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Card-based Method Cards for Universal Design

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Universal design (UD) is a legal requirement of any Norwegian ICT-solution aimed at the general public. Due to the fact that the field of accessibility is becoming more usability-focused, thus affecting disciplines such as Interaction design, it is necessary to learn more about how strategies to ensure universal design can be implemented by interaction designers using tools to support their work. This reserarch seeks to identify strategies that can be used to ensure UD in ICT projects and translate them into tools to aid in design processes. A selection of card-based design tools and their dimensions are explored in this work, to appropriately incorporate them into a fitting context of use. The research explores the perceived usefulness of method cards based on empirical data. Findings suggest that method cards require a a high level of detail for implementation as well as context-rich empirical data.

1. Introduction

Throughout their life course, most people will eventually experience some sort of mental or physical condition that limit their capacity to perform certain tasks. Disability is spreading due to the aging population, and chronic health conditions. As of 2015 fifteen percent of the world's population live with a form of disability (WHO, 2011). As public and private ICT-solutions are becoming prevalent in our daily lives, the consequences of being excluded if affected by a disability is great. It is thus important that we understand how to successfully avoid digital barriers that can prevent the effective use of digitalized systems. Universal design (UD) strives to make products, services and surroundings as accessible as possible, for as many as possible, and remove or lessen barriers that can prevent the effective use of a design that support user activities (DIFI, 2017). With this increasing awareness, providers of systems and services based on ICT (Information and Communications Technology) attempt to broaden their target audience, and as such minimize the need for costly specialized services.

In Norway, UD is a legal requirement of any publicly available ICT-solutions aimed at public use (BLD, 2013) and is regulated in an expanding range of domains – from education to aviation services aimed at public consumption. The requirements intend to ensure a minimum of accommodation to marginalized user group's needs, through a focus on accessibility standards that prevent technical barriers. This includes among other end-users with both physical and mental disabilities, as well as reading- or writing deficiencies and non-native speakers. The Agency for Public Management and eGovernment (DIFI) is responsible for ensuring that solutions conform to the legislation and legal standard, and initiates reviews and supervisions as well as training and guidance to the different sectors (DIFI, 2017). As a minimum criterion for UD fulfillment, a set of WCAG (W3C, 2008) 2.0 requirements must be met (DIFI, 2018). However, there is a growing consensus that adherence to such technical guidelines and requirements is not enough to make a solution as usable and accessible as possible (Røssvoll & Fuglerud, 2013). There is a call for viewing UD as a long-term commitment and design strategy, requiring end-user insights beyond the WCAG requirements (Gonzalez et. al., 2013; Scandurra, Holgersson, Lind & Myreteg, 2013).

Legislation affects ICT-projects to an increasing degree, as lawmakers are continuously increasing the scope of the UD regulations to which ICT-solutions need to conform (Universell, 2017). For ICT-providers it can be costly to retroactively design and fix issues to make an ICT-solution conform to accessibility standards (Røssvoll and Fuglerud, 2013). There are indications pointing to the importance of anchoring the process in UD values and focus from the very start have very positive outcomes for UD success (Hjartnes & Begnum, 2018; Begnum & Harder, 2016), while stakeholders are failing to recognize UD values do not allocate sufficient resources to ensure UD. Developing practices that allow early and continuous focus on UD embedded in the process is as such believed to be cost-effective. Knowledge about how to best proceed is thus needed, and the research community in the field of UD and ICT is currently making efforts in this direction.

Several researchers have called for models (Reichling and Cherfli, 2013; Bonacin, Baranauskas & Rodrigues, 2009) and tools (Lucke and Castro, 2016; Røssvoll and Fuglerud, 2013) to improve inclusive development processes, and as such bridge the gap between research and industry practice. Though there are tools to evaluate the conformance to WCAG guidelines as well as overall design approach methodologies, few tools exist that facilitate knowledge about what is required to succeed in a UD design process. Drawing on current research (Harder and Begnum, 2016; Begnum, Harder & Hjartnes 2018; Hjartnes & Begnum, 2018), it is considered paramount to learn more about how to increase the understanding of UD in project teams early on, and to facilitate cross disciplinary and cross-role team communication. Informant feedback also indicates the desire for increased detail, for example checklists or phase-wise project management tools and detail-oriented tools related to the specific project roles and tasks (Begnum, Harder and Hjartnes, 2018). .

This thesis focuses on new ways to utilize empirical data gathered by Begnum, Harder and Hjartnes (2018) to create tools supporting UD in ICT-development, focusing on the field of Interaction Design (IxD). The overall aim of the thesis is to spread knowledge about best practice for UD of ICT. Specifically, the thesis provides methodological contributions to UD in IxD, through exploring what type of tools may provide a useful means of communicating and supporting UD in IxD work. As such, the goal of the thesis is *to contribute to the envisionment and design of tools that can aid current and future IxD practice in order to promote and support UD in ICT development.* The following research questions are formulated:

1. What strategies have informants on ICT projects with UD success applied, or recommend others to apply, in order to ensure UD?
2. How can these strategies be translated into practice-related UD in IxD tools?
3. How useful do interaction designers perceive these tools to be with regards to supporting UD in IxD work?

The thesis is structured as follows: Section 1 introduces the research focus, Section 2 presents related research and Section 3 outlines the methodological approach. In Section 4 the results are presented, while Section 5 and 6 discuss findings, summarize and conclude. The audience for this thesis is mainly educators and practitioners within the field of IxD and related disciplines, though its contribution may benefit not only its audience, but also end-users and project owners.

2. Background

The research topic of UD of ICT is interdisciplinary and broad, ranging from the individual disciplines cooperating to create ICT-solutions, to aspects such as organizational and contextual factors, software engineering and design approaches. The focus of this thesis is on IxD and UD in ICT-project contexts. This section starts with defining IxD as a user-centered discipline within the larger field of User eXperience (UX), then moves to discuss UD in the context of ICT. Next, I briefly cover the currently very popular agile software development approach and current research recommendation for securing UD of ICT, in order to provide a background for the context in which practice-related work is likely to take place. Finally, I describe existing tools for supporting IxD work.

2.1 Interaction Design

Interaction design (IxD) is a discipline that aims to develop products that are usable. Preece et. al. (2015: p. 2) states that the IxD aim is "to reduce the negative aspects of the user experience while enhancing the positive ones. In essence, IxD is about developing interactive products that are easy, effective, and pleasurable to use – from the users' perspective. Interaction design is a term that describes a set of methods for design, and frameworks that ensure good user experiences. It is therefore considered an umbrella term of all parts of development of interactive products that are concerned with the user perspective (Preece et. al. 2015).

Currently, IxD is considered a part of the User eXperience (UX) field which is comprised of disciplines from diverse fields from which it draws practices and knowledge (Baxter, Courage and Caine, 2015). The User Experience Professionals Association defines UX as "Every aspect of the user's interaction with a product, service, or company that make up the user's perceptions of the whole. User experience design as a discipline is concerned with all the elements that together make up that interface, including layout, visual design, text, brand, sound, and interaction. UE works to coordinate these elements to allow for the best possible interaction by users. "(UXPA, 2010).

Most consider IxD grew out of Human Computer Interaction (HCI). HCI draws on fields such as psychology, computer science, human factors, and sociology, and has adopted empirical and methodological research methods from these fields (Lazar, Feng and Hochheiser, 2017). HCI focuses on the user's abilities and perception of systems that are developed rather than the actual design processes. An article on the changes of HCI research published from the years 1994-2014 (Liu et. al., 2014) finds that in that field user studies are increasingly prevalent, as are focuses on accessibility and context of use for interfaces. IxD is viewed as continuing the research traditions and legacy from HCI, but also drawing on design disciples, thus encompassing research traditions such as "research by design", "reflective practice" and "design research".

2.1.1 User-Centered Design

User-Centered Design (UCD) is a methodology for ensuring usable solutions, focusing on human factors and usability in the design of interactive systems (ISO 9241-11 in Standard Norge, 2011). UCD is a very common approach in IxD and related UX disciplines. Another term for UCD is HCD - Human-Centred Design. UCD is based on three principles as defined by Gould & Lewis (in Baxter, 2015): 1) "An early focus on users and tasks", which is typically ensured through researching users, their needs, task and context of use, 2) "Empirical measurement of product usage", which typically means testing the solution with users, and 3) "Iterative design", which typically means to go back and revise design based on user feedback. As illustrated by the typical activities, users are usually involved throughout a UCD process. However, the degree of user involvement and direct user contact may vary between projects, both overall and within phases.

HCD is similarly defined in the ISO 9241-210:2010 standard (Standard Norge, 2011), which divides the activities of the UCD process into four different phases: understanding use of context, specification of user requirements, design solutions and evaluation of designs. Phase 1 focus on understanding and defining context of use entails taking into consideration the characteristics of users and their activities, as well as their goals and their current and future contexts or environment in which they undertake activities. In Phase 2 user requirements are specified based on insights from Phase 1, and goals for the system. In Phase 3 design solutions are produced to solve user requirements in their intended contexts of use. User interface and user interactions for the system are taken into account and specified. The focus is on the system will solve user tasks and goals through a clear understanding of users. Rather than visual aspects of the system solutions are produced with specification of information architecture, interactions and concrete design. Finally, Phase 4 evaluates designs with feedback from users and by measurement of a solution's conformity to user requirements. As one iterates between the four phases until the final solution is completed, design evaluations happen throughout the process.

Different IxD (and UX) methods and techniques are often recommended based on these phases. However, the conceptual phases of design should not necessarily be distinguished from the later phases, as it will then move away from the ideas that are underlying the design. Creativity and practical activities are often tied together in the design process and fueled by inspiration and imagination. This entails having an open mind to broaden up the conceptual process, and step outside pre-conceived boundaries to explore ideation terrain. This "crafting" skill used to produce a desired design solution is considered an underappreciated part of conceptual phases of design. The Design Thinking movement is focused on this skill; teaching designers to explicitly "open" ideation and conceptualization, asking critical questions and thinking "outside the box", prior to "closing" with idea selection and concretization of design. As the design process continues, it is important that the evolving design keeps its basic concepts as it moves into organizational terrain, switch hands and is refined or changed along the way. In an ideal situation, the designer would follow the design from conception till later phases (Nelson and Stolterman, 2012).

2.2 Universal Design

Norwegian legislation defines UD as the "design or preparation of the main solution in the physical environment including Information- and communications technology (ICT) so that the common functions of the enterprise can be used by as many as possible, regardless of functional impairment" (BLD, 2017: § 17). The legislation was enacted July 2014 for new ICT-solutions, explicitly adding the educational sector from 2018 (Difi, 2017). All ICT-solutions targeted to the general public, including legacy systems and private services, are required to be universally designed from 2021. The Agency for Public Management and eGovernment (DIFI) currently reviews conformance to the legislation. As technology is evolving rapidly they are actively reviewing the relevance and possibilities of other standards to be implemented (BLD, 2016). To achieve the legislated goal, more research is called for to "… clarify issues linked to such things as the understanding of UD, development of technical and practical solutions…" (BLD, 2009).

First, what UD of ICT entails must be defined. In interactive systems design, accessibility is defined as: "usability of a product, service, environment or facility by people with the widest range of capabilities" (ISO 9241-171 in Standard Norge, 2011). As such, some use the terms "accessibility" and UD interchangeably, However, many UD researchers and professionals now make the distinction between "technical" and "usable" accessibility; stating both must be present in order to achieve UD (Røssvoll & Fuglerud, 2013). Technical accessibility entails adherence to formalized guidelines that increase accessibility of content. The current legislation is based on WCAG 2.0 guidelines for web-based systems (including most mobile applications). As such, the current legislation is only regulating technical accessibility.

WCAG 2.0 are a set of functional guidelines meant to increase accessibility of web content. Through following the WCAG recommendations for coding and development, the content of ICT-solutions are made more accessible for people with a wider range of needs and abilities. WCAG specifically focus on reducing "digital barriers" for users with visual impairments, hearing impairments, cognitive- and learning disabilities, motor-impairments, speech impairments, light sensitivity and any combination of these (W3C, 2008; Difi, 2015). They also ensure appropriate levels of flickering for users with epilepsy, and make sure solutions are compatible with updated assistive technologies. WCAG 2.0 are measurable and follow standards (W3C, 2017). With the introduction of WCAG 2.1 add a set of proposed guidelines that are less technical, focusing on accessible language and formulations, thus increasing accessibility to users at a lower secondary education level (W3C, 2018).

Usable accessibility is not as easily measured. Technical accessibility is often used summatively, while usable accessibility usually entails taking a user-centered approach through user-involvement, and user-goal-oriented design and testing. There are no regulations today targeting e.g. documenting an early and continuous focus on marginalized user needs. Early and continuous user testing, with both non-disabled and disabled users, is a recommend cost-effective approach to ensuring UD and broad usability (Reichling & Cherfi, 2013; Harder & Begnum, 2016). Rømen and Svanes (2011) found that solutions need to be tested with actual users and follow a user-centered approach to solve *all* usability issues, while adhering to WCAG standards were found to solve half of all usability issues. For usable accessibility, automated tools are not sufficient or replaceable of user or expert testing (Lazar, Feng & Hochheiser, 2017).

Universal design should as such also be considered to include both technical accessibility expressed in functional requirements and usable accessibility reflecting non-functional requirement. W3C's guidelines reflect this by the planned inclusion of a new set of guidelines WCAG 3.0 also called "silver" which are user-centered and research-focused accessibility guidelines (W3C, 2017). This focus is aided by the use of frameworks or models for ensuring UD (Reichling & Cherfi, 2013).

2.3 Agile Development

Development processes that focus on efficient work and quickly creating working solutions, and stress iterative development, feedback loops, collaboration and face-to-face communication to reduce wasting resources on overhead activities and documentation, can be considered "agile" (Preece et. al., 2015). Popular agile process models include Scrum and Extreme Programming (XP). Solutions are typically developed and tested in increments or iterations of partial deliveries developed in one to four week sprints (Scrum Alliance, 2013). Agile development is common in Norwegian ICT-projects, and its iterative nature allows for continuous requirement elicitation, software delivery and improvement. This development approach is reliant on self-sufficient development teams, which in modern ICT-projects requires cross-disciplinary collaboration. In addition, collaborations between team, management (facilitator), owner (customer), and end-users are needed in order to make sure the right system is delivered.

Efforts to merge UCD with agile processes have been researched. Common practices include having designers as part of the agile product team, but not necessarily as a full-time team member. Usually interaction designers conduct user research or design ahead of sprints or parallel with development to effectivize the process. The Nielsen Norman Group found the most effective practice to be to allow design and development to run as two separate tracks (Preece et. al., 2015).

Thorkildsen and Begnum (2016) conducted a literature study to identify patterns in agile user-centered projects (Agile UCD) compared with non-agile user-centered projects. Agile UCD projects utilize methods with low-user involvement for understanding user needs and tasks compared to its

counterpart. Pre-development and planning is also treated as a phase for expert work rather than user research. The study also found that issues with collaboration between developers and designers may affect projects negatively, proving that the principles of agile development are important throughout all of the organization.

2.4 Best Practice for Ensuring UD of ICT

Several efforts have been made to provide valuable insights to practices that are useful and necessary to succeed with UD of ICT. Research indicates that many of the methods used in the UD of ICT solutions support a qualitative approach that aligns with UCD principles (Begnum, 2016). There is an overall recommendation of using a combination of user-centered methods and processes, and expanding this with specific requirements to account for the varied needs and abilities of users. There are indications that UD and UX work are overlapping, and that UD could be viewed as "usability for all" (Begnum, 2016). UCD includes methods that put the needs of the user and their environment at the forefront of development. Understanding these aspects helps us design better solutions for users with disabilities. This is congruent with UD which seeks to reduce the difficulty users with disabilities have with using designs and solutions. Further, it is important that the team as a whole is positive to UD, in order to facilitate collaboration. Also, management must provide the resources necessary to do UD (and UX) work (Harder & Begnum, 2016).

In addition, early and frequent quality assurance through internal expert inspections, code validation and user testing, constructive and frequent communication across disciplines is important for the successful implementation of UD – both technical and usable aspects. Researchers have found it useful to support UD through the development of reusable artifacts as a way to structure the process (Lucke & Castro, 2016) and in order to collaborate with stakeholders and find a common language in design (Guerrero-Garcia, Gonzalez-Calleros & Gonzalez 2017). In order to get a common understanding, Hjartnes and Begnum (2018, see Appendix A) indicate it can be helpful for developers and team members to experience user testing, and to use user stories, storyboards, personas or other visualizations to share documentation and information within the team. As it is difficult to directly implement best-practice recommendations to individual projects it is recommended that they are best adapted with consideration to the specific context.

Røssvoll and Fuglerud (2013) provide a pragmatic literature review on the topic. They recommend heavy user involvement in both evaluation and design, including users who have disabilities. Begnum, Harder and Hjartnes (2018, see Appendix B) and Harder and Begnum (2016) identify a set of promoting and obstructing factors for UD in ICT-projects. These are found in four different levels: societal, organizational, processual and personal, pointing to both external and contextual factors and internal project and team factors. The 15 most frequently occurring factors are identified as Critical Success Criteria, and are:

1. Legislation, as the most important external factor
2. UD Anhoring (organizational awareness; internalized UD culture)
3. UD Priority & Focus (organizational vision; internalized UD culture)
4. UD Requirements in Requirements Specification
5. Time & Budget Resources
6. Equipment & Human Resources
7. UD Competence development
8. Design for All (DfA) mindset
9. UD Motivation & Interest
10. Enthusiasm for UD (positive attitudes)
11. UX & UD Needs Integration
12. Continuous UX &UD work (not just early and late focus)
13. Cross-disciplinary Collaboration

14. Internal UD Evaluation (including code validation)
15. Internal User Testing (including UD testing)

There is still not much research on how to integrate UD in agile settings. A scoping review by Hjartnes and Begnum (2018) provides a few recommendations for UD with regards to activities, workflow, frameworks and user-involvement in agile development of ICT-projects. No process recommendation for integrating UD into agile development was identified, and as such there is a call for more research on Agile Universal Design (AUD) process models; e.g. based on the parallel models suggested for UCD/agile integration. The Hjartnes and Begnum (2018) findings outline a model where practices that promote successful UD rely on a user-centered process, with user involvement in design and analysis, re-use of prototypes, and expert testing prior to testing with users with disabilities - much like previous research on UD of ICT suggests. However, the findings point to the need to better tailor specific UD and UCD methods to not disrupt the fast-paced agile development; prompting research focus on how to more efficiently employ user centered techniques to suit the agile model (Hjartnes & Begnum, 2018).

2.5 Tools Supporting IxD Work

Design artifacts and tools are commonly used in IxD as a way to generate requirements, design for a specific context and ease cognitive load by providing methodological representations (Wölfel & Meritt, 2013). When a situation is unsatisfactory or uncertain, the designer seeks to transform the situation by forming and exploring hypotheses. This process is iterative and continues as long as there is a need to further transform the situation after actions have been taken (Dalsgaard 2017). This process is known as inquiry, and it is commonly explores design problems to be solved. Dalsgaard defines designerly inquiry as *"An explorative and transformative process through which designers draw upon their repertoire of knowledge and competences as well as resources in the situation, including instruments, in order to create something novel and appropriate that changes an incoherent or undesirable situation for the better"* (2017: 24).

The transformation of the situation can be further elaborated as a process of "reflection-in-action", where the implementation of action causes the situation to talk back (Schön & Bennet, 1996). As changes in one aspect of the situation may affect another, the process of design is therefore an ongoing relationship between designers and the situations they are trying to improve. Designers are reliant on finding design opportunities and transforming their understanding of the domain they are designing for. In this context Dalsgaard (2017) describes design tools as *instruments of inquiry that aid in augmentation of the designers cognitive ability*.

Designers ability to innovate in relies on their knowledge within the domain which they are experienced in, it is therefore important that designers acquire the skills necessary to understand how to specify design in their respective fields in order to mitigate negative effects of inexperience or lack of awareness (Nelson & Stolterman, 2012). Repository tools can aid in this respect; describing techniques for e.g. inquiry as a methodology carrying tool. In the process of design inquiry it is also necessary for designers to be open to new ideas and possibilities. Augmentation can help in this regard.

Ideation tools can allow for easy perception of available technology and creative patterns that designers can use and apply (Yoon, Desmet & Pohlmeyer, 2016). They provide an externalization of frameworks and theory, seeking to provide actionables and inspire creativity (Bornoe, Bruun & Stage, 2016). A set of proven solutions that solve problems for specific contexts may also be considered design tools given the proper references, e.g. as customizable techniques, patterns or technology. Patterns have potential in providing inexperienced practitioners with the tools they need to solve a problem within a domain (Alves & Roque, 2010). On the other hand, tools may also limit

cognitive abilities through a diminished perception to those unfamiliar with all the tools (Dalsgaard, 2017). Tool effectiveness thus depends in large part on the experience of those that use them, and on how well adapt to and stimulate design problem solving (Bornoe, Bruun & Stage, 2016; Yoon, Desmet & Pohlmeyer, 2016). Below I present two quite different types of tools; project evaluation assessment tools and card-based design tools.

2.5.1 Project Evaluation Assessment Tools

A first attempt to utilize gathered empirical data from ICT-projects that have successfully implemented UD was done utilizing the PEVS strategy (Andersen, Dyrhaug & Jessen, 2002) to develop a project assessment tool. The Critical Success Criteria identified are used as a measurement on best practice for UD of ICT, as they are factors that impact or determine the success of a given process or project. As such, they are as useful to diagnose and manage in order to avoid potential problems (Andersen, Dyrhaug & Jessen, 2002; Begnum, Harder & Hjartnes 2018). Begnum, Harder and Hjartnes (2018) named this assessment tool UD3C; an acronym for Universal Design Critical Criteria Compliance. Figure 1 presents the tool.

