of novel forms and solutions rather than on the discovery of the ultimate truth, distinguishes design from science. Moreover, design is also concerned with preferences, feelings and the ability to interpret and address needs. Design depends upon knowledge from both science and the humanities, and therefore consilience and interdisciplinary work are necessary in inclusive design (Dalcher 2006). Kelly et al. (2008) advocate for a holistic approach that offers flexibility by considering the context and user involvement rather than an objective test of whether a particular set of guidelines has been followed. Dong (2007) observes that there is a shifting paradigm from discipline-specific research towards multidisciplinary research within UD. Holistic, interdisciplinary and context-driven approaches are also recognised as important aspects of UCD processes (Gulliksen et al. 2003).

My research only confirms and underscores the necessity of a holistic and interdisciplinary approach with an emphasis on empirical and contextual learning and knowledge creation.

6.1.4 Focus on a variety of users and usage contexts

The general advice in the IDAs is to focus on a wide range of users, various devices and usage situations. However, as pointed out in section 1.5.3, there is a lack of empirical-based advice on how to do this in practice. The requirement to focus on diversity is, in principle, where the IDAs differ from UCD, because the latter focuses on design for typical users from representative user groups (Gulliksen et al. 2003).

The variety of users has been a theme in all the projects. In Papers A, B, C and E, a matrix with some main categories of impairments is used as a simple tool to analyse (parts of) the ICT solution in question across diverse user groups. In Paper A, the overlap between design for people with impairments and design for impairing situations is also highlighted. While the experience is that such an analysis cannot in any way be used as a basis for requirement specifications, it is a simple and helpful tool to keep diversity in mind, and this can be used as a rough framework for ensuring the coverage of a wide range of different users. This will be further discussed in relation to RQ3 in section 6.3.2.

I also believe that the need for flexibility in the inclusive design of ICTs stems directly from the need to focus on diverse users and usage contexts. This topic will be discussed further in relation to RQ2 in section 6.2.

6.1.5 Involve diverse users early on and throughout the development process

In inclusive design, it is important to have an early and continual focus on diverse users, and the process of user involvement started quite early in all the projects. During the project proposal stage, we usually contacted some NGOs and asked them to participate in the project, making it clear that an important task for them would be to help in the recruitment of participants for the project from among their members. (An overview of the project participants and funding can be found in Annex A)

The initiative for the ICT barriers of the visually impaired project came from the NABP. They were actively involved in shaping the project proposal through several meetings. They were also engaged in finding funding. In the other projects, the NGOs were invited to participate in the project by the researchers. The NGOs did have the opportunity to comment on the project proposals, but meetings were not organised. The reason for not having any NGOs formally participating in the e-Vote project was mainly due to the timing of the call for tenders (8 July 2009, during the Norwegian summer vacation), and the short period from the tender call to the tender deadline (15 July 2009). It was not possible for us to engage NGOs during this inconvenient and short period.

Thus, in the majority of the projects, there was user involvement both at a system level and at an individual level (see the categorisation of user involvement in section 3.5). In the ICT barriers of the visually impaired project, the user involvement was participatory. In the other projects, the user involvement was of a consultative nature. Although we were able to involve users in all the projects, I believe that the active engagement of the NABP in the ICT barriers of the visually impaired project resulted in a special impact. In this project, the aspect related to the two higher levels of UD, namely the meso and macro levels (see **Table 4** on page 45), became more pronounced than in the other projects.

Long-established knowledge from UCD has shown that it is important to pay attention to both the strategic and operational commitment towards user participation among key stakeholders to get the necessary resources and support to perform user-related activities and to take their priorities into account (Gulliksen et al. 2003).

The necessity of involving people with impairments in inclusive design is underscored by many researchers. However, it is challenging to achieve real involvement in practice. Depending on the goals of the project, it is important to explain why the involvement of diverse users is necessary, what type of involvement will be adequate and how it can be done. This is further discussed in sections 6.3.1 and 6.3.2, respectively.

6.1.6 Facilitate communication between user and developer

While there has been user involvement in all the projects that form this research, it has also been the case that there has been a division of labour. Usually, the people doing the actual programming and development were not engaged in the user research. Most of the observations and interviews were conducted in the field (see section 4.6.1). One or two researchers visited the participants. It was rarely feasible to have more than two observers for user evaluations in the field. Thus, while myself and my colleagues had the opportunity to observe and learn from the users, one key question relates to how effective we were in communicating this knowledge to the developers.

It can be difficult to communicate some of the aspects that emerge from direct observation and interaction with users effectively and realistically. One example concerns the findings related to the use of queuing systems in the ICT barriers of the visually impaired project. I felt that it was difficult to communicate the consequences of poorly designed and implemented queuing systems fully. The number of unpleasant, embarrassing and frustrating situations that were described by the participants, and the voice, tone and body language that were used when these situations were described made a profound impression on me. When thinking of this, I can recall a quite strong feeling, impression and knowledge about the adverse effects of poorly designed queuing systems, even several years afterwards. We chose to list a number of citations from the participants in the project report (Fuglerud & Solheim 2008 pp. 66-68). However, I do not think that the reader will get anywhere close to gaining the same impression from reading the report as I got from communicating directly with the participants.

Another similar experience is related to observations of participants' difficulties when trying to log in to the e-voting system in the e-Vote 2011 evaluation. This was a challenge for many of the participants, and they took several minutes for this one operation. One mobility-impaired participant used around one hour for the log-in process and another around 22 minutes (Fuglerud & Tjøstheim 2012 pp. 123-127). For me, these episodes have made solid impressions. I have noticed that the knowledge related to these experiences often emerges when I think of new technology designs.

Such knowledge does not easily “sink in” unless experienced directly. Newell (2011) describes a case where the developers felt that the researchers doing the user research were exaggerating the difficulties of the users. Only after being persuaded to interact closely with the users did the developers fully realise what the real problems were (Newell 2011 p. 119).

This is one important reason as to why the transformation of findings from user research into requirements has been a challenge in the projects. For example, in the Diadem project, the requirement-definition work was partly done through workshops that included the developers and the researchers who had performed the user research, and partly by the project coordinator. While some of the observed difficulties and suggestions from the participants were quite specific and could quite easily be transformed into requirements (such as the need to fix bugs), other issues could be of a more general nature. Such general issues could have many different potential solutions or no obvious solution. The resulting requirements’ specification was mainly a textual description, sometimes in a table format. However, in many cases, it was difficult to see a connection between the user research and certain requirements.

This has also been experienced as a problem from the perspective of the developers. Often, the developers faced the need to consult various types of documents, such as reports from user research, non-functional and functional requirements and integration requirements etc., and to make design decisions based on this (Røssvoll & Fuglerud 2013). Kujala (2008) also points to the definition of user requirements as a challenge. He found that developers needed the results from user research to be presented in a more structured and formalised way. User-need tables were found to be useful for developers (Kujala 2008).

Experiences regarding creating requirements will be discussed more in the next section. However, the main point here is that some of the experiences and knowledge from working with and interacting with users may not be easily structured and formalised as requirements. Some types of knowledge are most easily acquired by direct interaction. This will be discussed further in section 6.3.1.1 (Empathy and motivation).

6.1.7 The process must be able to handle different stakeholders, conflicting requirements and changes in requirements

In the Diadem project and the ICT barriers of the visually impaired (VI) project, a focus group with various stakeholders was set up at the start as a part of the process for understanding users and their contexts. In both cases, the focus group provided useful and rich information and was an important source of knowledge and input for the subsequent user research, for creating requirements and for user evaluations. A broad range of issues relating to the context of use was pointed out. For example, in regards to Diadem, the question of who would help users to set up and personalise such a system was discussed. In the ICT barriers of the visually impaired project, technical, economical and organisational issues related to AT, the education system and the process of obtaining AT were discussed.

The collaboration with employees in NGOs has been invaluable for the recruitment of participants to the projects. Their advice and support have been important in terms of gaining access to potential users. Additionally, in many cases their knowledge has been important in relation to timing and practical issues surrounding user participation. For example, we were able to avoid clashing with important arrangements in the NGOs (annual meetings). In addition, in the e-Vote project and in the uTRUSTit project, we got the opportunity to use meeting rooms at the NGOs' premises in other cities (Ålesund and Drammen) for user evaluations and a focus group, respectively. This was an advantage because the place was familiar to the participants and it helped us to gain access to participants in other cities.

These examples show that communication and interaction with stakeholders is not only important for developing an understanding of the *context of use* (step two in UCD, see **Figure 4,** page 37). It is also important to acquire information to facilitate user involvement in practice, that is, it is important for understanding the *context of design* (see section 3.6).

Another challenge that is often mentioned in relation to inclusive design is that users with different impairments may have conflicting needs (Deng 2001; Langdon & Thimbleby 2010; Newell 2011 p. 117). In the uu-Authentication project, we paid particular attention to whether the introduction of audio to aid visually impaired people using an authentication solution would mean impediments to people with dyslexia (Paper C). We found that there were no direct conflicts and that both groups were positive regarding the solution. There were, however, issues concerning various preferences, which might be attributed to differences between the user groups, such as with the groupings of numbers. We concluded that such issues could be resolved through allowing for different preferences; that is, through personalisation.

One finding in the study on e-voting prototypes is related to the issue of conflicting user needs (Paper E). Here, we found that, in general, participants with various types of impairments (i.e. sensory, physical and cognitive) were almost unanimous when they ranked the five prototypes. An exception to this pattern was that the dyslexic participants ranked the prototype with party logos above the prototype that was preferred by most of the other participants. Outside of this, we did not observe any directly conflicting wishes or needs. Thus, participants across many different user groups may be almost unanimous about what a good or a poor design is. This suggests that in practice, it is possible to find a common design that can be made accessible and usable across diverse user groups.

Additionally, in the study about gaps in user knowledge (Paper D), I paid particular attention to the issue of whether I could identify particular patterns of problems or issues related to different types of impairments. The only such pattern found in this analysis was that visually impaired participants had more problems related to poor screen-reader accessibility than the other participants did. This is not surprising, since this was the only group that used screen readers. However, I am unaware of any reports on screen-reader accessibility affecting other user groups negatively. On the contrary, Petrie et al. (2004) explored the belief that accessibility may affect visual design negatively. A total of 100 websites were tested with 51 people with a variety of impairments. It was found that accessibility did not constrain visual design. Some of the most accessible sites also had visual designs encompassing graphics, complex layouts and photographs. It has also been hypothesised that screen-reader users might prefer deeper menu structures than sighted users. However, a study by Hochheiser and Lazar (2010) suggests that broad, shallow menu structures are better than deep menu structures for screen-reader users as well as for sighted users.

Sometimes the fear of conflicts between user needs leads to the assertion that inclusive design is too difficult or even impossible (Crawford 2010; Lazar 2007 p. 7). Interestingly, in the early days of UCD, Gould & Lewis (1985) noted similar objections. They encountered the argument that because people are so diverse, one would have to test hundreds of people to get reliable results and that this would be neither practical nor possible. The counter-argument by Gould and Lewis (1985) was that although a smaller sample cannot reveal all the problems of a design, it is better to identify some of the problems than not to identify any. Moreover, they stated that according to their experience, the problems are often not as idiosyncratic as they are initially thought to be. Often, the same problems appear for one user after another (Gould & Lewis 1985). This has also been my experience when working with people with many different types and degrees of impairments, such as in the e-voting project (Paper E).

Thus, it seems that the fear of insurmountable difficulties because of conflicting needs between people with different types of impairments is exaggerated. This is not to say that conflicting needs among various user groups or stakeholders will not occur or that they should be ignored. Conflicting user needs have been discussed in much of the previous research within systems development and UCD (Alsos & Svanæs 2011; Rasmussen et al. 2011; Subramanyam et al. 2010). In particular, PD has paid attention to how to deal with issues of conflicting needs and wishes among various stakeholders (Bødker 1996; Oostveen & Besselaar 2004; Rönkkö et al. 2008; Wagner 1993)(see also section 3.3). However, these findings show that the problem of potential conflicting needs between different groups of disabled people may be placed more on the same scale as conflicting needs between any user groups.

To summarise, this research has uncovered different preferences between different user groups. Accommodating different preferences has to do with flexibility and this is discussed in section 6.2. In general, ICT solutions have a big potential for improvement towards a common design that has significantly better accessibility and usability for various user groups than is the case for many ICT solutions today. This is because people with different types of impairments often struggle with many of the same problems.

Observing users, interacting with users and stakeholders, interacting with colleagues both inside the team and from other organisations and attending conferences have contributed to a continual learning process with regard to inclusive design. This has meant that the need or wish for changes in the requirements' specification could occur at any point during the projects. However, because users have typically been involved in evaluations of prototypes at the end of each development iteration, this has been the point in the development process where many new needs and requirements tend to emerge. (The challenge of involving users early on is discussed further in section 6.3.2.4.)

In the projects, a more or less formal review of the requirements was typically performed after the user evaluation of prototypes. In several projects, an issue and bug-tracker tool (Jira[19]) was used for managing requirements. With this tool, issues and requirements could be grouped, given a priority, a deadline, a responsible person and a status etc. This tool was primarily used by the developers. As discussed in the previous section, it is a challenge to transfer knowledge from the project members that conducted the user research to the developers. Thus, if handling the requirement-management tool and prioritising requirements are left to the developers, one risks important knowledge, some of which may be tacit, not being brought into the prioritising process. This is unfortunate because the activity of prioritising between the requirements should be an interdisciplinary task. It should include participants with a deep knowledge of the user needs and the context of use.

In general, it is beneficial to conduct a systematic and multidisciplinary review and prioritising process of the requirements, preferably with the aid of a tool for managing the requirements. However, the question remains regarding to what extent such tools are accessible and suitable in a setting including stakeholders and users with impairments. The issue of prioritising is discussed further in section 6.3.1.3 (Aid in prioritising).

6.1.8 Ensure conformance to accessibility standards and interoperability with AT

When evaluating the e-voting prototypes (Paper E) we found that none of the prototypes conformed fully to the accessibility guidelines referred to in the requirements' specification. In particular, the prototypes did not conform to the W3C WCAG guidelines, which are widely known as the de facto industry standard for accessibility. This is also what is required by the Norwegian Anti-Discrimination and Accessibility Act from 1 July 2014. As these accessibility requirements were so clearly stated in the call for e-voting tenders

[19] See https://www.atlassian.com/software/jira

(Paper E), it was somewhat discouraging that none of the prototypes conformed to these guidelines. Possible reasons for this may be that the developers lacked knowledge about accessibility or that it was not prioritised. A higher conformance level would probably have improved the accessibility of the prototypes. However, several of the problems identified through the user evaluations were not a direct violation of these guidelines, and would therefore not have been rectified by following these guidelines alone (Paper E).

An improved version of the winning e-voting prototype from the 2009 evaluation (Paper E) was used during the 2011 election in Norway. In a field study on this solution, we found that it did not have satisfactory technical compatibility with all the screen readers that were commonly used in Norway (Fuglerud & Tjøstheim 2012). It is worth noting that most users with disabilities in Norway do not freely select the type of AT that they use, but that this depends on the welfare system, as the welfare system chooses and pays for their equipment.

In Papers B and C, we show that accessibility guidelines can be in conflict with security requirements associated with authentication and identity management. Moreover, we argue that a straightforward implementation of accessibility guidelines in connection with security functionality will not always be possible.

Recent research suggests that conformance to WCAG 2.0 will only solve about half of the problems encountered by visually impaired users (Power et al. 2012), and also that the use of automatic tools to determine conformance will only detect about half of the WCAG 2.0 violations (Vigo et al. 2013).

I have found several areas where following WCAG did not necessarily ensure accessibility. Examples include accessibility of security functionality and issues related to cognitive accessibility. (See more about cognitive accessibility in section 6.1.9, for more on technology diversity and interoperability see section 6.2.1.3, and for more on standards and guidelines see section 6.2.3.3).

Therefore, the one-sided focus on following WCAG, for example in the Norwegian regulations for universal design of ICT, is worrying. As Newel (2011 p. 117) notes, there is a danger that the use of guidelines may become an excuse for not making an effort to understand the needs of people with disabilities. I support his warning that the heavy focus on the adherence to standards and guidelines can easily lead to a situation where accessibility is seen as a simple check that can be fixed towards the end of the design and development process.

6.1.9 Focus on a combination of usability and accessibility in context

Based on the user observations and interviews with participants from several different impairment groups, I have found that some of the most recurring problem areas are (Papers B, C, D and E):

- Inaccessible authentication mechanisms (Papers B, C and F)
- Poor screen-reader accessibility (Papers D, E and F)
- Difficulties related to navigation, scrolling and use of the mouse and keyboard (Papers D and E)
- Confusing and disorienting sequence, menu and page structures (Papers C, D and E)
- Poor layout and small text size (Papers D and E)

Similar issues have been found in other studies with participants from different impairment groups. In a study that included the blind and partially sighted, dyslexic, the physically impaired and hearing impaired, the following problem areas were pointed out: incompatibility with screen readers, confusing and disorienting navigation mechanisms, cluttered and complex page layouts, poor contrast and text and graphics that were too small (Petrie et al. 2004).

While inaccessible authentication mechanisms and poor accessibility for screen-reader users are genuine and major problems, this research and other studies with visually impaired people underscores that poor usability is an important part of the problem (Papers D, E and F) (Babu & Singh 2009; Leporini & Paternò 2004; Petrie et al. 2004; Power et al. 2012; Theofanos & Redish 2003). Moreover, while some difficulties related to navigation, scrolling and the use of the mouse have a solution that may be classified as accessibility related, such as allowing keyboard-only navigation, many of these problems are also related to confusing and disorienting page structures and navigation mechanisms, which are more usability related. Similarly, while small text may be regarded as an accessibility issue, it is clear that how much text is presented on one page will be related to the overall structure and page layout, which is again an important usability issue.

Thus, this research demonstrates and confirms that there is a close relationship between usability and accessibility. It is important to consider usability aspects in connection with accessibility. To be able to talk about these nuances and at the same time underscore the close relationship between accessibility and usability, some authors have suggested splitting the term accessibility into two; namely, *technical accessibility* and *usable accessibility* (see section 3.7.4).

6.1.10 Method triangulation: Use more than one method in user research

In Papers A, B, C and E, more than one method for user research was recommended. In all the projects, observations have been complemented with interviews and other methods (see **Table 7** on page 69). A focus group was formed for two of the projects. The persona method was used in two of the projects. In the e-voting project, conformance to guidelines was checked both manually and automatically through accessibility evaluation tools.

UCD implies the use and combination of several different methods and techniques for user research (Gulliksen et al. 2003). Moreover, it is generally accepted that empirical user evaluation is necessary in UCD and that various other user-centred methods, such as usability inspection and walkthrough methods, should be used as complementary methods rather than as substitutes for evaluations with users (Greenberg & Buxton 2008; Hollingsed

& Novick 2007). As in UCD, researchers in inclusive design suggest complementing empirical user evaluation with other methods, such as expert reviews (Zimmermann & Vanderheiden 2007), personas (Schulz & Fuglerud 2012) and theatre (Pullin & Newell 2007). See 6.3.2.4 for a more detailed discussion on the experiences with the methods used in this research and for recommendations based on these experiences.

6.1.11 Consider using multimodality

In Paper A, I assert that providing alternative modalities can be used to accommodate both various situations and people with different types of impairments. Modalities can be chosen according to the task, the environment and user capabilities. Multimodality can be a way to make a solution more accessible and inclusive in situations where the use of AT is not possible or practical, such as in mobile authentication (Paper C).

The connection between accessibility and mobile web interfaces has also been pointed out by other researchers (Harper et al. 2007; Knudsen & Holone 2012; Leitner & Strauss 2010; Oviatt 2003). Multimodal interfaces are inherently flexible, according to Oviatt (2003), and this key feature makes them suitable for both universal access and mobile computing. However, there is a concern about whether multimodality will lead to increased complexity, which again will be in conflict with ease of use (see section 1.5). This issue will be discussed further in connection with research question two in section 6.2.1.4.

6.1.12 Identity management mechanisms need to be inclusive

Authentication and identity management is a challenging area when it comes to accessibility and IDAs. Security functionality is often particularly inaccessible and difficult to use (Papers B, C and F). Through several of the projects, we have identified some main categories of challenges related to registration and authentication (Papers C and F) (Fuglerud & Tjøstheim 2012; Fuglerud et al. 2012):

- Physical and technical barriers
- Inadequate explanation and feedback during the log-in process
- Difficulties related to the sequence and order of a log-in process (particularly when one has to combine a PC, mobile phone, password, letter and PIN codes etc.)
- Unfamiliar or unclear concepts
- The continually increasing cognitive load associated with having to remember an increasing number of different user names combined with codes or passwords

There is great potential for improvement in this area. However, the increasing cognitive load associated with remembering user IDs and passwords for all the different ICT services cannot be solved in the realm of each individual ICT solution. There is a need for solutions at a higher level, that is, at a macro level (see **Table 4** on page 45), involving a number of aspects such as technical, security, economic, social, political, and legislation aspects etc.

These issues are the focus of large research projects working with electronic identity management solutions on a national and international level, such as in the FutureID[20] project. Moreover, inclusive identity management is, as pointed out in Paper B, essential for achieving adaptation and personalisation (see further discussion in section 6.2.3.4).

6.1.13 Personalisation and adaptation may be used to achieve flexibility

Personalisation and adaptation may be used to meet individual users' usability and accessibility needs and may increase the flexibility of an ICT solution (Papers B and C). However, these approaches also raise a range of new challenges, such as privacy and security related to user profiles, how to decide what functionality to keep as standard and what to personalise, the usability and accessibility of the personalisation mechanism itself and the accuracy and appropriateness of the adaptation mechanism. These issues are discussed further in connection with research question two in section 6.2.3.4.

6.1.14 RQ1 Summary

All of the thirteen elements of inclusive design that emerged through my research have also been discussed in previous research in UCD and inclusive design. This underlines the significance of the elements. I have also sought to bring some depth to the identified elements by describing my interpretation of them and how they have occurred in the projects. The purpose of this exercise, that is, the presentation and discussion of the various elements in this research, has been to synthesising related research, and to contribute with an overview of the important elements of inclusive design. The discussions relating to the second and third research questions will also shed light upon several elements, and my final list of the important elements of inclusive design is presented in the conclusion (section 7.1).

6.2 RQ2: The relationship between flexibility, complexity and simplicity

In this section, I discuss findings related to research question two: What is the relationship between "flexibility in use", complexity and "simple and intuitive to use" in mainstream ICT? Several researchers have called for flexibility in inclusive design, but this is not a trivial matter:

> To build applications and content that allows for heterogeneity, flexibility, and device independence is incredibly difficult, incredibly challenging, and incredibly necessary. (Harper & Chen 2012)

As flexibility is a natural consequence of the need to design for diversity and variability, it is particularly important to study the nature of it in relation to inclusive design. Findings that

[20] www.futureid.eu

can shed light on this have been reorganised and structured as shown in **Figure 8:** Relationship between flexibility, simplicity and complexity). They are categorised into the following themes: "diversity", "multimodality, alternatives and flexibility" and "approaches to reduce complexity". These themes are discussed in the following.

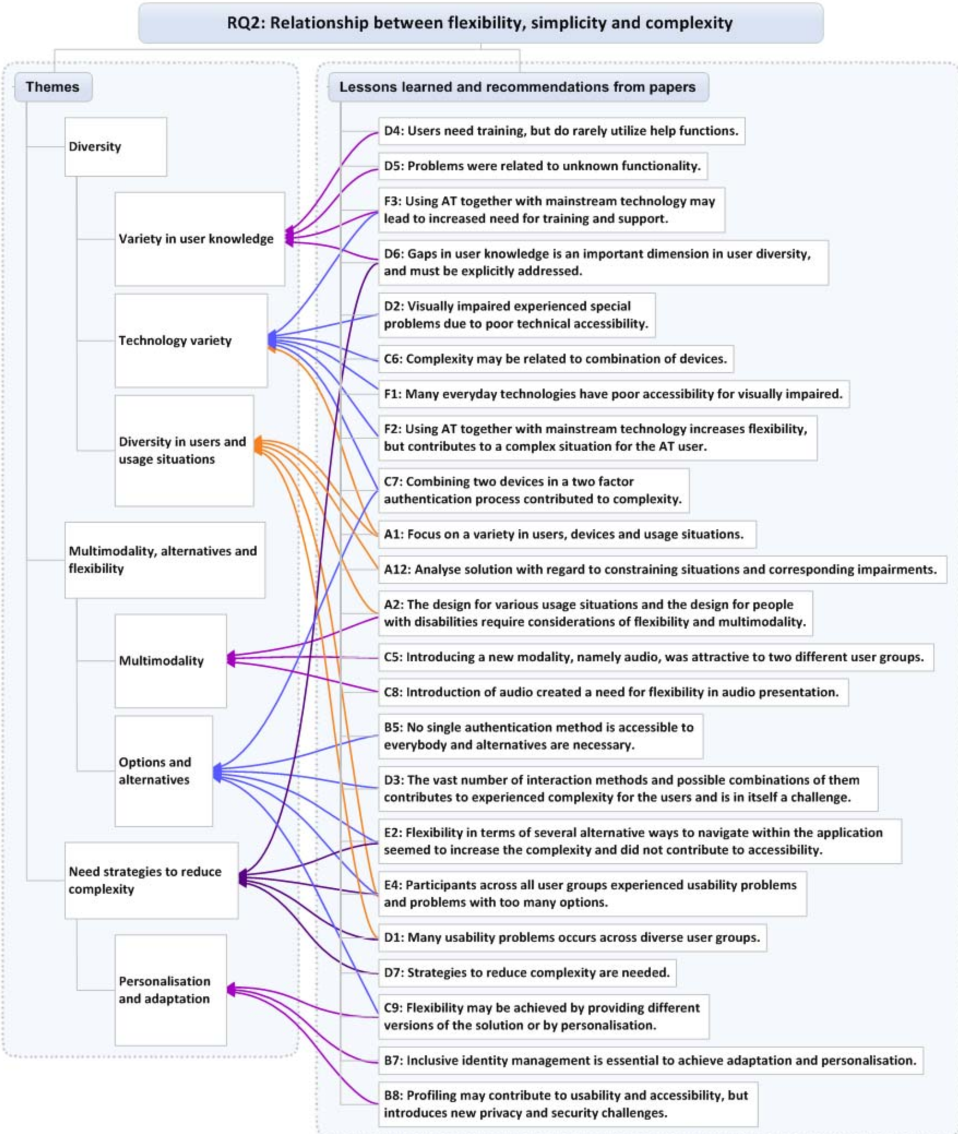

Figure 8: Relationship between flexibility, simplicity and complexity.