Begnum and Harder prototyped the first UDC3 version in 2017, attempting to predict a resulting UD quality ahead of time based on measurable key project factors. The tool relies on self-assessment and can be utilized both and priori to or during projects. Initial testing of the UDC3 tool on real-life projects by practitioners in the field reveal that the UDC3 tool provides an accurate representation of CSC compliance for UD projects. and can predict whether or not a project will succeed. We know of no existing ICT-project tools supporting processual UD knowledge, apart from the prototyped UDC3 self-assessment tool. However, Reichling and Cherfi (2013) propose a model where individual projects define goals that are measured through specific metrics and operations. They dictate that such models should be used early and continuously throughout the design process to evaluate adherence to accessibility goals for a given project. Thus it provides practitioners a custom project evaluation tool to follow and integrate into existing processes.

Different informants view the UD3C usefulness somewhat differently (Harder & Begnum, 2017; Begnum, Harder & Hjartnes, 2018). Explicit insights suggest UD3C is very useful in certain contexts, such as a communication tool in planning and early phases with stakeholders and management in order to allocate resources and implement strategies to ensure UD (Begnum, Harder & Hjartnes, 2018). Specifically, informants that worked in a consultancy agency where projects are deliveries to external clients, felt the tool could more clearly communicate what UD entails and make visible lacking activities in a project to ensure UD. The tool seems more relevant for high-level issues relevant to project managers and organizational stakeholders, while developers, designers and project managers ask for additional and more detailed tools to support in-practice work. Suggested tools include project management software integration and checklist-based tools to manage WCAG standards during the project process. Several practitioners indicate they use self-made tailored excel sheets today in order to simplify regulations and in-house standards.

UD3C EVALUATION - UNIVERSAL DESIGN CRITICAL CRITERIA COMPLIANCE

Step 1. Indicate if your project fulfills the UD critical success factors on the scale:	**Disagree**		**Agree**
1. There is a common understanding of UD in the project team and at all management levels (including any customer), and achieving UD is supported and viewed as positive.	**0**	**1**	**2**
2. The team has at least one person enthusiastic about UD, having a personal interest and motivation for ensuring universal usability.	**0**	**1**	**2**
3. The team has all the resources needed to ensure UD criteria; adequate time, budget and human resources; including access to assistive technologies, users and external competence.	**0**	**1**	**2**
4. The team has relevant UD competence and experience, e.g. UD principles in coding, IxD, content & visual design. Focus is on making design accessible and usable for everyone.	**0**	**1**	**2**
5. UD perspectives are integrated into all project activites; design, coding, UX/UCD & needs.	**0**	**1**	**2**
6. UD aspects are early and continously evaluated throughout the project, both through expert inspections and through user testing and real-user feedback including persons with disabilities.	**0**	**1**	**2**
7. The team embraces cross-disciplinary collaboration, open discussions and dialogue.	**0**	**1**	**2**

Step 2. Recieve 1 bonus point for:

a) A strategy for developing the UD competence in a team or organization.	**0**	**1**
b) Requirement specification includes criteria for UD, ensuring early and continuous focus.	**0**	**1**
c) An iterative or flexible process model, utilizing feedback from UD evaluations.	**0**	**1**
d) Extending internal evaluations with external inspections adds to UD quality control.	**0**	**1**

Step 3. Summarize your total:_____ point(s)

0-5 points: Your project is not fulfilling critical success factors for universal design, and is likely to struggle to achieve universal design.
6-11 points: Your project mostly fulfills critical success factors for universal design, but is unlikely to win universal design awards.
12-18 points: Your project fulfills most or all critical success factors, and is expected to achieve excellent universal design quality!

Figure 1: UD3C - Self Assessment of Critical Success Criteria Compliance

As such, our impression is project evaluation tools are found to be most useful at the start of the project for process and resource planning, or underway while changes could still be made to improve the process. In order to support in-practice IxD activities, our impression based from UD3C informant feedback it is more instructive tools is needed, providing a higher level of detail.

2.5.2 Card-Based Design Tools

Tangible method cards often use keywords, pictures and questions to augment designers' cognitive ability. Method cards can be detailed, explicit and instructive, and can be used to guide implementation of methodology, facilitate user requirements elicitation and externalize knowledge about the design domain. Their usefulness lies in their ability to narrow focus on facets of design, mediate stakeholder communication and to create awareness (Bornoe, Bruun & Stage, 2016). They can support and promote certain design patterns to expand on personal preferences or experience, help alter focus through bringing new perspectives and ideas to a design problem (Halskov & Dalsgård, 2006) and their use may fit in different stages in a design process such as analysis, idea generation and evaluation (Lucero & Arrasvuori, 2010).

Wölfel and Meritt (2013) divide card-based design tools into a set of three archetypes: 1) Context-specific 2) Repository/general-purpose and 3) Customizable cards. Each category of method cards can be considered in terms of dimensions, which define: a) their time and place of intended use, b) their level of customization, instructions and c) their formal qualities, such as the structure and visual content of the cards. The next subsections present the three method cards archetypes.

2.5.2.1 Context-Specific Method Cards

Context-specific method cards are used for a specific activity and provides context for designing within a certain domain or supporting a given agenda. They are also known as domain-specific method cards. Context-specific cards are often provided along with instructions on how to implement them (Wölfel & Meritt, 2013). One example of such specific activity is specification of user requirements, where several context-specific method cards are available. An example are the PLEX cards (Lucero & Arrasvuori, 2010) which aims to inspire designers to incorporate playfulness into the requirements elicitation. All stakeholders play using the PLEX cards in order to define solutions and specify requirements. Another example is creativity trigger cards, which focus requirements elicitation for innovative solutions (Burnay & Horkoff, 2016). Creativity trigger cards are designed for stakeholders to subjectively interpret ambiguous not-obvious qualities and apply them to a specific problem, in order to attempt to trigger stakeholders to take a different perspective to a problem.

Ambiguity is often present in context-specific order to allow for adaptability to many problems. Due to this fact, researchers find it necessary to limit use of cards in brainstorming to two or three at a given time (Burnay & Horkoff, 2016; Lucero & Arrasvuori, 2010). Context-specific method cards with higher level of abstraction can add a higher level of complexity to the design process without clear instruction of use. If they are unambiguous or too obvious they can work against their purpose of providing new perspectives to a design problem (Bornoe, Bruun & Stage, 2016). Context-specific method cards often rely on keywords and images to convey meaning.

2.5.2.2 Customizable Method Cards

Cards where designers are able to alter their contents, consider them in different formats or create their own, are defined as customizable (Wölfel & Meritt, 2013). They also often come with instructions on how-to be used, including at what specific point in the process they are to be used (if any). Customizable method cards typically promote empathy and communication, or the inclusion of and collaboration with stakeholders and users. A potential downside to the use of customizable cards is that it is time consuming to customize the cards, and without a domain expert the results of the customization process can be limited. The cards themselves may be self-evident, and provide only common sense (Bornoe, Bruun & Stage, 2016).

An example of a customizable method cards is the Inspiration Cards Workshop; a method designed to help create an understanding of a problem domain, and then generating appropriate ideas (Halskov & Dalsgård, 2006). The Inspiration Cards Workshop is to be used after initial field studies and user research. The specific method Cards to be used in the workshop is selected, tailored or created by designers, in order to convey information about the domain such as tropes, contextual information and users as well as interesting technologies. The cards can be reused or made for specific projects. In the workshops, method cards are combined to generate ideas.

2.5.2.3 Repository Method Card

Repository cards are more general-purpose and contain either a description of design methods or is designed as an open-ended inspiration to augment cognitive abilities. Repository method cards may contain information about expected outcomes, such as guidelines, pictures, method categories, templates and design examples (Wölfel & Meritt, 2013). Repository method cards are usually divided into categories, for example based on HCD phases. They have little or no usage instructions or ability to be customized. These cards are less useful for generating and eliciting requirements; rather they are useful as technique reminders and for storing ideas (Bornoe, Bruun & Stage, 2016).

Examples of repository method cards are the InnoMed inclusive service design method cards (InnoMed, 2018). This is a repository of 20 methods used within service design and UCD, focused

on providing a comprehensive “service design methodology”, where common service design and UCD methods are adapted by InnoMed. and sorted into categories reflecting a traditional design process. Some cards are used to gather, understand, and communicate user needs, while others are used to develop and test designs (InnoMed, 2018). Another example are IDEO Method Cards (IDEO, 2003), which have similar features to the InnoMed cards, but focus more on capturing user needs. IDEO have altered common user-centered methods to be used anywhere in the process without providing a specific methodology, and these are presented as repository method cards.

3. Research Approach

The overall research approach used in the thesis is exploratory and qualitative in nature. The three research questions formulated are open-ended, where the latter builds on the former questions. Using an exploratory and open approach, I first gain deeper insights to the strategies suggested from success projects, before forming and testing specific tool- and design assumptions to answer these open-ended questions (Leedy & Ormrod, 2015).

Further, the study has some phenomenological traits as it relies on gathering insights from informant perspectives on how implementation of UD practices through method-based tools is perceived and experienced (Leedy & Ormrod, 2014). It is likely that the type of users informing the research affect which strategies that are translated into actionable tools, and how users interpret and envision the implementation of tools affect how the tools are designed. The aim of the thesis is as such not to produce generalizable results, but rather to identify strategies for practice-related UD work based on empirical data in order to prototype tangible design tools. The thesis hopes to create tools that support, or have the potential to support, UD work for interaction designers. In addition, the research expects to identify potential problems and verify how valid the approach of translation strategies into method-based tools is.

With qualitative research methods I expect to gain insight to the unique contexts that affect implementation of practices to secure UD, in order to form design decisions. I utilize three main research methods to answer the research questions posed; 1) thematic content analysis of interview data to determine strategies, 2) empirically based prototyping to translate strategies to tools, and 3) user testing of the prototyped tools to further inform their design. These are detailed in the following sections 3.1, 3.2 and 3.3 respectively. Figure 4 in section 3.3 shows an overview of the research approach.

While the practical use of tools may be expressed more hands-on, the implementation and lasting usefulness requires they be adapted to the specific context, and thus contextual knowledge is required. Further it is important to understand how those affected by implementation respond to and perceive interventions to be used, and their impressions of a specific tool, through gathering explicit phenomenological knowledge. This research therefore seeks to identify a single type of design tool that emerges through the empirical data. Since the sample to be studied is local and limited, it may be harder to generate generalizable tools and practices to be used in bigger contexts, however the results should be sufficient to provide insights into when these tools are appropriate to use (Lazar, Feng & Hochheiser, 2017).

3.1 Thematic Content Analysis of Interview Data

Gathering insights through interviews can help identify relevant contexts and perceived usefulness of any tools with regards to the artifacts, actors and practices; here how they can support UD in the design process (Lazar, Feng & Hocheiser, 2017). At the start of the study, I was given access to 31 anonymized interview transcripts from designers, developers and managers on ICT-projects that have successfully achieved universally designed solutions. These transcripts were collected and used by Harder and Begnum (2016) and Begnum, Harder and Hjartnes (2018) to identify promoting and obstructive factors for UD of ICT, which should be considered Critical Success Criteria for UD of ICT and further explore their measurability and develop a project process supportive tool (UDC3, see section 2.5.1) To answer the first question «What strategies have informants on ICT projects with UD success applied, or recommend others to apply, in order to ensure UD?» these transcriptions are utilized.

Table 1 overviews the sample of informants. In the sampling process, “success” was defined as a project that received an honorable mention or award where UD was part of the criteria, as well as projects that were given honorable mention from a public organization or other reputable organization. Informants were sampled on the grounds that they worked directly or closely with UD in the successful ICT projects. The sample has varying UD experience, ranging from 1 to 7 years. Interaction design and developers are the disciplines mainly represented in the sample. Designers are represented from both state and private agencies, with an emphasis on the former. The 31 informants come from 21 different “success projects”.

The transcripts represent textual verbatim qualitative data, and the transcriptions were originally created and analyzed using audio-recordings for support. These audio recordings were not available to me, as they are personal identifiable data and as such should not be shared outside of their original context for which informed consent was given. The transcriptions also contain some information about body language where considered appropriate for interpreting the transcribed data.

Table 1: Informants from the Interview Transcriptions Used in this Thesis

No	Age	Gender	Title/Discipline	Company	Project
1	30-39	Female	Functional Designer	Consultant Agency #1	#5 #11
2	> 30	Female	Interaction Designer	Consultant Agency #1	#5 #11
3	40-49	Male	Interaction Designer	Consultant Agency #2	#4 #8 #9 #21
4	30-39	Male	Interaction Designer	Consultant Agency #3	#10
5	40-49	Female	Visual/Graphic Designer	Consultant Agency #2	#4 #8 #9
6	30-39	Male	Developer	Consultant Agency #4	#1 #12
7	50-59	Male	Developer	Consultant Agency #2	#4 #8 #9
8	> 30	Female	Developer	State Agency #1	#1
9	40-49	Male	(Web) Advisor	State Agency #2	#2
10	40-49	Male	Senior UD Advisor	State Agency #1	#1
11	30-39	Female	Developer	Private Agency #1	#3
12	40-49	Male	Developer	Private Agency #1	#3
13	30-39	Male	Interaction Designer	Private Agency #2	#6 #7
14	30-39	Male	Developer	Consultant Agency #8	#15
15	40-49	Female	Project manager	Consultant Agency #8	#15
16	40-49	Male	Creative Director	Consultant Agency #5	#16
17	30-39	Male	Interaction Designer	Consultant Agency #5	#16
18	30-39	Female	Interaction designer	Consultant Agency #4	#14*
19	30-39	Male	Creative Director	Consultant Agency #4	#20
20	30-39	Male	Developer	Consultant Agency #9	#6
21	30-39	Male	Developer	Consultant Agency #7	#2
22	40-49	Female	Interaction designer	State Agency #4	#8
23	40-49	Male	Communication advisor	State Agency #4	#8
24	> 30	Female	Developer	Consultant Agency #4	#14*
25	50-59	Female	Interaction designer	Consultant Agency #10	#13
26	50-59	Female	Interaction designer	Consultant Agency #10	#13
27	30-39	Male	Interaction designer	Consultant Agency #6	#17 #18
28	30-39	Female	Graphic/Interaction designer	State Agency #3	#20
29	30-39	Female	Interaction designer	Consultant agency #7	#19*
30	30-39	Female	Interaction designer	Consultant agency #7	#19*
31	30-39	Female	Project manager	Private Agency #3	#13

In order to answer the first research question of which strategies practitioners use to secure UD, a thematic content analysis was applied to the transcribed data. Though content analysis has been

undertaken by previous research on the same data (Harder, Begnum & Hjartnes, 2018; Harder & Begnum, 2017), it was deemed necessary to do a new analysis. Each interview transcript was read in full before coding, in order to obtain an overview of the data.

The original interviews were semi-structured, using a quite broad interview guide. Questions mainly concern UD practices of how informants carried out their work in their respective projects, as well as methodology and factors that promote or obstruct their work with UD. It also contains probes asked by the interviewers in order clarify respondents' responses to initial questions. My data analysis focuses on the answers to two of the original questions. First, a question is asked on the approach taken to ensure UD in the success projects. Second, a question on what informants would deem an ideal approach to ensure UD. These questions cover much of the same ground, and replies are overlapping. Thus, the transcribed answers to these two questions are analyzed as a consecutive text.

Based on the related research and early data analysis, some kind of method card approach to translate strategies into practice-related tools was deemed interesting. Prior research findings from the UDC3 tool prototyping process indicate the need for tools to address lower-level concepts and provide instructions in order to be helpful in discipline-specific practice (Begnum, Harder & Hjartnes, 2018). Since the aim of this thesis is to develop tools supporting UD in practical IxD work, method cards seem fitting to select as more in-practice and specific design tools.

While the UD strategies (viewed as high-level "themes") are largely emergent, an existing framework of code categories appropriate for this specific application is identified to support the coding process (Baxter, Courage & Caine, 2015). As such, the content analysis follows a directed approach in favor of purely emergent coding (Hsieh & Shannon, 2009), as the codes are based on the framework suggested by Alves and Roque (2010). They have identified a set of dimensions that is fitting for a method card type of tool. The dimensional "levels" includes title, context, problem, solution and example, and are separated into layers to be used in method cards, intended to provide inspiration or actionable patterns. These dimensions are common in all the three design-card archetypes, presented in section 2.5.2 (Wölfel & Meritt, 2013).

In the directed content analysis, *contexts*, *problems* and *solutions* are considered main themes. As strategies are defined by mapping of certain conditions or uncertainties to be solved through a set of actions, the focus of this analysis remain mostly on identifying problems and solutions (Freedman, 2013). Further, *statements*, *outcomes* and *causes* are considered secondary areas of focus, inspired by Lazar, Feng and Hochheiser (2017) recommendations on what to look for when coding textual qualitative data (p. 292). Codes are structured in a tabulated manner, using a structure allowing for a clear separation of content that is pertinent (main themes) and non-pertinent (secondary themes) and to support the goals of the analysis (Corbin & Strauss, in Bowen, 2009).

Next, a sort of nomenclature set of categories is created to represent all the identified strategies. In this procedure it was important to not separate strategies that were duplicates or highly similar and thus bring together categories to a higher level of abstraction which would then be the emergent themes (Lazar, Feng & Hochheiser, 2017).

3.2 Empirically Based Tool Prototyping

Based on the empirical interview data, method cards are considered appropriate for translating strategies into in-practice tools. A systematic approach to answering the second research question is implemented in the prototyping of card-based tools. First, card dimensions from each different types of method cards are cross-examined against the identified UD strategies from the empirical data, in order to explore in what ways strategies can be converted into "method cards". This helps

provide insights into which type of method cards fit best with the data from the content analysis. Wölfel & Meritt (2013) recommends exploring at least one card set from each of the three archetypes presented in section 2.5.2 before creating a new set. In order to choose and translate appropriate UD strategies from the empirical data into method card sets, a selection of current method cards is reviewed.

Table 2: Method card sets reviewed

Method card	Type	No. of cards
IDEO	Repository	50
Innomed – Inclusive Service Method Cards	Repository	21
SUTD – Design Method Cards	Repository	33
Inspiration Cards	Customizable	4
Sound Design Deck	Context-specific	68
Design Play Cards	Context-specific	13
Plex Cards	Context-specific	22

Our selection samples 7 different types of method cards representing different qualities and characteristics. In total 211 cards were sampled, see Table 2. The selection includes cards from all the three archetypes. By analyzing the frequency of UD strategies that match up to identified content categories from each of the three card archetypes, we are able to say whether a tool is appropriate or not in terms of content validity (Leedy & Ormrod, 2015). Cards are printed, and their dimensions analyzed and interpreted, to understand contents of common qualities in the cards. Their contents are then compared to the identified UD strategies.

Name: Sound Decoys

Context: A customary component of the gameplay is to deal with enemies along the game space.

Problem: In some situations it is convenient to divert enemies' attention and possibly to influence them to change their positions, either to be able to deal with one at time or to avoid confrontation at all.

Solution: Diverse forms of decoy can be included in the gameplay. Sound is particularly suitable for integrating meaningful decoy actions since it allows launching the decoy whilst avoiding visual contact. It also brings advantages both for the plausibility of the decoy and for its usefulness in spaces with reduced visibility.

Examples: In Thief game series [22], Garrett can draw special noisemaker arrows in order to divert enemies. In Metal Gear Solid 4 [18], Snake can do something similar by throwing empty magazines and additionally he can knock on nearby objects in order to attract an enemy's to a more convenient spot. In Commandos B.C.D. [31] all commandos can make a distracting noise by throwing stones to behind of enemies. Additionally, one of the commandos, Tiny, has an acoustic decoy as part of his equipment.

Relations: The fact that only some objects or actions can be used with the purpose of exploring their sonic properties may turn to be improper if they reveal an incomprehensibly unequal treatment regarding other aspects that are evident candidates to the same behavior. In that sense this pattern relates to the pattern *Coherence* (a pattern to be specified, addressing the overall sense of coherence among adopted solutions).

Figure 3: Template by Alves and Roque (2010) with examples from Sound Design Deck.

Then, the tangible card-based tools are designed drawing on the emerging themes from the content analysis, using the method card design template from Alves and Roque (2010), see Figure 3 Visuals represent the card meaning and aid participants grasp the meaning of the card and increase the rate of implementation (Burnay & Horkoff, 2016; Yoon, Desmet & Pohlmeyer, 2016). Flickr is searched for non-copyrighted images licensed under creative commons for this purpose, with terms relating to the strategy or title of the cards used as search terms in Flickr.

3.3 User Testing on Prototyped Tools

Upon completion of card-based tool designs, potential users test the prototypes to assess their perceived usefulness. Formative evaluations are used to evaluate method cards as early as possible, aimed at improving insights into what types of tools have a sufficient presence of familiarity and may aid IxD practitioners to considering UD aspects in their work. Formative evaluation is a form of usability evaluation utilized to explore early mock-ups, sketches and prototypes to influence the direction of the design (Baxter, Courage & Caine, 2015). As categories of usability principles can be operationalized in different manners that guide the evaluation (Benyon, 2014), it is important to define which design principles you want tested in the evaluation of early prototypes. Initial user testing is somewhat focused on gathering feedback on method cards categories from the nomenclature and identifying tool opportunities. Feedback on specific tool prototypes is aimed at helping determine whether the intended metric of measurement of the thesis' third research question is reached; whether the envisioned tools are perceived as useful to support UD in IxD work. Figure 4 shows how the research approach takes feedback into account.

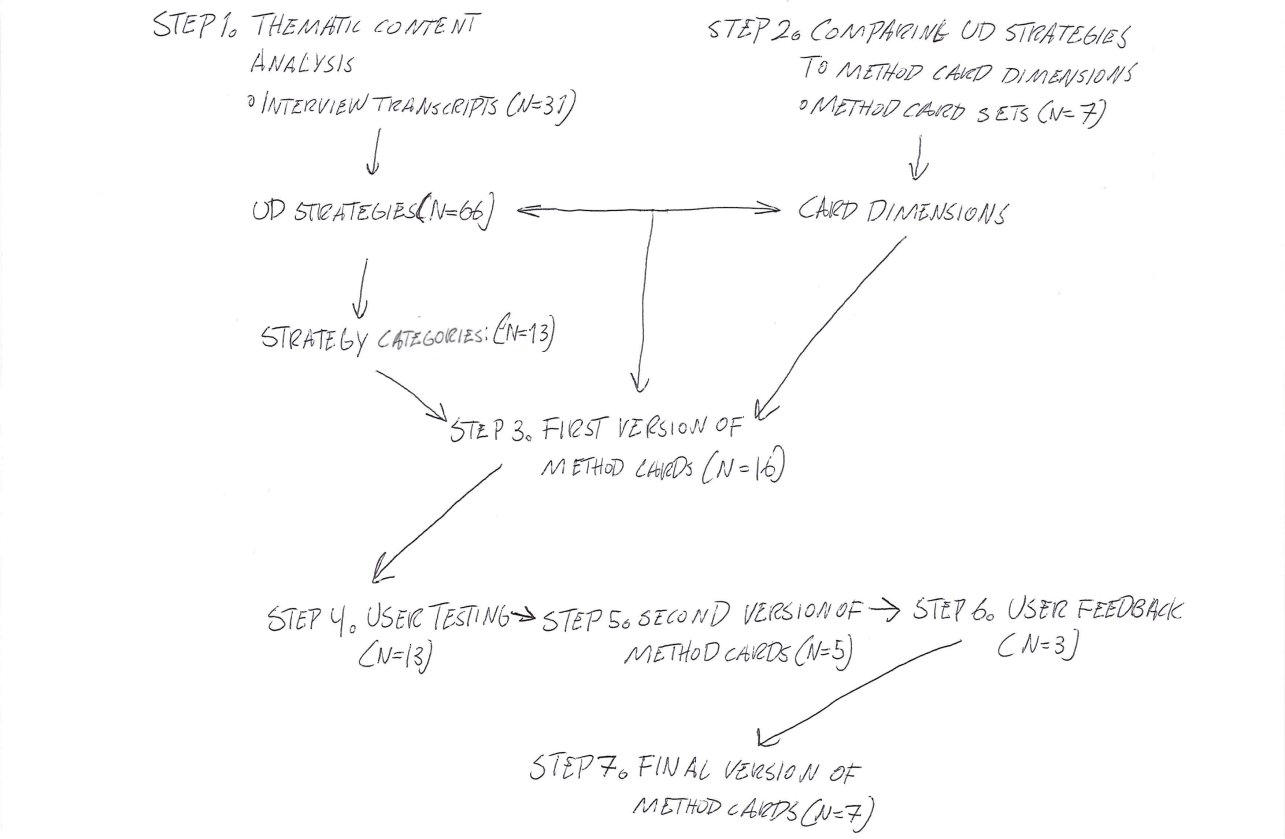

Figure 4: Overview of research approach

3.4 Research Ethics

Any data collected through user testing and tool feedback will be anonymized; only mentioning participants by number in notes, transcriptions and other texts used throughout the research. Data linking participant information to the anonymized dataset is safely stored on a separate flash-drive. No directly or indirectly identifiable information on users and informants are traceable in research texts, including specifics on the sites and organizations where the data collection take place. This somewhat limits transparency, but ensures participants are protected.

Participants are informed about the purpose of the study, and new data is only collected from participants that have consented to participate in the thesis study through, either by oral consent or written consent. The informants from previous studies are informed via email that their anonymized transcripts are being utilized for further research. This was done by one of the original researchers holding their contact information, Miriam Begnum, which is also the thesis supervisor. Should any sensitive information be collected, the study falls under Miriam Begnum's ongoing study "Assuring UD in the eSociety – Towards Understanding the Effects of Design Methodology", which is approved by NSD including updates on this thesis use of the data.

4. Results

In order to increase thesis readability, the choice is made to include specific information on the user testing sessions and the iterative design process as part of the results section. This means aspects related to methodological approach is combined with findings in the Results chapter, in order to better describe the process and outcome of the research approach.

4.1 Results from Thematic Content Analysis of Interview Data

A majority of the coded information from the interview transcripts falls into three themes: strategy, actions and outcome. A total of 66 different UD strategies were identified, based on the coded *solutions* to the coded *problems*. While some informants give rich and detailed answers to the questions, others answer more briefly and provide little *context* to the problems solved by their strategy. Thus it was necessary to make some assumptions about the relationships between solutions and problems based on knowledge about the domain when identifying strategies.

Several strategies are very similar or nearly identical to each other, as they are identified based on the mostly actionable parts of a design process, on prerequisites or causes for doing design activities or on any outcome from implementing a given strategy. Certain strategies are mentioned within other strategies. Strategies are grouped based on similarity and overlap. Also, identified strategies without much supplementary information (such as context or what actions are used to follow the strategy) is combined with other strategies – often with similar strategies mentioned by the same informant. The emerging reseracher-denoted themes from the content analysis are used as a title for each category. After categorization, the 66 strategies are reduced to 13 unique UD strategy categories identified from the empirical data.

The 13 identified UD strategies are displayed and briefly described in Table 3. The strategies are sorted based on their frequency-of mentions. Results show a predominant focus on evaluation, including user-testing and development of requirements for UD – both in terms of usable accessibility (focused on usability), and technical accessibility (relying on guidelines such as WCAG). Six strategies represent such ”Quality Assurance (QA) Strategies”: #1 Evaluation and adherence to guidelines (N=9), #7 User testing (N=5), #8 Specific requirements for UD (N=7), #12 Use of reference groups (N=2) and #13 Testing on users with assistive devices (N=).

Table 3: Overview of Identified UD Strategies

#	Strategy Category	Strategy Description	Frequency
1	Evaluation and adherence to guidelines	Code library and peer review of code. Use WCAG guidelines from the start, especially for designers new to UD. Testing with screen readers or specific tools.	9
2	Common solution for everyone	Having a design for all mindset, focus on usability, finding a common denominator for all users	7
3	Consider a wide array of users	Users not usually considered, «invisible» disabilities	7
4	Workshops, seminars and organizing groups.	Spreading enthusiasm and practices about universal design throughout organization.	7
5	Focusing on UD throughout process	Work with UD integrated, have it in the back of your head.	5
6	Integrate solution with existing technology	Make sure solution is compatible across platforms with assistive technologies.	5

#	Strategy Category	Strategy Description	Frequency
7	User testing	Frequently and early user test, see effect of users test.	5
8	Specific requirements for UD	Make requirements for universal design as part of usability goals, quality assurance of UD, and use of relevant WCAG guidelines	7
9	Incorporate assistive aspects	Add support for different technologies and platforms that do not require specialized assistive technology. I.e. Voice Over, and talkback.	4
10	Resources and support	Acquiring proper resources, collaboration from team.	3
11	Disability and external expertise	having someone with a disability on your team, bringing on external competence with UD,	3
12	Use of reference groups	Having a group of users or experts to get feedback on questions or designs.	2
13	Testing on users with assistive devices	Users who are avid used of assistive technology provide unique insights.	2

Strategies that promote UD principles and values are also well represented. Six strategies is interpreted as representingv ”Design for All (DfA) Strategies”: #2 Common solution for everyone» (N=7), #3 Consider a wide array of users (N=7), , #4: Workshops, seminar and organizing groups (N=7), #5 Focusing on UD throughout process (N=5), # 9 Incorporate assistive aspects (N = 4), and #12 Disability and external expertise (N=3). Lastly, emphasis is placed on concrete UD design activitites on organizational or processual levels – ”Practical Strategies”: #6: Integrate solutions with existing technology (N=5), and # 11 Resources and support (N=3).

Two UD Strategies «common solution for everyone» and «specific requirements for UD» promote UD as a part of designing usability as is the goal for IxD (Preece et. al. 2015). Viewed broadly ten codes focus on strategies that directly work towards improving the user experience for user with disabilities and all kinds of users including taking a broad view of user groups, and improving negative aspects. The four remaining codes are specific to organizational work with UD such as proper resources, workshops and seminars, use of expertise and reference groups. Indirectly these also work towards improving UD of solutions.

For UCD-principles, two codes focus on understanding context of users, two codes help define requirements, three codes focus on designing a solution with a clear understanding of user requirements in mind, and lastly four categories measure a solution through user feedback and conformity to requirements. This may indicate a predominant focus of strategies that focus on end-user feedback, rather most of the strategies consider the process holistically with frequent and early user feedback and understanding and iteration of requirements throughout. Thus it can be said that strategies identified to secure UD are also to a large degree aligned with user-centered principles.

4.2 Comparing UD Strategies to Method Card Dimensions

When applying the identified UD strategies in Table 2 in a tool prototyping process, the first step is cross-examining dimensions from each archetype of method cards against the identified strategies. As described in section 3.2, a sample selection of 7 different method cards was created, representing different qualities and characteristics and spanning all three design-card archetypes (see section 2.5.2). First, the selection of card types is printed, and their dimensions analyzed and interpreted. The review of the seven method cards found similar structures within the different archetypes. In

general, the method cards convey a theme, guideline, or description in order to help achieve a specific goal for their intended use. The goals, however, differ within the different method cards.

From the review a set of card dimensions that were typical for each of the three archetypes was defined, to understand contents of common qualities in the cards. These are visualized in Figure 5. Commonly, cards convey justification, benefits and expected outcome to a given method or concept. Especially in Repository cards, concepts or methods are often grouped into categories. In the review all method cards with the exception of one set use images to convey an idea. Concepts are conveyed in different ways, either in question form, sequence of steps, keywords, and inspirational aspects such as examples.

Further, the instructional and formal qualities of cards defined by textual content are analyzed and displayed in Table 4. For Repository method cards, these are outcomes from method usage, examples of method implementation, guidelines or required action for execution, illustrations, inspirations, strategies, and examples of solutions. For Customizable cards they are concept definitions, information about a domain, situations or context, as well as technology descriptions. Context-specific cards conveyed challenges or obstructions, questions, strategies and more abstract or non-obvious concepts.

Table 4: Instructional Qualities for Each Archetype

Customizable	Repository	Context-specific
Clear concepts	Method name	Challenges
Storing information about domain	Category of method	Obstructions
Situations or context	Instructions	Questions
Technology	Procedure and outcome	Strategies
		Abstract concepts

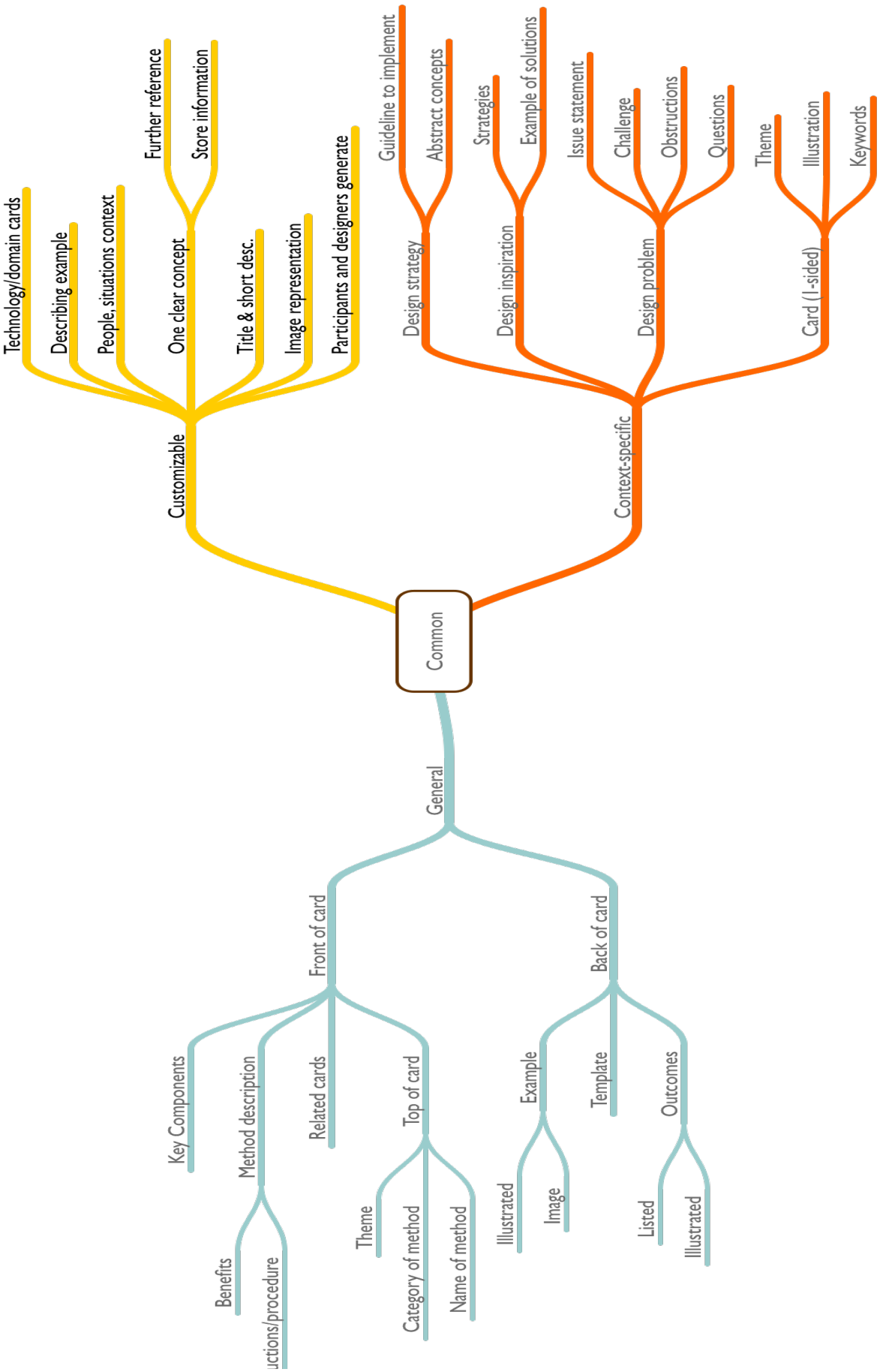

Figure 5: Common Card Dimensions for Each Archetype

The contents of the different method card archetypes and specific method cards in the reviewed sample are then compared to the identified UD strategies. By analyzing the frequency of UD strategies that match up to identified content categories from each of the three card archetypes, we are able to say whether a tool is appropriate or not in terms of content validity (Leedy and Ormrod, 2015). The dimension qualities summarized in Figure 2 and Table 3 are applied to all the identified 66 UD strategies, in order to see which strategies could be translated to specific card types.

By doing this, I find that 30 UD strategies appear fitting for translation into Customizable method cards, 37 strategies seem fitting for general Repository method cards, and 22 strategies seem fitting for translation into Context-specific method cards. The data suggest a strong focus in the successful ICT-projects are on methodology for UD Quality Assurance Strategies, which may be translated into Repository method cards. Context-specific method cards with abstract concepts are somewhat less matching the empirical data on strategies used. However, Context-specific cards could be suited for the activities related to creativity and idea generation, since the content analysis provided data that pertained to creative approaches in development of concepts. Finally, Customizable method cards provide information specific to the domain with regards to technology and user context, and cover some of the DfA Strategies, but seems the least matching to the empirical data.

As such, method cards from each archetype may be useful for translating UD strategies identified from the interviews, and is ranged according to the following perceived relevance: 1) Repository evaluation method cards used for UD QA, 2) Context-specific cards that support UD aspects in idea generation, and 3) Customizable cards holding knowledge specific to domain and technology.

4.3 Iterative Design Work: First Draft of Method Cards

As a first draft, a total of 16 cards are created based on the 13 UD strategies from the data analysis. 6 of the 16 cards are “Ideation cards”, of which most are belonging to the Context-specific archetype. The Ideation cards hold domain-specific knowledge and creative strategies. The other 10 cards are a set of “Evaluation cards”, presenting methodology-based strategies. The 16 drafted card topics are overviewed in Table 5, where blue table cells represent Evaluation cards. Both the Evaluation and Ideation cards are considered of the Context-specific archetype, as they are intended used at a specific point in the design process. However, the Evaluation cards can also be considered Repository in that they contain a methodological approach. Figure 6 shows examples of two Evaluation cards. Figure 7 shows examples of two Ideation cards.

Table 5: Card Topics for the First Draft of Method Cards

Card Topic	Description	Card Topic	Description
Usable by children	Making the solution usable for less visible or common user groups such as children might make it usable for everyone.	**Reference groups**	Gathering insights and feedback on what challenges and benefits from people with different needs can guide innovation early.
Compatible with assistive technology	A solution that is compatible with for example screen readers could benefit your visibility in Google search results and make it usable with Apple Voice over.	**Documenting criteria**	Choosing what to test and why is important into getting useful feedback. If you evaluate with experts they may overlook important aspects of your solution.

Integration of user groups	Having the mindset that everyone in your user group will be able to use your solution will prevent big changes later.	**Shared understanding of UD**	Make sure your team has a shared understanding of universal design and guidelines.
Personification of user needs	Thinking in broad strokes when it comes to your user group can be aided by the use of personas.	**Coworker with a disability**	Working together with someone who has special needs can help you gain a different perspective on usability.
Simplification of design	Using simple formulations, representations that help as many people as possible understand comprehend what information you are conveying.	**Different platforms**	Testing your solution on different platforms, interfaces, browsers etc. can make sure everyone has access to it.
Existing solutions	Look at how users with different abilities interact with existing solutions.	**Expert evaluation**	Bringing in accessibility experts to quality assure your solution can ensure your solution is usable by as many people as possible.
Testing with screen readers	Testing your solution with a screen reader is a good way of verifying a solution.	**Real life contexts**	Testing on users with impairments in real life scenarios can give you invaluable insights on how your solution is used.
Non-functional requirements	Adapting WCAG guidelines for design, content, and technology to your user persona will make it more **personal** and more **engaging**.	**Content accessibility**	How accessible is your content. Example: Imagine or simulate that you or someone you know has an impairment you need to design for.

Alves and Roque (2010) provides a synthesized template of how to present the dimension qualities (called “layers”) in the method cards. This template is used as a starting point for the tangible design. 7 of the 16 cards contained the layer dimension *example* from Alves and Roque (2010), as seen in Figure 3 “Non-functional requirements”. All of these are Evaluation cards: Non-functional requirements, Reference groups, Documenting criteria, Shared understanding of UD, Coworker with a disability, Real life contexts and Content accessibility. These cards provide examples of how to implement a concept or method, thus belonging more clearly to the Repository archetype.

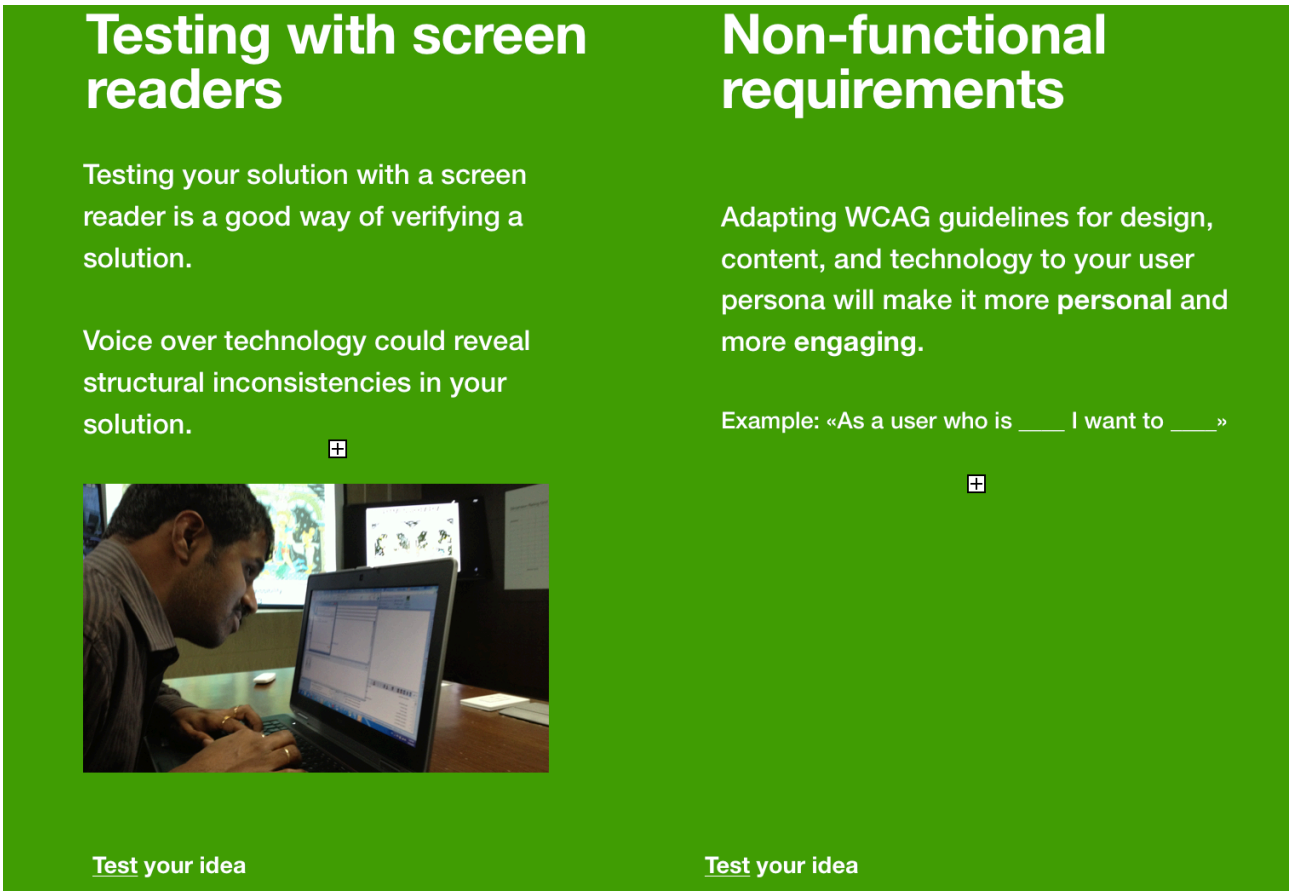

Figure 6: Evaluation Card Examples, First Draft

The researcher-denoted emerging themes from the content analysis are used as tentative *titles* for the method cards. 11 of the 16 cards used *visuals* to elaborate on the concepts, while the remaining five cards did not, as I could not find appropriate visuals for certain methods. The prototyped method cards do not provide a clear set of specific steps to conduct methods, but rather descriptions of each strategy with varying degrees of abstraction. The level of detail is largely dependent on their relevance to specific and detailed information in the empirical data. If strategies are well explained by interview informants, they are translated into more detailed method cards.