6.2.1 Diversity

Four challenges of diversity in IDAs are listed in **Table 3** on page 10. These are *user diversity*, *various usage situations, technology variety* and *variety in user knowledge.* The variety of user *technology,* which is also an aspect of the usage context or *usage situations*, has been an issue in several of the projects, in particular in relation to the various types of AT that users may have. In Paper E, we describe our approach to testing with regard to *technology variety*, both in terms of various platforms and browsers. The issue of diversity in *user knowledge* is discussed in Paper D. Some aspects of these challenges are discussed further in the next sub-sections.

6.2.1.1 User diversity

The diversity in the capability of individuals in a population is vast. Moreover, the capabilities may change rapidly and vary in intensity both within and between individuals. This leads to a demanding design environment, and a better understanding of diversity in user capabilities is called for (Keates, S. & Clarkson, P. J. 2003; Langdon & Thimbleby 2010).

User capabilities are commonly divided into cognitive, sensory and motor capabilities. In relation to the use of ICT, the sensory and motor capabilities are in some sense more fundamental than the cognitive functions. This is because the cognitive functions depend upon sensory and motoric input and output (Fairweather & Trewin 2010). That is, cognition may be regarded as a layer on top of the sensory and motor layers. The data input is transformed into meaningful information through cognitive processes such as memory, attention, recognition and problem solving. Impairments or distortions in these processes will naturally affect how people interact with computers (Fairweather & Trewin 2010). For people with cognitive impairments, it is therefore essential that we pay particular attention to cognitive accessibility.

As explained in section 1.5.1, the main strategy to accommodate diversity in sensory and motor capabilities is to make the information perceivable and operable to the user by offering flexibility in the input and output methods. Examples of this type of flexibility include offering various input and output modalities, interoperability with ATs and alternative presentation settings.

For a person to be able to process and understand the information, it must not only be perceivable and operable, but also presented in a way that is usable and cognitively accessible to that particular person. ICT is per se very information intensive. As the interfaces become more dynamic and complex, it becomes more cognitively demanding. This is why it is not enough to focus on technical accessibility for any user group. Usability and cognitive accessibility are, therefore, not only important for people with cognitive impairments, but, in fact, for everybody.

Many usability problems observed in the projects occurred across diverse user groups (Papers D and E). This is natural, because once the basic requirement of providing perceivable and operable information is met (i.e. the solution is technically accessible), then the remaining issues are likely to be related to usability. This also illustrates the close connection between usability and accessibility (see section 6.1.9).

Cognitive accessibility is, according to Pullin (2009 p. 83), one of the most difficult and least understood challenges facing inclusive design. More knowledge is needed about cognitive processes to be able to design very good interfaces for people with cognitive impairments.

While people with cognitive impairments may benefit from new and innovative support mechanisms, it is also the case that poor usability leads to poor cognitive accessibility for any user group. To increase the cognitive accessibility in inclusive design, it is therefore of imperative importance to focus on usability in general and on usability for people with reduced cognitive abilities in particular. Thus, a good starting point might be to tailor commonly used usability tools and techniques to work with diverse users, and particularly to work with people with cognitive impairments. Depending on what type of cognitive process is limited or adversely affected, the designer needs to focus on how to enhance these processes or possibly, on how to compensate by strengthening or building on other cognitive processes that are not affected.

For example, symbols and visual cues are important for people with dyslexia or limited language comprehension. This is probably why dyslexic participants in the e-Vote project rated the prototype with party logos above the other prototypes (Fuglerud & Røssvoll 2012). A good example of a solution that is accessible for people with dyslexia and limited language comprehension is the successful St Math application[21]. This is a game-based math curriculum for pupils in elementary and secondary schools. Its creator, Matthew Peterson, having dyslexia himself, wanted to make mathematics understandable for pupils with low language comprehension (Peterson 2011). While basing the application on sound pedagogical principles, he managed to eliminate all textual and word-based instructions, resulting in a highly effective tool for teaching mathematics (Shapiro 2013). However, this tool is mainly visual, and therefore not appropriate for blind people. The question is whether such a tool could be made accessible for people with visual impairments without increasing the complexity. In section 6.3.3.3, I discuss the tension between accommodating everybody in one solution versus providing tailored solutions for various user groups.

Cognitive accessibility is also closely connected to the issue of accommodating the variety in user knowledge, which is discussed in section 6.2.1.4.

6.2.1.2 Various usage situations

In Paper A, the connection between designing for people with various types of impairments and designing for various usage situations is demonstrated. An overview of

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[21] http://www.mindresearch.net/programs/

various types of situations that may put restrictions on a person's use of technology with parallels to corresponding impairments is given. For example, when designing ICT for use in a very noisy place where the user may not be able to hear alarms and sounds, the designer has to rely on other interaction modalities to alert the user. The alternative alert mechanisms may be useful when designing for hearing-impaired people too, and not only in a noisy environment. The point being that alternative interaction mechanisms are necessary whether designing technology to be used in a wide range of situations or designing for people with a wide range of impairments.

The connection between inclusive design and design for various situations becomes more pronounced when designing mobile services and many types of everyday technology, because these technologies will typically be used in various situations. Bringing along various types of ATs for use in various situations does not seem to be a feasible solution. Therefore, the alternative interaction mechanism needs to be built into the main solution so that it is flexible enough to be used in various situations, and this may be an advantage for people with impairments.

As is pointed out in Papers B and C, it is currently not always possible to combine security functionality with AT. The problem is that if third-party software, such as AT, can hook into authentication mechanisms, then malicious programs could mask as AT and violate the security. In such cases, it is necessary to build the alternative modalities into the security application and therefore multimodality may be particularly important in terms of making security mechanisms accessible. The authentication solution described in Paper C included audio only in certain parts related to conveying security information. In other parts of the application, a visually impaired user would need AT. However, at the time of development and in the Norwegian context, it was actually quite common for the visually impaired to have such AT installed on their mobile phones, because they would get such AT covered by the welfare system. Thus, what is practically feasible, acceptable and affordable in a situation and in a specific cultural setting, may best be determined through a design process that is aware of the technological, cultural and social context of use.

The ultimate goal of many of the IDAs is to eliminate the need for AT. However, in practice, one has to take the context into account to decide where the boundaries between the main solution and AT should be placed. For example, it is widely accepted today that in order for a website to be accessible to blind people, it must be usable with a screen reader together with a braille display and text-to-speech software (see an example of this type of AT in **Figure 1** on page 6). However, in order for a bank terminal to be accessible, one does not expect the blind person to bring a screen reader with them. The size of a braille display together with security issues associated with connecting an arbitrary screen reader to a bank terminal is probably the most prominent reason for that. The most common solution is to equip the bank terminal with audio output so that blind customers can listen to the dialogue using their own earplugs. Thus, it is important to recognise that what may be regarded as inclusive design in practice is context dependent, and therefore a holistic approach is required.

6.2.1.3 Technology variety and interoperability with assistive technology

The issue of technology variety is closely connected to the issue of interoperability with AT. Ideally, an ICT solution that has AT interoperability will give the user the flexibility to use whatever type of AT he or she needs or prefers together with the solution. In several of the cases in this thesis, there were deficiencies with regard to conformance with AT.

Moreover, the extra layer of technology that AT represents introduces challenges for AT users. One difficulty reported in Paper F was connected to frequent technical problems, such as hanging computers, error messages and system crashes. These problems are often attributed to poor interoperability. Related to this is the fact that adding AT to a system introduces more components to it. Often, the technical problems would go beyond one single component, tool or piece of equipment, and the more components there were, the more potential causes for the problem there were. Therefore, it was difficult to pinpoint what parts of the system had caused the technical failure in the study on the ICT barriers of the visually impaired. It does not help that the various components of a system are often provided by different suppliers. As the participants in the study pointed out, the difficulty in determining which component had failed made it difficult to determine who should be responsible for correcting the problem. This means that the technical problems not only occur more often for AT users, but that such problems are also more critical and difficult to handle, particularly when the AT is affected.

Another problem is that the AT needs to be continually updated along with the developments of the mainstream technology. The uptake of web 2.0 technologies, which enables rich interaction and content to be updated dynamically, poses particular challenges for AT users (Brown et al. 2012; Fuglerud et al. 2012; Gibson 2007; Hailpern et al. 2009) and for people with cognitive impairments (Fairweather & Trewin 2010). One part of the problem is that the AT industry is not able to keep up with the developments of the mainstream industry, and there are also other delaying factors such as the need for the translation of foreign AT software (as is often the case in Norway), and that there are financial, administrative or organisational factors involved in obtaining and maintaining the AT (Paper F). The resulting lag creates problems and barriers for people with impairments (Brown et al. 2012; Fuglerud & Solheim 2008). Another part of the problem is that developers need to learn about how to make the content accessible in these new environments (Brown et al. 2012; Fairweather & Trewin 2010; Fuglerud et al. 2012; Gibson 2007).

This illustrates that the flexibility in using various types of AT together with mainstream technology has also resulted in a highly complex situation for the AT users. This is an important reason as to why people with impairments sometimes prefer to use the emerging built-in accessibility features of new ICT, rather than well-established solutions from existing but separate AT suppliers. Some prefer built-in accessibility features even if they are less sophisticated than AT from established AT suppliers. For example, after the iPhone was introduced with a built-in VoiceOver functionality, many visually impaired users preferred this to a mobile phone with separate screen-reader software.

Thus, although it is currently accepted that inclusive design may be achieved through a combination of AT together with a mainstream solution (provided interoperability), a development towards more built-in accessibility functionality might eliminate many of the economic, organisational and technical difficulties described above. Such a development however, requires that mainstream developers acquire a high level of competence regarding accessibility.

Solving the problem of making ICT solutions more compatible, robust and accessible with AT requires coordinated work on all societal levels (see **Table 4** on page 45). The overall situation regarding what types of ATs are available for a particular user, lags in updates and the availability of support etc. must be handled at a macro level, while acquiring knowledge about how to make the technology technically accessible requires knowledge and decisions at the meso level. What is equally important is the actual user experience; that is, working with the accessibility and usability for AT users at the micro level.

6.2.1.4 Variety in user knowledge

Even when following the usability and accessibility guidelines, there are many possible ways in which to implement a particular type of ICT service, such as with an electronic form, which was used in several of the cases referred to in Paper D. This means that that the user faces the need to learn new ways of doing things when moving from one service or product to another, and sometimes within one service or product as well.

In the study about user knowledge (Paper D), I found that even though the set of case applications was quite small and similar (electronic forms in three out of four cases), different subsets of features were used in the various implementations, and the participants knew yet other subsets of the features. For example, the functionality of entering a date could be done in several ways, and some participants were familiar with one way of doing this, while others were familiar with another way. Thus, even if the participants had learned certain features beforehand, they might face the need to learn new ways of doing this for another service because this feature may have been implemented in different ways. For several of the participants this caused significant difficulties. Part of the problem was that there seemed to be a lack of consistency in how to do things, both within a service and across services (see more about consistency in section 6.2.3.3).

The analysis in Paper D indicated that a lack of ICT knowledge (i.e. a lack of experience regarding how to do things in an interface) and knowledge of how to interact with various features seemed to be a more severe obstacle to task completion than having an impairment, including a cognitive impairment. This conclusion was drawn on the basis that several of the cognitively impaired participants in the study performed better than people without a cognitive impairment did. The important factor seemed to be their level of previous ICT experience. People with little previous ICT experience appeared to be overwhelmed and lost. This was observed in several cases. It must, however, be taken into account that the participants in these studies did not have major cognitive impairments (see the description of participants in section 4.3.2). Nevertheless, these findings only underscore the challenge of diversity in users' knowledge and previous ICT experience when aiming at inclusive design.

In Paper F about ICT barriers of the visually impaired, I point out that using a combination of AT and a mainstream system places extra demands on the users' cognitive and learning abilities, and thus increases the demand for training. First, visually impaired people have less opportunity than others do to read error messages, instructions and learning materials, since these messages and materials are often inaccessible. Therefore, the visually impaired must be trained to handle issues covered by such inaccessible material. Secondly, there is a need for training in how to operate the AT, and in how to customise and optimise settings in the AT hardware and software. Third, there is a need for training in the use of AT in combination with other software, and last but not least, the frequency of change in the technology configuration may be higher for visually impaired individuals because of updates in both the AT and the mainstream technology. This requires more frequent learning of and adaptation to new configurations. Other researchers have also noted that visually impaired AT users have an extra mental load (Theofanos & Redish 2003), and are required to have considerable computer skills (Buzzi et al. 2010). As the ATs that visually impaired people use are typically relatively complex, these issues might be more pronounced for the visually impaired than for other users of AT. However, the same issues will probably be present to a greater or lesser extent for other groups of AT users as well.

These findings show that the notion of a design that is so easy to understand that it can be used regardless of the user's experience, knowledge and language skills, or current concentration level (see UD Principle 3 in Annex B) is rather challenging. It cannot be addressed by the designers alone, since it is affected by issues such as consistency with other solutions. The principle can of course function as a normative goal to strive for, but the danger is that it becomes an excuse for service providers and authorities not to consider the need for training and support related to the use of ICT. Some kind of standardisation effort with regard to defining a set of basic ICT functions may also be needed.

Even if ICT is inclusively designed, some basic training is needed, not least for AT users. In addition to legislation that requires inclusive design, other measures on a societal level are necessary to make people able to use mainstream ICTs. This means that when, for example, the Norwegian government decides to make online services the preferred means of communication with citizens and businesses (FAD 2012), it is of vital importance to accompany this with policies to ensure that people get the opportunity to acquire the necessary ICT skills.

6.2.2 Multimodality, alternatives and flexibility

The issue of multimodality was touched upon in the e-Vote study (Paper E). Several participants in the study, particularly people with reading difficulties, commented that they would like multimodal help in the form of instruction videos. Other researchers have found that animations can help people to learn to use interactive systems, and that many people prefer them as compared to explanations without animations (Shneiderman & Hochheiser 2001). However, too many animations or animations that are unclear or imprecise may confuse the user (Paper E).

The two user groups, people with visual impairments and dyslexia, were positive overall regarding the introduction of audio in the authentication solution (Paper C). However, this study showed that introducing audio also brought up new issues regarding operating the audio, and different preferences related to this.

The speed of the audio was an issue, and most of the users, but not all, found the audio in the prototype to be too slow. For visually impaired participants who did not read visually, slow audio was just a bit annoying. For some of the participants with dyslexia however, it caused some confusion because the audio would lag behind their visual reading, resulting in a form of dual asynchronous input. The problem of synchronisation when presenting identical information in two modalities (e.g. reading of and listening to the same text simultaneously) is also pointed out by Wickens (2002).

Another issue was related to the grouping of the digits when a six-digit code was read aloud. Roughly half of the participants preferred having two digits read aloud at one time. People with dyslexia were more likely to prefer one digit at a time to avoid mixing up the number sequence. Another example of divergent preferences concerned whether to have automatic repetition of the code or not. Some participants thought automatic repetition to be an advantage because they did not catch the whole code the first time it was read aloud, but others did not need it. Issues such as audio speed, repetition or not, and grouping of numbers could have been fine-tuned and optimised through several test iterations. However, as is implied in Paper C, some issues might not have one single optimal solution because users simply have different needs and preferences. The provision of personalisation through preference settings may be a solution in such cases (see more about personalisation and adaptation in section 6.2.3.4).

This research shows that the use of multimodality may in some situations be necessary to achieve accessibility for some users, and therefore it may be necessary to achieve inclusive design. I also found that the use of multimodality might lead to the need for personalisation, which, in turn, requires some functionality to manage the personalisation features (see section 6.2.3.4). Thus, introducing multimodality can introduce a new set of usability problems because new functions are needed to operate the new modality, and possibly for personalisation. Hence, it is likely that multimodality may increase the perceived complexity of a solution, and it is clear that providing multiple modalities is not in itself sufficient to accommodate everybody.

An important question therefore, is how to reduce the overall complexity of a solution. This is the theme of the next section.

6.2.3 Approaches to reducing complexity

Although complexity in terms of much functionality and many options probably is a more pronounced problem for some user groups than others, my findings suggest that it is a general problem across many user groups. As pointed out by Pullin:

> The danger of adding flexibility and complexity to achieve accessibility is that a product may become difficult to learn how to use in any of its different ways. It may be inclusive in principle, but not in practice. (Pullin 2009 p. 85)

However, it is evident from the previous discussion that a certain degree of flexibility in the input and output mechanisms of a solution may be necessary to accommodate diversity. The use of AT is (currently) necessary for some users, and it may also be necessary to provide multimodality. Consequently, it seems that a certain degree of complexity is inevitable in inclusive design of ICT.

Therefore, while keeping the flexibility that is necessary to provide sensory and physical accessibility, it is of particular importance to pay attention to how to reduce the overall complexity to provide cognitive accessibility. There are several ways of doing this, and in the following, I will discuss some approaches to reducing complexity:

- Limiting the number of features, functions and options
- Layered interfaces
- Standardisation and consistency
- Personalisation and adaptation
- Limiting the number and frequency of updates

6.2.3.1 Limiting the number of features, functions and options

One potential misguided approach to flexibility for the user is to provide different ways to get at the same functionality. In the evaluation of the e-Vote prototypes (Paper E), four of the five prototypes had a navigation menu to the left of the screen. The software vendors had undoubtedly included this navigation menu because of the “Accessibility and usability requirements of the e-vote system” (E-vote 2011 2009). Here, adherence to the Elmer 2 guidelines (NHD 2006), which is a comprehensive set of principles and specifications for the design of Internet-based forms, was required. The Elmer 2 guidelines require a navigation area on the left side of the screen consisting of one menu item for each page in the form[22]. The purpose of the left menu is to provide an option to navigate directly to each page. Another way to navigate between the pages is simply to use the previous or next buttons, and these buttons are also required by the Elmer 2 guidelines (see NHD (2006 p. 29)).

[22] A screenshot of a form conforming to Elemer 2 is provided in Paper D and in Figure 1 in Paper E.

Out of the five prototypes that were evaluated, the one prototype without the left navigation menu was preferred by most of the participants, and we largely attributed this preference to the lack of this navigation menu. Without the menu, the user interface became less crowded and thereby less complex. It also became more accessible for participants requiring magnification (Paper E). The Elmer guidelines were also followed in three of the four cases referred to in Paper D. Here, too, I found that many participants had problems with navigation, that few tried to use the navigation menu and that they did not seem to grasp how to use it.

This is in line with the findings of Dickinson et al. (2011). They found that the multiple ways in which it is possible to carry out a task constitute a fundamental conceptual difficulty because this increases the complexity of the interface. This was also the reason for the decision to avoid the use of menus and to reduce the number of options in a redesign of an e-mail system for older users (Dickinson et al. 2011). They found that although there might be good arguments for including multiple pathways in some systems, it is not helpful to introduce them to older learners.

I conclude that one should be cautious about including multiple pathways to the same functionality in mainstream systems, and particularly in systems that are not used very often, such as an e-voting system.

6.2.3.2 Layered Interfaces

Layered interfaces and scaffolding are related approaches to reduce the number of options, functionality and information that a user is exposed to (Lee 2004; Shneiderman 2003). For example, one can divide the menu options into layers. The main layer or menu includes only the most commonly used options, while other less frequently used options are included in the next layer, often as a separate “advanced” menu. In this way, complicated functionality can be hidden from users who will never need to access it. However, one consequence is also that it becomes harder to find the advanced functionality.

I have observed problems across several of the cases with a mechanism for hiding and showing information through expand (+) and collapse (−) buttons. In the ICT working-life project, this mechanism was used for expanding and collapsing chapters in an e-learning course. Some of the participants were not familiar with the expand/collapse mechanism (Fuglerud 2005). In several of the projects a similar problem occurred in connection with attaching (uploading) a document to a form, because participants were not familiar with how to expand and collapse file folders and therefore could not find the relevant document (Paper D).

A similar problem was observed by Cranor et al. (2006). In an interface providing privacy information and settings, a layered approach was chosen. They used expand (+) and collapse (−) buttons in a summary of privacy policy settings to allow the user to choose their preferred level of detail. However, in user tests, it was observed that the expand/collapse functionality was not completely intuitive, and a more obvious way of showing and hiding details was called for (Cranor et al. 2006).

Other findings suggest that the elderly (Lim 2010) and people with dyslexia (Dickinson et al. 2003) experience difficulties in using layered interfaces. In addition, as I point out in Paper D, there is a challenge in selecting a basic functionality set; that is, the functionality that one would expect the user to be able to understand and use. This problem is also highlighted by Dickinson et al. (2003):

> A classic problem with current systems is that there is too much evident functionality which makes the interface crowded, confusing and hard to remember. To manage all the functionality the developers normally layer the information, hiding functions in menu systems.... The problem, in general, is not one of excess functionality per se, but of the excess interface complexity which is consequent on the additional functionality. Recognition that excess functionality often results in interface complexity is not, however, a solution to the problem; the question becomes: if functionality must be reduced, how should necessary, core functionality be selected? (Dickinson et al. 2003)

The discussion above shows that there are several challenges with layered interfaces. There is a need for frameworks and methods to define and prioritise the basic layer (Paper D), but the usability and accessibility of functionality to hide and show layers is also of importance. These issues are also related to the issue of user-interface consistency within a service and across services, as discussed in the next section.

6.2.3.3 Standardisation and consistency

The first of Shneiderman's eight golden rules of interface design is to "strive for consistency" (Shneiderman 1998). Standards, guidelines and style guides are used to achieve consistency. While Shneiderman recognises that following this rule can be tricky because there are many different forms of consistency, he recommends that exceptions should be few and comprehensible (Shneiderman 1998).

Three out of the four case applications described in Paper D involved electronic forms following the Elmer guidelines. However, the inconsistencies in how features were implemented caused problems for the users, as explained in section 6.2.1.4. It is therefore necessary to define a set of basic interaction mechanisms that is accessible and usable, which people can learn through basic ICT training, and which service designers may build upon when designing services for the general population. A standardised way to present help functionality should also be included in such a basic set of features (Paper D). For such a solution to work, however, the issue must be addressed at several societal levels (see **Table 4** on page 45). The decision and funding to develop such a standard must be taken at a political level and for it to have a substantial impact, it would probably be necessary to have some legal enforcement of it (macro level). A decision to follow a certain standard can be taken in a project by a service provider, or by an educational institution or organisation; that is, at the meso level.

According to Ahmed and Ashraf (2007), the overall consistency of ICT solutions will generally be lost because of the way in which designers usually work; that is, by copying various previous projects and manually adapting these elements to new contexts. They argue that a model-based user-interface approach based on design patterns will help in maintaining an overall consistency (Ahmed & Ashraf 2007). In particular, they illustrate how different kinds of patterns can be used as building blocks for the establishment of a layout model for task and dialog presentation. Such an approach may help alleviate the problem of inconsistencies. Reducing the number of ways in which to do things will contribute to better cognitive accessibility. It may also contribute to better technical accessibility if the patterns are thoroughly checked for conformance to accessibility standards.

Another challenge is that most accessibility standards and guidelines are intended for applications used in a desktop environment, although guidelines for accessible designs on mobile phones, tablets and other devices are emerging. Due to the trend towards greater device diversity, there is an urgent need for advice on accessible design in these contexts too. In addition to a wider variability in devices and usage contexts, there are also issues related to what kind of AT one may assume that the user has. In general, there is less AT available for use together with mobile devices than for use in a desktop environment, and there is even less available AT for use together with other types of technology, such as public self-service terminals and smart things and appliances. In any case, whether developing for desktop environments or for other environments, a combination of adherence to existing standards and guidelines, and a process that is sensitive to the usage context and users' needs is necessary.

In summary, even when comparing similar applications that follow the same guidelines, the implementations of various features vary so much that they appear as different for the users. This will often have consequences for the overall consistency between services and within services. This research confirms that lack of consistency causes trouble for the users, and therefore that consistency is an important issue. However, Grudin (1989) discusses some of the complexity surrounding this issue. He convincingly argues that consistency is a design goal that must be considered along with other design goals, such as performance. He also suggests that consistency may be more important when designing user interfaces for a wide range of users and situations (as is the case in inclusive design), than, for example, when designing special-purpose tools where efficiency is more important.