The Evaluation cards provide a set of *methods* for designers such as «Different platforms», which requires testing the solution on different platforms to make sure everyone has access to it. No further instructions are prepared for the Evaluation card set. Some of the Ideation cards are by nature more abstract as to allow users to interpret cards to their own context, for example «Simplification of design» requires designers to consider how they formulate design concepts in a way most users can comprehend. Other cards use clearer concepts such as «Compatible with assistive technology» in Figure 4, which highlights the benefits of creating a solution which is compatible with screen readers as it will improve search engine optimization.

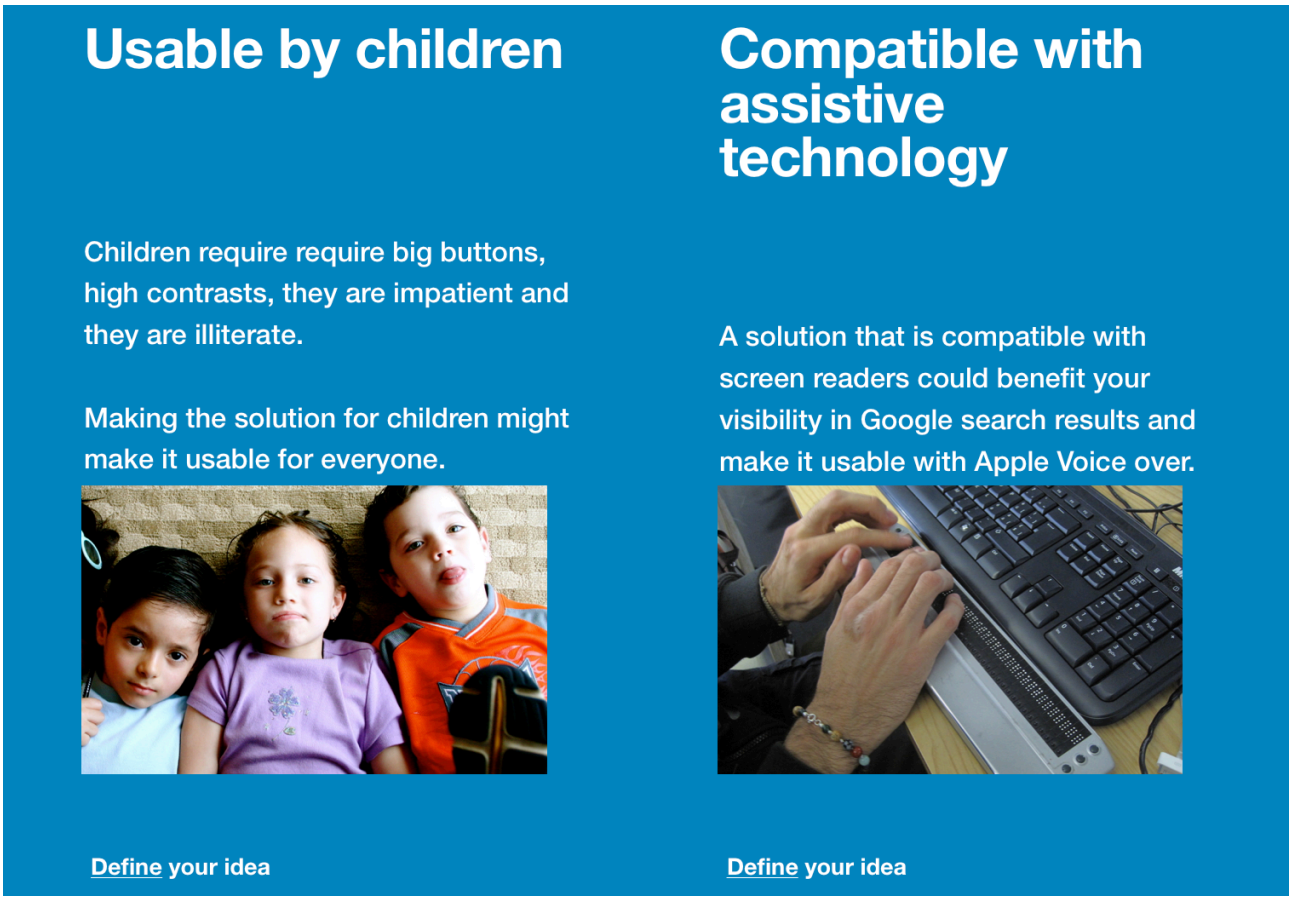

Figure 7: Ideation Card Examples, First Draft

4.4 User Testing: First Draft of Method Cards

In order to assess the first card set draft, I utilized students from a Norwegian Master program in IxD, in a UCD-methodology class. From the class, 13 IxD master students are recruited to help assess the cards. As the thesis topics was overlapping with the learning outcome of the UCD-course, I was allotted a 2 hour session within a whole-day course seminar. The aim of the test session is defined as *collecting feedback from the students on how useful they feel the first draft of cards are within a UCD process*. Based on the drafted method cards, the test session is divided into four steps: an ideation test, an evaluation test, card sorting through affinity diagramming and an open usefulness discussion.

4.4.1 Ideation Test

First, the 6 Ideation cards are tested. The aim is to receive user feedback on the usability of the cards for supporting UD perspectives in creative activities, where concepts are generated to solve a problem at hand. The test set-up do not focus on quantitative findings, and do not compare the quality or quantity of the generated ideas using the cards to a control-group not using the cards. The aim is only to evaluate and gain insight into how cards can be used, and their perceived usefulness in supporting UD perspectives when creating design concepts to a problem.

The first step in the Ideation Test is to pair the 13 participants in groups of two and two (one group of three due to the uneven number). This resulted in 6 paired groups. The 6 groups are then presented the problem task at hand, and each group is given the deck of 6 Ideation cards. The problem task given was: “Imagine you are making a communication system for NTNU, given that people are starting to turn away from the tools NTNU are providing its users”. This problem task is chosen to match the current course focus, and thus also match the participants’ experience, ensuring

they had sufficient domain knowledge to successfully utilize the cards (Bornoe, Bruun & Stage, 2016; Yoon, Desmet & Pohlmeyer, 2016).

The groups then brainstorm creative ideas to solve the problem task, using the Ideation cards. Participants would take turns playing one card each and generating an idea using that card. Cards that follow either trigger new ideas, or build and iterate on previous ideas. The participants are given 15 minutes to ideate before writing down their main idea on a post-it. Summarizing participants' experiences with using the cards closes the Ideation Test.

4.4.2 Evaluation Test

Second, the 10 Evaluation cards are tested. The aim is to receive user feedback on the usability of the cards for supporting UD perspectives in evaluation activities of concepts. The test set-up do not focus on quantitative findings, and do not compare the quality or quantity of the generated ideas using the cards to a control-group not using the cards. The aim is only to evaluate and gain insight into how cards can be used, and their perceived usefulness for supporting UD perspectives when evaluating solutions (based on face-value) or concepts (tested).

The participants continue the testing in their 6 paired groups. This time around they are given a set of 10 Evaluation cards each. Next, they are asked to independently plan how to evaluate their main idea from the Ideation Test, using the Evaluation cards. As participants are engaged to actively reveal their opinions of the design and provide suggestions, the Evaluation Test can be considered cooperative (Benyon, 2014: p. 221). Participants are given 15 minutes to write down evaluation methods on post-its for their main ideas.

4.4.3 Affinity Diagramming

Thirdly, participants are asked to group their ideas in an exercise of affinity diagramming. The purpose of this step was to allow the participants to cluster and label the data generated from the user testing, to help gain an overview of what focuses are triggered by the cards. The ideas generated can then be analyzed to see if they hold a focus on UD concepts and strategies. Two and two groups are merged for this exercise to limit the number of diagrams, creating 3 groups of 6-7 participants in each. Next, the 66 identified strategies from the content analysis are also re-grouped using affinity diagramming by the 3 participant groups, in order to see if new and less obvious UD-strategies appear.

4.4.4 Usefulness Discussion

At the end of the test session, participants are asked open questions about their experiences with and insights while using both types of cards; how the cards helped in the generation of ideas, how evaluation of an idea changed the original ideas, and what they thought about their usefulness in ideation, planning and evaluation. No direct questions are asked with regards to UD, in order not to lead the participants and create bias. Questions were asked in an unstructured plenary session to allow the researcher to follow-up on any interesting feedback (Lazar, Feng & Hochheiser, 2017). The aim of the usefulness discussion is to help guide the design of the cards, and help uncover potential frustrations users have with the design (Krug, 2010). In the open usefulness discussions, the cards are used as "probes" to elicit feedback (Lazar, Feng & Hochheiser, 2017).

The perceived usefulness of the cards is assessed through gathering insights from participants, both during Ideation and Evaluation Tests and in a plenary session discussing usefulness. Feedback was mostly given on the cards in general, with just a small number of the individual cards mentioned in particular. In the plenary feedback session, only a handful of the 16 participants participated,

however at least one participant from each of the 6 groups in the test sessions voiced their opinion on their experience with the two sets of cards.

On the overall Ideation and Evaluation testing implementation, the participants criticize the design problem given with the task. They express a clearer design brief with a problem statement would have better stimulated idea creation and made them more motivated to use the cards. Further, one participant feels that while the cards forced an early focus on usability, they would have focused on it given more time without the cards. Finally, the cards were more difficult to use at the beginning, as the participants were not used to the cards yet.

User feedback points to several cards being unclear and require more examples or guidelines to instruct their implementation. An example was the Ideation card "Compatible with assistive technology", which didn't have guidelines for implementation, just a motivation for usage. Other Ideation cards provided good inspiration for the ideation phase. An example is "Usable by children", that gives specific examples on how to implement the concept in addition to a motivation for usage. The "Integration of user groups" card also inspire participants to consider a wider target user group, and particularly helped one of the six groups generate creative ideas. In addition, several of the images seemed to add little context to help understand the method cards.

User feedback also points to many of the cards holding too obvious concepts and seemed to mirror what the students had been taught in the class from before. As such, some of the ideas or methods from the cards had already been considered prior to the use of the method card, making the cards redundant in certain cases. In other words, the cards did not always match the participants' skill levels – sometimes being too obvious and other times being too unclear. The latter is more critical than the former, as not all cards in a set need to be useful for all users. In the Ideation test participants had to wait for their team member before playing a new card and generating a new idea. As cards and ideas sparked new ideas in both participants of a group simultaneously, this aspect was reported as restricting idea generation. Thus, Ideation cards could potentially be more useful either as a tool for a single designer, or as a participatory method to include end-users and stakeholders that are not as trained in spontaneous ideation.

4.5 Iterative Design Work: Second Draft of Method Cards

A second iteration of the cards was designed initial user insights fresh in mind. Results from the user testing described in 4.4 is therefore presented here, along with their implications for the design work. As there is a danger of overgeneralizing findings from user feedback sessions (Benyon, 2014), supportive guidelines and insights from related research is considered alongside user feedback, to better guide the final design of the method cards.

Overall, Ideation cards were found to be too instructional, and several participants noted that the cards didn't provide enough creative concepts to stimulate idea creation, and that they are too obvious. Burnay and Horkoff (2016) suggest that to stimulate creative requirements it requires the presentation of qualities that are uncommon, and as such can help break defaults or subjective criteria. Thus, in future improvements on Ideation cards it seems wise to either abstract Ideation cards, iterate the Ideation cards to present more uncommon strategies or provide more customization to the cards. Burnay and Horkoff (2016) suggest for the design of cards to inspire creative problems that they are:

- "Non-functional, they have no clear-cut satisfaction criteria, and are somehow subjective"
- "Point to uncommon qualities of product or services, as a way to break defaults. They are expected to provoke reaction from the stakeholders".
- "Should not be too specific, and open to interpretation"

- "Should be sufficiently ambiguous but still understandable by stakeholders to help them produce creative ideas".

However, the reason for selecting method cards as tools to facilitate UD in IxD work, was these are more specific and as such fit assumptions based from previous research on what kind of tools can best support in-practice IxD activities. User feedback on the first draft of cards indicates the method cards are still not specific enough. The second design iteration thus needs to accommodate more specificity, in order to increase usability.

The first user testing of the Evaluation cards indicates these are able to refine the original idea and are easier to use than the Ideation cards. An issue with the Evaluation cards was they tended to be more process focused, which made it more difficult to generate good ideas from them. Based on Burnay and Horkoff (2016) and user feedback, the following guidelines are derived to guide the re-design the Evaluation cards:

A) Cards should foster creative qualities instead of being overly focused on process issues.
B) Conceptual qualities should be less obvious, to break defaults and provoke reactions.
C) Methodological cards should be more specific and require a guideline or example for implementation.
D) Visuals are unnecessary if they do not correlate or clarify the concept so to not create confusion about concepts.

Participants felt that the affinity diagramming of their ideas was unnecessary. However, by analyzing the emerging clusters of ideas generated by the participant groups we are able to consider areas of focus that the cards may have stimulated. The three groups clustered their findings into the following categories; Group 1: Platforms, Personalization, Personas & disabilities, Information/system architecture, Recruiting, Group 2: Understanding & testing, Accessibility testing, Accessibility/Inclusive, Structure/Attributes, Website, Platform and Group 3: Accessible, Platforms, and Language. At least four of these categories are clearly linked to UD. There is a focus on ensuring cross-platform accessibility, and all groups include an accessibility category. There is further a focus on understanding user needs, exemplified in "Personas & Disabilities" and "Recruiting" categories. Several cards include navigational structure and information architecture aspects, and these aspects are also present in the affinity diagrams – e.g. "structure" and "information/system architecture" categories. The «forced» focus on accessibility was apparent in all three groups and thus the next iteration focused on less obvious wording in congruence with guideline B).

4.5.1 Redefining UD Categories

After the feedback session the first draft of cards is examined using the four derived re-design guidelines to explore possible improvements. The guidelines are also used to identify or refine previously identified UD-strategies from the content analysis. In order to design for guidelines A) and B) the original 13 categories and their respective strategies from the content analysis are re-grouped using affinity diagramming. A set of five categories emerge as the main themes. These can be considered creative, conceptual and less process-focused. As such, instead of identifying new UD-strategies relevant for method cards, a stricter categorization of the identified strategies emerged. Instead of 13 strategies, 5 overarching strategies from the empirical data are proposed. These are: 1) DfA Mindset, 2) Common Denominator, 3) Challenge Perspectives, 4) Made to Test and 5) Adaptable. Table 6 overviews these identified strategies and their related sub-strategy.

Table 6: Overarching UD strategies

Code	Description	Categories
DfA Mindset	Being open to new possibilities and integrating new ways of thinking:	5) Focusing on UD throughout

	Exploring options you normally wouldn’ t and taking time to learn new aspects of a design.	
Common Denominator	Consider «invisible» user traits, and look for common traits in user’s context of use so that the solution benefits same person in different situations.	2) Common solution 3) Consider wide array of users
Challenge Perspectives	If you are open to new possibilities it can feel more like opening a new door rather than being forced down a narrow and difficult path.	4) Workshops, seminars and organizing groups. 10) Resources and support. 11) Disability and external expertise.
Made to Test	Testing with how extreme users understand and use your solution can help you cover a large spectrum of users.	1) Evaluation and adherence to guidelines. 7) User testing. 8) Specific requirements for UD. 12) Use of reference groups. 13) Testing on users with assistive devices.
Adaptable	Make the solution integrated with different platforms and technology. This will allow people to access and interpret information in different ways.	6) Incorporate solution with existing technology. 9) Incorporate assistive aspects.

4.6 User Feedback: Second Draft of Method Cards

To test out the new strategies, I conducted a semi-structured focus group interview. This would allow me to follow up and validate the data gathered from the initial workshop with the same participants (Lazar, Feng & Hochheiser, 2017). A group of three IxD master students from the UCD methodology class participated in a 15 minute interview session. Participants were provided a sample description for each category. They were asked how they would implement each of the new strategies if they were in the form of card-based tools, how they could have been used in their current or previous work, and how they sought to solve the same problems detailed in each strategy.

Participants expected the cards to have a clearer path to implementation. One participant noted: “I would expect method cards to provide direct action in the form of a bullet-point or checklist to carry out the method”. In addition the participants desired a clear summary of the method, expected outcomes, how to recruit for it, and key points to consider while carrying out the method. Finally there was a desire for resources required as well as instructions for how to analyze data output.

In terms of solving issues presented in the UD strategies, one participant said he would have solved differing needs through focus groups and interviews in order to identify different needs. As well as finding participants through gatekeepers that can help with recruitment. Participants thought the concepts present could be inspiring it would be far more useful to have a clear structure for how to implement each concept into the design process.

4.7 Iterative Design Work: Final Method Cards

Of the tested cards, the Evaluation cards have the most detailed UD strategy descriptions in the qualitative interview data. Less obvious concepts paired with guidelines seems inefficient at inspiring users. Users desire for concrete steps to implement methods and concepts. Therefore, a fifth guideline is added: E) Method cards should have a clear sequence of steps for implementation.

The next design iteration focuses on improving the methodological aspects of the cards, moving further towards general methodology-based cards to accommodate this need.

The existing 16 cards are grouped according to the five identified overarching UD-strategies, in order to see if they support the same overall purpose. This comparison reveals the overarching strategies can be further divided by relation to methodology. In short strategies 1) and 2) (marked in Table 6) focus on including a wider set of users in research activities: "Common Denominator", strategies 3), 4) and 5) focus on challenging perspectives and adapting solutions to different platforms and technology through inclusive user testing and evaluation activities with clear-cut testing-criteria: "Testing Your Perspectives".

With the new categories Ideation cards and Evaluation cards conformed to new groups: "Common Denominator" and "Testing Your Perspectives" both categories are methodology-based (see Table 7). For example, "Reference Groups", a former Evaluation card, fell over into "Common Denominator". As did "Non-Functional Requirements" as it deals with user research and definition of requirements. "Existing Solutions", a former Ideation card, fell over into "Testing Your Perspectives" as it corresponds strongly with the "Real Life Context" evaluation card.

Table 7: Overarching UD strategies mapped to existing method cards

Code	Description
Common Denominator	Consider wide array of users, Integration of user groups, Personification of user needs, Simplification of design, Reference groups, Non-functional requirements, Content accessibility,
Testing Your Perspectives	Documenting criteria, Shared understanding of UD, Coworker with a disability, Different platforms, Expert evaluation, Real life contexts, Content accessibility, Testing with screen readers

In total 8 cards became part of Testing Your Perspectives, all of them previously Evaluation cards. In total 7 cards became part of Common Denominator, 3 of them former Evaluation cards and 4 of them former Ideation cards. One card did not fit into the two categories and was scrapped: "simplification of design", while "usable by children" went back to the original category of "consider wide array of users".

Based on the level of detail identified in the empirical data for the relevant strategies, former Ideation cards are grouped according to methodological approach and bringing uncommon and creative qualities to each methodology. Then they are supplemented with *user research* methods and *evaluation methods*. Using prevalent methods from the content analysis and supplementing there is a clear connection between methods used and their strategic outcome. Such as challenging perspectives is achieved through testing on users in real context, expert evaluations and self-evaluation in organized settings.

The resulting method cards are therefore grouped in two parts based on activity, goal and methodology: Common denominator which seeks to enable a more inclusive user involvement and Testing your perspectives which focuses on inclusive evaluation methods with and without users, resulting in two and three cards respectively including one card to elaborate creative and uncommon qualities. These are presented in Figures 8-9. The revised cards use a layout similar to the one initially used, based on the template Alves and Roque (2010). However, the re-design guidelines based on Burnay and Horkoff (2016) and user feedback improves card contents, and there is now an emphasis on adding non-obvious aspects to common methodology, images are removed save for the icon on the back of each card as per guideline D), and clear instructions in the form of steps as informed by other method card sets and user feedback. *Examples* are included and help translate instructions into actionable design patterns.