My research supports the view that consistency is important, but also that inclusive design cannot be achieved by a stronger focus on standards and guidelines alone. The issue of consistency must be holistically addressed in the overall context, because it is affected by cultural and social factors, such as the users' experience and training, the usage context and the design process.

6.2.3.4 Personalisation and adaptation

Personalisation and adaptation is also a recommended approach to reduce complexity in inclusive design. This refers to what extent an ICT solution can be customised to fit the users' needs. A major challenge of personalisation is the process of identification of the user and establishing a user profile. The first obstacle is the *registration and authentication* process to identify the user (see also section 6.1.12). It is not possible to find one single authentication method that will be accessible for all users (Paper B). Therefore, it is necessary to offer alternative authentication mechanisms to achieve inclusive identification. This again leads to more choices and potentially increased complexity. Other challenges include the capturing of user preferences, and determining what kind of personalisation or adaptivity should be provided. In general, functionality where the user can adjust their preferences adds more features to the application and more work for the user. In that sense, it may increase the complexity of the user interface. The possibility of having one global user ID and profile, to be used across various services, would reduce this problem.

The goal of the e-Me project was to make *identification technology* more accessible, and several prototypes were developed. The e-Me OpenID prototype has several alternative log-on methods. OpenID allows the user to log in to multiple websites with the same credentials (userID and password). The idea behind the e-Me OpenID is that the user should be able to log in to various services by selecting an authentication method that is accessible and preferable for him or her. The e-Me OpenID service would also hold some basic user information in a user profile. One drawback with the solution is that the user has to choose from among several alternative authentication methods (five alternatives in the prototype) every time it is used. In that way, the solution introduces more options and thus more complexity. On the other hand, in relation to the real-world context where users have to remember a vast number of different user names and passwords, the solution may both increase accessibility and reduce complexity by offering a single accessible way to log in to various services.

It is difficult to predict whether this approach could be a sustainable solution. It depends on many things, such as security and trust issues, the business model of developing and maintaining such a solution and whether enough services would adopt the accessible OpenID solution.

From a user perspective, there is the question of trusting one service to manage all the personal information and access to various services on the users' behalf. Another question is whether the advantage of having one place to log in to various services outweighs the inconvenience of increased complexity because of having to select between several options each time. Another aspect that needs further investigation is the possibility of offering the right authentication method to the user before the user has authenticated, and without compromising the user`s privacy. One of the problems with this is that if users openly provide their authentication preferences, it may be possible to infer things about the user (Paper B). For example, if the user prefers authentication by pictures, one might infer that there is a high probability that the user has some form of reading or writing difficulty, possibly because of being young or having an impairment. In a survey among screen-reader users, respondents were asked whether they would like a website to detect if they used a screen-reader or not. 86.5% of the respondents were very or somewhat comfortable with allowing screen-reader detection if it resulted in better accessibility (WebAIM 2014).

The aim of the Global Public Inclusive Infrastructure (GPII) Initiative is to create a global infrastructure that will include a user profile stored in the Cloud (or on a card). The vision is that any interface will be able to adapt to the user automatically based on the user's needs that are stored in their global profile (Vanderheiden & Treviranus 2011; Vanderheiden et al. 2013). However, this initiative also faces challenges in moving out of the research laboratories. According to Vanderheiden (2013), an entire new ecosystem is necessary for the solution to be successful. It seems that the scope and complexity of the challenges related to developing a global ID with an associated user profile have not been fully appreciated in previous efforts.

Adaptivity refers to the extent to which the ICT solution can change itself to suit a particular user. One of the goals of the Diadem project was to develop an intelligent system that would adapt automatically and dynamically to the particular user. The focus group in this project stressed that older users and users with cognitive impairments needed a relatively long time to learn an interface, and that they may get very confused and feel very insecure if the interface changes, for example, due to software updates. Even small changes, such as minor changes in the visual appearance, could be problematic. Another concern that was mentioned during the user evaluations of the Diadem prototype was that if the user interface looked different from one user to another, it would be more difficult to get help from peers.

A variant of this problem was revealed in the ICT barriers of the visually impaired project. Here, visually impaired AT users had experienced difficulties in getting get help from their teachers because the teachers did not recognise the user interface of an application when it was altered by the users' magnification software (Fuglerud & Solheim 2008).

The Diadem technology would take electronic forms from various vendors and transform them into a common look and feel. Then, the interface would adapt itself to the particular user with several Diadem-specific adaptive support mechanisms. However, the user investigations gave ambiguous results. On the one hand, users appreciated having one common look and feel. They also appreciated one of the supporting mechanisms for navigation. This mechanism would "grey out" the completed fields in the form. This provided clear visual feedback regarding the progress of the work and made it easy to spot where to continue. On the other hand, we found that the adaptivity mechanisms, such as multimodal messages, were often inaccurate and disturbing rather than relevant and helpful (Solheim 2009). For example, one such mechanism was triggered if a participant took a long time or clicked several times on "unclickable" areas of the screen. Then, the participant would get a message inboth text and audio suggesting that she or he had to click inside a field to proceed. The users, however, were often not aware of having a problem. The participants would therefore often become confused, frustrated and unsecure when the “intelligent” message popped up, because they had not understood what they had done wrong to activate the message. Furthermore, it seemed that the additional audio function, which was meant to be beneficial for this user group, also became a source of confusion. It appeared to come from nowhere and the participants did not see the relevance of the audio message. Dickinson et al. (2011) also found that automatic alterations to the user interface can be disconcerting to the users.

> Although adaptivity is considered a good approach to meeting diverse user needs, there is always the risk of confusing the user with dynamic interface updates. (Savidis & Stephanidis 2004)

Even if there are examples of successful adaptation mechanisms, such as the T9 word-prediction system for writing on a mobile phone (Newell et al. 2002), the experiences referred to above point to several challenges regarding personalisation and adaptivity. More work on the usability, accessibility and consistency of personalisation features and mechanisms is necessary. I also conclude that one should be wary about introducing dynamic changes in a user interface and that adaptivity must be used with particular care.

6.2.3.5 Limiting the frequency and number of updates to the user interface

Frequent changes and updates to user interfaces constitute a major problem for many people and particularly for people using AT, as described in section 6.2.1.3, and for people with cognitive impairments, as described in the previous section. There are, of course, many reasons for the need to update ICT services, such as anything from security threats, new versions of browsers, new standards and the need to fix bugs and improve the overall service. However, it may not be necessary to update the user interface every time a new version is launched.

In one study, it was found that software engineers often, rather than asking the users, made their own assumptions about changing things in the user interface, such as text messages and output formatting (Albayrak et al. 2009). They did this because they found it easy to do so and because they believed that it would not be very costly or time consuming to update their proposed solution later. Moreover, it is often the case that updates are made without any concern for accessibility, and therefore, many sites actually become less accessible over time (Lazar et al. 2007; Vigo et al. 2007).

My impression is that service providers in general are not aware of the great strain updates and changes in the user interfaces may cause for many users, and it seems to be the case that accessibility is not well enough integrated into the maintenance and upgrading processes. Any updates to the user interface should be well founded, well tested and planned.

6.2.4 RQ2 Summary

Inclusive design is about accommodating diversity, and the ways in which to accommodate four types of diversity have been discussed: user diversity, various usage situations, technology variety and variety in user knowledge. Perceivable and operable interfaces for people with various sensory and motor abilities can be provided through alternative input and output modalities and interoperability with AT. The need for built-in multimodality will depend upon the type of technology and the usage context, including security requirements.

Increased flexibility in terms of the functionality to select and operate alternative modalities, to combine with AT and potentially, extra functionality for preference settings and personalisation may easily increase the complexity of a solution. The lack of consistency within and between services will also contribute to the perceived complexity for users with different levels of experience and knowledge.

The increased complexity reduces the usability and thus the cognitive accessibility. There is a close relationship between usability and accessibility. Reduced usability and cognitive accessibility is a great challenge for all user groups and particularly for people with cognitive impairments. Therefore, it is necessary to focus on how to reduce the overall complexity of a solution while keeping the required flexibility.

Five different ways to reduce complexity for the users are identified and discussed. Limiting the number of features, functions and options can reduce complexity. When the functionality must be reduced, the question is how to select the necessary core functionality, and some form of prioritising must be done. This is also necessary when aiming for layered interfaces and personalised and adaptive interfaces. The question remains regarding what part of the functionality should be common for all users and what part of the functionality should be personalised.

Standardisation and consistency are important, both to achieve interoperability with AT and to increase consistency within and between services. However, there are many standards and also different forms for consistency. The development of cross-service solutions, such as IIDM and common profiles, are part of the solution to create easy, accessible and efficient mechanisms for personalisation and adaptivity.

Last, but not least, it is necessary to consider the need for user-interface updates carefully, both with regard to technical accessibility and with regard to cognitive load in connection with new versions and updates of ICT solutions.

6.3 RQ3: The challenges that diversity poses in relation to UCD and PD

In section 6.1 (RQ1: The key elements in inclusive design), I examined important elements of the IDAs more closely. Several of these elements correlate to well-known principles in

UCD. However, studies on design practices in the ICT industry reveal that there is a gap between theory and practice, both with regard to UCD (see section 3.6) and inclusive design (see section 3.7.11). In this section, I will discuss some challenges of diversity that have emerged from this research and I will relate these to existing knowledge from UCD and PD. The first theme is the issue of knowing the user when the user is "everybody". This is related to the second theme, which concerns questions about whom to involve, how and why. The last theme in this section concerns challenges related to involving diverse users, in particular users with disabilities, in the inclusive design process.

6.3.1 Knowing the user when the user is everybody

The concept "user-centred" when the user is everybody seems difficult, or even impossible. Perception barriers have been found to be the most significant barrier to inclusive design in industry (Dong et al. 2004). An important reason for these perception barriers may stem from the seemingly utopian goal of designing for everybody. Why bother thinking about everybody when this surely is impossible anyway? An adverse effect of this may be that because everybody is such an elusive goal, advocates for IDA, including myself, often come up with examples of people that should be included, such as blind people. This again may give the impression that inclusive design is some kind of niche activity to include small user groups with special needs.

Thus, it is very understandable that rather than trying to include everybody in a user-centred process, developers should look for tools and checklists to aid them in inclusive design.

One simple approach that is used to keep diversity in focus involves analysing the solution against some main categories of disabilities, as suggested in Papers A, B and C. In Paper A, the disability categories are analysed together with usage situations. In Papers B and C, various methods of authentication are analysed with regard to these categories. A tabular analysis provides us with indications of the challenges for each of the main user groups, but complementary methods to address actual usability and accessibility in a concrete context are needed.

Recently, there has been an increasing interest in the development and use of user models, including models of people with disabilities (Kaklanis et al. 2012; Modzelewski et al. 2012; Mohamad et al. 2011). It is pointed out that developers of mainstream technology do not have a detailed understanding of the needs of people with disabilities, and virtual user models have been suggested to increase the researchers' understanding of these users (Mohamad et al. 2011). It has been suggested that such models might reduce or even eliminate the need for producing real prototypes (Modzelewski et al. 2012). The models can be used in early development stages (Modzelewski et al. 2012) and for testing virtual prototypes (Kaklanis et al. 2012). Although many researchers stress that these tools will be used as a supplement to user involvement, there is a risk that automated-accessibility evaluation tools and user-modelling tools will be used alone and instead of including people with impairments in design activities.

I argue that user involvement is necessary because it can fulfil other purposes than user models, profiles and automatic-accessibility evaluation tools can. User models are quite impersonal, without much social, cultural and political character. It is important to examine and communicate such aspects and purposes. In the following, I will examine aspects related to user involvement in the projects.

6.3.1.1 Empathy and motivation

The opportunity to meet, observe and interview many people with disabilities has taught me some important lessons. Before the ICT barriers of the visually impaired project, I had informally observed visually impaired individuals interacting with ICT, both my husband and others, for about 20 years. Therefore, I felt that I had some insight into the ICT challenges of the visually impaired in advance of the project. However, the possibility of systematically observing and interviewing the many participants with visual impairments through the project gave me a much more nuanced picture. Over several months, we visited 28 visually impaired participants. It brought to the fore that there was a huge variation in the knowledge, experience and capabilities among individuals with visual impairments, and the many contextual conditions that affect the possibilities of ICT usage were highlighted. It clearly demonstrated how ICT accessibility might have a profound impact on people's daily lives. We also gained more insight into the complicated interplay between various factors, such as the institutional, political, organisational and individual factors, which influence ICT usage (Fuglerud & Solheim 2008). The awareness of the variation in any "user group" has only been reinforced through the other projects where we have had the opportunity to systematically observe and interview people with various types of impairments in connection with ICT usage. Often, participants have brought to our attention new aspects that influence a usage situation. Many of the meetings have made a long-term impression on me (see details in section 6.1.6), and the experience has undoubtedly increased my empathy and understanding of the situation of impaired people in general and has increased my commitment to inclusive design.

In his book "Design and the Digital Divide: Insights from 40 years in Computer Support for Older and Disable People", Newell (2011 pp. 116-119) notes that design for everyone is not a particularly useful design goal. Actually, many of the early efforts in design for a group of disabled people, or even for one particular disabled person, have led to developments in mainstream technology (see section 6.3.1.2). Newell (2011 p. 119) describes experiences where developers, after having being persuaded to interact closely with older people, changed their views on the users' needs in ways that were important for the design process. He argues that arranging for the developers to interact with older people resulted in an increased level of empathy among developers that would not have occurred through reports passed on from others.

The necessity of developing empathy with the users was reinforced during a personal meeting with Newell (2012). When discussing the challenge of engaging students and developers in industry in inclusive design, he underscored that the involvement of users with impairments is necessary to make the work interesting and to sensitise developers to their needs.

The importance of developing a relationship between the user and the designer is also emphasised in Pullin et al. (2011). They describe experiences from student assignments where the students would design interactive technologies for one of their grandparents (Pullin et al. 2011). Many of the resulting designs were surprising, innovative and highly appreciated by industry. In reflecting on these experiences, Pullin et al. (2011) suggest that the close personal relationship between the designer and the user (students designing for a grandparent), and the fact that they were engaging in the design for one particular person, in contrast to a population, or even a persona, contributed to the successful ideas.

In a study comparing two kinds of feedback to developers from usability evaluation, namely usability reports with observations of user tests, it was found that both types had strengths and weaknesses (Hoegh et al. 2006). The strengths of user observation were that it facilitated a rich understanding of usability problems and it created motivation and empathy with the users. They too mention that observations seem to bring about a long-term effect beyond the current project (Hoegh et al. 2006). Including people with disabilities early on in the development process will, according to Henry (2007 p. 13), give a high return on investment by making team members highly motivated, and thus helping them to address accessibility issues with effectiveness and efficiency.

The importance of learning from people directly instead of through second-hand information is underscored by many other researchers (Alm & Newell 2008; Askheim 2011; Gould 1995; Pullin 2009). Newell (2011 p. 119) asserts that there is a need to include methods in design where developers are “exposed” to users at some time. To let developers watch videos of users performing tasks can be an effective way of improving communication between users, designers and developers (Hoegh et al. 2006; Masoodian 1999). However, video recording requires consent by the users. Although many of the participants in the projects in this research gave such consent, some were also reluctant about this, which of course was fully respected.

During the projects, I have gained experience with guidelines, checklists and the persona method in addition to quite a lot of user contact. Although empathy, commitment and the deep understanding of users are some of the aspects that that one tries to establish through the persona method (Grudin & Pruitt 2002), it does not give the same experience as working with real people. The persona method may be regarded as a kind of user modelling. Although this method may include some social aspects, particularly when informed by user studies (Maier & Thalmann 2010), this approach is descriptive, including mainly idealistic patterns.

Based on these experiences and the similar experiences and reflections of other researchers, I am convinced that working with real people, particularly with potential users with impairments, is simply more informative, educational, enlightening, engaging, motivating, socially rewarding and challenging than working exclusively with checklists and user models. The importance of this aspect should not be underestimated.

6.3.1.2 Learning and innovation

There is often an overlap between the constraints that a particular disability places on a design and the constraints that a particular usage context or situation requires of the design (Paper A). This is highlighted as a potential source for innovation:

> Accommodating a broader spectrum of usage situations forces researchers to consider a wider range of designs and often leads to innovations that benefit all users. (Shneiderman 2000)

Thus, moving from design for different usage situations to inclusive design is one possibility in terms of creating innovations and inclusive designs. Moving in the opposite direction from inclusive design to new design ideas is also a possibility. History has shown that many efforts in developing technology to assist people with impairments have resulted in innovations that later have laid the foundation for a broad range of mainstream technologies (Jacobs 2002; Magar 2011; Newell 2011). A design for a person or group of persons with a disability can result in technology that can be very useful for people without impairments in situations or contexts where one or more senses or abilities are constrained (Paper A). Inclusive design can therefore result in innovative designs that can be useful for everybody (Dong et al. 2004; Fuglerud & Sloan 2013; Newell 2011).

The importance of context is acknowledged in UCD. Models of impaired users usually focus on the capabilities of people with impairments independent of context. However, as stated in Paper B, problems arise and are formulated in the context of an application. The use of virtual user models will not give information about the needs and behaviours of impaired users in context, which is necessary for solving real-world problems. An efficient way for designers to get a deep understanding of the challenges and needs of people with impairments is therefore through direct contact in context.

Examples, experiences and research referred to in Fuglerud and Sloan (2013), suggest that acquiring a deep and detailed knowledge of impaired people and their needs in relation to a context has been an important factor in inclusive design innovations. Such deep knowledge can be achieved through user involvement and ethnographic methods. Observation of task solving in a natural context with a subsequent semi-structured interview has been a central approach in all the projects in this thesis. This has resulted in a rich knowledge regarding the factors of importance for ICT use by impaired people in real contexts. Often, new problem areas on the outskirts of the research topic at hand have emerged. This has inspired new project proposals and research projects. Authentication, for example, was not a particular focus in our first projects, but the observations and interviews of users in context made us aware of the fact that the lack of inclusive authentication and identity management was a major accessibility barrier for people with different types of disabilities. This led to the development of the uu-Authentication project and the e-Me project, which focused on these challenges.

Pullin and Newell (2007) argue that the consideration of "extreme users", that is, older users or users with disabilities, can act as an effective form of provocation within the design process, which again can inspire the creation of new and innovative ideas.

An important point when involving impaired people in ICT development is that they can contribute with design ideas based on their broad experience in coping with specific constraints that are related to their impairment. Participants in our studies have sometimes shown us or described to us very unusual, new and creative ways of using technology. A few such examples came up during the field study of the ICT barriers of the visually impaired project (Fuglerud & Solheim 2008). For example, one blind participant showed how she had found a particular type of Dictaphone helpful for rehearsing music pieces when she did not have music notes in an accessible format. As people with disabilities have had to cope with specific impairments in various situations during their daily lives, they have lots of experience with alternative ways of coping. They know what solutions are effective in accommodating their particular needs for particular tasks in a particular situation. In that way, people with disabilities have a broad base of experience related to certain design challenges, such as designs for situations where a capability is constrained. This base of experience can be a rich source of ideas and creativity.

User participation, as opposed to user consultation, or merely observing users, has a better potential for knowledge building (see categorising of user involvement in section 3.5). Participation enhances people's ability to engage in the consideration of choices and options that may have implications for their lives (McIntyre-Mills 2010). Even though people are experts in terms of their own situation, they may not consciously have considered all of the important aspects of a particular ICT solution. For example, for one of the participants in the e-voting evaluation, the authentication process was such a hurdle that he required e-voting without any authentication whatsoever. However, this is not a conceivable option because it breaks with the principle of one vote per citizen. The e-Vote evaluation included one observation and interview with each participant (Fuglerud & Tjøstheim 2012), and therefore there was little room for a deeper level of mutual learning. Participatory design may support a process where both the participant and the designer reflect on, learn, develop and even change their views. It can enable people to give their points of view, but also to consider the implications of their ideas (McIntyre-Mills 2010). It may be the case that the participant in the mentioned example would have accepted the need for some kind of authentication during e-voting if there had been enough time to learn more about the implications of no authentication. Moreover, with more time, we as researchers might have learned enough from the participant to be able to suggest a solution that would have been acceptable in this respect.

According to Kyng (2010), there is a growing recognition of the crucial role of users in innovation. Ethnographic methods have become increasingly popular in academia, although the form and intention is debated (Dourish 2006). It is argued that deep knowledge is important for steering creativity into areas that matter, and this can result in innovations that solve real-world problems (Blomberg et al. 2003). Successful design groups in industry, such as the IDEO, engage with extreme users and use ethnographic methods to inform and challenge the design (Pullin & Newell 2007; Pullin 2009). As IDEO employees have stated, ”nowhere is a deep understanding of user needs more important than in the integration of new technologies in our daily lives” (Nielsen & Pullin 2005).

6.3.1.3 Aid in prioritising

In the previous discussions, the need for developing various types of prioritising has been pointed out:

- Prioritising and dealing with conflicting needs of various users and stakeholders (see section 6.1.3).
- Prioritising between the vast number of standards and guidelines, with potentially conflicting or at least diverging content (see sections 3.7.3 and 6.2.3.3).
- Prioritising and selecting what functionality to keep and what to discard so that the user interface does not become too crowded and complex, or if using layering techniques, what to keep in the front layer and what to put in secondary layers etc. (see sections 6.2.3.1 and 6.2.3.2).
- Prioritising what functionality to keep the same for all users and what functionality can be personalised (see section 6.2.3.4).
- In an idea-generation and creativity phase, it is necessary to prioritise what ideas are relevant and may solve real-world problems (see section 6.3.1.2).

There are certainly various models and theories to support these prioritising activities. Vanderheiden (2000) has provided a framework for prioritising among features in inclusive design (see section 3.7.3). Keates and Clarkson (2003) propose quantifying design exclusion through the use of population capability data (see section 3.7.7), and prioritising accordingly. Lee et al. (2010) propose a structural approach when combining various design components.

While these methods are valuable and provide important guidelines and perspectives to aid the prioritising process, I will stress the importance of empirical experience and knowledge from diverse users and usage contexts as the input to the prioritising and decision-making process. Engagement with users will make the designers aware of details that otherwise could not have been discovered. These details may make an important difference to the outcome of the design. Pullin et al. (2011) underscore that the act of design does not descend into detail, but rather that the details are often where the most profound issues reside. They point out that the details, far from being mere details, are what constitute the design. This is, in a way, contradictory when designing for everybody, where details of the users are somewhat levelled out because there are so many of them.

I conclude that prioritising frameworks is important in inclusive design because of the enormous complexity, amount of information and the number of decisions to be made. Collaboration activities between the designers or developers and users can prevent the details being lost in generalisations. Users can also help to shed light on the relative importance of issues related to their real-world experiences. These are also weighty arguments for user involvement and fieldwork in inclusive design.

6.3.2 Dealing with diversity when involving users

Assuming that involving people with impairments in the development process is one main key to more inclusive ICT solutions, I think the practical, structural and political aspects of this issue have to be highlighted. Even though we have been able to recruit a number of impaired people during the projects, it has been challenging. While challenges related to user involvement have been described in the UCD literature (see section 3.6) and the inclusive design literature (section 3.7.11), it has been less discussed and problematised in the inclusive design literature. In addition, while the literature prescribes user involvement, I have found few details on how to get access to users, which users to select and how to address representativeness. Thus, in the following, I will discuss challenges and issues related to user involvement in the inclusive design process. While the discussion is based on the experiences with the methods used (described in chapter 4) and the resulting processes in this research, the purpose of the discussion is to come up with some advice or guidelines for practitioners of inclusive design.

6.3.2.1 Empowerment, participation and democracy

For the NGOs participating in the projects included in this thesis, the democracy aspect has been an important underlying motivation for participation (see the overview of project participants in Annex A).

Having relations with NGOs has been an important factor in the effort to involve users in this research. I have had the closest relations with the NABP. The ICT barriers for the visually impaired project was the project with the most explicit political goals. They explicitly stated that they needed documentation to support their political work to include the visually impaired in the information society. The NABP was active in developing the project proposal, raising funding, helping to organise and participating in the focus group and recruiting participants for observation and interviews. This project was a documentation project, and did not include any development. In the other projects, the main contribution from the NGOs was to assist in the recruitment of participants for user evaluations.

A more active involvement of NGOs in the other projects might have resulted in different outcomes in terms of the focus and proposed solutions. However, for the NGOs, it is also a question about resources, priority and potential impact. They do not have the capacity to engage politically in every development project. In situations where there are no close ties between the NGOs and the vendors, it may very well be the case that the most impact will actually be gained from recruiting participants. Thereby, the NGOs give the project teams the possibility of meeting with and gaining more knowledge about their members as users of the vendors’ future ICT solutions.

The experiences from the early Scandinavian participatory design projects are of particular relevance to inclusive design. The goals of the Scandinavian participatory design approaches were user empowerment, participation and democracy (Bjerknes & Bratteteig 1995; Kyng 2010). However, these aspects have diminished, and the focus today is more on user participation as a means to improve the design (Kyng 2010). Similarly, while the democratic ideals were mentioned in the early works of UD in Norway, these ideals do not appear as clearly in the subsequent literature in the ICT area. And, unfortunately, the new Norwegian regulations on universal design of ICT, which came into force on 1 July 2013 (FAD 2013), do not contain anything about user involvement.

Although the difficulty of getting access to users is identified as a barrier to inclusive design (Dong et al. 2003), this issue is hardly problematised in the literature. There are few suggestions on how to improve the situation other than reducing the need for user involvement by providing user models and similar methods.

The issue of access to users concerns the “context of design” (Svanæs & Gulliksen 2008). By addressing the context of design at the outset of the inclusive design project, one might reveal opportunities for removing obstacles to user involvement, and for tailoring the necessary activities into the development process better.

There are researchers and practitioners who are extremely aware of the democratic aspect of inclusive design. However, the most common arguments for why IDAs are important concern ethics, demographics, commercial incentives, and legislation (Darzentas & Miesenberger 2005). These ideas have clear parallels to the notions of ethics, values and democracy in the early participatory design initiatives. According to Kyng (2010), it is important to make these ideals explicit. In a framework for future practices in participatory design, Kyng (2010) suggests addressing areas such as ideals, intellectual property rights, funding, users and settings, user interests, project outcomes and techniques for participation in the new settings (the last issue will be discussed more in section 6.3.2.4). These areas are equally relevant to inclusive design.

It may be necessary to develop regulatory measures to increase the involvement of impaired people in mainstream ICT development significantly. The user involvement in the Scandinavian participatory design projects in the seventies and eighties was within frames that the inclusive design projects of today do not employ. Legislation in Scandinavia requires involvement and cooperation with the trade unions when acquiring and developing new technology for use within the organisation (Andersen et al. 1986 pp. 36-39). For example, it is stated in the Norwegian Working Environment Act § 4-2 (Arbeidsmiljøloven 2005) that:

> The employees and their elected representatives shall be kept continuously informed of systems used in planning and performing the work. They shall be given the training necessary to enable them to familiarise themselves with these systems, and they shall take part in designing them.

The sections on technology, participation and control are further elaborated on in the Agreement between working-life parties that is, the data agreement between the Norwegian Confederation of Trade Unions and the Confederation of Norwegian Enterprise (LO-NHO 1994-97).

While the trade unions work within an organisation that acquires technology, NGOs working for the rights of disabled people do not have any formal bonds with the developers of mainstream technology. I envision that some kind of agreement or structure to regulate or promote cooperation between NGOs and vendors of inclusive mainstream technology would be highly beneficial. The early work in PD that led to the agreements between the unions and the employers can be an inspiration here. Addressing how to create the conditions for involvement and for safeguarding user interests is a major challenge that should be explicitly addressed in future inclusive design research.

6.3.2.2 Which users to include

While it has been a time-consuming and challenging task to recruit user participants for the projects in this research, this may be even more challenging for industry. The constraints of limited resources in terms of time, economics and the access to users, make it almost impossible to choose and select an ideal predefined sample of users to participate in an inclusive design project, if it is indeed possible to define such an ideal sample.

In UCD, the general advice is to include a sample of representative users. Although there are various interpretations of what is meant by representative users (see section 3.5), a common strategy is to divide the target population into subpopulations to reflect its diversity. The number of users recruited from each subpopulation reflects the size of that subpopulation relative to the target population. In inclusive design, it will not be feasible to recruit samples of participants with various types of disabilities to match a sample that is statistically representative in relation to the whole population. Overall, the notion of including representative users in a statistical sense is difficult, if not impossible in inclusive design.

When recruiting participants for the focus groups in this research, the emphasis was on selecting people with a high level of experience and with knowledge of relevance to the domain and the user groups in question. Several participants in the focus groups were employees at NGOs or at public competence centres and some participants had impairments. The participants in the focus groups participated at a system level, and their task was to speak up for the members of their organisation, or the group for which they were knowledgeable about. This type of participant corresponds more or less to the participatory design–political delegation interpretation of representative users (see section 3.5). The contributions from these system-level participants were very valuable. They contributed by bringing in their experiences with a much wider range of users than would have been possible to include in a single project.

The strategy of recruiting users for observation and interview sessions was to aim at broad diversity (see section 4.3.3). These participants represented only themselves; that is, they participated at an individual level. By complementing focus groups with observations and interviews, we were better able to appreciate and understand the comments and recommendations from the focus groups, because it helped us to exemplify issues and to put them into context. However, users with a minor level of sensory or motor impairment would often not add any significant new aspects to the studies in terms of accessibility and usability issues.

When it came to cognitive impairments, the situation was different. First, it was more challenging to recruit people with cognitive impairments, and second, we did not involve people with high levels of cognitive impairments. This was because we presupposed that the participants had to have a minimum level of ability to be able to understand the ICT, and because recruiting people who are not able to give informed consent would require additional ethical, methodological, and legal considerations.

In contrast to the experiences with the participants with minor physical or sensory impairments, the participants with minor cognitive disabilities, the elderly, and people with low ICT skills would often shed new light on various aspects of the design. The issues that were revealed by these participants were often related to cognitive constraints, such as a lack of experience and training, the overall complexity and variety of ICT features, and a lack of or misleading information and difficult terms and labels in the ICT solution. Thus, I support Vanderheiden’s (2000) assertion that cognitive constraints may be regarded as a separate dimension in inclusive design (see section 3.7.3).

In practice, the number of participants in an inclusive design process for the development of mainstream ICT will be quite limited. In such cases, I suggest that it is more fruitful to concentrate on involving participants with medium and extreme degrees of sensory and physical impairment, rather than people with minor degrees of impairment, because they will probably reveal more issues and the most challenging issues. Moreover, if these participants are able to use the solution, participants with lower levels of impairments will likely be able to use the solution as well.

There is much to be gained by including people with cognitive impairments who are able to give their informed consent. It is important to adapt the process to the users (Zajicek 2006). For example, by allowing more time, smaller groups and making them feel at ease by underscoring that it is the solution that is in focus, not their performance etc. There is a need for more knowledge in relation to whether it may be fruitful and feasible to include people with high degrees of cognitive impairment in the development of mainstream ICT.

The reasoning behind what subgroups of users to include does not only depend on the types of impairments in a population, but also depends on what types of features are included in the interface and what a person can do. For example, whether a person can see the screen, use a mouse, use a keyboard or remember passwords or not. In taking this perspective, it becomes quite clear that being able to see the interface or not are two quite different things, and then it may be natural to split blind and partially sighted people into two subgroups. Likewise, if an interface has drag-and-drop functionality, it becomes clear that there is a big difference in being able to use a mouse or not. Then it may be natural to include keyboard-only users as a subgroup. Moreover, if the solutions require that these users interact through certain types of AT, the type of AT and the expertise in using these types of AT can form the basis for splitting users into more subgroups. The idea is to divide the users into distinct categories based on characteristics that one expects to have a major impact on the experienced usability and accessibility of the solution. To aid this assessment one could use expert opinions, capability data across populations and reports from empirical studies.

When reflecting on the recruitment process for evaluation sessions, it can be useful to take the perspective of the ability-based design (see section 3.7.9) and focus on what the user can do in contrast to what the user cannot do. A task or action can be accomplished in various ways. Focusing on how the users' abilities can be utilised and even strengthened to be able to perform a particular task may open up for new ideas on how to do it.

In section 6.1.4, I recommend using a matrix with some main categories of impairments as a simple tool to analyse the diversity of users in relation to features of an ICT application. Such a matrix could also be a point of departure when identifying and selecting participants for user involvement. While one dimension in the matrix should be the subgroups of users, other dimensions to consider could be the various types of features in question and the usage situations.

Kujala and Kauppinen (2004) have suggested a process for identifying and selecting users and user groups for UCD. Inspired by this, and the Norwegian Standard "Universal design: User participation and ICT" (NS 11040 2013), I suggest the following steps when considering which users to include in inclusive design.

1. Develop a preliminary list of users by at least considering the following groups:

- people that are blind
- people that are partially sighted
- people that are deaf
- people that are hard of hearing
- people with physical impairments, including dexterity
- people with voice or speech impairments
- people with various cognitive impairments
- people with little ICT experience and
- people with combined impairments (the elderly often have several minor impairments)

2. Identify important user characteristics in relation to tasks and features. The user groups may be further divided according to the abilities required to perform the various tasks of the ICT solution. There are, of course, many aspects that might be important in addition to impairments, such as constraining contexts, expertise in using AT, ICT skills, knowledge, language skills, domain experience, age, social belonging, cultural background and so forth. A matrix can be a relatively simple and useful tool in this work.

4. Identify and prioritise user groups by considering the degree of diversity or overlap between different user characteristics. The focus should be on retaining groups that increase the knowledge about diversity among the development team within the available constraints and resources. While selecting participants with a minor degree and high degree of one type of impairment would demonstrate a span in diversity, developers with little experience of people with impairments might learn more from including people with medium and high degrees of sensory and physical impairment.

5. Consider various complementary types of participation when involving users. By including participants with a broad knowledge about certain user groups at a system level, one can draw upon knowledge about a broader range of users than it is possible to include in one project. However, dividing people into user groups is a way to structure, sort and generalise knowledge. Involving users at an individual level can serve other purposes, such as preventing details being lost in generalisations, as well as creating empathy, motivation and learning opportunities among the development team, as discussed previously.

6. Make all parties aware of their roles and responsibilities. The development team, the participants and possibly the group that is represented will provide more accurate and better contributions if they are aware of their roles. Being explicit about who the participants are representing, themselves or a group, and about the purpose of the participation, can also influence the choice of method and how to interpret the results.

7. Consider the characteristics of the actual participants in relation to coverage of diversity. Even if having carried out a thorough analysis of what user groups and user characteristics to include in a project, it is not always feasible to recruit participants to match with this wish list. It is therefore important to map the characteristics and knowledge of the actual participants with the original list of users to include. It is often necessary to supplement the design process with knowledge about user groups that are not covered by information from experts, literature, guidelines and capability data.

6.3.2.3 The number of users

Practitioners in inclusive design will often ask how many users is it necessary to include. It is important to note that there is a difference between the activity of coming up with new design ideas, performing user evaluations to uncover usability and accessibility issues (i.e. formative evaluation[23]), and performing statistical measurements to decide on the number

[23] Expert inspection or user testing to provide feedback to improve the usability of the product during the UCD process is called formative evaluation. Summative evaluation performed towards the end of the development can be used to validate usability and accessibility requirements, to provide a benchmark, or to provide a basis for comparison of different products (Borsci et al. 2013; ISO 20282-2 2013).

and the extent of such issues (i.e. summative evaluation)(Sandnes 2011 p. 346). A quote by Dunne illustrates this point (Pullin & Newell 2007): “Populations can validate a design, but individuals can inspire new thinking”. Thus, some users should be included in the design process from the beginning to inspire innovation and inclusive design solutions.

Several inclusive design innovations have sprung out of in-depth work with few users or even one single user (see section 6.3.1.2). However, addressing only one single user group can introduce problems for other user groups (Gregor et al. 2002; Keates, S. & Clarkson, J. 2003 p. 48; Newell 2011 p. 117). Therefore, it is also necessary to address the needs of various user groups when developing inclusive designs. This can be done by formative user evaluations or trials. This approach is used when the goal is to uncover usability and accessibility problems so that they can be fixed. Conducting user trials is, according to Keates (2003), a cornerstone of inclusive design. It is difficult or even impossible, even for experts, to design a genuinely accessible product without some type of user trial (Keates, S. & Clarkson, J. 2003 p. 140).

Research from usability testing has found that testing with five users is needed to have an 85% chance of detecting problems that affect 31% of users (Sauro 2000) in a fairly homogenous user group. To have an 85% chance of detecting problems that affect 10% of the users, it is necessary to increase the number to eighteen users. As the curve is nonlinear, and begins to flatten out around five users, it is commonly accepted that testing with five users from a representative user group is a cost-effective way of uncovering the most common usability problems for that user group (Nielsen 2000; Sauro 2000; Turner et al. 2006). This is known as the “five-user assumption” (Borsci et al. 2013). Moreover, if one has the possibility of testing fifteen users, it is suggested that these users are split into three test iterations of five users and that the design is improved after each test, rather than testing all fifteen users at the same time (Nielsen 2000). The reliability of the five-user assumption depends hugely on the homogeneity of the target population and sample of users, the type of technology that is tested, and also on the evaluation technique that is employed. See Borsci et al. (2013) for a thorough discussion of the background of the five-user assumption, and a more informed approach to decide upon the number of users needed for a cost-effective usability test.

When the target population of an ICT solution is diverse, the population should be split into representative subgroups based on various characteristics, such as experience and knowledge (Dumas & Redish 1999). As some of the characteristics would probably overlap between different subgroups, it is recommended that three to four users per subgroup are included when having two subgroups, and three additional participants from each subgroup if having more than two subgroups (Borsci et al. 2013; Nielsen 2000; Turner et al. 2006). A typical usability test should include between six and twelve participants from two to three subgroups (Dumas & Redish 1999). In inclusive design it is necessary to consider more subgroups because of heterogeneity in the user sample. (See the discussion about user groups in the previous section).

During the projects, many of the problems uncovered in the task-solving activities were related to cognition rather than perception or physical access (see section 6.2.1.1). If keeping to the distinction between technical accessibility and usable accessibility (see section 3.7.4), these are problems that can be characterised as relating to usable accessibility. Problems that pose major barriers for people with impairments will often affect people without impairments as well, although not so profoundly. In other words, it seems to be the case that many usability problems are often *amplified* or intensified for people with disabilities. This is in line with Petrie and Kheir (2007), who note that disabled and non-disabled people often encounter the same problems, although they may be differently affected by them. Similarly, Henry (2007 p. 116) asserts that evaluations with impaired people will easily uncover issues that impact most users. I argue that one would generally need more participants without any impairment to uncover many of the usability problems uncovered by people with impairments. User evaluations with disabled people can therefore be an effective means through which to uncover usability problems in general, as well as to uncover accessibility problems.

In the two e-voting evaluations, the goal was two-fold, to uncover usability and accessibility problems and to evaluate whether the solution was inclusively designed. Respectively, 24 and 30 participants from various user groups were included (see **Table 8**). After between 15–20 evaluations, most of the issues had been noted before; that is, the usability and accessibility issues revealed started to converge. This was probably because many issues overlapped between the subgroups of impaired people. For example, both a blind and a mobility-impaired person need an interface that can be operated by keyboard only. Further, an elderly person may encounter many of the same issues as a younger person with some memory or concentration impairments. Similarly, because a deaf person often has sign language as his or her first language, she or he may experience similar problems as a non-native speaker without a hearing impairment. When the goal of a user trial is to evaluate to what extent the ICT solution is inclusively designed, one needs a broader sample of users (see for example standard about summative test method (ISO 20282-2 2013) and a procedure on how to decide upon the most suitable number of participants in (Borsci et al. 2013)).

In summary, based on the discussion above, I suggest that many of the recommendations from UCD can be applied in inclusive design. It seems reasonable to extend the principle of including at least three participants in each subgroup when there are more than two subgroups to inclusive design. However, this is of course dependent on how the subgroups are selected. The number of users will also be dependent upon the purpose of the activity, whether it is to inspire new thinking, to uncover usability and accessibility problems or to measure to what extent particular user groups are included or excluded.

6.3.2.4 Ethical issues

In section 6.3.2.4 I discuss ethical issues in relation to this research. Ethical issues are not only important in relation to research but in relation to inclusive design in general. Both

European and Norwegian data protection legislation are particularly strict in relation to the handling of “sensitive personal data”. Information about physical or mental health or condition, including disability, is regarded as sensitive personal data, and this must be taken into account in inclusive design projects.

It is important to treat people with natural respect. At the same time, when including diverse users in the design process, there will inevitably be huge variations among the participants. This requires a continual sensitivity and flexibility in relation to each participant. The researcher must therefore be prepared to adapt and adjust the activities to the participants pace, energy and capabilities. For example, in the e-vote project the participants used from less than a minute to one hour for the log-in process (Fuglerud & Tjøstheim 2012 pp. 123-127). In another case, the sign interpreter was delayed, and the deaf participant and I had to improvise to be able to communicate. After some gesticulation, we ended up using a text editor so that we could communicate by typing. Thus, it is necessary to adapt the process to the participant, and sometimes to be creative and to improvise. This is also underscored by Culén and Velden (2013).

The question of payment to or compensation for participants is particularly important for the development of mainstream ICT. Besides being a means to a practical end, namely to make it easier to recruit people for participation in a project, it gives some signals about the value, meaning and role of the participant. A participant being paid by an NGO might behave differently to a participant being paid by a vendor or a project. However, the practical and administrative issues surrounding compensation may constitute barriers to user involvement.

In a traditional PD project, the workers will ideally participate throughout the project duration, and they will normally participate during their working hours. Their participation is therefore paid for through their normal salary. The situation is different in the inclusive design of mainstream ICT, where individual participants will usually participate independently of their work status.

Payment to disabled or older participants may raise issues with regard to tax rules and income limits in relation to salary, benefits or pension rules. Tax exemption for user participation in inclusive design activities may stimulate participation. However, the current limit for tax-free payments in Norway is equivalent to a few hours of work[24]. It is perceived by many as involving too much administration in relation to the dividend to go beyond this limit. Due to such obstacles, Newell (2011 p. 121) suggests considering other types of rewards for participants in inclusive design, such as travel allowances, coffee breaks, organising time for socialising or offering computer training. An important outcome of the early PD projects was training material for the trade union members (Kyng

[24] The current tax-free limit in Norway is NOK 1000, and would normally allow for two–four hours of participation. If the work is performed for an NGO, the tax-free limit is NOK 6000 (Skatteetaten 2014).

2010). Similarly, developing training materials for members of NGOs could be an outcome in inclusive design projects. Actually, in the Diadem project and e-Me project, presentations at NGO seminars were given as a small reward to the organisations for their efforts in helping with the recruitment of participants (Fuglerud 2008).

To facilitate user involvement, the principal, practical and economic issues surrounding participation for NGOs and individual participants need to be explicitly addressed.

6.3.3 Dealing with diversity in the design process

Even if users have been recruited for participation in a project, several other issues must be considered. A challenge in inclusive design is that the methods, materials and techniques used with participants need to be inclusive to allow diverse users to participate. In this section, I discuss issues that are related to the methods used and the inclusive design process.

6.3.3.1 Inclusive methods, materials and techniques

In the projects, we put extra effort into making the information and materials, such as the instructions necessary for task-solving activities, accessible to the participants. We, for example, offered information in alternative formats, such as accessible electronic formats, auditory information and sign interpretation.

The “thinking-aloud” technique was used for the evaluation of prototypes or existing applications in all the cases. Since we did not focus on efficiency, we were able to prompt the user to comment if he or she was silent. As the sessions were conducted in an informal and conversational atmosphere, this worked quite well for most of the participants, and therefore I have found thinking aloud to be a valuable method. However, in addition to some challenges concerning getting participants to speak while doing, this method is particularly challenging when communicating with deaf participants through a sign interpreter, as experienced in the e-voting project. Then both the participant and the observer needed to share their attention between the prototype, the participant or observer and the sign interpreter. The thinking-aloud method may also be difficult for participants with cognitive impairments. If the cognitive load becomes too high, it may interfere too much with the task-solving activity (Dickinson et al. 2007).

Empirical evaluation of the evolving prototypes in iterations is considered as the best practice in UCD (see section 3.4). However, working with lo-fi paper prototypes, commonly used in early development phases of both UCD and PD, is not suitable for all user groups. When it comes to visually impaired people, it is important that the prototype is technically accessible, or they may not be able to interact with the prototype at all.

Through the Diadem project, we found that unstable and error-prone prototypes were not suitable for elderly people, people with cognitive impairments and people with low ICT literacy. The users were highly sensitive to disturbances and unnecessary interruption, and were easily distracted and led astray when they had to relate to additional error handling (Solheim 2009). Memmel et al. (2007) recommend using hi-fi prototypes from the outset when elderly users are involved. Other researchers have found that lo-fi prototypes are not suitable for people with cognitive disabilities because it may be difficult for them to handle abstractions (McGrenere et al. 2006).

This suggests that prototypes should be medium to hi-fi, that is, running and technically accessible, before they are presented to the elderly, people with low ICT literacy and people with visual or cognitive impairments. At the same time, early user involvement is recommended. This may be a dilemma, because requiring hi-fi and accessible prototypes for user-based activities may delay user involvement. Therefore, it is necessary to find efficient ways to communicate with users during the design process and particularly before accessible hi-fi prototypes are built. While participatory design methods and techniques for people with sensory and cognitive disabilities is a relatively new research area, interesting ideas and experiences can be found in e.g. (Culén & Velden 2013; Galliers et al. 2012; Slegers et al. 2013).

In the Diadem project and the ICT barriers of the visually impaired project, focus groups were held at the beginning of the project. Both focus groups were highly informative, and this can be a productive method for early user involvement in inclusive design projects. However, some adaptations to accommodate the participants may be necessary. It is advised to have smaller groups when the participants are elderly (Zajicek 2006), and to emphasise a friendly atmosphere which allows social interaction and collaboration among the participants (Lindsay et al. 2012b).

It is important to become familiar with the techniques and conventions to facilitate communication with participants with impairments, see e.g (ODEP). NGOs can often provide tips and advice on such aspects. For example, when conducting focus groups one can encourage all participants to identify themselves and the person being addressed, to make it easier for participants with sensory impairments to follow the conversation. One should also take great care to use the microphone to aid hearing-impaired people who rely on an inductive loop.

The persona method is another user-centred method that was used in three of the projects. Although this method does not usually involve users directly, it should be based on knowledge stemming from user research and previous contact with users (Schulz & Fuglerud 2012). In the Unimod project, people with ample experience with the user group in question participated actively during a persona-creation workshop (see section 4.4.5). The process of creating the personas was an effective tool with which to communicate and learn about important aspects and characteristics of the user group. During the persona-creation workshop, a number of real-life stories were told to illustrate characteristics and the types of behaviour of the user groups in question. Several of these stories were remembered by the workshop participants and could therefore easily be drawn upon later in the project. My interpretation is that Bødker et al. (2012) refer to similar experiences when they note that personas can help activate and reframe pre-existing knowledge about use.

Real-life stories from the user sessions in the projects have also been shared in the projects, but the stories shared during the persona-creation process were better remembered and more often referred to and used in later project activities than the stories from user sessions were. I believe this has to do with the setting where the stories were told and retold. Sharing the stories in an active and creative persona-creating process is different to reading such stories in a report and is different to more randomly told anecdotes during meetings or other project activities.

The main advantage of using personas in the e-voting project was as a tool for testing the prototypes. The personas were used as a preparation and a kind of pre-pilot for the subsequent usability and accessibility evaluation sessions with users.

Based on these experiences with the persona method, I would say that it could work quite well as a communication and learning tool and as a tool for preparing for evaluations with users. As such, this research confirms that the persona method can be complementary to, and amplify the effectiveness of other user-centred methods, as suggested by Pruitt and Grudin (2003). I also agree with Bødker et al. (2012) that personas cannot in any way substitute for the involvement of real users in such design activities.

In summary, the key is to find tools and approaches to engage users and stakeholders early on in meaningful and concrete activities and discussions related to the ICT solution in question.

6.3.3.2 Iterative and parallel design

In the e-voting project, we had the chance to evaluate several prototypes from different vendors in parallel (Paper E). We presented five parallel designs to the participants. After having tried all the prototypes, we asked the participants to rank them. Although many of the participants ranked the same prototype as best, they also pointed out good design elements in the other prototypes. While one of the solutions was selected, I believe that some of the best ideas from the other prototypes could have been integrated into the selected solution.

In the Diadem project and in the ICT barriers of the visually impaired project, participants performed task-solving activities with existing ICT solutions (Papers D and F). Particularly in the ICT barriers of the visually impaired project, this activity created many comments about concrete accessibility problems and potential solutions. In this project, participants evaluated several different applications. The trying out of several different applications put participants in the mode to discuss the advantages and disadvantages of various solutions. Using various solutions in sequence and then discussing them was quite effective in spurring the participants on to make associations in enough detail to be able to discuss concrete accessibility barriers and solutions (Paper F). Sometimes, during the discussions, participants would find and show other web services to us in order to demonstrate a specific problem and how that problem was solved in yet another service.

The intention of parallel design is to allow for user feedback and creativity based on several design ideas. This is recommended when developing novel systems where there is little previous guidance available (Nielsen 1993 p. 85; Sharp et al. 2006 p. 429). It also helps to avoid the problem of designers settling too quickly for a design concept before trying out alternative ideas (Gulliksen, J. et al. 2000). It has been found to supplement observation and interviews:

> Listening to users discuss the alternative designs can amplify designers' understanding of the intended purpose(s) of the artefact and may provide information that does not come out of initial interviews, observations, and needs analysis. (Abras et al. 2004)

Parallel design suggestions can open up the design space. It may be a fruitful approach in inclusive design when searching for design ideas to accommodate diversity. However, the recommendation from UCD of starting the process by producing several alternative lo-fi prototypes may be problematic, as discussed in the previous section. Comparing alternative and existing ICT solutions can be a concrete and useful alternative that can be performed early on in a development process before the hi-fi prototypes have been developed. This can be a good starting point for communicating with users in inclusive design. However, using existing solutions as example designs may require a certain level of imagination and abstraction ability from the user. This may be a challenge, particularly for users with cognitive impairments. The development and use of rapid-prototyping tools for creating technically accessible prototypes is therefore another important research area within inclusive design.

6.3.3.3 Design for one vs. design for all

In the discussion in the UD community, the provisions of alternative solutions for certain groups of the disabled have often been rejected. A recurring example in these discussions is a situation where wheelchair users have to enter a building through a back door or a kitchen door because of inaccessible stairs to the front door. This is not regarded as an acceptable solution and is used as an argument for a single common solution. Providing a text-only version of a website aimed at blind people is another example. The argument in this case for having one common solution concerns the danger that the text-only version will not be maintained in the long term because it will inevitably receive lower priority than the main solution.