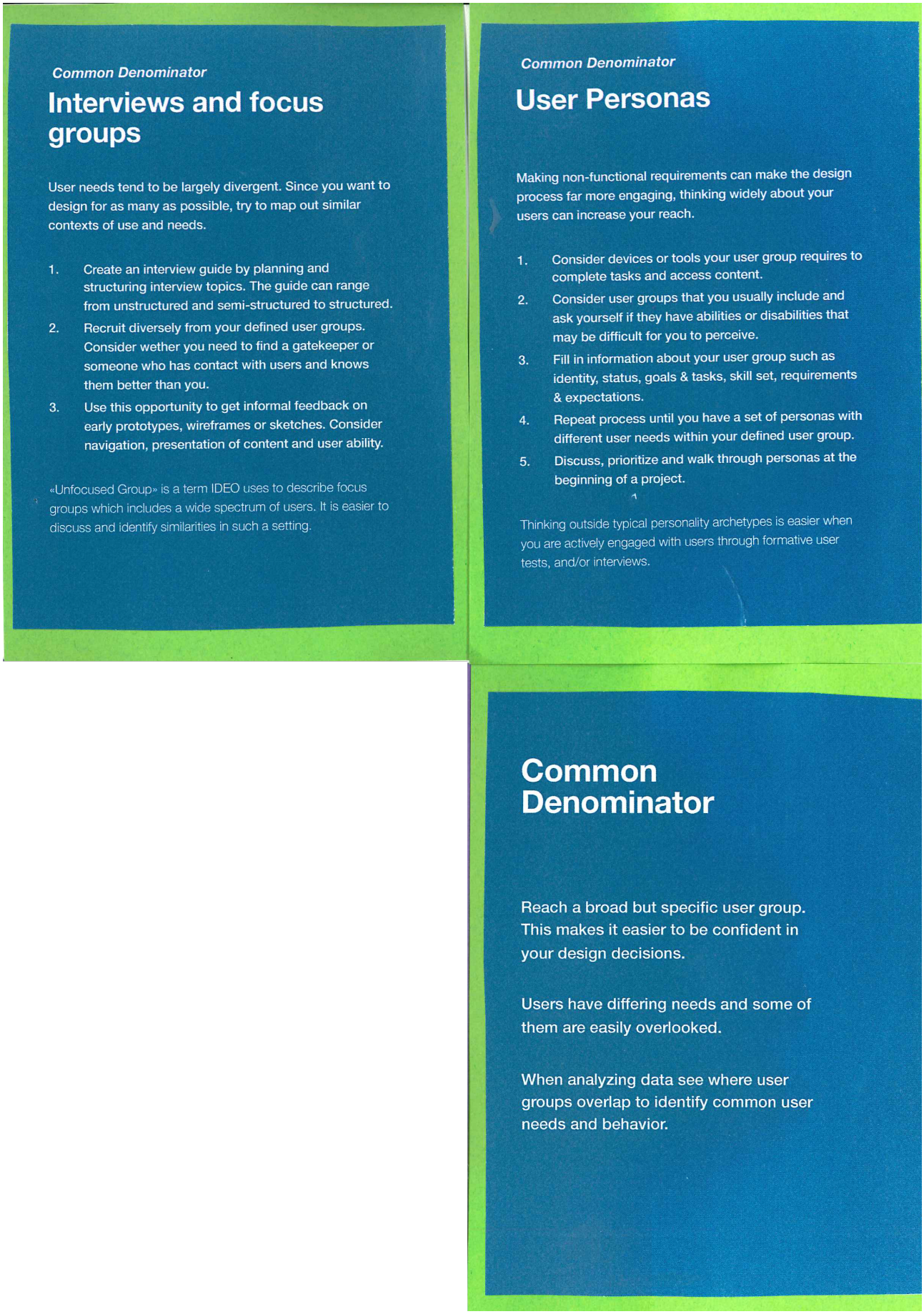

Figure 8: Common Denominator cards

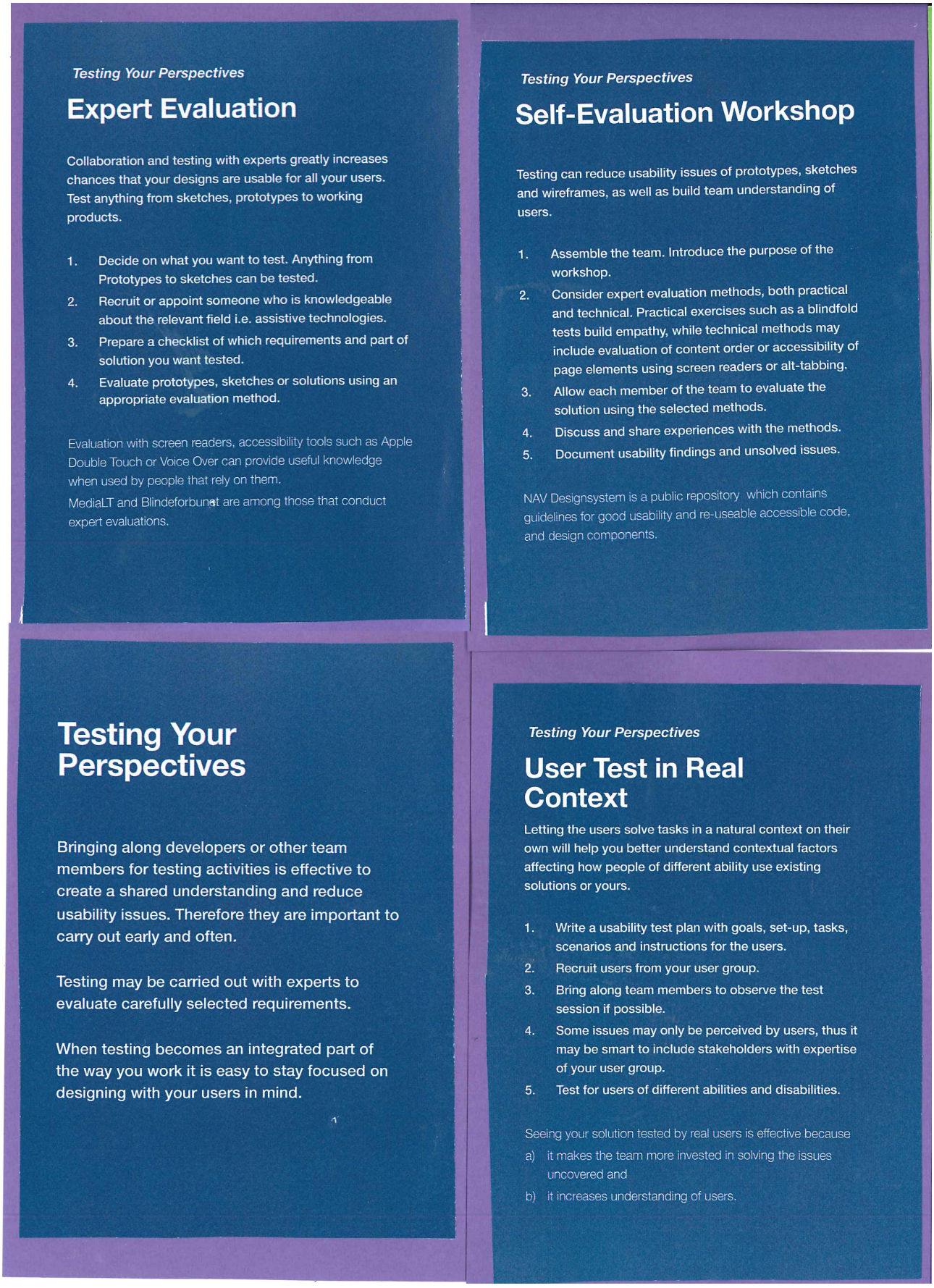

Figure 9: Testing Your Perspective Cards

5. Discussion

5.1 Identifying UD Strategies from ICT Success Projects

My first research question asks "What strategies have informants on ICT projects with UD success applied, or recommend others to apply, in order to ensure UD?". These strategies are difficult to translate directly into method cards as they refer to another set of guidelines which are too comprehensive to mention within a method card.

In total I found 66 strategies across the 31 informants from the analysis based on two questions. These were quite similar since they could be reduced to 13 unique strategies with varying degrees of overlap. A limitation of the study is that the data is re-used from earlier research. It was not possible to ask follow-up questions when participants said something of interest to this research, several informants gave brief responses with little context which could enrich the findings if clarified. Most informants mention several strategies, generally providing a good level of detail for a handful of them. A result of this is that the research includes only strategies with provided context, and thus cannot ensure that the most important strategies are represented in the findings. Presenting detailed strategies does make up for this. For future research the detail level means that important detailed strategies which are not found here may be uncovered in future research.

Findings suggest a large focus on strategies that deal with adherence to technical guidelines, among them strategically defining a custom set of guidelines based on project needs as well as early understanding and frequent validation. The sample has a noticeable focus on technical aspects as a significant part of the sample is represented by developers, and the sample population have worked on ICT solutions of which WCAG and technical accessibility is a significant but only one part (Røssvoll & Fuglerud, 2013). However, laws and regulations are focused on this aspect of accessibility. Since the focus may change in the future towards other standards this it may affect what strategies would be identified in the future (BLD, 2016). Thus, the findings may be less essential for the IxD field. The strategies and thus the method cards developed in this study are in large part cross-disciplinary. Design work is less law-regulated and it may for some be less pertinent to follow up.

The results show several recommendations to adapt requirements to the specific project. This proves that the recommendation from Røssvoll and Fuglerud (2013) to use UCD-methods combined with a unique understanding and required practices to design for the user group is prevalent in the sample. Results also coincide well with findings from Hjartnes and Begnum (2018) on AUD projects with emphasis on common understanding of UD created through user testing, understanding and knowledge of UD principles. However, there is a little focus on sharing documentation in the sample compared to the literature, and the focus is rather on definition of requirements for both UD and usability. This could be an indication that this is not an important strategy for UD practitioners in order to succeed.

5.2 Translating UD Strategies to IxD Tools

Next, the second research question explores: *"How can these strategies be translated into practice-related UD in IxD tools?* Developed method cards which were drafted as first a set of evaluation and ideation tools to be used together to develop and evaluate potential ideas and design. There seemed to be strong evidence that further focus should be attributed to the evaluation cards. As Begnum, Harder and Hjartnes (2018) find that informants suggest lower-level concepts are better to implement on a discipline-specific level, whereas higher-level issues are better to address with project evaluation tools. In addition, participants in the user tests also found the detail level too low for the method cards.

Due to the prevalence of method-related strategies it seemed like a good decision to develop card-based design tools. As higher-level concepts were also noticeably prevalent there is no dispute that developing a project evaluation tool is justified. In fact, one test session participant expressed a desire to use a checklist-type of tool for the concepts presented in the cards. However, since the sample is predominantly interaction designers, many of them are found to be using specific methods, or strategies to succeed with UD.

Previous research by Begnum, Harder and Hjartnes (2018) also find checklist for integration with project management tools with phase-specific recommendations. Best practice methodological approaches are mentioned as well as recommendations for each discipline. Other tools could have been utilized as well for this research. Another example found in the data is the re-usable artefacts stored in a repository (Lucke and Castro, 2016). The Web Accessibility Initiative have such repositories which store example solutions to both accessibility and usability problems, these are reusable and in some ways provide the same benefit as method-based design tools in that they can be adapted to solve design problems (W3C, 2018).

Comparing my final method cards to other context specific cards such as the PLEX Cards (Lucero & Arrasvuori, 2010) the level of detail is much higher in this research ideation cards, yet other cards convey creative qualities far better due to their non-obvious nature. In addition, visuals used here are confusing rather than helping users grasp the meaning of a particular cards as they intend too. Customizable cards were hardly explored in this thesis, though the data contained information about domain users and technologies there was not enough empirical data to support implementation. As customizable cards are used to store information about the domain, thus seem less applicable for the purpose of translating strategies into tools. To be of value to the design process they require domain experts to design, and should be created for each new project (Bornoe, Bruun & Stage, 2016). Findings support the need for lower level knowledge for implementation of success criteria (Begnum, Harder & Hjartnes, 2018), and expanding knowledge of users. These include but are not limited to visual impairments, hearing impairments, motor impairments, elderly, persons with temporary conditions that affect regular function such as pregnancy, physical injury and children. Thus this card archetype may be appropriate for future work.

The first iteration of method cards seemed to work decently considering they were lacking content and had many issues which were uncovered in the feedback. Better work could have been done in preparation for the first workshop, insights could have been gathered upfront to uncover obvious issues with some cards. The final set of cards were much higher quality than the original two iterations. Different iterations proved that larger amounts of data had to be abstracted and analyzed to fit together in a smaller set. This is due to the required detail level of UD-based method cards. It was difficult translating strategies to method cards for this reason, in order to support users in solving design problems it was not enough to have empirical data. Supplementary information from other method cards was as essential.

If I had done this research from scratch I would have conducted a new interview study to acquire more details and ask informants to deepen their responses for more details. It is likely that conducting the study with IxD and designer professionals would yield more interesting results for developing non-technical method-based design tools. The 13 main UD categories identified in this study indicate what common strategies are used to ensure UD, and can be used as areas of focus in further development of design tools.

Through this study I have found that you require information about how methods that support strategies mentioned are carried out in detail. Knowing more about what sort of qualities the informants consider each strategy to help design for would help aid creativity. Users require clear point-by-point steps of how to carry out methodologies. Several of the found categories were

requested by informants in checklist format, indicating the level of detail found here was sufficient for this purpose. What was lacking for the context-specific method cards was creative aspects, uncommon qualities, and non-obvious strategies. Some are presented, but the lack of presence of these qualities is most likely due to the fact that informants discussed their approach rather than their solution.

To translate UD strategies into method-based design tools a set of guidelines was developed as a result of findings from this research:
A) Cards should foster creative qualities instead of being overly focused on process issues.
B) Conceptual qualities should be less obvious, to break defaults and provoke reactions.
C) Methodological cards should be more specific and require a guideline or example for implementation.
D) Visuals are unnecessary if they do not correlate or clarify the concept so to not create confusion about concepts.
E) Method cards should have a clear sequence of steps for implementation.

5.3 UD Usefulness of Prototyped IxD Tools

Finally, the third research question asks "*How useful do interaction designers perceive these tools to be with regards to supporting UD in IxD work?"* In order to measure this the primary focus was to evaluate face credibility of the cards; wether they would help interaction designers solve design problems with creative ideas or useful methodology.

I hosted a test session with interaction design master students to test the first iteration of cards. This session evaluated all 16 method cards Ideation cards, Evaluation cards, ideas generated and general usefulness of the cards. Ideation test assessed method cards in a brainstorming and ideation context. In this context there was a problem with several of the cards being too general and obvious to participants in the field of usability, thus it didn't provide participants with much creative requirements or ideas. For this purpose, it would make sense to have the cards embody more creative concepts. Due to the fact that the data proved to largely focus on process or method aspects rather than creative requirements, the context-specific method cards didn't work as well as anticipated. There were similar issues with the evaluation cards, participants noted that several of the cards were quite obvious or even redundant.

Providing too many cards that mention accessibility is viewed as negative or as forcing a specific agenda into the IxD work. This could indicate that the cards focus on accessibility is not viewed an important part of conceptual or early design and rather as a concern for web coding in which the focus is on content accessibility. As such the cards should benefit from a focus on usable accessibility rather than technical accessibility (Røssvoll & Fuglerud, 2013). Work better with the categories which are found to support a user-centered, goal-oriented and user-involved approach. In fact, when cards are too obvious or lack a level of interpretation they work against their best intentions (Bornoe, Bruun & Stage, 2016).

A second round of iteration was carried out reducing the number of method cards to 5. These cards were evaluated with three of the same participants from the first test session in a focus group interview. This interview found that though increasing the level of detail for each of the cards, there was still missing a clear path or instruction for implementation. Thus, the final method cards created provided both creative and ideation aspects which gave recommendations and areas of focus as well as instructional step-based guidelines. This final iteration has yet to be tested formally but based on informal feedback from peers I expect results to be positive as user-feedback has been integrated into the cards throughout the research.

5.4 Limitations of the Study

As a control group was not used for this workshop it is hard to measure the exact impact of the method cards. Some participants noted that they would have eventually thought about accessibility given more time. Since several of the concepts presented in the cards were obvious to them they were less helpful. However, such an effect has not been measured in this case, if the participants had been given a design problem to solve without the method cards and then administered the method cards at a later stage, this effect could have been measured. Then we would have been able to see if in fact accessibility had come up naturally in the discussion.

Another limitation of the study was that the design problem was not clear to several of the participants in the study. The issue was with the fact that there didn't seem to be a motivational factor to solve the problem as there was a lack of obstacle. The design problem didn't have a challenge that needed to be solved or overcome such as an obstruction or issue. The feedback session at the end of the user test also relied on participants speaking their mind in an open classroom, which might have biased the data in only acquiring feedback from students who are comfortable with speaking in front of the rest of the class.

The sample from the iterative design work represents interaction designer students where only a handful have work experience, thus it is hard to generalize their perceptions to other populations such as those found in the data used for content analysis. Thus the study is only able to say something about cards perceived usefulness with interaction designers and interaction design students within a limited sample.

The interview transcriptions analyzed did not contain data that was possibly relevant to clarify. Some things such as body language is lost in the interview transcripts. The researchers who gathered the data may have been given a more holistic impression of what the sample were trying to say, and this might not be part of the data collected. Some phrases could be interpreted in different ways as much of the transcripts are written directly of conversations. Interview transcripts also included how participants worked in general to achieve UD, some which might not concern the project which were the basis for sampling. Additionally, some data may concern ideal strategies, which may not have been implemented or used in practice. As such they could be considered as mere opinion rather than pragmatic knowledge.

Due to the fact that strategies and objectives were used primarily to identify important data, some data may have been overlooked that did not conform to these two codes. A similar consequence may fall from excluding certain questions in the interview transcripts which may also contain information about strategies or objectives that were relevant for the analysis. Strategies are identified through content analysis on the data. Due to fact that interview transcripts use a semi-structured approach with questions that directly answer which strategies are used, this method appears to be valid. Though the answers to each question cannot be assumed to provide answers in every case.

To measure perceived usefulness through interviewing participants about completing a task, the participants may be affected by the novelty of administering method card to a familiar design activity. This research doesn't seek to elicit participant perception of use before or after administering the method cards to solve the task. Thus the cards are only evaluated in terms of face validity based on the subjective judgements of interaction designers (Leedy and Ormrod, 2015).

6. Conclusion

Previous research indicates recommendations and promoting factors for achieving universal design (UD) in ICT-solutions. This knowledge can be utilized in a variety of ways. As this study has shown strategies for securing universal design can be translated into tools that may support universal design. Through knowledge and awareness of best practice and promoting factors we may be able to promote and ensure usability for all. This thesis aimed to contribute to the envisionment and design of tools that can promote UD in current and future IxD practice. To effectively create tools to support current best practice it is necessary to first understand the context of use where such tools are implemented. Further, that method cards may support IxD work using a qualitative research approach that bases itself on empirical data and iterative design work with user involvement we find perceived usefulness of card-based design tools to promote UD can be improved by higher levels of detail and instructional and clear guidelines. In 31 transcribed interviews 13 strategies were categorized and identified. These are translated into method cards which are intended for use with practitioners in interaction design and to provide them with the necessary knowledge to implement UD strategies. Tentative user feedback indicates cards require A) Cards should focus on creative qualities over process issues, B) Conceptual qualities should be less obvious, C) Methodological cards should require guidelines or examples, D) Visuals should correlate or clarify concepts E) Method cards should have a clear sequence of steps for implementation. Future research should investigate in more depth how these specific method cards work in real life practice. Through an exploratory, iterative research approach this thesis shows how empirical data can be used to inform design decisions in order to support practitioners. This research was able to identify strategies that support UD, translate these into IxD tools, and document perceived usefulness of such tools.

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Appendix A: Hjarnes and Begnum (2018, awaiting print)

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Challenges in Agile Universal Design of ICT

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Abstract

Universal design (UD) of ICT is about creating solutions that are usable and accessible for as many end-users as possible. Currently, agile development is a common approach in ICT-projects. This article investigates the challenges for ensuing UD in agile ICT-projects. We propose the term «agile universal design» (AUD) to denote UD in agile ICT-projects. Through a scoping review, we find that traditional user-centered and quality control activities may be seen as disruptive in the agile process. On the other hand, promotion of stakeholders and user involvement throughout the development process and in all phases fit well with UD approaches. Seven practical AUD challenges are identified and point to the fact that securing high quality usability aspects for users with a diverse set of needs require more than limited early attention followed by mere sporadic user focus. We find main AUD issues to be: a) capturing, communicating, keeping track of and quality assure requirements from stakeholders and users in the process towards developing a final solution, b) balance time spent on user-involved activities with development activities. The article discusses the challenges and the need for more research on AUD methodology.

Keywords: Agile, User-Centered, Universal Design, ICT-projects, Best-Practice

Introduction

The focus on universal design (UD) has increased steadily over the last decades. In Norway UD regulations enacted in July 2014 (BLD 2017; KMD, 2013), state all new ICT-solutions (including most apps) targeted to the public must adhere to a minimum accessibility level. As of 2021, all new ICT-solutions must also be universally designed. As a result, companies have been required to alter their practices, integrating UD in ICT design and development. There is ongoing industry and research focus on integrating user-centered design (UCD) approaches into agile development – suggesting user-centered agile (UCA) approaches (Miller, 2005; Sy, 2007; Beyer, 2010; Silva da Silva, Martin, Maurer & Silviera, 2011). However less focus is granted to extending the user-centered focus to UD within an agile framework – exploring AUD (agile UD). Agile and agile-like development approaches are currently common in ICT-projects. This article focuses on identifying challenges and current practices for AUD, in order to pave the way for future research. Our overall research question is: *What are key challenges for ensuring UD in UCA projects?*

Background

The word «agile» is often applied to a development process which follows a certain set of practices, usually including face to face communication, iterative feedback loops and incremental delivery of software. Agile developments have a set of beliefs which underline such practices, focusing on achieving efficiency and reduced waste (Preece, Sharp & Rogers, 2015). Scrum and Extreme Programming (XP) are two of the most popular agile models, where software is delivered after 1-4 week long «Sprint» increments (Scrum Alliance, 2013).