However, when promoting for a common solution as the right thing to do, it is a paradox that many ATs (i.e. technologies for a single user or user group) have become successful mainstream technologies later on (see section 6.3.1.2). In very much the same manner as small-scale parallel designs may be used in inclusive design development projects, one may regard AT or special solutions as parallel design suggestions along a long-term pathway for more inclusive mainstream technology. Developers of inclusive mainstream technology may have much to learn from AT research and development.

Rather than focusing on one common solution, the capability approach focuses on dignity, treating people with equal respect and providing equal opportunities. This perspective can be used to guide the design of inclusive ICT solutions as well. The results of this research suggest that flexible and multimodal interfaces, which in theory should include all users, may become more complex and thus less cognitively accessible. Providing several alternative solutions rather than one common design does not need to be in conflict with the goal of inclusive design as long as dignity and equal opportunity are taken into account and alternatives are provided for all users. The first principle of UD tells us to "Provide the same means of use for all users: identical whenever possible; equivalent when not" (Sevilla et al. 2007).

Design for one vs. design for everybody is also discussed by Pullin (2009). He points out that today's highly automated production methods allow for the flexibility to build a wider range of relatively focused products rather than multipurpose products with a vast number of functions and modalities, which are so complex that extensive personalisation, instructions and training are necessary. In other words, he suggests that the personalisation can happen at the production stage (Pullin 2009 p. 76), which is actually done by the retailers of the hardware and computers, such as Dell[25]. However, there may be social challenges with this option, such that it is difficult to learn from other people that do not have the same interface or functionality (see section 6.2.3.4). There is a need for more knowledge on personalisation in the early stages, during production, or during set-up and installation as a means to inclusion.

6.3.4 RQ3 Summary

The mantra from Gould and Lewis, "know your user", is even more challenging in inclusive design than in UCD and PD, because inclusive design is about making the mainstream designs accessible and usable for everybody. This is a great challenge and paradox, because it is obviously not possible to know all the users when aiming at everybody.

Designers need first-hand knowledge and experience with a range of different user groups to be able to design inclusively. In particular, it is necessary to know about impaired users and their challenges in relation to a usage context. It is in my opinion that this type of knowledge can best be gained through interaction with and observation of impaired users in a usage context.

Interacting with people with disabilities will, in addition to producing concrete knowledge about users' functional and cognitive abilities, also often create empathy and motivation,

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[25] http://www.dell.com/

enhance mutual learning between users and developers, spur innovation, and help in prioritising and making informed design trade-offs.

While I do not think that it is feasible to include a statistically representative sample of users in inclusive design projects, it is necessary to have some knowledge about and guidance on how to select user participants. Therefore, based on the experiences from this and related research, I have given some advice with regard to how to identify and select user participants in inclusive design. Users from various subgroups should be selected according to the type of application and context, but one should at least consider including users from the main categories of disabilities. I have found that the recommendation of including at least three participants in each subgroup is a reasonable principle in formative user evaluations. This research supports the idea of including users with significant to extreme degrees of sensory and physical impairment in addition to users with cognitive impairments. It is important to be explicit about the roles of the participants, for example, whether the participants represent a group or only themselves.

Some issues relating to inclusive methods and techniques when involving users with disabilities have also been discussed. In contrast to previous practices in UCD and PD, where users are often involved by working with lo-fi prototypes, prototypes need to be more mature and technically accessible in inclusive design. This is a challenge because it may delay user involvement. A concrete way in which to engage with users early on in inclusive design may be to draw upon several existing accessible solutions to start a discussion about features and designs. The best features from alternative solutions may be merged into one solution, or may be regarded as potential parallel functionalities for personalisation or adaptation.

Personalisation, possibly at various stages (production, set-up or runtime), may be a solution to the challenge of accommodating diversity while avoiding complex and complicated multipurpose products. As long as all user groups are provided with equal opportunities, respect and dignity, it is my opinion that parallel and alternative solutions may be acceptable.

7 Conclusion and suggestions for further research

The first three sections in this chapter correspond to the research questions presented in section 1.6 (page 14). Here, I will summarise the conclusions from this research. During the discussion, several open questions and suggestions for further research are also given. These suggestions are summarised in the last and final section of this chapter.

7.1 What are the key elements in IDAs?

In chapter 6, important elements of inclusive design have been identified and discussed. This exercise confirms that most of these elements are known from research within UCD, usability and PD. The usability aspect appears to be at least as important, if not more important in inclusive design, as it has been in traditional UCD. This is because the use of ICT is very cognitively demanding and puts high demands on a user's ability to assimilate and interpret information and to communicate.

An overview of the various elements that emerged from my research and those found in related research is given in **Table 13**. The elements identified through my research are listed in the first column, and the column marked "Discussed in section" lists the section in which that element is discussed. A cross in the column marked "Related work" indicates that this element emerged from the summary of previous and related work presented in section 3.8.

Since it is widely recognised that IDAs should be based on a user-centred approach, it is not surprising that many of the identified elements can actually be recognised from the UCD literature. UCDS is one of the most detailed descriptions of a user-centred approach. In the column marked "Corresponds to UCDS principle" in **Table 13**, I give a rough indication of how the elements may compare to or relate to the principles of UCSD (see the descriptions of these principles in section 3.4).

The projects that this research is based upon and my perspective also constitute a limitation in relation to the discussion of the elements in **Table 13**. For example, the two last elements in the table are not discussed. This is not because these elements are not relevant, but because this was not a focus in the projects. Thus, I did not gain enough experience with these elements during my research to be able to shed light on them.

Table 13: Key elements of inclusive design

Key elements of inclusive design	Discussed in section	Related work	Corresponds to UCDS principle
Based on a user-centred development process with an early focus on diverse users and their usage context, iterative development and empirical evaluation with impaired users.	6.1.1	X	1,2,3,4,5,6,7,12
Organisational commitment towards and knowledge about inclusive design is necessary. It is recommended that an “inclusive design advocate” be appointed.	6.1.2		8,9
The approach must be holistic, interdisciplinary and context driven.	6.1.3	X	8,10
Focus on the variety of users and usage contexts.	6.1.4 and 6.3.2	X	
Involve diverse users early on and throughout the development process.	6.1.5 and 6.3	X	
Strive for inclusive methods and let users compare several alternative designs in an early phase.	6.3.2.4		
Facilitate communication between user and developer.	6.1.6, 6.3.1 and 6.3.2.4		4
The process must be able to handle different stakeholders, conflicting requirements and changes in requirements.	6.1.7	X	
Ensure conformance to accessibility standards and interoperability with AT.	6.1.8	X	
Focus on a combination of accessibility and usability in context.	6.1.9 and 6.2.1	X	
Method triangulation – use more than one method in user research.	6.1.10, 6.3.2 and 6.3.2.4		4,5,6
Consider using multimodality.	6.1.11 and 6.2.2		
Identity management mechanisms need to be inclusive.	6.1.12		
Personalisation and adaptation may be used to achieve flexibility.	6.1.13 and 6.2.3.4	X	
Consider ethical issues and pay special attention to vulnerable user groups	6.2.1.1 and 6.3.2.4	X	
Utilise a framework to prioritise requirements and features.	6.3.1.3	X	
Focus on approaches to reduce complexity.	6.2.3		
Focus on equitable use before special solutions.	6.3.2.1 and 6.3.3.3	X	
Focus on user abilities and what users can do.	6.3.1.2, 6.3.2 and 6.3.2.4	X	
Acquire knowledge about user capabilities across populations.		X	
Process customisation: The process must be adapted and implemented locally in each organisation.			11

7.2 What is the relationship between flexibility, complexity and simplicity in mainstream ICT?

This research shows that while various input and output modalities, interoperability with AT and alternative presentation settings may give the necessary flexibility with which to accommodate people with sensory and motor impairments, it also increases the complexity of the solution. This reduces the usability and thus the cognitive accessibility.

While these types of flexibility may be necessary in inclusive design, it is important to place the focus on how to reduce the overall complexity. Five main approaches to reduce the complexity in ICT solutions have been identified and discussed:

- **Limiting the number of functions in an ICT interface to the necessary core functions.** The main challenge of this solution is to select the minimum but necessary number of core functions.
- **Utilising layered interfaces, which hide advanced or seldom-used functionalities.** The challenge with this solution is how to decide what functionality should be hidden, and to make it easy to find the hidden functionality.
- **Standardisation and providing consistent interfaces.** Challenges with this solution are related to interpretations of standards and to prioritising and making trade-offs when it is not possible to follow all the requirements or when the requirements are conflicting.
- **Personalisation and adaptation.** The main challenge with this solution is related to the accessibility and usability of authentication, to establishing user profiles, to handling privacy, to deciding what parts of the functionality should be personalised, and what parts should be general, and to making the personalisation and adaptation functionality accessible and usable.
- **Limiting the frequency and number of updates.** New interface features and changes in interfaces may have bigger consequences for the usability and accessibility of ICT solutions than developers are often aware of. These aspects must be taken into account before releasing updates.

I have found that guidelines and standards are important but far from sufficient in inclusive design, and that a deep understanding of the great diversity of users, the challenges of each user group and their context are necessary. This is the theme of the last research question.

7.3 What challenges does diversity pose in relation to UCD and PD?

Research in UCD and PD has documented the importance of user involvement repeatedly. Knowing the user is even more challenging in inclusive design than it has been in previous approaches. The fact that it is impossible to know everybody does not lessen the need to gain a deep understanding of the users. It is the knowledge about the span in human capabilities, and how this span affects ICT usage in context, and in particular the knowledge about users at the extremes of the scale, which can challenge the designers to make interfaces to accommodate as many users as possible.

I have found that involving people with impairments in the design process is not only important in terms of gaining knowledge about user variety, but also in terms of *motivating* designers to design inclusively and to *inspire learning, innovation* and *empathy* with their users. It seems that empathising with the users is necessary both to *want* to find inclusive solutions and to be *able* to find inclusive solutions. Moreover, involving people with disabilities will be of great importance and will *aid in prioritising activities* during the design process, because they can bring relevant issues and details to the surface. However, this requires the designers to pay close attention to which users to involve and to how the process is handled. Various types of user involvement can serve different purposes. It is therefore important to be explicit about the roles of user participants and the purpose of their involvement. A stepwise process for identifying and selecting user participants in inclusive design is suggested.

A mixture of methods is necessary in inclusive design. Existing methods and techniques need to be modified to allow people with disabilities to participate in the development process. This research has provided insights from the use of focus groups, empirical evaluations using the thinking-aloud method, the persona method and the role of prototype maturity. Presenting parallel design solutions to users, possibly by including some existing and accessible designs, can be a vehicle to let the users engage early on in concrete discussions about design.

Finally, I suggest that the central focus of inclusive design should be to offer equal opportunities through solutions that are perceived by the users to provide equal dignity and opportunity when compared to others. This may be achieved through one single inclusive solution and through personalisation or adaptive interfaces at the production, set-up or runtime stages.

These recommendations build upon and extend the knowledge from previous work in UCD and PD into inclusive design. A main challenge in relation to user involvement remains though, and that concerns how to create conditions that can make it easier to recruit and involve user participants with disabilities in development projects. This and several other suggestions for further research are discussed in the next and last section of this thesis.

7.4 Suggestions for further research

ICT solutions are penetrating our everyday lives and are increasingly used in all kinds of situations. Inclusive design is important for democracy and participation in society. During my research, it has become increasingly apparent to me that many of the challenges related to creating an information society for all cannot be solved within separate development projects.

While user involvement seems to be more of an ideal than a reality in UCD, it is even more challenging in inclusive design. Addressing how to create better conditions for user involvement is a major challenge that should be explicitly addressed in future work. To get a substantial increase in the involvement of people with impairments in the development of inclusive mainstream technology, regulations or frameworks at a societal level are necessary. Future work would benefit from being inspired by the early work in PD in this respect. This work led to legislation requiring user involvement when introducing new technology into organisations and agreements between the working-life parties. Similarly, the development of agreements between parties in society, such as NGOs on the one side, and possibly procurers of ICT on the other side, might be considered to aid inclusive design. While such ideas might seem foreign in many parts of the world, I believe that Scandinavia has a history and a structure where such developments might be possible. Practical, ethical and economic aspects of participation, including useful methods and accessible techniques should be further explored.

A myriad of methods and techniques for user involvement and user research have been proposed in PD and UCD. However, many of these methods and techniques cannot be used successfully with impaired people because they are not accessible. These methods and techniques must therefore be adapted or new must be developed to be useful when working with people with disabilities. More research on existing and new methods and techniques for user participation in inclusive design is therefore necessary.

I have suggested some approaches to reduce the complexity of inclusive ICT solutions, but further research along this line is necessary. There is a need for frameworks and methods to define and prioritise the basic functionality, whether one is aiming at layered or personalised interfaces. The usability and accessibility of functionality to hide and show layers, and to personalise, is also of importance. However, if the basic functionality has a different look and feel from one application to another, the overall effect across services may be that of increased complexity. Research beyond that of the individual ICT solutions may contribute to standardisation in this area and might alleviate this situation.

The issue of creating inclusive identity management is still one of the great challenges in relation to inclusive ICT. A reduction in the accessibility and usability problems that people face in relation to managing their usernames and passwords would be a great improvement. The potential of having one global user ID and profile, to be used across various services, would also provide for easier personalisation and adaptation. Research efforts that take the scope and complexity of these challenges into account are needed.

The emerging Internet of Things (IoT), including various smart objects with sensors and networking facilities, will challenge our present screen-dependent interaction paradigm. While there have been significant research efforts on the technical aspects of the IoT, such as hardware platforms, software infrastructure and application scenarios, the human–interface aspects are just beginning to receive attention. Multimodality in such environments can contribute to accessible solutions, provided they are not to complex. More research on how to include multimodality in intelligent things to make them accessible to everybody is needed.

Technology diversity can be associated with the explosive development in the market of end-user devices, were ICT services can be accessed and used via everything from wristbands, smartphones, e-readers, netbooks, tablets and televisions to gaming consoles. The connection and interaction with everyday technology via personal devices is another possibility for achieving accessibility. The idea is that a user can interact with intelligent things and everyday technology through their personal device. The advantage with this would be that interaction could be transformed to suit the user according to his or her profile on a familiar device. This requires research into the interplay between everyday technology and personal devices.

As all-encompassing and technically accessible solutions have a tendency to become very complex, which is in conflict with simplicity and thus with inclusive design, one could also explore approaches for producing more focused ICT solutions, in contrast to multipurpose designs. For service providers, this may be done through personalisation at various stages in the production process. However, it is important to keep the goals of inclusive design, namely, equal dignity and opportunity, in mind when exploring such solutions.

8 References

Abascal, J. & Azevedo, L. (2007). *Fundamentals of inclusive HCI design*. Proceedings of the 4th international conference on universal access in human computer interaction: coping with diversity, Beijing, China: Springer-Verlag.

Abras, C., Maloney-Krichmar, D. & Preece, J. (2004). User-centered design. In Bainbridge, W. (ed.) *Encyclopedia of human-computer interaction*: Thousand Oaks: Sage Publications.

ADAA. (2013). *Act relating to a prohibition against discrimination on the basis of disability (the anti-discrimination and accessibility act) [Eng: Translated laws]* [Unofficial translation of the Act 2013-06-21-61] Oversatte lover: Norsk lovgivning oversatt til andre språk: Juridisk bibliotek i Oslo, Universitetet i Oslo. URL: http://www.ub.uio.no/ujur/ulovdata/lov-20130621-061-eng.pdf.

Ahmed, S. & Ashraf, G. (2007). Model-based user interface engineering with design patterns. *J. Syst. Softw.*, 80 (8): 1408–1422. doi: 10.1016/j.jss.2006.10.037.

AID. (2007). *Norge undertegner FN-konvensjon om rettighetene til personer med nedsatt funksjonsevne. Pressemelding nr.:32 [Eng: Norway signs the UN Convention on the Rights of Persons with Disabilities, Press release. No.: 32]*. In Arbeids- og inkluderingsdepartementet (ed.). 2007-03-30: Regjeringen.no. URL: http://www.regjeringen.no/nb/dep/aid/pressesenter/pressemeldinger/2007/32.html?id=461971.

Albayrak, O., Kurtoglu, H. & Biaki, M. (2009, 1-3 Dec. 2009). *Incomplete software requirements and assumptions made by software engineers*. Software Engineering Conference, 2009. APSEC '09. Asia-Pacific. 333–339 pp. doi: 10.1109/apsec.2009.39.

Alm, N. & Newell, A. (2008). Creating innovative partnerships with users in developing assistive technology computers helping people with special needs. In Miesenberger, K., Klaus, J., Zagler, W. & Karshmer, A. (eds.) Lecture notes in computer science, vol. 5105: Springer Berlin/Heidelberg. pp. 130–137. ISBN: 978-3-540-70539-0.

Alsos, O. A. & Dahl, Y. (2008). *Toward a best practice for laboratory-based usability evaluations of mobile ICT for hospitals*. Proceedings of the 5th Nordic conference on human–computer interaction: building bridges, Lund, Sweden: ACM. doi: 10.1145/1463160.1463162.

Alsos, O. A. & Svanæs, D. (2011). *Designing for the secondary user experience*. Proceedings of the 13th IFIP TC 13 international conference on human-computer interaction - Volume Part IV, Lisbon, Portugal. 2042292: Springer-Verlag. pp. 84–91.

Andersen, N. E., Kensing, F., Lassen, M., Lundin, J., Mathiassen, L., Munk-Madsen, A. & Sørgaard, P. (1986). *Professionel systemudvikling, erfaringer, muligheder og handling*. Århus: Teknisk Forlag A/S.

Anskaffelsesloven. (2006). *Lov om offentlige anskaffelser*. *[Eng: The Public Procurement Act]*. Oslo, Norway. LOV-2012-12-14-82. URL: http://www.lovdata.no/all/nl-19990716-069.html. (accessed: 2012-11-06).

Answers. (2011). *What are the disadvantages and advantages of biometrics?* 2011-11-02. URL: http://wiki.answers.com/Q/What_are_the_disadvantages_and_advantages_of_biometrics (accessed: 2013-04-05).

Arbeidsmiljøloven. (2005). *Lov om arbeidsmiljø, arbeidstid og stillingsvern mv.* [in Norwegian]. *[Eng: Act relating to working environment, working hours and employment protection, etc.]*. Norway. LOV-1977-02-04-4. LOV-2013-06-21-61. URL: http://lovdata.no/dokument/NL/lov/2005-06-17-62. (accessed: 2014-03-16).

Arrue, M., Vigo, M. & Abascal, J. (2007). Automatic evaluation of mobile web accessibility. In Stephanidis, C. & Pieper, M. (eds.) Lecture notes in computer science, vol. 4397 *Universal access in ambient intelligence environments*: Springer: Berlin/Heidelberg. pp. 244–260.

Askheim, O. P. (2011). 'Meeting face to face creates new insights': Recruiting persons with user experiences as students in an educational programme in social work. *Social Work Education*: 1–13. doi: 10.1080/02615479.2011.590972.

Aslaksen, F., Bergh, S., Bringa, O. R. & Heggem, E. K. (1997a). *Universal design: Planning and design for all.* The Norwegian State Council on Disability. URL: http://home.online.no/~bringa/universal.htm. (accessed: 2013-02-25).

Aslaksen, F., Bergh, S., Bringa, O. R. & Heggem, E. K. (1997b). *Universell utforming - planlegging og design for alle. [Eng: Universal Design - Planning and design for all]*: 54: Rådet for funksjonshemmede. URL: http://home.online.no/~bringa/universell.htm. (accessed: 2013-02-25).

Babu, R. & Singh, R. (2009, 6-9 Aug.). *Understanding blind users' accessibility and usability problems in an online task*. Fifteenth Americas Conference on Information Systems, San Francisco, California, USA.

Baecker, R. M., Grudin, J., Buxton, W. A. S. & Greenberg, S. (eds.) (1995). *Readings in human computer interaction: Toward the year 2000.* 2 ed. San Francisco, California: Morgan Kaufmann Publishers Inc. 950 pp.

Bailey, M., Dittrich, D. & Kenneally, E. (2013). *Applying ethical principles to information and communication technology research: A companion to the menlo report*. 8. Oct. 2013. 14 pp. URL: http://www.caida.org/publications/papers/2013/menlo_report_companion_actual_formatted/menlo_report_companion_actual_formatted.pdf.

Bak, J. O., Nguyen, K., Risgaard, P. & Stage, J. (2008). *Obstacles to usability evaluation in practice: A survey of software development organizations*. Proceedings of the 5th Nordic conference on human–computer interaction: building bridges, Lund, Sweden: ACM. pp. 23–32. doi: 10.1145/1463160.1463164.

Bannon, L. (1991). From human factors to human actors: The role of psychology and human–computer interaction studies in system design. In Greenbaum, J. M. & Kyng, M. (eds.) *Design at work: Cooperative design of computer systems*: Lawrence Erlbaum Associates, Incorporated.

Bansler, J. (1989). Systems development research in scandinavia: Three theoretical schools. *Scandinavian Journal of Information Systems*, 1: 3–20.

Baskerville, R. L. (1999). Investigating information systems with action research. *Communications of the Association for Information Systems*, 2 (19).

Baxter, G. & Sommerville, I. (2011). Socio-technical systems: From design methods to systems engineering. *Interacting with Computers*, 23 (1): 4–17. doi: 10.1016/j.intcom.2010.07.003.

Berntsen, D., Tjugen, O. H. & Thoresen, K. (eds.) (2002). *Norsk regnesentral 1952–2002 [Eng: Norwegian Computing Center 1952–2002]*. Oslo: Grafisk produksjon: AIT Otta-AS. 392 pp.

Bickenbach, J. E. (2010). Ethical considerations in applying the icf. In Mpofu, E. & Oakland, T. D. (eds.) *Rehabilitation and health assessment. Applying the icf guidelines*, New York: Springer Publishing Company. pp. 47–66.

Billi, M., Burzagli, L., Catarci, T., Santucci, G., Bertini, E., Gabbanini, F. & Palchetti, E. (2010). A unified methodology for the evaluation of accessibility and usability of mobile applications. *Universal Access in the Information Society*: 1–20.

Birks, M. & Mills, J. (2011). *Grounded theory: A practical guide*: SAGE Publications. ISBN: 9781848609938.

Bjerknes, G. & Bratteteig, T. (1995). User participation and democracy. A discussion of scandinavian research on system development. *Scandinavian Journal of Information Systems*, 7 (1): 73–98.

Blomberg, J., Burrell, M. & Guest, G. (2003). An ethnographic approach to design. In Julie, A. J. & Andrew, S. (eds.) *The human-computer interaction handbook: Fundamentals, evolving technologies and emerging applications*: L. Erlbaum Associates Inc. pp. 964–986. ISBN: 0-8058-3838-4.

Boivie, I., Gulliksen, J. & Göransson, B. (2006). The lonesome cowboy: A study of the usability designer role in systems development. *Interacting with Computers*, 18 (4): 601–634. doi: 10.1016/j.intcom.2005.10.003.

Borsci, S., Macredie, R. D., Barnett, J., Martin, J., Kuljis, J. & Young, T. (2013). Reviewing and extending the five-user assumption: A grounded procedure for interaction evaluation. *ACM Trans. Comput.–Hum Interact.*, 20 (5): 1–23. doi: 10.1145/2506210.

Brajnik, G. (2008). *Beyond conformance: The role of accessibility evaluation methods*. Proceedings of the 2008 international workshops on web Information systems engineering, Auckland, New Zealand: Springer-Verlag. doi: 10.1007/978-3-540-85200-1_9.

Brajnik, G., Yesilada, Y. & Harper, S. (2012). Is accessibility conformance an elusive property? A study of validity and reliability of wcag 2.0. *ACM Transactions on Accessible Computing*, 4 (2): 1–28. doi: 10.1145/2141943.2141946.

Bratteteig, T. (2003). *Making change: Dealing with relations between design and use*. PhD thesis: University of Oslo, Norway, Faculty of mathematics and natural sciences. 265 pp.

Brown, A., Jay, C., Chen, A. & Harper, S. (2012). The uptake of web 2.0 technologies, and its impact on visually disabled users. *Universal Access in the Information Society*, 11 (2): 185–199. doi: 10.1007/s10209-011-0251-y.

Brynn, R. (2009). *Universell utforming og tilgjengelighet: Politikk og lovgivning i inn- og utland [Eng: Universal design and accessibility: Policy and law at home and abroad]*. Report no: IS- 1756: Sosial- og helsedirektoratet, Deltasenteret. p. 107. http://www.bufetat.no/Documents/Bufetat.no/Deltasenteret/Publikasjoner/UU_og_tilgjengelighet_politikk_og_lovgivning_i_inn_og_utland.pdf.

Bunt, A., Conati, C. & McGrenere, J. (2004, 13–16 Jan.). *What role can adaptive support play in an adaptable system?* IUI'04, Madeira, Funchal, Portugal.

Burrell, J., Treadwell, P. & Gay, G. K. (2000). *Designing for context: Usability in a ubiquitous environment*. Proceedings of the 2000 conference on universal usability, Arlington, Virginia, USA: ACM. pp. 80–84. doi: 10.1145/355460.355477.

Buzzi, M., Buzzi, M., Leporini, B., Mori, G. & Penichet, V. (2010). *Accessing google docs via screen reader*. ICCHP 2010, Vienna, Austria: Springer: Berlin/Heidelberg. 92–99 pp. doi: 10.1007/978-3-642-14097-6_17.

Bygstad, B., Ghinea, G. & Brevik, E. (2008). Software development methods and usability: Perspectives from a survey in the software industry in norway. *Interacting with Computers*, 20 (3): 375–385. doi: 10.1016/j.intcom.2007.12.001.

Bühler, C. (2008). Design for all: From idea to practise. In Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. & Bühler, C. (eds.) Lecture notes in computer science, vol. 5105 *Computers helping people with special needs*: Springer Berlin/Heidelberg. pp. 106–113.

Byrne, E. & Alexander, P. M. (2006). *Questions of ethics: Participatory information systems research in community settings*. Proceedings of the 2006 annual research conference of the South African institute of computer scientists and information technologists on IT research in developing countries, Somerset West, South Africa: South African Institute for Computer Scientists and Information Technologists. pp. 117–126. doi: 10.1145/1216262.1216275.

Bødker, S. (1996). Creating conditions for participation: Conflicts and resources in systems development. *Hum.-Comput. Interact.*, 11 (3): 215–236. doi: 10.1207/s15327051hci1103_2.

Bødker, S. (2006). *When second wave HCI meets third wave challenges*. Proceedings of the 4th Nordic conference on human-computer interaction: changing roles, Oslo, Norway: ACM. pp. 1–8. doi: 10.1145/1182475.1182476.

Bødker, S., Christiansen, E., Nyvang, T. & Zander, P.-O. (2012). *Personas, people and participation: Challenges from the trenches of local government*. Proceedings of the 12th participatory design conference: Research Papers - Volume 1, Roskilde, Denmark: ACM. pp. 91–100. doi: 10.1145/2347635.2347649.

Cajander, Å. (2011). *Usability - who cares? The introduction of user-centered systems design in organisations*: Uppsala University Faculty of Science and Technology. 122 pp.

Carbonell, N. (2006). Ambient multimodality: Towards advancing computer accessibility and assisted living. *Universal Access in the Information Society*, 5 (1): 96–104. doi: 10.1007/s10209-006-0027-y.

Center for Universal Design. (2010). *Ronald l. Mace.* 2012, Date: 2012-04-24. URL: http://www.ncsu.edu/project/design-projects/udi/center-for-universal-design/ron-mace/. (accessed: 2010-09-07).

Clarkson, J., Coleman, R., Keates, S. & Lebbon, C. (eds.) (2003). *Inclusive design: Design for the whole population*: Springer–Verlag: London.

CM/Rec. (2009). *Recommendation cm/rec(2009)8 of the committee of ministers to member states on achieving full participation through universal design (adopted by the committee of ministers on 21 october 2009 at the 1068th meeting of the ministers' deputies)*: Council of Europe, Committee of Ministers. URL: https://wcd.coe.int/ViewDoc.jsp?Ref=CM/Rec%282009%298&Language=lanEnglish&Site=CM&BackColorInternet=C3C3C3&BackColorIntranet=EDB021&BackColorLogged=F5D383. (accessed: 2011-12-06).

Constantine, L. L. & Lockwood, L. A. D. (2000). *Software for use: A practical guide to the models and methods of usage-centered design*: Addison-Wesley. 579 pp. ISBN: 0-201-92478-1.

Cooper, M., Sloan, D., Kelly, B. & Lewthwaite, S. (2012). *A challenge to web accessibility metrics and guidelines: Putting people and processes first*. Proceedings of the international cross-disciplinary conference on Web accessibility, Lyon, France: ACM. pp. 1–4. doi: 10.1145/2207016.2207028.

Cornford, T. & Smithson, S. (1996). *Project research in information systems. A student's guide*. London: Macmillan Press LTD. ISBN: 0-333-64421-2.

Crang, M. & Cook, I. (2007). *Doing ethnographies*. Los Angeles–London–New Delhi–Singapore: Sage Publications Ltd. 244 pp. ISBN: 9780761944461.

Cranor, L. F., Guduru, P. & Arjula, M. (2006). User interfaces for privacy agents. *ACM Trans. Comput.–Hum Interact.*, 13 (2): 135–178. doi: 10.1145/1165734.1165735.

Crawford, R. (2010). *Gary shapiro claims universal design principles are impossible*: National Association of the Deaf. URL: http://www.nad.org/blogs/rosalinecrawford/gary-shapiro-claims-universal-design-principles-are-impossible (accessed: 2013-10-20).

CUD. (1997). *The principles of universal design* Version 2.0 - 4/1/97: Center for Universal Design, NC State University. URL: http://www.ncsu.edu/project/design-projects/udi/center-for-universal-design/the-principles-of-universal-design/ (accessed: 2012-06-18).

CUD. (2008). *History of universal design*: Center for Universal Design. URL: http://www.ncsu.edu/ncsu/design/cud/about_us/ushistory.htm (accessed: 2012-09-27).

Culén, A. L. & Velden, M. (2013). The digital life of vulnerable users: Designing with children, patients, and elderly. In Aanestad, M. & Bratteteig, T. (eds.) Lecture notes in business information processing, vol. 156 *Nordic contributions in is research*: Springer Berlin Heidelberg. pp. 53–71. ISBN: 978-3-642-39831-5.

Czaja, S. J. & Lee, C. C. (2007). The impact of aging on access to technology. *Univers. Access Inf. Soc.*, 5 (4): 341–349. doi: 10.1007/s10209-006-0060-x.

Dalcher, D. (2006). Consilience for universal design: The emergence of a third culture. *Universal Access in the Information Society*, 5 (3): 253–268.

Darzentas, J. & Miesenberger, K. (2005). Design for all in information technology: A universal concern. In Andersen, K., Debenham, J. & Wagner, R. (eds.) Lecture notes in computer science, vol. 3588 *Database and expert systems applications*: Springer: Berlin/Heidelberg. pp. 406–420. ISBN: 978-3-540-28566-3.

Datatilsynet. (2005a). *Veileder: Bruk av personopplysninger i forsking. Del i meldeplikt eller konsesjonsplikt?* 28.06.2005: Datatilsynet. 8 pp. URL: http://www.datatilsynet.no/upload/Dokumenter/veiledere/forskningsinfo_del_i_1_0.pdf. (accessed: 2006-01-25).

Datatilsynet. (2005b). *Veileder: Bruk av personopplysninger i forsking. Del ii hvilke regler gjelder for forskning?* 08.07.2005. 19 pp. URL: http://www.datatilsynet.no/upload/Dokumenter/veiledere/forskningsinfo_del_ii_1_0.pdf. (accessed: 2006-01-25).

Deng, J. (2001). *Accommodating mobility impaired users on web*, April: Department of Computer Science, University of Maryland, College Park, MD 20742 USA.

Denzin, N. K. & Lincoln, Y. S. (eds.) (1994). *Handbook of qualitative research*. Thousand Oaks, CA: Sage.

Dickinson, A., Eisma, R. & Gregor, P. (2003). *Challenging interfaces/redesigning users*. Proceedings of the 2003 conference on universal usability, Vancouver, British Columbia, Canada: ACM. pp. 61–68. doi: 10.1145/957205.957217.

Dickinson, A., Arnott, J. & Prior, S. (2007). Methods for human–computer interaction research with older people. *Behav. Inf. Technol.*, 26 (4): 343–352. doi: 10.1080/01449290601176948.

Dickinson, A., Eisma, R. & Gregor, P. (2011). The barriers that older novices encounter to computer use. *Universal Access in the Information Society*, 10 (3): 261–266. doi: 10.1007/s10209-010-0208-6.

Diskriminerings- og tilgjengelighetsloven. (2008). *Lov om forbud mot diskriminering på grunn av nedsatt funksjonsevne* [in Norwegian]. *[Eng: Act relating to a prohibition against discrimination on the basis of disability]*. Norway. LOV-2008-06-20-42. LOV-2011-06-24-30. URL: http://www.lovdata.no/all/hl-20080620-042.html. (accessed: 2013-03-23).

Dong, H., Keates, S., Clarkson, P. & Cassim, J. (2003). Implementing inclusive design: The discrepancy between theory and practice universal access theoretical perspectives, practice, and experience. In Carbonell, N. & Stephanidis, C. (eds.) Lecture notes in computer science, vol. 2615: Springer: Berlin/Heidelberg. pp. 106–117. ISBN: 978-3-540-00855-2.

Dong, H., Keates, S. & Clarkson, P. (2004). Inclusive design in industry: Barriers, drivers and the business case In Stary, C. & Stephanidis, C. (eds.) Lecture notes in computer science, vol. 3196 *User-centered interaction paradigms for universal access in the information society*: Springer: Berlin/Heidelberg. pp. 305–319. ISBN: 978-3-540-23375-6.

Dong, H. (2007). *Shifting paradigms in universal design*. Proceedings of the 4th international conference on universal access in human computer interaction: coping with diversity, Beijing, China: Springer-Verlag. pp. 66–74. doi: 10.1007/978-3-540-73279-2_8.

Dourish, P. (2006). *Implications for design*. Proceedings of the SIGCHI conference on Human Factors in computing systems, Montreal, Quebec, Canada: ACM. pp. 541–550. doi: 10.1145/1124772.1124855.

DRC. (2004). *The web: Access and inclusion for disabled people. A formal investigation conducted by the disability rights commission*. 14. april 2004, London. 56 pp. URL: http://www-hcid.soi.city.ac.uk/research/DRC_Report.pdf.

Dumas, J. S. & Redish, J. C. (1999). *A practical guide to usability testing.* Revised edition ed. Oregon, USA: Intellect Books. 404 pp. ISBN: 1-84150-020-8.

Dumas, J. S. & Salzman, M. C. (2006). Usability assessment methods. *Reviews of Human Factors and Ergonomics*, 2 (1): 109–140. doi: 10.1177/1557234x0600200105.

E-Access Bulletin. (2011). *Lack of interoperability 'is biggest accessibility barrier'.* E-Access Bulletin Live, Date: 21. July 2011. URL: http://www.headstar.com/eablive/?p=609. (accessed: 2012-12-27).

E-vote 2011. (2009). *Accessibility and usability requirements: Project: E-vote 2011. System specification document*. 5. May 2009: Norwegian ministry of local government and regional development. 35 pp. URL: http://www.regjeringen.no/upload/KRD/Kampanjer/valgportal/e-valg/Anskaffelse/Accessibility_and_Usability_Requirements.pdf. (accessed: 2012-06-18).

Eason, K. D. (1984). Towards the experimental study of usability. *Behaviour & Information Technology*, 3 (2): 133–143. doi: 10.1080/01449298408901744.

EC. (1995-2007). *Design for all (DfA)* Europe's Information Society Thematic Portal: The European Commission. URL: http://ec.europa.eu/information_society/policy/accessibility/deploy/dfa/index_en.htm (accessed: 2007-04-17).

EC. (2004). *On the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts*: Official Journal of the European Union. Directive 2004/18/EC. URL: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2004:134:0114:0240:en:PDF.

EC. (2005). *i2010 - a european information society for growth and employment*. Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and The Committee of the Regions, Report no 229 final. 01.June 2005: Commission of the European Communities. 12 pp.

EC. (2007). *Communication "european i2010 initiative on e-inclusion - to be part of the information society". Europe's Information Society. Thematic portal*: European Commission. URL: http://ec.europa.eu/information_society/activities/einclusion/bepartofit/overview/index_en.htm. (accessed: 2012-06-18).

EC. (2010). *Overview of the european strategy in ICT for ageing well.* European Commission, Information Society and Media, Date: October 2010. URL: http://ec.europa.eu/information_society/activities/einclusion/docs/ageing/overview.pdf. (accessed: 2012-04-05).

EC. (2011a). *E-inclusion policy* Europe's Information Society, Thematic Portal: ec.europa.eu. URL: http://ec.europa.eu/information_society/activities/einclusion/policy/index_en.htm (accessed: 2011-12-06).

EC. (2011b). *Overview of running eu-funded projects in the area of assistive technologies and ambient assisted living*: European Commission, BU31 01/66, Directorate General for Information Society and Media.

EC. (2012a). *Eaccessibility – opening up the information society* e-Inclusion. 4. Jun. 2012: Europe's Information Society, Thematic Portal. URL: http://ec.europa.eu/information_society/activities/einclusion/policy/accessibility/index_en.htm (accessed: 2012-12-29).

EC. (2012b). *Helping older people to access the information society* e-Inclusion. 2012-06-04: Europe's Information Society Portal. URL: http://ec.europa.eu/information_society/activities/einclusion/policy/ageing/index_en.htm (accessed: 2013-04-04).

EDeAN. *General, what is the european design for all e-accessibility network edean*: European Design for All e-Accessibility Network. URL: http://www.edean.org/central.aspx?sId=64I160I327I323I259530&neID=341&neTa=60&tbid=0&lrID=2&oldUIID=aI599I0I2&acID=1 (accessed: 2012-11-15).

EDeAN. *Glossary of terms* [Web page]: EDeAN - European Design for All and e-Accessibiility Network. URL: http://www.education.edean.org/index.php?filters=f37 (accessed: 2013-04-09).

EDeAN. (2009). *Legislation & standards*: European Design for All e-Accessibility Network. URL: http://www.education.edean.org/index.php?row=1&filters=f6 (accessed: 2009-12-14).

Egger, F. N. (2000, 14-19 Dec.2000). *Lo-fi vs. Hi-fi prototyping: How real does the real thing have to be? «teaching HCI» workshop*. OZCHI2000, Sydney, Australia.

Ehn, P. (1993). Scandinavian design: On participation and skill. In Schuler, D. & Namioka, A. (eds.) *Participatory design. Principles and practice*: Lawrence Erlbaum. pp. 41–77.

EIA&EIF. (1996). *Resource guide for accessible design of consumer electronics; linking product design to the needs of people with functional limitations.*: A Joint Venture of the Electronic Industries Association and the Electronic Industries Foundation. URL: http://www.empowermentzone.com/products.txt.

EIDD. (2006). *European institute for design and disability*. URL: http://www.design-for-all.org/ (accessed: 2007-11-13).

Eikhaug, O., Gherawo, R., Plumbe, C., Berg, M. S. & Kunur, M. (eds.) (2010). *Innovating with people. The business of inclusive design*: The Norwegian Design Council 96 pp.

Eisma, R., Dickinson, A., Goodman, J., Syme, A., Tiwari, L. & Newell, F. (2004). Early user involvement in the development of information technology-related products for older people. *Univers. Access Inf. Soc.*, 3 (2): 131–140. doi: 10.1007/s10209-004-0092-z.

Ekern, L. (2009). Hva betyr betaling for forskningens kvalitet. [Eng: What does payment mean for research quality]. *Fagbladet Forskningsetikk*. URL: http://www.etikkom.no/no/Aktuelt/Aktuelt/Fagbladet-Forskningsetikk/Arkiv/2009/2009-1/Hva-betyr-betaling-for-forskningens-kvalitet/ (accessed: 2010-11-09).

Ellcessor, E. (2010). Bridging disability divides. *Information, Communication & Society*, 13 (3): 289–308. doi: 10.1080/13691180903456546.

Emery, V. K., Edwards, P. J., Jacko, J. A., Maloney, K. P., Barnard, L., Kongnakorn, T., Sainfort, F. & Scott, I. U. (2003, 10-11 Nov.). *Toward achieving universal usability for older adults through multimodal feedback.* ACM Conference on Universal Usability, Vancouver. 46–53 pp.

EU. (2006). *Ministerial declaration, approved unanimously*. 11. June 2006, Riga, Latvia. URL: http://ec.europa.eu/information_society/activities/ict_psp/documents/declaration_riga.pdf.

EU Digital Agenda. *Digital agenda for europe* EUROPA > Summaries of EU legislation > Information society. 25. Jun. 2010: Europa.eu, the official website of the European Union. URL: http://europa.eu/legislation_summaries/information_society/strategies/si0016_en.htm (accessed: 2013-04-05).

EU Digital Strategy. *Digital strategy, i2010 strategy, eeurope action plan, digital strategy programmes* EUROPA > Summaries of EU legislation > Information society: Europa.eu, the official website of the European Union. URL: http://europa.eu/legislation_summaries/information_society/strategies/ (accessed: 2013-04-05).

FAD. (2012). *På nett med innbyggerne. Regjeringens digitaliseringsprogram. [Eng: On the web with the citizens]*. Report, P-0971 B, Oslo: Fornyings- administrasjons- og kirkedepartementet,. URL: www.publikasjoner.dep.no.

FAD. (2013). *Forskrift om universell utforming av informasjons- og kommunikasjonsteknologiske (IKT)-løsninger*. *[Eng: Regulation for universal design of information and communication technology (ICT) solutions]*. Norway: Fornyings- administrasjons, og kirkedepartementet. FOR-2013-06-21-732. URL: http://uu.difi.no/regulations-universal-design-ict/regulation-universal-design-information-and-communication. (accessed: 2013-07-10).

Fairweather, P. & Trewin, S. (2010). Cognitive impairments and web 2.0. *Universal Access in the Information Society*, 9 (2): 137–146. doi: 10.1007/s10209-009-0163-2.

Fernandez, A., Abrahao, S. & Insfran, E. (2012, 14-15 May 2012). *A systematic review on the effectiveness of web usability evaluation methods*. Evaluation & Assessment in Software Engineering (EASE 2012), 16th International Conference on. 52–56 pp. doi: 10.1049/ic.2012.0007.

FFO. (2000). *Mål og middel. Brukermedvirkning for full deltaking og likestilling: Håndbok for brukerrepresentanter fra funksjonshemmedes organisasjoner. [Eng: Objectives and means. User involvement for full participation and equality]*. 2000-02-15: Funksjonshemmedes fellesorganisasjon. 33 pp. URL: http://www.ffo.no/upload/Dokumenter/Brukermedvirkning/maal_og_middel.pdf.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, 12 (2): 219–245. doi: 10.1177/1077800405284363.

FN-Sambandet. (2013). *Fns konvensjon om rettighetene til personer med nedsatt funksjonsevne [Eng: Convention on the Rights of Persons with Disabilities]*. URL: http://www.fn.no/Bibliotek/Avtaler/Menneskerettigheter/FNs-konvensjon-om-rettighetene-til-personer-med-nedsatt-funksjonsevne (accessed: 2013-12-12).

St.meld. nr. 17 (2006-2007). *Eit informasjonssamfunn for alle [Eng: An Information Society for All]* 180 pp.: Fornyings- og administrasjonsdepartementet. URL: http://www.regjeringen.no/upload/FAD/Vedlegg/IKT-politikk/stm17_2006-2007_eng.pdf.

Friedman, B., jr., P. H. K. & Borning, A. (2006). Value sensitive design and information systems. In Zhang, P. & Galletta, D. (eds.) *Human-computer interaction in management information systems: Foundation*, NY: M.E. Sharpe, Inc.

Fuglerud, K. & Dale, O. (2011). Secure and inclusive authentication with a talking mobile one-time-password client. *Security & Privacy, IEEE*, 9 (2): 27–34. doi: 10.1109/MSP.2010.204.

Fuglerud, K. & Tjøstheim, I. (2012). E-valg, tilgjengelighet og personer med nedsatt funksjonsevne [Eng: E-voting, accessibility and people with disabilities]. In Segaard, S. B. & Saglie, J. (eds.) Rapport 2012:3, *Evaluering av forsøket med e-valg 2011. Tilgjengelighet for velgere, tillit, hemmelig valg og valgdeltakelse*, Oslo: Institutt for sammfunnsforskning. pp. 85–157.

Fuglerud, K. S. (2005). *IKT for et inkluderende arbeidsliv. [Eng: ICT for an inclusive working life]*. Report. NR Notat, 1009. 2005-11-15, Oslo: Norsk Regnesentral. 28 pp. URL: http://publ.nr.no/?q=Fuglerud.

Fuglerud, K. S. (2006). Full deltakelse for alle? Delrapport IKT [Eng: Full participation for all? Report on the ICT area. In *Full deltakelse for alle? Utviklingstrekk 2001-2006. Del 2*, Oslo. pp. 91–146. ISBN: 978-82-8081-079-3.

Fuglerud, K. S. (2007). *Hvordan utforme IKT for personer med kognitive funksjonsnedsettelser – en litteraturgjennomgang. [Eng: How to design ICT for persons with cognitive disabilities - a literature review]*. Report. NR notat. 2007-07-27: Norsk Regnesentral. 16 pp. URL: http://www.nr.no/files/dart/einclusion/Fuglerud_2007_Unimod_Design-for-CD.pdf.

Fuglerud, K. S. (2008). *IKT for alle [Eng: ICT for all]* [Popular science presentation]. 2008-11-13. Bekkestua bibliotek.

Fuglerud, K. S. & Solheim, I. (2008). *Synshemmedes IKT-barrierer. Resultater fra undersøkelse om IKT-bruk blant synshemmede. [Eng: ICT barriers of the visually impaired]*. Report, 1016. March 06, 2008, Oslo: Norwegian Computing Center. 91 pp.

Fuglerud, K. S. (2009, 19-24 July 2009.). *ICT services for every citizen: The challenge of gaps in user knowledge*. Proceedings of the 5th International Conference on Universal Access in Human-Computer Interaction. Addressing Diversity. Part I: Held as Part of HCI International 2009, San Diego, CA, USA: Springer-Verlag. 38–47 pp. doi: 10.1007/978-3-642-02707-9_5.

Fuglerud, K. S., Halbach, T., Dale, Ø., Solheim, I. & Schultz, T. (2009a). *Accessibility and usability evaluation of e-vote prototypes*. Report. 24. Nov. 2009: Norwegian Computing Center. 54 pp. URL: http://www.regjeringen.no/upload/KRD/Kampanjer/valgportal/e-valg/e_valg_systemlosning/report_evoting_usability_accessibility_eval_nr_iter2_final.pdf.

Fuglerud, K. S., Reinertsen, A., Fritsch, L. & Dale, Ø. (2009b). *Universell utforming av IKT-baserte løsninger for registrering og autentisering. [Eng: Universal design of ICT-based solutions for the registration and authentication]*. NR report. Jan. 31, 2009, Oslo: Norwegian Computing Center. 60 pp.

Fuglerud, K. S. (2010). *Etikk og personvern ved brukerinvolvering i utvikling av universelt utformede løsninger. Retningslinjer for e-me prosjektet. [Eng: Ethics and privacy of userinvolvement in the development of universally designed solutions. Guidelines for the e-Me project]*. Report. NR Notat. 2010-12-13: Norsk Regnesentral, . 20 pp. URL: http://publ.nr.no/5475.

Fuglerud, K. S., Tjøstheim, I., Gunnarsson, B. R. & Tollefsen, M. (2012). Use of social media by people with visual impairments: Usage levels, attitudes and barriers. In Miesenberger, K., Karshmer, A., Penaz, P. & Zagler, W. (eds.) Lecture notes in computer science, vol. 7382 *Computers helping people with special needs*: Springer Berlin Heidelberg. pp. 565–572. ISBN: 978-3-642-31521-3.

Fuglerud, K. S. & Røssvoll, T. H. (2012). An evaluation of web-based voting usability and accessibility. Universal Access in the Information Society, 11 (4): 359–373. doi: 10.1007/s10209-011-0253-9.

Fuglerud, K. S. & Sloan, D. (2013, 21 - 26 July 2013). *The link between inclusive design and innovation: Some key elements*. HCI International 2013, Las Vegas, Nevada, USA: Springer.

Følstad, A. & Skjetne, J. H. (2007). *Brukersentrert utvikling av offentlige elektroniske tjenester: En veileder til prosjektledere. [Eng: User-centered development of electronic public services: A guide for project managers]*. Sintef Rapport. 2007-29-08: SINTEF. 33+7 pp.

Følstad, A., Anda, B. C. D. & Sjøberg, D. I. K. (2010). The usability inspection performance of work-domain experts: An empirical study. *Interacting with Computers*, 22 (2): 75–87. doi: 10.1016/j.intcom.2009.09.001.

Galliers, J., Wilson, S., Roper, A., Cocks, N., Marshall, J., Muscroft, S. & Pring, T. (2012). *Words are not enough: Empowering people with aphasia in the design process*. Proceedings of the 12th Participatory Design Conference: Research Papers - Volume 1, Roskilde, Denmark. 2347643: ACM. pp. 51-60. doi: 10.1145/2347635.2347643.

Garson, G. D. (1995). *Computer technology and social issues*. Harrisburg, USA: Idea Group Publishing. 444 pp.

Gemou, M. & Bekiaris, E. (2009). *Evaluation framework towards all inclusive mainstream ICT*. Universal Access in HCI, Part I: Springer-Verlag: Berlin, Heidelberg. 480–488 pp.

Gibson, B. (2007). *Enabling an accessible web 2.0*. Proceedings of the 2007 international cross-disciplinary conference on Web accessibility (W4A), Banff, Canada: ACM Press. doi: 10.1145/1243441.1243442.

Gjerstad, L. (2001). *Lett kognitiv svikt. [Eng: Moderate cognitive impairment]*. URL: http://www.dia-online.no/artikkel.asp?ID=79. (accessed: 10. May 2013).

Gould, J. D. & Lewis, C. (1985). Designing for usability: Key principles and what designers think. *Commun. ACM*, 28 (3): 300–311. doi: 10.1145/3166.3170.

Gould, J. D. (1995). How to design usable systems. In Baecker, R. M., Grudin, J., Buxton, W. A. S. & Greenberg, S. (eds.) *Human-computer interaction: Toward the year 2000*, San Francisco: Morgan Kaufmann Publishers, Inc. pp. 93–121.