Human-centered (also called user-centered) design is defined as anchored in user needs, with user focus in all phases of design and development (ISO, 2010). Begnum and Thorkildsen (2017) indicate methodological differences agile versus non-agile projects implementing UCD. UCA projects have less focus on methods directed at understanding needs and contexts of use, and more focus on interface design, while non-agile UCD projects value higher levels of user involvement earlier. UCA projects tend to prioritize implementing features over early user-involvement and understanding (Silva da Silva, Martin, Maurer & Silviera, 2011). This can result in processes which to a lesser degree consider user needs, and where direct user contact only occur in the evaluation phase. UCD teams often directly involve users and stakeholders – workshops are frequent in design and insight phases – and use a larger variety of methods (Begnum & Thorkildsen, 2017).

The 2005 Disability Act defines UD of ICT as the design of any services or systems created through an electronics-based process so that they may be used, accessed and understood to the greatest extent (NDA, 2017). The Norwegian Agency for Public Management and eGovernment (DIFI) defines the minimum criteria to be AA conformance of WCAG 2.0, with a few guideline exceptions (DIFI, 2017). Beyond adhering to regulations and requirements, the focus of UD of ICT is on achieving usable and accessible solutions. Harder & Begnum (2016) conducted an interview study with designers and developers on projects having recognized success with UD in ICT. Factors that promote and obstruct UD were identified, mainly related to anchoring an understanding of and culture for UD on organizational levels merging UX and UD work and having the time for these activities, early and iterative quality assurance (QA) and user testing, and team collaboration. Nine of the thirteen projects followed a fully agile development, while two implemented agile elements into existing processes.

Research Approach

A scoping review is undertaken to explore and refine the research question**.** A scoping review allows the researcher to form and synthesize current knowledge on a specific topic. The goal is to provide the opportunity to identifying gaps in current knowledge and pave the way for future research; using the scoping review as a starting point for a larger research effort (Jesson, Matheson & Lacey, 2011). Unlike traditional literature reviews, it doesn't necessary rely on the newest published research. Instead the search may be based on two or three key articles to provide a set of theories. This scoping review is based on Begnum & Thorkildsen (2017) and Harder and Begnum (2016). Both articles indicate that anchoring a user focus in early in the project affect UD and UCD. Collaboration between designers and developers also seems key, as communication influences efficiency of user research work and strengthens a common focus. Based on Begnum and Harder (2016), the assumption is that successful UD requires high-contact user-centeredness, i.e. methods that involve users directly. As Begnum and Thorkildsen (2017) found indications that UCA processes may be «less» user-centered than non-agile user-centered processes, it is an interesting perspective to evaluate the «user-centeredness» of AUD. Based on the analysis of previous work, the following sub-questions guided the scoping review: Which practices emerge to ensure UD in agile ICT-projects? How does AUD practice compare to identified promoting factors for UD success in ICT-projects?

1.1 Searching, Screening and Analyzing Literature

Agile methodology search terms are derived from Begnum and Thorkildsen (2017) who suggest that “agile” covers “lean”, “scrum” and “extreme programming”. Further, “sprint” is considered a central part of any agile process and included as search term. “Universal Usability”, “Inclusive Design”, “Design for All”, “User-Sensitive Inclusive Design” and “Ability-Based Design” are all overlapping terms for UD (Harder & Begnum, 2016). We chose to focus on actively and broadly used terms, thus omitting “universal usability”, “user-sensitive inclusive design” and “ability-based design”. Thus, our initial search string was: (scrum OR "extreme programming" OR sprint OR agile OR lean) AND ("universal design"OR "inclusive design" OR "design-for-all").

Table 1. Final Search Results.

Database	Search String	Returned	Included
IEEE	("agile development" OR "agile methodology" OR "agile process" OR scrum OR "extreme programming" OR sprint) AND ("universal design" OR "inclusive design" OR "design for all")	21	3
Springer-Link	"universal design" OR "inclusive design" OR design+for+all OR e-inclusion OR disability OR impairment OR accessibility AND "agile development" OR "agile methodology" OR "agile process" OR scrum OR "extreme programming" OR sprint NOT medicine OR obesity OR "body composition" OR geriatric OR cardiology OR "lean mass" AND “computer science”	101	8
ACM	"universal design" OR "inclusive design" OR design+for+all OR e-inclusion OR disability OR impairment OR accessibility AND "agile development" OR "agile methodology" OR "agile process" OR scrum OR "extreme programming" OR sprint OR lean NOT medicine OR obesity OR "body composition" OR geriatric OR cardiology OR "lean mass"	42	3
Total		**191**	**14**

Oria is a cross-database search which was our starting point to identify which databases should be included, consequently identifying ACM, IEEE and Springer-Link as relevant. Individual search returned 1 result from ACM, 165 from Springer-Link and 124 from IEEE. However, iteratively adapting the search to the three different databases yielded more precise results, reviewing keywords used in relevant articles returned. For all three databases, the revision (agile OR lean) to ("agile development" OR "agile methodology" OR "agile process") yielded better results. In Springer-Link, the search term “computer science” was added to narrow its broad range of topic, whereas ACM digital library tends to yield very specific results. Both needed a broader set of terms to cover UD; “e-inclusion”, “disability”, “impairment” and” accessibility”. Further, Springer-Link and ACM limit the number of irrelevant medical results through exclusion terms “Obesity”, “body composition”, “geriatric”, “cardiology” and “lean mass”. For IEEE these search terms were distracting Final searches returned 191 results, see Table 1.

The goal was to select 10 to 15 peer-reviewed articles. A combined focus on UD and agile is required for inclusion. Some form of discussion of both topics together, directly or indirectly, was

considered fitting to ensure relevance. In addition, UCD was an inclusion criterion, with involvement of users as per the ISO–standard (ISO, 2010). The articles had to focus on how to include marginalized users or ensure UD. They may target a single group, i.e. people with hearing impairments, as long as findings can be generalized to other groups. 14 articles were included. They are read using the SQ3R approach; a survey, question-based and focused re-reading approach (Jesson, Matheson & Lacey, 2011). We use an open and interpretative analysis approach to iteratively summarize and form emergent theories on topics within AUD.

Findings

Seven issues emerge as important challenges to solve in order to ensure UD in agile projects.

1.2 Requirements are hard to elicit

Involving users with severe disabilities introduces added challenges with regards to needs elicitation and collaborative communication. Guerrero-García et.al. (2017) suggest artifacts and metaphors can be helpful to elicit needs, such as capturing project vision and persona on worksheets to display so that they are constantly visible. This helps the team focus design on the variety of different users with different needs, providing functionality specific to users of different abilities. Together with scenarios they help communicate needs of users that cannot be present in a cycle or phase (Gkatzidou, Pearson, Green & Perrin, 2011). Among stakeholders scenarios and personas may be particularly useful to elicit requirements and user needs, as these can help contextualize the problems. User and task-focused representations are preferred to traditional software developments such as use cases (Prior et. al. 2013). In some cases, a user advocate can improve communication between users and agile team (Gkatzidou, Pearson, Green & Perrin, 2011; Prior, Waller, Black & Kroll, 2013). Needs can be elicited from experts if users are unavailable.. When eliciting needs with experts it is important to validate these needs later with target users (Røssvoll & Fuglerud, 2013).

1.3 Insights are hard to keep track of

As requirements emerge they must hold a manageable form, and a challenge is keeping track of insights iteratively gathered from user-centered activities during the agile process; especially insights related to needs and context of use (Guerrero-García, González-Calleros & González, 2017). Agile prefers “working software” to “comprehensive documentation” (Agilemanifesto.org 2001), and advocates documentation should be kept to a minimum. Modifying the agile rules too much can create production blocks. But as good communication is found to be a prerequisite for successful UD, especially in communication between developers and designers, there is a need for certain documentation to be present. A common language among users, stakeholders and team members is presented as a prerequisite for eliciting needs and co-design in agile development (Raike et. al., 2008; Memmel, Reiterer & Holzinger, 2007). Use of UCD techniques combined with efforts of information and documentation sharing is promoted. Several propose to include experts and other stakeholders in user-centered work to assure data collected from end-users are not missed (Guerrero-García, González-Calleros & González, 2017; Røssvoll & Fuglerud, 2013; Gonzalez et. al., 2013). Røssvoll & Fuglerud suggest gathering requirements in one document make them easier to manage (2013). Some researchers suggest additional sprints or time dedicated to work on documentation (Williams et. al., 2015; Guerrero-García, González-Calleros & González, 2017). In addition to being discussion pieces, hi-fi prototypes can thus save valuable resources in the team (Memmel, Reiterer & Holzinger, 2007).

1.4 Limited User Requirement Oversight

The cycles and iterations of an agile process compensate for limited early insights as opposed to more traditional waterfall-like development models (Kaneyama, Goto & Nishino, 2015). As agile processes are adaptive to changing requirements, they are viewed as well suited to UD and collaboration with users (Williams et. al., 2015; Raike et. al., 2008). Nonetheless, one of the main problems addressed is how changing requirements affect the development process of inclusive systems. It is widely recognized that initial sprints should include methods to learn about users and contexts of use (Prior et. al., 2013, Kaneyama, Goto & Nishino, 2015; Scandurra, Holgersson, Lind & Myreteg, 2013; Guerrero-García, González-Calleros & González, 2017). Techniques such as observation of users' daily activities, document analysis and interviews with users and stakeholders are among those recommended. Further, as full up-front user requirement oversight is not likely, continuous user involvement and emergent requirement discovery should extend a shorter up-front requirements elicitation phase (Raike et. al., 2008). Reaching a common and correct understanding of needs is necessary to achieve accessibility and usability (Gonzalez et. al., 2013; Scandurra, Holgersson, Lind & Myreteg, 2013; Memmel, Reiterer & Holzinger, 2007). The need for continuous close collaboration with stakeholders, experts and (disabled) users seem to increase in AUD compared to UCA.

1.5 User Involvement Takes Time

User-involved approaches are widespread in the scoped literature, with stakeholders and users appearing as frequent collaborators for requirements elicitation and design. To integrating UD with agile development, user needs are identified prior to and during development, ensuring usable software is being developed (Memmel, Reiterer & Holzinger, 2007). User-involvement in certain activities is presented as imperative to success, such as evaluation (Scandurra, Holgerssob, Lind & Myreteg, 2013). However, it may be time-consuming and costly to do a user-centered project, and even more so focused on UD and involvement of marginalized user groups. Researchers imply agile processes don't inherently support UCD work, and that user involvement may delay or alter the agile process – necessitating an integrated approach (Gkatzidou et.al., 2011). Gkatzidou et.al. (2011) and Williams et.al. (2015) find that methods such as workshops result in a lot of design alternatives and design feedback, and working with this data can slow down development. Bonacin, Baranauskas and Rodrigues (2009) highlight that adapting user-centered techniques to an agile schedule is challenging as developers struggle to balance tasks when also required to participate in non-coding tasks.

1.6 Quality Assurance Takes Time

Based on the elusive nature of requirements related to eliciting, keep track of and communicating, QA is also challenged. User needs must be evaluated continuously in inclusive design processes (Lucke & Castro, 2016). Failure is typically recognized later in the process when users evaluate the solution, resulting in added cost (Gkatzidou, Pearson, Green & Perrin, 2011). However, assessing accessibility early can reduce cost, which usually accumulates with late assessments (Reichling & Cherfi, 2013; Scandurra, Holgersson, Lind & Myreteg, 2013). It is recommended that end users test prototypes early and throughout the process (Røssvoll & Fuglerud, 2013). Williams et. al. (2015) suggest testing with at least hearing-impaired, visually impaired and cognitively impaired users. Traditional user tests take time to prepare and carry out. Testing in each cycle can add time delays (Røssvoll & Fuglerud, 2013). As user-involved QA takes time and effort, and frequent user-evaluations slows down the process, getting the time and money to adequate ensure UD seems a major AUD challenge. Efforts are thus made to adapt or develop new evaluation techniques tailored to agile processes (Memmel, Reiterer and Holzinger, 2007). Bonacin, Baranauskas and Rodrigues

(2009) model evaluation workshops at the end of each development cycle. Williams et.al. (2015) run user-trials between sprints instead of traditional post-sprint meetings. Other researchers prefer informal expert assessments as means of evaluation reducing the need for user trials and detect major usability issues prior to testing with end-users (Kaneyama, Goto & Nishino, 2015; Røssvoll & Fuglerud, 2013; Gonzalez et. al., 2013).. However, expert evaluations must also be validated with user tests (Røssvoll & Fuglerud, 2013).

1.7 No AUD Process Model to Guide

Custom process models can be developed by teams with expert knowledge of development methodology, and adapted to specific design situations (Bonacin, Baranauskas & Rodrigues, 2009). However, as of today there is no general AUD process model available, and projects must design AUD development processes on their own. In Bonacin, Baranauskas and Rodrigues (2009) model, user involved design is in focus. Users can contribute with experiences and ideas for conceptualization and design, and later evaluate. Gkatzidou et.al. (2011) in their UIDM model (users, innovators, developers and modelers) ensure stakeholders are included in every step of planning, implementation and evaluation.

1.8 Lacking Team Effort Undermines Efforts

In order to achieve UD, a solution must have "usable accessibility" as well as "technical accessibility" (Reichling & Cherfi, 2013; Røssvoll & Fuglerud, 2013). To ensure inclusiveness and usability for all, it is important to shift from focus on implementing a quantity of features, to value UD and UX feature qualities. Having the team knowledge to achieve "technical accessibility" is further essential. It can be difficult for inexperienced developers to interpret guidelines on their own and translate them into action (Law & McKay, 2007). Further, negative attitudes among team members can undermine efforts to ensure UD. The team should ideally also have enough knowledge to educate customers on best practice.

Discussion

Research efforts that seek to achieve inclusive or UD of ICT solutions consider user-centered methods useful (Gonzalez, et.al., 2013; Bonacin, Baranauskas & Rodrigues, 2009; Røssvoll & Fuglerud, 2013). Begnum and Thorkildsen (2017) indicate that agile UCD processes are less user-centered than non-agile UCD processes, but this does not hold true for the literature-based AUD practices. Instead, the AUD processes largely favor collaborative and user-involved design methodologies. A lot of focus is given to user-involved methodology, including stakeholders, experts and end-users. The literature suggest a high degree of user-centeredness in agile processes ensure UD. These activities may be time-consuming but are believed to save time and cost later on. Research however implies that there are difficulties adapting these methods to the agile process. Issues arise when UCD work is required to be done in a timely fashion (Bonacin, Baranauskas & Rodrigues, 2009). This is particularly true for elicitation and design phases, where a proper understanding of user needs anchors the process. A general impression is that experts and stakeholders are perhaps involved as "stand-ins" to a much larger extent than what is needed in comparison to direct end-user focus.

There are also issues related to communication and documentation in all parts of the process. A poor user needs understanding can be a product of a lack of communication between team members, lack of triangulation of research methods or inclusion of experts or stakeholders. It is as such challenging to capture, communicate and quality assure requirements, ideas and insights from stakeholders and users with diverse abilities and disabilities. Comparing the discussion in scoped

literature to Harder and Begnum (2016) highlights the need for knowledge among team members of agile processes and UCD techniques. Members need to understand UD values and the proper usability engineering methods to adapt these to development processes that fit the specific context and users.

Begnum and Thorkildsen (2017) confirm prototypes and scenarios are used to facilitate design discussions. A number of articles deal with how to avoid added cost of doing UD, usability and user-centred work in agile projects. However, there appears to be few attempts to adapt design methods to be more agile. There is more focus on adapting the agile processes to make room for the UCD methods and techniques within the cycles of development, and some attention is given to making user evaluation more efficient.

User testing every cycle is experienced as cumbersome and costly, while too much expert review without user feedback risks less usable and accessible solutions. Expert evaluation is a common method used in development cycles, and is considered efficient and timesaving. A general practice seems to be that experts and stakeholders test the solution before it reaches end-users, allowing the team to fix obvious usability and accessibility issues and as such save resources. It's recommended that evaluation work start as early as possible to avoid increasing cost. A common recommendation is having evaluation work run one sprint ahead of development work. There seems to be a need for more research on making quality assessment methods more fitting for AUD, for example increased re-usability of design artifacts.

When comparing best practice recommendations to Harder and Begnum (2016), we see similarities in the key factors promoting successful UD. Most notably is the emphasis on accessibility and UD from the very start and throughout the process, with the inclusion of external and internal experts. Also mutually recognized is the importance QA and interdisciplinary cooperation based on a common understanding of UD. Including developers as part of user-testing first hand with disabled users is explicitly mentioned at least once, while most focused on including the entire team. While Harder and Begnum (2016) find that UD should be included in all phases, the AUD literature is less explicit about this and is focused on including user-centered and participatory methodology in all phases. What was not emerging from the AUD literature was the importance of an UD culture within organizations. This could be due to researchers working independently on developing solutions and not being part of an organization. However, the AUD literature is concerned with minimizing costs between UD and usability work. As such, the importance of ensuring adequate resources are allocated to UD efforts within a real-life project is recognized. This, as well as the need to elicitate real user needs from early phases, seems to be the driving force behind the importance of UD anchored on organizational levels.

Comparing Harder and Begnum (2016) with the AUD literature highlights AUD workflow issues. Some researchers note the agile process is not fully compatible with UCD methodology, calling for more knowledge on how to more efficiently employ UCD methods in agile processes in order to reduce cost (Røssvoll & Fuglerud, 2013). Harder and Begnum (2016) identify tentative promoting and obstructing factors critical to the success of UD. These findings required more work with regards to generalizability, and this also appears to be a common issue within the reviewed literature. Literature on the topic largely reveals prevalence of context-dependent frameworks and models with principles, guidelines and methods that seek to ensure UD of ICT solutions. Røssvoll & Fuglerud (2013) find best-practice recommendations should be adapted to individual projects with care and consideration to the specific situation. This is understandable, as proposed frameworks and models reviewed are adapted to specific problems for a certain user group, as such there is little generalizability.

When comparing our findings to Begnum and Thorkildsen (2017), literature points to a including a wider set of user needs and early, to a larger degree involve end-users in order and iteratively quality ensure UD in agile ICT development. Promotion of stakeholders and user involvement throughout the design and development process is deemed important to ensure UD quality, however how to integrate the recommended activities into the an agile process without delaying or adding to much extra cost is still not clear. Findings indicate the agile processes are suitable to emerging requirements and iterative design efforts, but that high levels of user-involvement and frequent quality control evaluations may be perceived as disruptive to the agile development process. In order to balance the agile rapid speed of development with the necessary degree of user-centered anchoring, trade-offs must be made. Real-life AUD process issues are relevant for future research efforts. There seems to be a large focus on how iterations and sprints can be altered to make room for the UCD work, especially in early and late phases of projects. Future AUD models could focus on a set of defined principles important to ensuring the goals, accessibility and usability, as well as agile principles. Such modeling may help ensure a common understanding of accessibility throughout the team as well as guide the process activities and workflow.

Conclusion

This article uses the term AUD to denote UD in agile ICT-projects. A scoping review was undertaken to provide an overview of current AUD challenges, to pave the way for future research. Seven AUD challenges are identified: 1) Requirements are hard to elicit, 2) User-centered insights are hard to keep track of, 3) User requirement oversight is limited, 4) User-centered activities takes time, 5) Quality assurance takes time, 6) AUD process model to guide development is lacking, and 7) Lacking team collaboration undermines UD efforts. Synthesizing the findings, we find key AUD challenges related to a) capturing, communicating, keeping track of and quality assure requirements from stakeholders and users as part of the agile development process, and b) balance time spent on user-involved activities with development activities.. Further AUD research should focus on strategies for continuous needs elicitation and QA, creating a general AUD process model and provide guidance on how and when to merge user-involvement into agile development with minimal team disruption.

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Appendix B: Begnum, Harder and Hjarnes (2018, in review)

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Tool for Ensuring Universal Design: Predict ICT-Project Success through UD3C Critical Criteria Compliance

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This study aims to provide insights into project practices suited to ensure a successful implementation of universal design in the development of Information and Communication Technology (ICT), such as web-based services and applications. Further, we explore how to utilize the identified positive practices to aid projects in assessing their ability to achieve universal design. We apply an interpretive and exploratory research approach, gathering empirical data from 24 projects that have created award-winning ICT-solutions achieving universal design. Through 34 informant interviews we identify 86 characterizing factors grouped into 22 main-categories. These are classified as Societal, Organizational, Processual or Personal factors. Some are promoting universal design, while others are obstructive. Next, we investigate which should be considered Critical Success Criteria (CSC) for universal design. We identify 15 CSC, which we use to iteratively prototype and test a self-assessment tool for ICT-projects; UDC3 - Universal Design Critical Criteria Compliance. The contribution of the paper is three-fold; First, a theoretical contribution on influential factors for securing universal design in ICT, providing practitioners, researchers and politicians with added knowledge. Second, a prototyped project tool with the potential to increase universal design awareness, promote best practices, aid project planning and communication and improve resource allocations. UDC3 predicts the likelihood of universal design success based on scored CSC compliance. Preliminary UDC3 validation and end-user feedback are positive. Third, an approach to measuring universal design quality beyond technical accessibility, and predict the likelihood of achieving universal design in end-results prior to completion.