Grace, G. L. (1966). Application of empirical methods to computer-based system design. *Journal of Applied Psychology*, 50 (6): 442–450. doi: 10.1037/h0024049.

Greenberg, S. & Buxton, B. (2008). *Usability evaluation considered harmful (some of the time)*. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Florence, Italy: ACM. pp. 111–120. doi: 10.1145/1357054.1357074.

Gregor, P., Newell, A. F. & Zajicek, M. (2002, 2002). *Designing for dynamic diversity: Interfaces for older people*. Proceedings of the fifth international ACM conference on Assistive technologies, Edinburgh, Scotland: ACM. pp. 151–156. doi: 10.1145/638249.638277.

Grudin, J. (1989). The case against user interface consistency. *Commun. ACM*, 32 (10): 1164–1173. doi: 10.1145/67933.67934.

Grudin, J. (1991). Interactive systems: Bridging the gaps between developers and users. *Computer*, 24 (4): 59–69. doi: 10.1109/2.76263.

Grudin, J. & Pruitt, J. (2002). *Personas, participatory design and product development: An infrastructure for engagement*. Proceedings of Participation and Design Conference (PDC2002), Sweden. 144–161 pp.

Grudin, J. (2005). Three faces of human–computer interaction. *Annals of the History of Computing, IEEE*, 27 (4): 46–62.

Grønvall, E. & Kyng, M. (2011). *Beyond utopia: Reflections on participatory design in home-based healthcare with weak users*. Proceedings of the 29th Annual European Conference on Cognitive Ergonomics, Rostock, Germany: ACM. pp. 189–196. doi: 10.1145/2074712.2074750.

Gulliksen, J. & Lantz, A. (2000). Organisation and communication for usable ucd. In Gulliksen, J., Lantz, A. & Boivie, I. (eds.) Trita-na-d0006, cid-72, *How to make user centred design usable*, Stockholm, Sweden

Gulliksen, J., Goransson, B., Boivie, I., Blomkvist, S., Persson, J. & Cajander, Å. (2003). Key principles for user-centred systems design. *Behaviour and Information Technology*, 22 (3): 397.

Gunderson, J. (2009). *Functional accessibility testing using best practices*. Proceedings of the 5th International Conference on Universal Access in Human-Computer Interaction. Addressing Diversity. Part I: Held as Part of HCI International 2009, San Diego, CA: Springer-Verlag. doi: 10.1007/978-3-642-02707-9_57.

Göransson, B. (2004). *User-centred systems design: Designing usable interactive systems in practice*: Uppsala, Faculty of Science and Technology.

Hailpern, J., Guarino-Reid, L., Boardman, R. & Annam, S. (2009). *Web 2.0: Blind to an accessible new world*. Proceedings of the 18th international conference on World Wide Web, Madrid, Spain: ACM. pp. 821–830. doi: 10.1145/1526709.1526820.

Hanson, V. & Crayne, S. (2005). Personalization of web browsing: Adaptations to meet the needs of older adults. *Universal Access in the Information Society*, 4 (1): 46–58. doi: 10.1007/s10209-005-0110-9.

Haptic technology. (2013). 7 January 2013: Wikipedia. URL: http://en.wikipedia.org/wiki/Haptic_technology#cite_note-1 (accessed: 22. February 2013).

Harper, S. (2006). Is there design-for-all? *Universal Access in the Information Society*, 6 (1): 111-113.

Harper, S., Yesilada, Y. & Goble, C. (2007). Building the mobile web: Rediscovering accessibility? *Universal Access in the Information Society*, 6 (3): 219–220.

Harper, S. & Chen, A. Q. (2012). Web accessibility guidelines: A lesson from the evolving web. *World Wide Web*, 15 (1): 61-88.

Head, E. (2009). The ethics and implications of paying participants in qualitative research. *International Journal of Social Research Methodology*, 12 (4): 335 – 344.

Henry, S. L. (2007). *Just ask: Integrating accessibility throughout design*: Lulu.com. ISBN: 1430319526.

Hochheiser, H. & Lazar, J. (2010). Revisiting breadth vs. Depth in menu structures for blind users of screen readers. *Interacting with Computers*, 22 (5): 389–398.

Hoegh, R. T., Nielsen, C. M., Overgaard, M., Pedersen, M. B. & Stage, J. (2006). The impact of usability reports and user test observations on developers' understanding of usability data: An exploratory study. *International Journal of Human-Computer Interaction*, 21 (2): 173–196. doi: 10.1207/s15327590ijhc2102_4.

Hollingsed, T. & Novick, D. G. (2007). *Usability inspection methods after 15 years of research and practice*. Proceedings of the 25th annual ACM international conference on design of communication, El Paso, Texas, USA: ACM. pp. 249–255. doi: 10.1145/1297144.1297200.

Horton, S. & Leventhal, L. (2008). Universal usability. In Harper, S. & Yesilada, Y. (eds.) Human–computer interaction series, *Web accessibility*: Springer London. pp. 345–355. ISBN: 978-1-84800-050-6.

Hwang, W. & Salvendy, G. (2010). Number of people required for usability evaluation: The 10±2 rule. *Commun. ACM*, 53 (5): 130–133. doi: 10.1145/1735223.1735255.

ISO 9241-11. (1998). *Ergonomic requirements for office work with visual display terminals (vdts) - part 11: Guidance on usability*. Geneva, Switzerland: International Organization for Standardization. ISO 9241-11:1998.

ISO 9241-171. (2008). *Ergonomics of human-system interaction - part 171: Guidance on software accessibility*. Geneva, Switzerland: International Organization for Standardization. ISO 9241-171:2008. p. 88.

ISO 9241-210. (2010). *Ergonomics of human system interaction: Human-centred design for interactive systems*. Geneva, Switzerland: International Organization for Standardization. ISO 9241-210:2010. p. 32.

ISO 20282-2. (2013). *Usability of consumer products and products for public use -- part 2: Summative test method*. Geneva, Switzerland: International Organization for Standardization. ISO/TS 20282-2:2013. p. 50. URL: http://www.standard.no/no/Sok-og-kjop/produktkatalogen/Produktpresentasjon/?ProductID=653652.

ISO/IEC Guide 71. (2001). *Guidelines for standardization to address the needs of older persons and people with disabilities*. Geneva, Switzerland: International Organization for Standardization and International Electrotechnical Commission.

Jacobs, S. (2002). *The electronic curb-cut effect.* ICDRI. URL: http://www.icdri.org/technology/ecceff.htm. (accessed: 2008-10-05).

Jameson, A. (2002, 17-19 June 2002). *Usability issues and methods for mobile multimodal systems*. ISCA, Kloster Irsee, Germany.

Kaklanis, N., Moustakas, K. & Tzovaras, D. (2012). *A methodology for generating virtual user models of elderly and disabled for the accessibility assessment of new products*. Proceedings of the 13th international conference on Computers Helping People with Special Needs - Volume Part I, Linz, Austria. 2363881: Springer-Verlag. pp. 295–302. doi: 10.1007/978-3-642-31522-0_44.

Kane, S. K., Shulman, J. A., Shockley, T. J. & Ladner, R. E. (2007). *A web accessibility report card for top international university web sites*. Proceedings of the 2007 international cross-disciplinary conference on Web accessibility (W4A), Banff, Canada: ACM. pp. 148–156. doi: 10.1145/1243441.1243472.

Karat, J. & Karat, C. M. (2003). The evolution of user-centered focus in the human–computer interaction field. *IBM Systems Journal*, 42 (4): 532–541. doi: 10.1147/sj.424.0532.

Keates, S. & Clarkson, J. (2003). *Countering design exclusion. An introduction to inclusive design*: Springer. 227 pp. ISBN: 1852337699.

Keates, S. & Clarkson, P. J. (2003). Countering design exclusion: Bridging the gap between usability and accessibility. *Universal Access in the Information Society*, 2 (3): 215–225.

Keates, S., Clarkson, P. J. & Robinson, P. (2004). Design for participation: Providing access to e-information for older adults. *Universal Access in the Information Society*, 3 (2): 149–163.

Keates, S. (2006). Pragmatic research issues confronting HCI practitioners when designing for universal access. *Universal Access in the Information Society*, 5 (3): 269–278.

Keates, S. (2007). *Designing for accessibility: A business guide to countering design exclusion* Mahwah, New Jersay: Lawrence Erlbaum Associates, Inc., Publishers. ISBN: 978-0-8058-60-96.

Keates, S. & Varker, P. (2007). Establishing design best practices for users with cognitive and learning difficulties. In *Universal access in human computer interaction. Coping with diversity*. pp. 706–715.

Keinonen, T. (2008). *User-centered design and fundamental need*. Proceedings of the 5th Nordic conference on Human-computer interaction: building bridges, Lund, Sweden. 1463183: ACM. pp. 211–219. doi: 10.1145/1463160.1463183.

Kelly, B., Nevile, L., Draffan, E. A. & Fanou, S. (2008). *One world, one web ... But great diversity*. Proceedings of the 2008 international cross-disciplinary conference on Web accessibility (W4A), Beijing, China: ACM. doi: http://doi.acm.org/10.1145/1368044.1368078.

Kelly, B., Sloan, D., Brown, S., Seale, J., Lauke, P., Ball, S. & Smith, S. (2009). Accessibility 2.0: Next steps for web accessibility. *Journal of Access Services*, 6 (1-2): 265–294.

Klironomos, I., Antona, M., Basdekis, I., Stephanidis, C. & for, E. D. S. (2006). White paper: Promoting design for all and e-accessibility in europe. *Universal Access in the Information Society*, 5 (1): 105–119.

Knudsen, L. E. & Holone, H. (2012). *A multimodal approach to accessible web content on smartphones*. Proceedings of the 13th international conference on Computers Helping People with Special Needs - Volume Part II, Linz, Austria. 2363958: Springer-Verlag. pp. 1–8. doi: 10.1007/978-3-642-31534-3_1.

Kraft, P. & Bansler, J. P. (1994). The collective resource approach: The scandinavian experience. *Scandinavian Journal of Information Systems*, 6 (1): 71–84.

Kujala, S. & Kauppinen, M. (2004). *Identifying and selecting users for user-centered design*. Proceedings of the third Nordic conference on Human-computer interaction, Tampere, Finland: ACM. pp. 297–303. doi: 10.1145/1028014.1028060.

Kujala, S. (2008). Effective user involvement in product development by improving the analysis of user needs. *Behaviour & Information Technology*, 27 (6): 457–473. doi: 10.1080/01449290601111051.

Kyng, M. (1994). *Scandinavian design: Users in product development*. Proceedings of the SIGCHI conference on human factors in computing systems: celebrating interdependence, Boston, Massachusetts, United States: ACM. doi: 10.1145/191666.191673.

Kyng, M. (2010). Bridging the gap between politics and techniques: On the next practices of participatory design. *Scandinavian Journal of Information Systems*, 22 (1): Article 5.

Lai, J., Honda, T. & Yang, M. C. (2010). A study of the role of user-centered design methods in design team projects. *AI EDAM*, 24 (Special Issue 03): 303–316. doi: 10.1017/S0890060410000211.

Langdon, P. & Thimbleby, H. (2010). Inclusion and interaction: Designing interaction for inclusive populations. *Interacting with Computers*, 22 (6): 439–448. doi: 10.1016/j.intcom.2010.08.007.

Law, C., Yi, J., Choi, Y. & Jacko, J. (2008). A systematic examination of universal design resources: Part 2, analysis of the development process. *Universal Access in the Information Society*, 7 (1-2): 55–77. doi: 10.1007/s10209-007-0100-1.

Lazar, J. (2007). Introduction to universal usability. In Lazar, J. (ed.) *Universal usability. Designing computer interfaces for diverse users*, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England: John Wiley & Sons Ltd. p. 610. ISBN: 978-0-470-02727-1.

Lazar, J., Allen, A., Kleinman, J. & Malarkey, C. (2007). What frustrates screen reader users on the web: A study of 100 blind users. *International Journal of Human-Computer Interaction*, 22 (3): 247–269.

Lazar, J., Feng, J. H. & Hochheiser, H. (2010). *Research methods in human–computer interaction*: Wiley Publishing. 446 pp. ISBN: 0470723378, 9780470723371.

Leahy, D. & Broin, U. O. (2009, June 14 - 17). *Social networking sites and equal opportunity: The impact of accessibility*. 22nd Bled eConference, eEnablement: Facilitating an Open, Effective and Representative eSociety, Bled, Slovenia. pp. 17–31.

Lee, A. (2004). *Scaffolding visually cluttered web pages to facilitate accessibility*. Proceedings of the working conference on Advanced visual interfaces, Gallipoli, Italy: ACM. doi: 10.1145/989863.989875.

Lee, Y.-C., Chao, Y. H. & Lin, S.-B. (2010). Structural approach to design user interface. *Computers in Industry*, 61 (7): 613–623. doi: 10.1016/j.compind.2010.01.003.

Leitner, M.-L. & Strauss, C. (2010). *Organizational motivations for web accessibility implementation - a case study*. Proceedings of the 12th international conference on Computers helping people with special needs: Part I, Vienna, Austria: Springer-Verlag. pp. 392–399.

Leonard, D. & Rayport, J. F. (1997). Spark innovation through empathic design. *Harvard Business Review*, 75 (6): 102–113.

Lepofsky, M. D. & Graham, R. N. M. (2009). Universal design in legislation: Eliminating barriers for people with disabilities. *Statute Law Review*, 30 (2): 97–122. doi: 10.1093/slr/hmp007.

Leporini, B. & Paternò, F. (2004). Increasing usability when interacting through screen readers. *Universal Access in the Information Society*, 3 (1): 57–70.

Lid, I. M. (2012). Developing the theoretical content in universal design. *Scandinavian Journal of Disability Research*, 15 (3): 203–215. doi: 10.1080/15017419.2012.724445.

Lim, C. S. C. (2010). Designing inclusive ICT products for older users: Taking into account the technology generation effect. *Journal of Engineering Design*, 21 (2/3): 189–206. doi: 10.1080/09544820903317001.

Lindgren, A., Chen, F., Amdahl, P. & Chaikiat, P. (2007). *Using personas and scenarios as an interface design: Tool for advanced driver assistance systems*. Universal Access in HCI, Part II, HCII 2007: Springer-Verlag Berlin Heidelberg. 460–469 pp.

Lindsay, S., Brittain, K., Jackson, D., Ladha, C., Ladha, K. & Olivier, P. (2012a). *Empathy, participatory design and people with dementia*. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Austin, Texas, USA: ACM. pp. 521–530. doi: 10.1145/2207676.2207749.

Lindsay, S., Jackson, D., Schofield, G. & Olivier, P. (2012b). *Engaging older people using participatory design*. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Austin, Texas, USA. 2208570: ACM. pp. 1199–1208. doi: 10.1145/2207676.2208570.

LO-NHO. (1994-97). *Tilleggsavtale ii: Rammeavtale om teknologisk utvikling og datamaskinbaserte systemer.* ("Dataavtalen").

Loiacono, E. & Djamasbi, S. (2012 online first). Corporate website accessibility: Does legislation matter? *Universal Access in the Information Society*: 1–10. doi: 10.1007/s10209-011-0269-1.

Madan, A. & Dubey, S. K. (2012). Usability evaluation methods: A literature review. *International Journal of Engineering Science and Technology*, 4 (2): 590–599.

Magar, P. (2011). *History of assistive technology.* Buzzle.com, Date: 2011-10-12. URL: http://www.buzzle.com/articles/history-of-assistive-technology.html. (accessed: 2012-09-11).

Maier, R. & Thalmann, S. (2010). Using personas for designing knowledge and learning services: Results of an ethnographically informed study. *Int. J. Technol. Enhanc. Learn.*, 2 (1/2): 58–74. doi: 10.1504/ijtel.2010.031260.

Masoodian, M. (1999). Facilitating communication during usercentred design. In Gulliksen, J., Lantz, A. & Boivie, I. (eds.) *How to make user centred design usable*: Report number: TRITA-NA-D0006, CID-72, KTH, Stockholm, Sweden. URL: http://cid.nada.kth.se/pdf/cid_72.pdf.

Massanari, A. L. (2010). Designing for imaginary friends: Information architecture, personas and the politics of user-centered design. *New Media & Society*, 12 (3): 401–416. doi: 10.1177/1461444809346722.

McGrenere, J., Davies, R., Findlater, L., Graf, P., Klawe, M., Moffatt, K., Purves, B. & Yang, S. (2003). *Insights from the aphasia project: Designing technology for and with people who have aphasia*. Proceedings of the 2003 conference on universal usability, Vancouver, British Columbia, Canada. 957225: ACM. pp. 112–118. doi: 10.1145/957205.957225.

McGrenere, J., Sullivan, J. & Baecker, R. M. (2006). *Designing technology for people with cognitive impairments*. CHI '06 Extended Abstracts on Human Factors in Computing Systems, Monteral Quebec, Canada: ACM. pp. 1635–1638. doi: 10.1145/1125451.1125750.

McIntyre-Mills, J. (2010). Participatory design for democracy and wellbeing: Narrowing the gap between service outcomes and perceived needs. *Systemic Practice and Action Research*, 23 (1): 21–45. doi: 10.1007/s11213-009-9145-9.

MD. (2007). *Universell utforming – begrepsavklaring [Eng: Universal design - Clarification of the concept]*: Miljøverndepartementet. p. 16. ISBN: 978-82-457-0417-4.

Memmel, T., Reiterer, H. & Holzinger, A. (2007). *Agile methods and visual specification in software development: A chance to ensure universal access*. Proceedings of the 4th international conference on universal access in human computer interaction: coping with diversity, Beijing, China: Springer-Verlag. pp. 453–462.

Miesenberger, K. (2011). *Mini-seminar about challenges in universal design. Discussion and personal communication*. Addressee: Miesenberger, K., Herstad, J., Holone, H., Svanæs, D. & Fuglerud, K. S. University of Oslo (2011-11-07).

Milne, S., Dickinson, A., Carmichael, A., Sloan, D., Eisma, R. & Gregor, P. (2005). *Are guidelines enough?: An introduction to designing web sites accessible to older people*, 44, 3: IBM Corp. pp. 557–571. URL: http://researchweb.watson.ibm.com/journal/sj/443/milneref.html.

Modzelewski, M., Lawo, M., Kirisci, P., Connor, J. O., Fennell, A., Mohamad, Y., Matiouk, S., Valle-Klann, M. & Gökmen, H. (2012). *Creative design for inclusion using virtual user models*. Proceedings of the 13th international conference on Computers Helping People with Special Needs - Volume Part I, Linz, Austria: Springer-Verlag. pp. 288–294. doi: 10.1007/978-3-642-31522-0_43.

Mohamad, Y., Velasco, C., Pullmann, J., Lawo, M. & Kirisci, P. (2011). Virtual user concept for inclusive design of consumer products and user interfaces. In Stephanidis, C. (ed.) Lecture notes in computer science, vol. 6766 *Universal access in human-computer interaction. Users diversity*: Springer: Berlin/Heidelberg. pp. 79–87. ISBN: 978-3-642-21662-6.

Mrazek, D. & Rafeld, M. (1992). *Integrating human factors on a large scale: Product usability champions*. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Monterey, California, United States: ACM. pp. 565–570. doi: 10.1145/142750.142989.

Muller, M., Millen, D. R. & Strohecker, C. (2001). *What makes a representative user representative? A participatory poster*. CHI '01 Extended Abstracts on Human Factors in Computing Systems, Seattle, Washington: ACM. pp. 101–102. doi: 10.1145/634067.634129.

Mumford, E. (1996). *Systems design: Ethical tools for ethical change*: ICS.

Mumford, E. (2000). A socio-technical approach to systems design. *Requirements Engineering*, 5 (2): 125–133. doi: 10.1007/pl00010345.

Mumford, E. (2006). The story of socio-technical design: Reflections on its successes, failures and potential. *Information Systems Journal*, 16 (4): 317–342. doi: 10.1111/j.1365-2575.2006.00221.x.

NCD. (2001). *The accessible future*. 21. June 2001, Washington, USA: National Council on Disability. 138 pp.

Ness, N. E. (2011). *Hjelpemidler og tilrettelegging for deltakelse: Et kunnskapsbasert grunnlag*: Tapir Akademisk. ISBN: 8251927013, 9788251927017.

Nevile, L. (2005). *Adaptability and accessibility: A new framework*. Proceedings of the 17th Australia conference on computer-human interaction: Citizens online: considerations for today and the future, Canberra, Australia: Computer-Human Interaction Special Interest Group (CHISIG) of Australia.

Newell, A., Arnott, J., Carmichael, A. & Morgan, M. (2007). *Methodologies for involving older adults in the design process*. Proceedings of the 4th international conference on universal access in human computer interaction: coping with diversity, Beijing, China: Springer-Verlag. pp. 982–989.

Newell, A., Gregor, P., Morgan, M., Pullin, G. & Macaulay, C. (2011). User-sensitive inclusive design. *Universal Access in the Information Society*, 10 (3): 235–243. doi: 10.1007/s10209-010-0203-y.

Newell, A. (2012). *Experiences in inclusive design*. Addressee: Fuglerud, K. S. Dundee (Informal meeting 2012-11-29).

Newell, A. F., Carmichael, A. & Gregor, P. (2002). Information technology for cognitive support. In Sears, A. & Jacko, J. A. (eds.) *The human-computer interaction handbook: Fundamentals, evolving technologies and emerging applications,*: Lawrence Erlbaum Publishers. pp. 464–481.

Newell, A. F. (2011). *Design and the digital divide: Insights from 40 years in computer support for older and disabled people*. Synthesis lectures on assistive, rehabilitative, and health-preserving technologies: Morgan & Claypool Publishers. 177 pp. ISBN: 978-1-60845-740-3.

NHD. (2006). *Simplified forms for the private sector: Elmer 2 user interface guidelines for governmental forms on the internet*. Report: Norwegian Ministry of Trade and Industry, Norway. 34 pp. URL: http://www.elmer.no/retningslinjer/pdf/elmer2-english.pdf. (accessed: 2009-08-04).

Nielsen, I. & Pullin, G. (2005). A simple secret for design. *Interactions*, 12 (4): 48–50. doi: 10.1145/1070960.1070987.

Nielsen, J. & Norman, D. *The definition of user experience*. URL: http://www.nngroup.com/articles/definition-user-experience/ (accessed: 2013-18-11).

Nielsen, J. (1993). *Usability engineering*. San Diego, USA: AP Professional, Academic Press. 362 pp. ISBN: 0-12-518406-9.

Nielsen, J. (1994). *Usability inspection methods*. Conference Companion on Human Factors in Computing Systems, Boston, Massachusetts, USA: ACM. pp. 413–414. doi: 10.1145/259963.260531.

Nielsen, J. (1998). *Personalization is over-rated* Jakob Nielsen's Alertbox. 1998-10-04. URL: http://www.useit.com/alertbox/981004.html (accessed: 2001-02-05).

Nielsen, J. (2000). *Why you only need to test with 5 users* Jakob Nielsen's Alertbox. 2000-03-19: NN/g Nielsen Norman Group. URL: http://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/ (accessed: 2013-01-20).

Nordby, K. (2003). *Design for all, shaping the end-users' tel-eeurope. ETSI's involvement in laying the foundation for an all-inclusive eeurope* [Powerpoint presentation]. URL: http://www.telenor.com/wp-content/uploads/2012/05/T04_1.pdf.

Nordby, K. (2004). Eaccessibility for all: The role of standardisation in shaping the end-users' tel-eeurope. *Telektronikk*, 100 (1): 4–13. URL: http://www.telenor.com/wp-content/uploads/2012/05/T04_1.pdf.

Norman, D. A. (1983). *The design of everyday things*. New York: BasicBooks. 257 pp.

Norman, D. A. (1988). *The psychology of everyday things*: BasicBooks. 257 pp.

NS 11040. (2013). *Universell utforming: Brukermedvirkning og IKT [Eng: Universal design: User participation and ICT]*. Oslo, Norway: Standard Norge. NS 11040:2013. p. 24. 2013-12-12. URL: http://www.standard.no/no/Sok-og-kjop/produktkatalogen/Produktpresentasjon/?ProductID=669903.

Nussbaum, M. C. (2011). *Creating capabilities. The human development approach*. Cambridge, Massachusetts, and London, England: The Belknap Press of Harvard University Press. 237 pp. ISBN: 978-0-674-05054-9.

Obrenovic, Z., Abascal, J. & Starcevic, D. (2007). Universal accessibility as a multimodal design issue. *Commun. ACM*, 50 (5): 83–88. doi: 10.1145/1230819.1241668.

ODEP. *Communicating with and about people with disabilities* [Webpage]. In Office of disability policy (ed.) Disability Policy. Employment Practice. Full Inclusion: United States Department of Labor,. URL: http://www.dol.gov/odep/pubs/fact/comucate.htm (accessed: 2014-02-27).

Oliver, M. (1996). Defining impairment and disability: Issues at stake. In Barnes, C. & Mercer, G. M. (eds.) *Exploring the Divide*: The Disability Press. pp. 29–54. URL: http://www.disability.co.uk/sites/default/files/resources/ex%20div%20ch3.pdf. (accessed: 2013-04-03).

Olivier, M. (1990). *The individual and social models of disability*. Joint Workshop of the Living Options Group on people with established locomotor disabilities in hospitals, The Research Unit of the Royal College of Physicians.

Oosterlaken, I. (2010, January 26th – 29th, 2010). *Applying sen's capability approach to technological artifacts & engineering design – accounting for human diversity (revised & extended version)*. CEPHAD 2010, The borderland between philosophy and design research, Copenhagen.

Oosterlaken, I. (2012). Inappropriate artefact, unjust design? Human diversity as a key concern in the capability approach and inclusive design. In Oosterlaken, I. & Hoven, J. (eds.) Philosophy of engineering and technology, vol. 5 *The capability approach, technology and design*: Springer Netherlands. pp. 223–244. ISBN: 978-94-007-3879-9.

Oostveen, A.-M. & Besselaar, P. v. d. (2004). *From small scale to large scale user participation: A case study of participatory design in e-government systems*. Proceedings of the eighth conference on Participatory design: Artful integration: interweaving media, materials and practices - Volume 1, Toronto, Ontario, Canada: ACM. pp. 173–182. doi: 10.1145/1011870.1011891.

Oviatt, S. (2003). Flexible and robust multimodal interfaces for universal access. *Universal Access in the Information Society*, 2 (2): 91–95.

Paddison, C. & Englefield, P. (2003). *Applying heuristics to perform a rigorous accessibility inspection in a commercial context*. Proceedings of the 2003 conference on universal usability, Vancouver, British Columbia, Canada: ACM. doi: 10.1145/957205.957228.

Personal Data Act. (2001). *Act of 14 april 2000 no. 31 relating to the processing of personal data*: Lovdata. LOV-2012-04-20-18. URL: http://www.ub.uio.no/ujur/ulovdata/lov-20000414-031-eng.pdf.

Peterson, M. (2011). *Teaching without words* [Video]. 8. June 2011. TEDXOrgangeCoast. URL: http://www.youtube.com/watch?v=2VLje8QRrwg.

Petrie, H., Hamilton, F. & King, N. (2004). *Tension, what tension?: Website accessibility and visual design*. Proceedings of the 2004 international cross-disciplinary workshop on Web accessibility (W4A), New York City, New York: ACM. pp. 13–18. doi: 10.1145/990657.990660.

Petrie, H., Hamilton, F., King, N. & Pavan, P. (2006). *Remote usability evaluations with disabled people*. Proceedings of the SIGCHI conference on Human Factors in computing systems, Montreal, Quebec, Canada: ACM Press. doi: 10.1145/1124772.1124942.

Petrie, H. & Kheir, O. (2007). *The relationship between accessibility and usability of websites*. Proceedings of the SIGCHI conference on Human factors in computing systems, San Jose, California, USA: ACM Press. doi: 10.1145/1240624.1240688.

Power, C., Freire, A. P., Petrie, H. & Swallow, D. (2012). *Guidelines are only half of the story: Accessibility problems encountered by blind users on the web*. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Austin, Texas, USA: ACM. pp. 433–442. doi: 10.1145/2207676.2207736.

Pruitt, J. & Grudin, J. (2003). *Personas: Practice and theory*. Proceedings of the 2003 conference on Designing for user experiences, San Francisco, California: ACM. doi: 10.1145/997078.997089.

Pullin, G. & Newell, A. (2007). Focussing on extra-ordinary users. In Stephanidis, C. (ed.) Lecture notes in computer science, vol. 4554 *Universal acess in human computer interaction. Coping with diversity*: Springer: Berlin/Heidelberg. pp. 253–262. ISBN: 978-3-540-73278-5.

Pullin, G. (2009). *Design meets disability*: MIT Press. 341 pp. ISBN: 978-0-262-16255-5.

Pullin, G., Rogers, J., Banks, R., Regan, T., Napier, A. & Duplock, P. (2011, 18-20 April 2011). *Social digital objects for grandparents*. Include 2011 conference on inclusive and people-centred design, Helen Hamlyn Centre, Royal College of Art, London, UK: Royal College of Art, London.

Raskin, J. (2000). *The humane interface: New directions for designing interactive systems*. Reading, Massachusetts: Addison-Wesley Longman Inc. ISBN: 0-201-37937-6.

Rasmussen, R., Christensen, A. S., Fjeldsted, T. & Hertzum, M. (2011). Selecting users for participation in it projects: Trading a representative sample for advocates and champions? *Interacting with Computers*, 23 (2): 176–187. doi: 10.1016/j.intcom.2011.02.006.

Rosson, M. B. & Carroll, J. M. (2001). *Usability engineering: Scenario-based development of human–computer interaction*: Morgan Kaufmann Publishers.

Rømen, D. & Svanæs, D. (2011). Validating wcag versions 1.0 and 2.0 through usability testing with disabled users. *Universal Access in the Information Society*: 1–11. doi: 10.1007/s10209-011-0259-3.

Rönkkö, K., Hellman, M. & Dittrich, Y. (2008). *Pd method and socio-political context of the development organization*. Proceedings of the Tenth Anniversary Conference on Participatory Design 2008, Bloomington, Indiana. 1795245: Indiana University. pp. 71–80.

Røssvoll, T. & Fuglerud, K. (2013). Best practice for efficient development of inclusive ICT. In Stephanidis, C. & Antona, M. (eds.) Lecture notes in computer science, vol. 8009 *Universal access in human-computer interaction. Design methods, tools, and interaction techniques for einclusion*: Springer Berlin Heidelberg. pp. 97–106. ISBN: 978-3-642-39187-3.

Sandnes, F. E. (2011). *Universell utforming av IKT-systemer*. Oslo: Universitetsforlaget. 385 pp. ISBN: 978-82-15-01491-3.

Sauro, J. (2000). *Why you only need to test with five users (explained)* [Web Page] Measuring usability. 2010-03-08. URL: http://www.measuringusability.com/five-users.php. (accessed: 2013-02-13).

Savidis, A. & Stephanidis, C. (2004). Unified user interface development: The software engineering of universally accessible interactions. *Universal Access in the Information Society*, 3 (3): 165–193.

Schulz, T. & Fuglerud, K. S. (2012, 2012/01/01). *Creating personas with disabilities*. Computers Helping People with Special Needs: Springer Berlin Heidelberg. 145–152 pp. doi: 10.1007/978-3-642-31534-3_22.

Section 508. (2007). *Section 508*. June 2007. URL: http://www.section508.gov/ (accessed: 2007-06-14).

Sevilla, J., Herrera, G., Martínez, B. & Alcantud, F. (2007). Web accessibility for individuals with cognitive deficits: A comparative study between an existing commercial web and its cognitively accessible equivalent. 14 (3): 12. doi: http://doi.acm.org/10.1145/1279700.1279702.

Shackel, B. (2009). Usability - context, framework, definition, design and evaluation. *Interact. Comput.*, 21 (5-6): 339–346. doi: 10.1016/j.intcom.2009.04.007.

Shapiro, J. (2013). Beyond gamification: Cutting-edge technology meets alternative, progressive education. *Forbes*. URL: http://www.forbes.com/sites/jordanshapiro/2013/02/06/beyond-gamification-cutting-edge-technology-meets-alternative-progressive-education/.

Sharp, H., Rogers, Y. & Preece, J. (2006). *Interaction design: Beyond human–computer interaction*. 2nd Edition ed. 776 pp.

Shaver, E. (2009). *A short history of human factors and ergonomics.* Date: 2011-06-02. URL: http://www.thehumanfactorblog.com/2009/01/06/a-short-history-of-human-factors-and-ergonomics/. (accessed: 2009-01-06).

SHDIR. (2003). *Universell utforming over alt! Planlegging og utforming av uteområder, bygninger, transport og produkter for alle.* Artikkelsamling: Sosial- og helsedirektoratet, Avdeling for levekår, Deltasenteret og Statens råd for funksjonshemmede. p. 138. ISBN: 82-8081-033-1.

SHDIR. (2006a). *Full deltakelse for alle? Utviklingstrekk 2001-2006. Del 1 [Eng: Full participation for all? Trends from 2001 to 2006. Part 1]*: Nasjonalt dokumentasjonssenter for personer med nedatt funksjonsevne og Sosial- og helsedirektoratet. p. 89. ISBN: 978-82-8081-079-3. http://www.helsedirektoratet.no/publikasjoner/rapporter/full_deltakelse_for_alle__del_2_56576.

SHDIR. (2006b). *Full deltakelse for alle? Utviklingstrekk 2001-2006. Del 2 [Eng: Full participation for all? Trends from 2001 to 2006. Part 2]*: Nasjonalt dokumentasjonssenter for personer med nedatt funksjonsevne og Sosial- og helsedirektoratet. p. 389. ISBN: 978-82-8081-079-3. http://www.helsedirektoratet.no/publikasjoner/rapporter/full_deltakelse_for_alle__del_2_56576.

Shneiderman, B. (1998). *Designing the user interface. Strategies for effective human–computer-interaction*. 3rd ed.: Addison Wesley Longman, Inc. ISBN: 0-201-69497-2.

Shneiderman, B. (2000). Universal usability. *Commun. ACM*, 43 (5): 84–91. doi: 10.1145/332833.332843.

Shneiderman, B. & Hochheiser, H. (2001). Universal usability as a stimulus to advanced interface design. *Behaviour & Information Technology*, 20 (5): 367–376.

Shneiderman, B. (2003). *Promoting universal usability with multi-layer interface design*. CUU 2003, Vancouver, British Columbia, Canada: ACM. 1–8 pp. doi: 10.1145/960201.957206.

Skatteetaten. (2014). *Skattefrie kontantytelser i arbeidsforhold* [Webpage] Lignings-ABC. 2014-02-18: Skatteetaten.no. URL: http://www.skatteetaten.no/no/Radgiver/Rettskilder/Handboker/Lignings-ABC/Kapitler/S/?mainchapter=73647&chapter=73647#x73647 (accessed: 2014-03-20).

Skjerdal, N. V. (2005). *Universell utforming: Fra ideal til rettsnorm. [Eng: Universal Design: From ideal to rule of law]*, NOU 2005:8, vedlegg 1: Justis- og politidepartementet,. URL: http://www.regjeringen.no/nb/dep/jd/dok/nouer/2005/nou-2005-8/18.html?id=390776. (accessed: 2013-12-08).

Slegers, K., Duysburgh, P. & Hendriks, N. (2013). *Chi 2014 workshop: Participatory design with people with cognitive or sensory impairments*. 2013-11-28. URL: http://pdwithimpairmentschi2014.wordpress.com/ (accessed: 2014-02-13).

Sloan, D., Andy, H., Hamilton, F., Kelly, B., Petrie, H. & Phipps, L. (2006). *Contextual web accessibility - maximizing the benefit of accessibility guidelines*. Proceedings of the 2006 international cross-disciplinary workshop on Web accessibility (W4A): Building the mobile web: rediscovering accessibility?, Edinburgh, U.K.: ACM Press. doi: 10.1145/1133219.1133242.

Solheim, I. (2009). *Adaptive user interfaces: Benefit or impediment for lower-literacy users?* Proceedings of the 5th International Conference in Universal Access in Human-Computer Interaction. Part II: Intelligent and Ubiquitous Interaction Environments, San Diego, CA: Springer-Verlag. 758–765 pp. doi: 10.1007/978-3-642-02710-9_84.

St.meld. nr. 34 (1996-97). *Resultater og erfaringer fra regjeringens handlingsplaner for funksjonshemmede og veien videre* [in Norwegian] *[Eng: Results and experiences from the government's plans for the disabled and the way forward]*: Sosial- og helsedepartementet. URL: http://www.regjeringen.no/nb/dep/ad/dok/regpubl/stmeld/19961997/st-meld-nr-34_1996-97.html?id=191142 (accessed: 2011-09-15).

NOU 2001: 22. *Fra bruker til borger. En strategi for nedbygging av funksjonshemmende barrierer* [in Norwegian] *[Eng: From User to Citizen. A strategy for the dismantling of disabling barriers]*: Sosial- og helsedepartementet. URL: http://odin.dep.no/shd/norsk/publ/utredninger/NOU/030001-020008/index-dok000-b-n-a.html.

St.meld. nr. 40 (2002-2003). *Nedbygging av funksjonshemmende barrierer. Strategier, mål og tiltak i politikken for personer med nedsatt funksjonsevne* [in Norwegian] *[Eng: Dismantling of Disabling Barriers. Strategies, objectives and political measures aimed at persons with a reduced functional ability]*: Det kongelige sosialdepartement. URL: http://www.regjeringen.no/upload/kilde/sos/rap/2004/0001/ddd/pdfv/220598-sle-engelsk-stmeld40-2002-2003.pdf).

Stake, R. E. (2005). Qualitative case studies. In Denzin, N. & Lincoln, Y. (eds.) vol. Chap. 17 *The sage handbook of qualitative research.*: Sage Publications. pp. 443–466.

Stephanidis, C., Akoumianakis, D., Sfyrakis, M. & Paramythis, A. (1998). *Universal accessibility in HCI: Process-oriented design guidelines and tool requirements*. Proceedings of the 4th ERCIM Workshop on "User Interfaces for All". p. 15.

Stephanidis, C. & Salvendy, G. (1998). Toward an information society for all: An international research and development agenda. *International Journal of Human-Computer Interaction*, 10 (2): 107–134.

Stephanidis, C. (1999). *Designing for all in the information society: Challenges towards universal access in the information age*. ERCIM ICST Research Report. 107–134 pp.

Stephanidis, C. (2001). Adaptive techniques for universal access. *User Modeling and User-Adapted Interaction*, 11 (1): 159–179.

Stephanidis, C. & Savidis, A. (2001). Universal access in the information society: Methods, tools, and interaction technologies. *Universal Access in the Information Society*, 1: 40–55.

Stålbrôst, A. (2008). *Forming future with it: The living lab way of user involvement*: Luleå Unviersity of Technology, Business Administraion and Social Sciences, Division of Informatics. 62 pp.

Subramanyam, R., Weisstein, F. L. & Krishnan, M. S. (2010). User participation in software development projects. *Commun. ACM*, 53 (3): 137–141. doi: 10.1145/1666420.1666455.

Svanæs, D. & Gulliksen, J. (2008). *Understanding the context of design: Towards tactical user centered design*. Proceedings of the 5th Nordic conference on Human-computer interaction: building bridges, Lund, Sweden: ACM. doi: 10.1145/1463160.1463199.

NOU 2005:8. *Likeverd og tilgjengelighet* [in Norwegian] *[Eng: Euality and accessiblity]* 377 pp.: Justis- og politidepartementet. URL: http://www.regjeringen.no/en/dep/jd/documents-and-publications/nouer/2005/nou-2005-8.html?id=390520.

Theofanos, M. F. & Redish, J. (2003). Bridging the gap: Between accessibility and usability. *interactions*, 10 (6): 36–51. doi: http://doi.acm.org/10.1145/947226.947227.

Thorén, C. (2004). The procurement of usable and accessible software. *Universal Access in the Information Society*, 3 (1): 102–106.

Turner, C. W., Lewis, J. R. & Nielsen, J. (2006). Determining usability test sample size. In Karwowski, W. & Raton, B. (eds.) vol. 3 *International Encyclopedia of Ergonomics and Human Factors*: CRC Press.

Umeå University. (2009). *ICT services and system development and division of epidemiology and global health, opencode 3.6*. Umeå: Department of Public Health and Clinical Medicine, Umeå University, Sweden. URL: http://www.phmed.umu.se/enheter/epidemiologi/forskning/open-code/.

UN. (2006). *Convention on the rights of persons with disabilities*: United Nations. URL: http://www.un.org/disabilities/convention/conventionfull.shtml (accessed: 2011-12-16).

UN. (2013). *Convention and optional protocol signatures and ratifications*. URL: http://www.un.org/disabilities/countries.asp?navid=12&pid=166 (accessed: 2013-12-16).

Vanderheiden, G. (2000). *Fundamental principles and priority setting for universal usability*. Proceedings on the 2000 conference on universal Usability, Arlington, Virginia, United States: ACM Press. doi: 10.1145/355460.355469.

Vanderheiden, G. & Treviranus, J. (2011). Creating a global public inclusive infrastructure. In Stephanidis, C. (ed.) Lecture notes in computer science, vol. 6765 *Universal access in human-computer interaction. Design for all and einclusion*: Springer Berlin Heidelberg. pp. 517–526. ISBN: 978-3-642-21671-8.

Vanderheiden, G., Treviranus, J., Gemou, M., Bekiaris, E., Markus, K., Clark, C. & Basman, A. (2013). The evolving global public inclusive infrastructure (gpii). In Stephanidis, C. & Antona, M. (eds.) Lecture notes in computer science, vol. 8009 *Universal access in human-computer interaction. Design methods, tools, and interaction techniques for einclusion*: Springer Berlin Heidelberg. pp. 107–116. ISBN: 978-3-642-39187-3.

Vavik, T. & Gheerawo, R. (2009). The challenges in universal design. In Vavik, T. (ed.) *Inclusive buildings, products & services: Challenges in universal design*, Trondheim, Norway. pp. 4–24. ISBN: 9788251923446.

Vavik, T. & Keitsch, M. M. (2010). Exploring relationships between universal design and social sustainable development: Some methodological aspects to the debate on the sciences of sustainability. *Sustainable Development*, 18 (5): 295–305. doi: 10.1002/sd.480.

Vigo, M., Arrue, M., Brajnik, G., Lomuscio, R. & Abascal, J. (2007). *Quantitative metrics for measuring web accessibility*. Proceedings of the 2007 international cross-disciplinary conference on Web accessibility (W4A), Banff, Canada: ACM. doi: 10.1145/1243441.1243465.

Vigo, M., Brown, J. & Conway, V. (2013). *Benchmarking web accessibility evaluation tools: Measuring the harm of sole reliance on automated tests*. Proceedings of the 10th International Cross-Disciplinary Conference on Web Accessibility, Rio de Janeiro, Brazil. 2461124: ACM. pp. 1–10. doi: 10.1145/2461121.2461124.

W3C WAI Users. (2005). *Involving users in web projects for better, easier accessibility*. 2010-04-07. URL: http://www.w3.org/WAI/users/involving.html (accessed: 2012-11-01).

W3C WCAG 2.0. (2008). *Web content accessibility guidelines 2.0, W3C recommendation 11 december 2008*. URL: http://www.w3.org/TR/WCAG20/ (accessed: 2013-03-02).

Wagner, I. (1993). A web of fuzzy problems: Confronting the ethical issues. *Commun. ACM*, 36 (6): 94–101. doi: 10.1145/153571.163290.

Walsham, G. (2005). Learning about being critical. *Information Systems Journal*, 15 (2): 111–117. doi: 10.1111/j.1365-2575.2004.00189.x.

Wattenberg, T. (2004). Beyond standards: Reaching usability goals through user participation. *ACM SIGACCESS Accessibility and Computing* (79): 10–20.

WebAIM. (2014). *Screen reader user survey #5 results.* 2014: WebAIM, an intiative of Center for Persons with Disasbilities at Utah State University, Date: 2014-02-26. URL: http://webaim.org/projects/screenreadersurvey5/#srdetection. (accessed: 2014-03-17).

Wickens, C. D. (2002). Multiple resources and performance prediction. *Theoretical Issues in Ergonomics Science*, 3 (2): 159–177.

Wobbrock, J. O., Kane, S. K., Gajos, K. Z., Haradam, S. & Froehlich, J. (2011). Ability-based design: Concept, principles and examples. *ACM Trans. Access. Comput.*, 3 (3): 1–27. doi: 10.1145/1952383.1952384.

Wågø, S., Høyland, K., Kittang, D. & Øvstedal, L. (2006). *Universell utforming: Begrepsavklaring. [Eng: Universal design: Term clarification]*. Report, SBF51 A06014: SINTEF Byggforsk AS, Arkitektur og byggteknikk. 54 pp.

Yin, R. K. (2013). *Case study research : Design and methods*. Fifth ed. Los Angeles, Calif., US: Sage Publications. ISBN: 978-1-4522-4256-9.

Zajicek, M. (2006). Aspects of HCI research for older people. *Universal Access in the Information Society*, 5 (3): 279–286.

Zimmermann, G. & Vanderheiden, G. (2007). Accessible design and testing in the application development process: Considerations for an integrated approach. *Universal Access in the Information Society*, 7 (1-2): 117–128. doi: 10.1007/s10209-007-0108-6.

PART III
APPENDIX

Annex A. Projects, financial support and participants

Some of the project participants helped in recruiting participants to user-centred activities, such as focus groups and user evaluations. These are marked with a star (*). However, in some of the projects, we had help from NGOs that were not formally project participants. These organisations are marked with two stars (**).

Project	Financial support[26]	Project participants
ICT – working life	The IT-FUNK programme in the Research Council of Norway.	- Norsk Regnesentral - Compello Software AS - Apropos Internett AS - Gilde Vest BA (*) - Oslo Airport (*)
Diadem	The European Union's 6th Framework programme for research and technological development.	- Brunel University (UK) - Norsk Regnesentral (NO) - Karde AS (NO), - More AS (NO) - Bluegarden AS (NO) - CSI-Piemonte (IT) - Sheffield City Council (UK) - Turin Municipality (IT) - Seniornett (**) - Sunnaas Rehabilitation Hospital (**)
ICT barriers of the visually impaired	The IT-FUNK programme in the Research Council of Norway, Fornyings- og administrasjonsdepartementet (FAD), Dokumentasjonssenteret and Deltasenteret.	- Norsk Regnesentral - NABP[27] (*)
Unimod	The VERDIKT programme in the Research Council of Norway.	- Norsk Regnesentral - Karde AS - More AS - Brønnøysundregistrene - Åstvedt AS (*) - TellU AS - Norkart AS

[26] Project participants have also contributed with unpaid efforts.

[27] NABP: Norwegian Association for the Blind and Partially Sighted.

uu-Authentication	The IT-FUNK programme in the Research Council of Norway.	- Norsk Regnesentral - Karde AS - Tellu AS - Encap AS - Brønnøysund Register Centre - Storebrand AS - DIFI - NABP (*) - Dyslexia Norway (*)
e-Vote	The Norwegian Ministry of Local Government and Regional Development (KRD).	- Norsk Regnesentral - Several NGOs (**)
e-Me	The VERDIKT programme in the Research Council of Norway.	- Norsk Regnesentral - Karde AS - Tellu AS - Encap AS - Brønnøysund Register Centre - Storebrand AS - DIFI[28] - NABP[29] (*) - Dyslexia Norway (*) - Seniornett (**)

[28] Norwegian Directorate for Administration and ICT.

[29] The Norwegian Association of the Blind and Partially Sighted.

Annex B. The seven principles of universal design

An interdisciplinary group at the Center for Universal Design at North Carolina State University developed seven principles of universal design (CUD 1997). These principles are generic, and are adopted within a wide range of design disciplines, from architecture and product design to the design of ICT products and services.

The principles are copied from the Center for Universal Design (CUD 1997). They are presented in the following format: name of the principle, intended to be a concise and easily remembered statement of the key concept embodied in the principle; definition of the principle, a brief description of the principle's primary directive for design; and guidelines, a list of the key elements that should be present in a design that adheres to the principle. (Note: Not all guidelines may be relevant to all designs.)

PRINCIPLE ONE: Equitable Use
The design is useful and marketable to people with diverse abilities.

Guidelines:

- **1a.** Provide the same means of use for all users: identical whenever possible; equivalent when not.
- **1b.** Avoid segregating or stigmatizing any users.
- **1c.** Provisions for privacy, security, and safety should be equally available to all users.
- **1d.** Make the design appealing to all users.

PRINCIPLE TWO: Flexibility in Use
The design accommodates a wide range of individual preferences and abilities.

Guidelines:

- **2a.** Provide choice in methods of use.
- **2b**. Accommodate right- or left-handed access and use.
- **2c.** Facilitate the user's accuracy and precision.
- **2d.** Provide adaptability to the user's pace.

PRINCIPLE THREE: Simple and Intuitive Use
Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

Guidelines:

- **3a.** Eliminate unnecessary complexity.
- **3b.** Be consistent with user expectations and intuition.
- **3c.** Accommodate a wide range of literacy and language skills.
- **3d.** Arrange information consistent with its importance.
- **3e.** Provide effective prompting and feedback during and after task completion.

PRINCIPLE FOUR: Perceptible Information
The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

Guidelines:

4a. Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information.
4b. Provide adequate contrast between essential information and its surroundings.
4c. Maximize "legibility" of essential information.
4d. Differentiate elements in ways that can be described (i.e., make it easy to give instructions or directions).
4e. Provide compatibility with a variety of techniques or devices used by people with sensory limitations.

PRINCIPLE FIVE: Tolerance for Error
The design minimizes hazards and the adverse consequences of accidental or unintended actions.

Guidelines:

5a. Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded.
5b. Provide warnings of hazards and errors.
5c. Provide fail safe features.
5d. Discourage unconscious action in tasks that require vigilance.

PRINCIPLE SIX: Low Physical Effort
The design can be used efficiently and comfortably and with a minimum of fatigue.

Guidelines:

6a. Allow user to maintain a neutral body position.
6b. Use reasonable operating forces.
6c. Minimize repetitive actions.
6d. Minimize sustained physical effort.

PRINCIPLE SEVEN: Size and Space for Approach and Use
Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

Guidelines:

7a. Provide a clear line of sight to important elements for any seated or standing user.
7b. Make reach to all components comfortable for any seated or standing user.
7c. Accommodate variations in hand and grip size.
7d. Provide adequate space for the use of assistive devices or personal assistance.

Please note that the Principles of Universal Design address only universally usable design, while the practice of design involves more than consideration for usability. Designers must also incorporate other considerations such as economic, engineering, cultural, gender, and environmental concerns in their design processes. These Principles offer designers guidance to better integrate features that meet the needs of as many users as possible.