Keywords: universal design; accessibility; software development process management; designing software; people with disabilities; government technology policy

Responsible Editorial Board Member: Name

1. INTRODUCTION

The American architect Ronald Mace introduced the concept of Universal Design (UD) in the mid-eighties. He said: "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" (Connell et al., 1997; D'souza, 2004). UD has been applied to several fields, where ICT is one of the more recent ones (Røssvoll & Fuglerud, 2013). Mace and a group of architects, product designers, engineers and environmental design researchers compiled seven general principles for UD, emphasizing ergonomics and usability aspects. However, current UD legislations for ICTs are mainly concerned with technical accessibility aspects, rather than usability aspects (Norwegian Ministry of Local Government and Modernisation, 2013).

Researchers agree that accessibility standards and guidelines are valuable tools to ensure UD (Røssvoll & Fuglerud, 2013; Schulz et al., 2014; Bai et al., 2016; Scott, Spyridonis & Ghinea, 2015). However, there is a distinction between technical accessibility (as measurable through guidelines) and universal usability (also called "usable accessibility") in real contexts of use. Technical accessibility is regulated through guidelines and standards, of which the most important for the Norwegian ICT-industry is the Web Content Accessibility Guidelines (WCAG). WCAG was generated with the goal of providing a single shared standard for accessibility (W3C, 2008). The high focus on technical accessibility through WCAG is powerful, but also pose challenges related to universal usability - including making sure key assistive technologies are compatible with the systems being developed.

A distinction between technical and usable accessibility is recommended (Røssvoll & Fuglerud, 2013; Garrido et al. 2013; Schulz et al. 2014; Abascal et al. 2015; Aizpurua, Arrue & Vigo, 2015; Jung et al. 2015). For an ICT-solution to be regarded as universally designed, both technical accessibility and universal usability must be in place - for as many users as possible, to the largest extent possible. The Norwegian government has initiated an ambitious aim for the country to be universally designed by 2025, and a section of the Norwegian legislation for UD is dedicated specifically to ICTs (Anti-Discrimination and Accessibility Act of 2009, Norwegian Ministry of Children and Equality, 2017). Regulations for the Norwegian ICT-industry using WCAG went into force in 2014, stating new ICT-solutions targeted to the general public must be universally designed. Despite efforts at legal, institutional and technical levels, there are still numerous websites and web-based services that are not yet accessible (Chen et al. 2015).

As of 2021, all ICT-solutions, both new and existing, are to be universally designed. As a result, Norwegian companies have been required to alter their practices around the development and design of ICT-solutions, and integrate UD quality in ICT design and development. According to Fuglerud and Sloan (2013) there is a heavy focus on adhering to the regulations and standards set forth by the legislations, and a lack of emphasis on the development process. The fulfillment of regulated guidelines might not be the equivalent of ensuring universally designed and universally usable web sites (Garrido et al. 2013; Røssvoll & Fuglerud, 2013; Schulz et al. 2014; Aizpurua, Arrue & Vigo, 2015; Jung et al. 2015; Abascal et al. 2015). There are limited insights into practices suited to ensure a successful implementation of UD in ICT, where both technical accessibility and universal usability is ensured.

This article sets out to provide more insight into promoting practices by investigating the characteristics of projects achieving UD of ICT. We ask the following research questions:

(i) What are the characterizing factors of ICT-projects that have successfully achieved universal design?

(ii) Which factors should be considered Critical Success Criteria (CSC) for universal design?

(iii) How can the findings be utilized to support projects in universal design planning and management?

Our assumption is that a practical contribution to measuring project-level practices critical for success will provide UD management and planning support in ICT-projects, and help transfer research insights into the practice field. An "ICT-project" is defined as a project dedicated over time to building a new solution or improving on an existing ICT-solution. An ICT-solution may be a partly or fully digitalized service, website, part of a website, software or mobile application. "Practices" are understood as methods, cultures, procedures or processes identified in an ICT-project. "Critical Success Criteria" (CSC) for UD are as such practices deemed critical in order to succeed with the implementation of UD based on the empirical data.

The rest of the paper is organized as follows; in Section 2 we present related research and background for our study. Section 3 outlines our research methodology; including sampling, data collection and our analytical approaches. This is followed by a presentation of results in Section 4; starting with sample comparisons as we extend previous research, moving to re-analyzing the full sample and identifying characterizing factors, determining which of these are critical for success and, finally, utilizing these to prototype a project tool. Section 5 briefly discuss our findings, their limitations and implications. In Section 6, we summarize and conclude.

2. RELATED WORK

There are ongoing efforts to improve knowledge on processual best practices for UD of ICT. Lazar, Goldstein and Taylor (2015) point out a shortcoming in accessibility regulations is they leave out organizational aspects like enforcing the implementation of compliance monitoring and process guidelines. Ensuring compliance to legislations and industry standards in requirement specification is very important, but processual quality control of contextual, usable accessibility can be random despite requirements (Begnum & Foss-Pedersen, 2017).

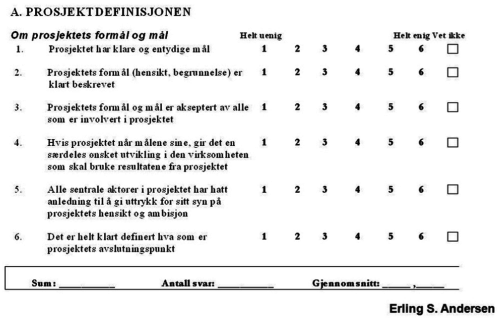
Further, according to Khang and Moe (2008) several researchers have identified that the competence of team

members, as well as the project manager, can be linked to project success. Critical individual competence includes technical, administrative and interpersonal factors (Khang & Moe, 2008). They also find that if the team and project management are not dedicated to project success, the competence level is insignificant, because motivational factors include a clear and common understanding of the project goals and objectives. Harder and Begnum (2016) also emphasize the importance of having a UD focus anchored at management levels, in addition to having the correct competence and personal qualities among team members.

Thus, organizational barriers, competence barriers and awareness barriers are indicated by previous research. Literature recommend the following seven principles for inclusive ICT development: 1) holistic and interdisciplinary teams and/or process, 2) based on user-centered design principles, 3) adopting and applying accessibility standards and guidelines, 4) using an iterative development, 5) focus on users with disabilities, - early and throughout, the entire design process, 6) use of empirical evaluations with various impairments represented and 7) focusing on the entire user experience (Fuglerud & Sloan, 2013; Røssvoll & Fuglerud, 2013; Schulz et al. 2014; Scott, Spyridonis & Ghinea, 2015). Seven tentative UD success factors were indicated from our preliminary study targeting successful ICT-projects in Norway (Harder and Begnum, 2016), coincide well with previous work, including links between organizational dedication, individual competence and project success. These are: 1) Proper resources with a profound understanding of what UD is, accompanied by thorough 2) anchoring and 3) top-level understanding of UD on a business level, which allows for an 4) early and continuous focus throughout the development process, with good 5) team collaboration who are free to do 6) frequent user testing, alongside 7) various methods of internal and external quality assurance. Harder and Begnum (2016) also recommends fostering interdisciplinary collaboration with early and continuous focus on UD, using an iterative process model with frequent quality assurance and user contact.

Defining criteria to measure and indicate a project's success is challenging (Khang & Moe, 2008). Reichling and Cherfi (2013) suggest that in order to manage, measure and implement accessibility during a project, a model should be followed and integrated into the existing process. They propose a method to be used to measure goals early and continuously in the process. Andersen, Dyrhaug and Jessen (2002) suggest using Critical Success Factors (CSF) as indicators of individual aspects that are either absent or present in a project, affecting the overall success or effectiveness of the implementation process; including the team's performance and ability to follow the given time frame and budget.

It is suggested that CSF can be used both to evaluate and predict the overall project success and to provide a view of the current state of projects, so that problems and opportunities may be identified early on. Andersen and Jessen (2000) propose the Project Evaluation Scheme (PEVS) tool for project success evaluation of both the current project status and possible future outcomes. PEVS is a questionnaire with five categories. Each of the categories is divided into two subcategories, and within each of the 10 subcategories there are 6 questions, resulting in a total of 60 critical success factors. In order to measure compliance, the scheme adopts a Likert scale per CSF, ranging from 1 (disagree completely) to 6 (agree completely). Figure 1 shows an excerpt from the PEVS questionnaire.



A. PROSJEKTDEFINISJONEN

Om prosjektets formål og mål	Helt uenig					Helt enig	Vet ikke
1. Prosjektet har klare og entydige mål	1	2	3	4	5	6	☐
2. Prosjektets formål (hensikt, begrunnelse) er klart beskrevet	1	2	3	4	5	6	☐
3. Prosjektets formål og mål er akseptert av alle som er involvert i prosjektet	1	2	3	4	5	6	☐
4. Hvis prosjektet når målene sine, gir det en særdeles ønsket utvikling i den virksomheten som skal bruke resultatene fra prosjektet	1	2	3	4	5	6	☐
5. Alle sentrale aktører i prosjektet har hatt anledning til å gi uttrykk for sitt syn på prosjektets hensikt og ambisjon	1	2	3	4	5	6	☐
6. Det er helt klart definert hva som er prosjektets avslutningspunkt	1	2	3	4	5	6	☐

Sum: _____ Antall svar: _____ Gjennomsnitt: ____,____

Erling S. Andersen

Figure 1. PEVS Questionnaire Excerpt (Slideplayer, 2015).

3. RESEARCH APPROACH

The study is empirical and exploratory; aiming to provide rich insights into how Norwegian ICT-projects have been able to ensure UD. The overall research approach is qualitative, which is appropriate for studies seeking to understand how people interpret their experiences, elicit tacit knowledge and subjective insights into informal, unstructured and complex practices in organizations (Merriam, 2009:p5; Marshall & Rossman, 2011:p91). Empirical data is gathered both from "success projects" that have delivered universally designed ICT-solutions and "failed projects", mainly through semi-structured interviews (see Section 3.1 and Section 3.2).

An exploratory approach enables us to change the course of action throughout the study as new insights make this appropriate (National Ethics committees,

2010). Our research process of data collection, analysis and prototyping has been iterative, with each iteration providing new perspectives, see Figure 2. As such, our study has hermeneutic and interpretive qualities. Since experiences and perspectives are collected from project participants on factors perceived as contributing to, or hindering, successful implementation of UD, the study also has phenomenological traits (Leedy & Ormrod, 2014).

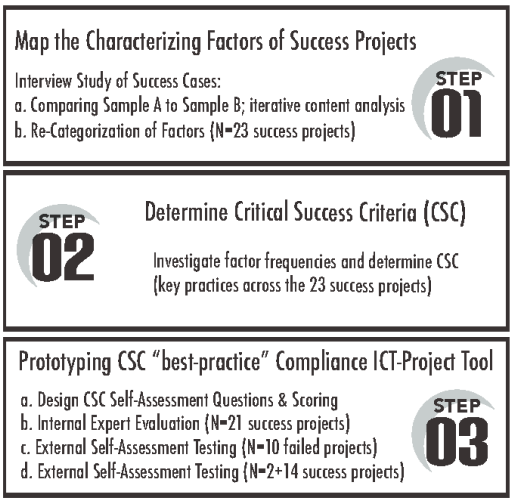


Figure 2. Overall Research Approach

In order to answer the first research questions, we investigate characterizing factors in ICT-projects that have successfully achieved UD in their solutions. We extend a preliminary interview study of success cases, increasing our sample of 13 informants across 12 projects (Sample A) with 18 new informants from 9 new success projects (Sample B). We first check for significant differences in background variables between the samples in order to make sure the samples are comparable.

Next, we compare factors mentioned in the two samples by applying the categories from the preliminary study through a summative (a-priori) coding approach (Hsieh & Shannon, 2005). After sample comparisons, the full sample is re-analyzed applying a directed coding approach in order to improve our understanding of both positive and negative factors affecting the implementation of UD. By increasing the number of informants to a total of 34 informants from 23 projects, the resulting characterizing factor overview holds increased validity, reliability and generalizability. The iterative data analysis is explained in more detail in section 3.3.2.

Our second research focus is on identifying critical practices for achieving UD. This is investigated by looking at the frequency of mentions in the 34 interview transcripts. In order to define a tentative limit as to what constitutes enough mentions for a category to be classified as a critical criteria, the decision was made to regard a characterizing factor as critical if more than two thirds of informants mention it (i.e. more than 22 of the 34 sources) as well as it being mentioned on average more than twice per project (i.e. have more than 46 mentions overall). As many characterizing factors are mentioned repeatedly, this frequency-of-mention threshold was later increased from 46 to 50+ mentions (i.e. 2.2 times per project) in order to identify the most critical factors.

The aim of the third research question is to increase the support of project process planning and control related to UD of ICTs. A question-based form inspired by PEVS is used to design a CSC project self-assessment tool. The rating process against the questions is based on Kitchenham's feature analysis score model design (Kitchenham, 1996a; 1996b; 1997; Begnum, Ribu & Tollefsen, 2008), and adjusted through expert assessment. Compliance to identified CSC is evaluated based on a total score, which then gives you a success prediction. Through iterative testing and refinement against both failed (N=10) and successful (N=24) projects, the ability to predict UD quality in resulting solutions is explored. Its design and usability is also investigated. We name the tool UD3C, an acronym for Universal Design Critical Criteria Compliance. Feedback is collected via e-mail, focus group and phone interviews.

3.1. Sample Selection

3.1.1. "Success" Sample

A prerequisite for participation is direct affiliation with a project linked to the successful development of an ICT-solutions with a high universal design quality. There is currently no clear way of identifying universal design "success" in ICT-solutions. One may argue that download, sales or usage numbers are a measure of success, however such quantitative measures would not prove that a solutions is usable for marginalized users. But there are no usage statistics readily available showing how many marginalized users uses ICT-solutions. One could look at fulfilling regulated guidelines ensuring technical accessibility as a measure of universal design success. However, technical accessibility of is not equivalent to universal design (as mentioned by e.g. Garrido et al. 2013; Røssvoll & Fuglerud, 2013; Schulz et al. 2014; Aizpurua, Arrue & Vigo, 2015; Jung et al. 2015; Abascal et al. 2015).

Universal design is also tied to usability. Since each ICT-solution has a different purpose and characteristics, expert or user testing usually evaluates usable accessibility in prototyped or finalized solutions. Investigating and testing a range of ICT-solutions was discussed for sampling, selected e.g. based on usage statistics, but this approach was deemed inefficient.

Instead, we were able to identify a range of awards given ICT-solutions by independent and reputable juries and organizations, that have evaluated and applauded universal design aspects. In these identified design awards, honorable mentions seems used only when there are several strong candidates to win among the nominees and is thus considered equivalent to being a runner up. Further, we looked at awards given from public authorities. Here, we identified the professional community of the Norwegian Agency for Public Management and eGovernment (DIFI) as a reputable authority that systematically evaluates universal design qualities of Norwegian websites and services. We consider the professional community at DIFI as equivalent of a jury and their ratings as equivalent of a design award/honorable mentions. Based on this, we were able to identify a fitting success sample using the following inclusion criteria and definition: A "success project" is a ICT-project that:

- Wins a design award where universal design is a central criteria., or
- Receives an honorable mention in a design award where universal design is a central criteria.

In order to make the selection criteria more transparent, an overview of identified project awards is presented in Table 1. The time range for the various awards span from 2010 until 2017, with more than half from 2014 or later. The left column summarizes the number of included success projects affiliated with each award. Some projects are affiliated with more than one award. Two awards remains unnamed, due to traceability concerns.

It should be noted that the universal design criteria does differ between the awards. Some awards are mainly focusing on design for all and inclusive aspects, while others include universal design as one of several key criteria. The Innovation Award for Universal Design and The Design for All Award, both distributed by Design and Architecture Norway (DOGA), are specifically targeted towards UD. The latter is co-distributed with The Delta Centre; the national resource centre for accessibility and social inclusion, within the Norwegian Directorate for Children, Youth and Family Affairs. The included ICT-projects that have won these awards have done so in the competition categories of interactive design or interaction design. The Badge for Good Design, also distributed by DOGA, has a broader design award focus and is including UD as a sub-criterion. The Farmand Award has a category with more specific UD criteria, and is targeted towards public services. DIFI also focuses on public services and public websites, and emphasize WCAG specific criteria in their annual rankings and awards. Projects that have received 5 or 6 out of the 6 possible stars in DIFIs Online Quality Evaluations is viewed as successful projects.

Table 1. Awards and Success Project Frequency

Award	Distributor	Projects
Innovation Award for Universal Design	DOGA	5
Design for All Award	DOGA/The Delta Center	3
Badge for Good Design	DOGA	6
Farmand Award	Farmand AS	3
Public Website of the year, Online Quality	DIFI	6
Digital Service of the year, Online Quality	DIFI	1
Unnamed: Young design	-	1
Unnamed: International	-	1

3.1.2. "Failed" Sample

ICT-projects both successful and failed in achieving UD are included when checking the preciseness of the scoring model of UDC3. If the tool works well and have a high validity, successful projects receive high scores while failed projects receive low scores. Validity tells you how well you can measure the findings the study aims to produce. Internal validity is to which degree the research design and the data allows the researcher to draw precise conclusions about cause and effect or other relationships within the data (Leedy & Ormrod, 2014). External validity tells you to which degree you can generalize the findings onto other populations and contexts than those represented in the study; such as other participants, situations or at a different point in time (Lazar, Feng & Hochheiser, 2010). We both want the internal validity (measuring what is meant to be measured) and the external validity (ability to predict success in new projects) to be tested. Our attempt defining and identifying projects that has failed in achieving universally designed ICT-solutions is largely based on media coverage. Due to time limitations and scope restrictions, extensive testing of failed projects have not been performed. Inclusion criteria for participation as an assessor from a "failed project" are:

- The ICT-project has received negative press for their UD efforts by a reputable source on UD quality, and
- The assessor is an interaction designer, designer, developer, project manager or in a similarly position closely related to the UD work in the ICT-project.

Based on these criteria, we sampled projects from a private company that has recently received a negative UD review by Funka. Funka is a reputable company specialized in UD evaluation, and have measured web accessibility in Norway, USA, Canada, Australia and all EU member states on behalf of the European Commission. Using a personal connection, we were able to identify 20 potential assessors within the sampled company. All of these came from completed projects that had not had a UD focus or achieved UD success as defined in this thesis. The sampled company has, to our best knowledge, never received an award, nomination or honorable mention linked to UD or gotten a positive DIFI review or rating. The 20 assessors were approached via email, and asked for participation.

3.2. Data Collection

The interview study draws on audience content; feedback collected, directly or indirectly, from an audience group (Lazar, Feng & Hocheiser, 2010). Semi-structured, in-depth personal interviews are used in order to maintain a solid foundation and framework, exposing the respondents to the same questions and themes, while simultaneously allowing for flexibility and follow-up questions (Rogers, Sharp & Preece, 2011). The data collection approach of the preliminary study (Harder & Begnum, 2016) is repeated, using an interview guide consisting of 21 questions divided on two main sections. The first part concerns personal experiences related to practices for successfully achieving UD in Norwegian ICT projects, and consists of 5 questions. 6 questions map background variables. The second part concerns methodic style and epistemologies, and consists of 10 questions. This study focuses on the first section of the interview guide and the questions concerning UD practices in Norwegian ICT projects, which are largely open-ended.

A total of 30 in-depth personal interviews were conducted (Sample A and Sample B, giving a N=31), as well as a focus group interview (N=3). One of the informants, in Sample A, cancelled the face-to-face interview and opted to fill out and return the interview guide in writing. The averaged duration of an interview was 45 minutes. All interview study participants received information about the study, and gave written consent for participation and for audio recording as supplement to hand-written notes. Recordings were transcribed verbatim. Unless contradictory views are specified during the interview, informants who were interviewed together about the same project are treated as two informants with identical transcripts. The final data set holds interview transcripts from 34 informants, covering 23 ICT-projects. Several informants want the information to be anonymous due to confidentiality agreements in the respective projects. As a consequence, all data is pseudonymized. The study is reported to the Data Protection Official for Research (NSD).

3.2.1. UDC3 Evaluation by E-mail

Data collection from the "failed" sample is completed per email. Upon identifying failed projects, potential assessors were contacted by email and asked about willingness to participate in the study, assessing their projects in retrospect using our self-assessment tool and return these per email along with any comments.

3.2.2. UDC3 Evaluation in Focus Group

A focus group interview with informants from identified success projects not already included in samples A or B is conducted. In addition to using the semi-structured, in-depth personal interview guide, this focus group is also used as part of the UDC3 evaluation. The focus group complete self-assessments using the tool, and the usefulness of the tool is discussed.

3.2.3. UDC3 Evaluation by Phone Interviews

In an e-mail update on the study and its tentative findings, the informants in success samples A and B were asked to participate in tool evaluation using phone interviews. Through face-to-face interviews have the highest response rates (Leedy & Ormrod, 2014), phone interviews are more time-efficient. In our case, relationships with the informants were already established, as all participants in the phone interviews were former informants in the in-depth interview study. The purpose of the phone interviews was UDC3 feedback and score model validity confirmation. A semi-structured interview guide was used to get feedback on the perceived usefulness, including wether participants found any of the questions unclear or difficult to answer. Follow-up questions were used to either clarify or ask more about potential contexts of use.

3.3. Data Analysis

3.3.1. Quantitative Analysis

In order to investigate statistical differences between Sample A and Sample B, the empirical data is converted from semantic to numeric. As most variables are at nominal level, Pearsons Chi-Square is selected to check significance. Quantitative data are also gathered by e-mail, focus group and phone self-assessments to iteratively test the UDC3 scoring model and prediction validity.

3.3.2. Qualitative Data Analysis

A thematic content analysis is performed after converting the audio recordings into text-based media content in the shape of interview transcripts. The goal of qualitative content analysis is recognition of significant themes and categories within a body of content through careful coding and interpretation (Zhang & Wildemuth, 2009). By analyzing the individual cases and comparing them, higher-level patterns can appear (Lazar, Feng & Hochheiser, 2010). The goal is typically to provide insights into particular phenomena, support the development of new theories or validate existing theories (Zhang & Wildemuth, 2009). As a consequence of the overlapping responses to the open-ended questions, the transcripts are analyzed as a continuous text, as opposed to questions consecutively. Our qualitative findings thus consists of recognizing recurring thoughts and concerns among the informants, and we view repetitive tendencies as characterizing factors of success projects.

The Norwegian legislation making UD of ICT mandatory is still fairly new, and the deadline for complying with it is not yet expired. Due to the adolescence of the discipline there are few pre-defined codes in the existing literature. While working on topics without established theories to build coding categories on in advance, emergent coding is an appropriate approach (Lazar, Feng & Hoccheiser, 2010). This is also called conventional content analysis (Hsieh & Shannon, 2005). Emergent coding was therefore the approach utilized in the pre-study of Sample A. Coding categories are derived directly and inductively from text data during the analysis (Yin, 2012), and subsequently structured into a nomenclature; a list of numbered categories that represent all the possible answers to a question (Lazar, Feng & Hoccheiser, 2010). According to Weber an reliability goal in qualitative research is ensuring different persons would code the same text in the same way (Lazar, Feng & Hochheiser, 2010). This is called reproducibility, inter-coder reliability or investigator triangulation. The preliminary study coding was completed separately by two different researchers (utilizing theoretical triangulation with different coder backgrounds and theoretical perspectives) and reached an inter-code reliability of 98 % overlap between a total of 150 promoting codes and 95 % overlap between the 57 obstructive codes (Harder & Begnum, 2016).

As this study seeks to verify findings from Sample A (N=13) by comparing it to Sample B (N=18), the codes identified by Harder and Begnum (2016) are used in a summative content analysis of the 18 new transcripts (Hsieh & Shannon, 2005). This is also called a-priori or deductive coding (Lazar, Feng & Hoccheiser, 2010; Yin, 2012). By using the a-priori coding structure, samples are compared through a frequency analysis of mentions. When Sample A was analyzed in the pre-study, the data was handled manually. As the data load increases with Sample B, the transcripts were imported into the NVivo program for qualitative data analysis. Adding codes and categories (nodes) and informants (cases) into NVivo, linking relevant transcript sections to nodes, offers a more sophisticated data handling less prone to human error. Statistical inference was also used to investigate significant differences between the two samples.

The complete data set of interview transcriptions was re-analyzed using a directed content analysis approach, with preliminary findings guiding initial codes (Hsieh & Shannon, 2005). The directed approach does not use a strict a-priori coding scheme or a fully emergent approach. Instead, a-priori codes and categories are used as a basis while still allowing new codes or categories to emerge. Note that the directed content analysis was iterated; first on N=31 from 21 projects in Sample A and B and later on N= 34 informants across all 23 projects. As NVivo was used, code-classification examinations and improved categorization of codes could be explored relatively easy. Feedback on UD3C usability was merely summarized as common in formative-iterative usability testing.

4. RESULTS

Table 2 overviews the interview sample. Informants 1-13 are from Sample A, 14-31 are from Sample B and 32-34 are from the focus group interview. The sample consists of 16 designers, 14 of whom are interaction designers; 11 developers, both front-end and back-end; and seven informants with other roles, including project management. 15 of the 23 projects are linked to the public sector, while 8 are from the private sector.

The companies that informants represent are categorized as either Private, State or Consultant Agencies. Private agencies are composed of privately owned companies, both profit and non-profit. State agencies consist of organization that is partially or entirely owned and operated by the government. Companies employing experts that are hired out as consultants are categorized as Consultant Agencies. The sample holds 21 informants from consultant agencies (62 %), 9 informants from state agencies (26 %) and 4 informants from private agencies (12 %). The overweigh of consultants in the sample is due to the use of consultants in public sector projects. Consulting informants are linked to their employed workplace even if affiliated with the success of a costumer company.

After increasing the sample size (N) from preliminary findings, we check whether codes and categories remain valid and consistent, or if they need to be altered, combined or renamed to better reflect the extended findings. The next sections present this iterative analysis.

Table 2. Informant Profiles

No	Age	Gender	Role	Company	Project
1	30-39	Female	Functional Designer	Consultant Agency 1	5,11
2	<30	Female	Interaction Designer	Consultant Agency 1	5,11
3	40-49	Male	Interaction Designer	Consultant Agency 2	4,8,9,21
4	30-39	Male	Interaction Designer	Consultant Agency 3	10
5	40-49	Female	Graphic Designer	Consultant Agency 2	4,8,9
6	30-39	Male	Developer	Consultant Agency 4	1,12
7	50-59	Male	Developer	Consultant Agency 2	4,8,9
8	<30	Female	Developer	State Agency 1	1
9	40-49	Male	Web Advisor	State Agency 2	2
10	40-49	Male	Senior UD Advisor	State Agency 1	1
11	30-39	Female	Developer	Private Agency 1	3
12	40-49	Male	Developer	Private Agency 1	3
13	30-39	Male	Interaction Designer	Private Agency 2	6,7
14	30-39	Male	Developer	Consultant Agency 8	15
15	40-49	Female	Project Manager	Consultant Agency 8	15
16	40-49	Male	Creative Director	Consultant Agency 5	16
17	30-39	Male	Interaction Designer	Consultant Agency 5	16
18	30-39	Female	Interaction Designer	Consultant Agency 4	14
19	30-39	Male	Creative Director	Consultant Agency 4	20
20	30-39	Male	Developer	Consultant Agency 9	6
21	30-39	Male	Developer	Consultant Agency 7	2
22	40-49	Female	Interaction Designer	State Agency 4	8
23	40-49	Male	Communication Advisor	State Agency 4	8
24	<30	Female	Developer	Consultant Agency 4	14
25	50-59	Female	Interaction Designer	Consultant Agency 10	13
26	50-59	Female	Interaction Designer	Consultant Agency 10	13
27	30-39	Male	Interaction Designer	Consultant Agency 6	17,18
28	30-39	Female	Graphic/Interaction Des.	State Agency 3	20
29	30-39	Female	Interaction Designer	Consultant Agency 7	19
30	30-39	Female	Interaction Designer	Consultant Agency 7	19
31	30-39	Female	Project Manager	Private Agency 3	13
32	40-49	Female	Developer	State Agency 5	22,23
33	<30	Male	Developer	State Agency 5	22
34	30-39	Female	Interaction Designer	State Agency 5	22

4.1. Comparing Sample A to Sample B

We could not find any relationships between characterizing factors and background variables: gender, age, years of UD experience, self-evaluated UD experience, interest trigger for UD, professional role, type of agency or process approach (agile, hybrid or non-agile). There were no statistically significant differences between the samples related to background variables.

Looking at characterizing factors for the successful projects in Sample A, two overarching categories are identified; **promoting** factors and **obstructive** factors. A promoting factor is a practice identified as helpful for UD, while an obstructive factor negatively affects the ability to ensure UD. In order to validate the preliminary findings, we map Sample B against the coding structure from Sample A: 1) how many informants mention codes, and 2) how many times codes are mentioned.

Results from the sample comparison are presented in Table 3, Table 4, Table 5, Table 6, Table 7, Table 8, Table 9 and Table 10. "Mentions" refers to how many times codes in the category are mentioned across interviews; "Informants" refers to how many informants have mentioned codes in this category and "Percentage" is the percentage of the samples and overall that mention them. "A" refers to Sample A and "B" refers to Sample B, while "N" refers to the total A+B sample (N=31).

In order to facilitate transparency new codes are marked with an asterisk (*) in tables 3, 4, 5, 6, 7, 8, 9 and 10,

while original codes from Sample A is detailed in Harder and Begnum (2017). Minor coding and category changes made based on the expanded sample are detailed in the paragraphs 4.1.1 and 4.1.2.

Table 3. Societal Level Promoting Factors

Category	Short Description	Codes	Mentions	Informants	Percentage
Legislation and Tech. Drivers	Legislation gives priority; Feedback and support from authorities/suppliers	27, 145, 146, 147, 151*, 152*, 154*	A:18 B:41 N:59	A:9 B:14 N:23	A=69% B=78% N=74%

Table 4. Organizational Level Promoting Factors

Category	Short Description	Codes	Mentions	Informants	Percentage
Anchoring	Understanding/awareness in management levels; UD & Usability strategy	2, 6, 10, 11, 41, 45, 69, 71, 77, 79, 80, 81, 82, 83, 84, 90, 91, 102, 138, 153*	A:17 B:107 N:124	A:10 B:18 N:28	A=78% B=100% N=90%
Resources	Human/Economic resources, Available ATs	19, 94, 95, 96, 115	A:28 B:49 N:77	A:11 B:18 N:27	A=85% B=100% N=87%
Focus	Good-practice library; Disabled co-workers; Ensuring UD competence; UX/UD-department or group	1, 18, 20, 28, 48, 49, 64, 76, 78, 86, 89, 109, 133, 143, 149	A:18 B:35 N:53	A:8 B:18 N:26	A=61.5% B=100% N=84%
Reputation	External/Internal visibility & recognition	7, 70, 73, 74, 85, 87, 88, 144	A:12 B:6 N:18	A:3 B:6 N:9	A=23% B=33% N=29%

Table 5. Processual Level Promoting Factors

Category	Short Description	Codes	Mentions	Informants	Percentage
User Focus	Early & frequent user feedback; Continuous low-cost accessibility/usability testing, with disabled users; Prioritizing user needs; Real user feedback	5, 21, 33, 34, 35, 38, 39, 42, 43, 50, 51, 61, 62, 63, 67, 68, 93, 107, 119, 120, 125, 126, 127, 128, 129, 130, 132, 150	A:53 B:78 N:131	A:12 B:18 N:30	A=92% B=100% N=97%
Quality Assurance	Clear UD quality demands; Early quality checks of code, design, content; Milestone controls; Automated validation; Internal & External inspections	9, 22, 23, 26, 52, 53, 56, 116, 117, 118, 121, 122, 123, 124, 134, 135, 136	A:37 B:49 N:86	A:12 B:18 N:30	A=92% B=100% N=97%
UD Focus	Early & Throughout project; Requirement specification; Costumer priority; Design for all, Collaboration	4, 12, 47, 54, 57, 59, 60, 92, 97, 98, 99, 100, 101, 108, 148	A:59 B:76 N:135	A:12 B:17 N:29	A=92% B=94% N=93.5%
Cooperate	Interdisciplinary QA discussions/user testing; Cross-disciplinary full-member co-located teams; Establish roles and dialogue	15, 29, 30, 58, 65, 110, 111, 112, 113, 114	A:37 B:31 N:68	A:11 B:14 N:25	A=85% B=78% N=81%
Simplicity	Simple/Mobile first; Common minimum	37, 104	A:6 B:23 N:29	A:5 B:9 N:14	A=38% B=50% N=45%
Agile	Iterative development, continuous feedback; Flat structure, personal responsibility	24, 25, 36, 46, 72, 103, 105, 106, 131	A:10 B:16 N:26	A:5 B:9 N:14	A=38% B=50% N=45%

Table 6. Personal Level Promoting Factors

Category	Short Description	Codes	Mentions	Informants	Percentage
Personal Qualities	Enthusiasm; Empathy; Innovative	3, 13, 14, 16 17, 31, 32, 44, 75, 137, 139, 140	A:25 B:32 N:57	A:13 B:18 N:31	A=100% B=100% N=100%
Competence	UD Mindset; Experience	8, 40, 55, 66, 142, 143, 141	A:34 B:51 N:85	A:11 B:15 N:26	A:85% B:83% N:84%

Table 7. Societal Level Obstructing Factors

Category	Description	Codes	Mentions	Informants	Percentage
Legislation and Tech. Challenges	Trends, Framework and Law not supporting accessibility	12, 21, 56, 57, 58*, 59*, 60*	A:5 B:20 N:25	A:4 B:9 N:13	A=31% B=50% N=42%

Table 8. Organizational Level Obstructing Factors

Category	Description	Codes	Mentions	Informants	Percentage
Lack of UD Anchoring	Lack of UD understanding; Lack of usability culture; Resistance to UD	6, 8, 10, 11, 18, 20, 24, 28, 29, 31, 42	A:26 B:32 N:58	A:13 B:15 N:28	A=100% B=83% N=90%

Table 9. Processual Level Obstructing Factors

Category	Description	Codes	Mentions	Informants	Percentage
Constraints	Time, Economy, Resources; Lacking competence; Lacking test equipment; User unavailability		A:23 B:71 N:94	A:11 B:18 N:29	A=85% B=100% N=93.5%
Process Issues	Lack of interdisciplinary cooperation in design & tests; Sequential process model with testing and UD at the end of development process	9, 15, 20, 23, 25, 26, 27, 33, 36, 37, 38, 39, 40, 43, 46, 52, 53, 54	A:20 B:31 N:51	A:8 B:15 N:23	A=61.5% B=83% N=74%
Lack of UD Focus	Lack of UD focus and priority; Lack of user focus; Lack of UD QA	2, 17, 30, 32, 44, 45, 48	A:18 B:17 N:35	A:8 B:14 N:22	A=61.5% B=78% N=71%

Table 10. Personal Level Obstructing Factors

Category	Description	Codes	Mentions	Informants	Percentage
Lack of UD Competence	Lack of knowledge and understanding; Lack of interest; Negativity; Inexperience	3, 4, 5, 7, 14, 47, 49	A:23 B:27 N:50	A:9 B:15 N:24	A=69% B=83% N=77%

4.1.1. Promoting Factor Changes

We identify four new promoting factors. Codes 151, 152 and 154 are interpreted as Societal; referring to frameworks (e.g. Apple) supporting UD, how positive media attention make UD more marketable, and the possibilities of new technology to demonstrate UD aspects. The three are added to the category Legislation, triggering a rename to "Legislation and Technical Drivers". Legislative factors are recognized as being Societal factors, and not Organizational. Code 153 is

about understanding UD business value, and is added to the category UD Anchoring. Further, six codes are slightly expanded: 37 on simplification adds content/process; 97 on UD focus adds user insight; 102 linking UD, usability and UX adds service design; 117 on internal quality control adds UD responsibility; 120 on early testing adds checking existing solutions; and 130 on testing with disabled users adds assistive technologies.

4.1.2. Obstructive Factor Changes

Three obstructive codes emerge; 58, 59 and 60 on lacking consequences for legal non-compliance, WCAG standards being too extensive, and lack of UD focus in public acquisitions. All codes are interpreted as belonging to the category Legislation, renamed "Legislation and Technical Challenges" on Societal level. Seven codes are altered: 4 on negative attitudes adds media; 9 on collaboration issues specifies developer/designer issues; 13 on availability for testing adds geographical issues; 33 on cost priority includes quantity of features over quality; 35 on lacking resources adds lack of supportive tools; 53 on graphic design adds UD restraining creativity; and 55 on common sense adds that WCAG not always fit real user needs.

4.2. Re-Categorizing Characterizing Factors

Using NVivo, the extended data set is iteratively re-categorized, first from a dataset of N=31 informants (21 projects, adding Sample B) and later using the full dataset of N=34 (23 projects, adding focus group). Upon completion, an overview is made of 86 characterizing factors from the success projects, visualized in Tables 11 and 14. They are distributed across 4 top categories called "levels"; grouping factors as Societal, Organizational, Processual or Personal. The levels are further split into 22 main-categories with 45 sub-categories, and finally 9 sub-sub-categories.

When conducting the comparative analysis, similar codes from coding researchers were merged into categories but kept as separate codes in order to preserve detail and transparency. This means there were overlapping codes within some categories. With the now directed approach, overlapping nodes (codes) are merged. This makes frequencies more reliable.

4.3. Determining Critical Success Criteria

In order to be as specific as possible, a CSC is determined on the lowest possible factor category level reaching the threshold (see Section 3). If a sub-sub.category reaches the threshold, this is a CSC. If not and the sub-category fulfills the threshold, the sub-category is a CSC, etc. As the category labeling indicates, promoting and obstructing factors seems connected. Obstructing factors may be mainly a lack of promoting factors. Based on this, a practice is considered CSC if either obstructive or promoting factors reaches the threshold. We find 15 CSC:

Societal level:

(i) Legislative Support

Organizational level:

(ii) Awareness (in category "UD Anchoring")

(iii) Priority (in category "UD Anchoring")

(iv) Competence building (in "UD Strategy")

Processual level:

(v) Requirements Spec (in "Early & Clear Focus")

(vi) Needs Integration (in "UD/UX Integration")

(vii) Continuous Focus (in "UD/UX Integration")

(viii) Team Collaboration (in "Process Qualities")

(ix) User Testing (in "Quality Control")

(x) Internal (in "Quality Control")

(xi) Time&Budget (in "Resources"/"Lack of Resources")

(xii) Equipment&Human Resources ("Lack of Resources")

Personal level:

(xiii) DfA Mindset ("Competence"/"Lack of Competence")

(xiv) Interested (in the category "Personal Qualities")

(xv) Enthusiastic (in "Personal Qualities")

Legislative Support is the only critical Societal factor. On Organization level a positive versus a negative culture towards UD is impacting the projects, with CSC: anchored UD **Awareness** and **Priority**, and strategic **Competence building**. Processual CSC are tied to project management: specifying UD needs in **Requirements**, enough **Resources** (time, money, people and equipment), **Quality Control** with frequent **Internal** inspections and **User Testing**, and UD and UX **Needs Integration** in **UD/UX-work**, ensuring a **Continuous Focus** on end-users.

In addition, cross-disciplinary **Team Collaboration** is critical for project success. On a Personal level, the data indicates it's critical that at least one person on the project team is **Enthusiastic** about UD, and that team members are **Interested** in learning and applying a **DfA Mindset**.

Table 11. Characterizing Factors (Mentions:N), + Promoting - Obstructing

	Main-Category	Sub-Category	Sub-Sub-Category
Societal	+ Legislative Support (23:34) - Legislative Issues (7:34)	+ Legal Consequences (21:34) + Ensured Priority (15:34) + Supporting Tools (4:34) - Complexity (7:34) - Lack of Consequence (2:34)	
	+ Positive Media (4:34) - Negative Media (4:34)		
	+ Technical Drivers (7:34) - Technical Challenges (7:34)	+ Framework (6:34) + New Technology (1:34) - Framework (4:34) - New Technology (3:34)	
Organizational	+ UD Anchoring (32:34) - UD Resistance (32:34)	+ Priority (30:34) + Awareness (27:34) - Ignorance (39:34) - Indifference (24:34)	
	+ UD Strategy (27:34)	+ Build Competence (24:34) + Expert Group (15:34) + Reputation (11:34) + Visibility (11:34) + Disabled Employees (10:34) + Best-PracticeLibrary (10:34)	
Processual	- Lack Resources (34:34) + Resources (27:34)	- Lack Time & Budget (34:34) - Lack Equipment&HR (25:34) + Time&Budget (23:34) - Equipment&HR (18:34)	
	+ Quality Control (33:34)	+ User Testing (33:34)	+ Real (27:34) + Direct (23:34) + Early (23:34) + Frequent (23:34) + Guerrilla (6:34)
		+ Internal (29:34)	+ UX Inspection (21:34) + Code Inspection (19:34) + UD Checkpoints (19:34) + Code Validation (13:34)
	+ UD/UX Integration (33:34) - UD Separation (16:34)	+ Needs Integration (29:34) + Continuous Focus (25:34) + Simplicity (13:34)	
	+ Process Qualities (28:34) - Process Issues (22:34)	+ Team Collaboration (28:34) + Iterative & Flexible (24:34) - Collaboration Issues (14:34) - Inflexible Process (12:34)	
	+ Early & Clear Focus (25:34) - Late & Weak Focus (11:34)	+ UD Requirements (25:34)	

4.4. Utilizing Findings: Project Compliance

We prototype a project evaluation tool based on PEVS to explore the measurability of the CSC. The assumed target user was a project manager, with secondary user groups project owners and project team participants such as designers and developers. Figure 3 shows the first draft in the upper left corner, consisting of seven questions with a Likert scale of 0-6 points per question. Some CSC are split across several questions, and others are combined, in order to make sense to the end-user. Through a collaborative design process, revisions increased the question specificity related to the CSC content.

The iterative prototyping process has four key evaluation points; 1) expert inspections to design UDC3 and create a scoring model based on success sample, 2) failed sample self-assessment to check scoring model validity and usability check, 3) focus group interview and self-assessments to check scoring model, usability and usefulness, and 4) phone interviews and self-assessments to check UDC3 scoring model, usability and usefulness as self-assessment tool.

Further, the predictability of a Critical Criteria Compliance (C3) score on project success is investigated. The second and third versions of simplified the scoring system based on a feature analysis approach, in order to explore the predictiveness based on scores from the question-based CSC compliance. The second version had 10 questions, where 7 are scored 0-2, while three bonus questions give an additional point each if fulfilled. In the third version, the questions were altered to better measure Quality Control CSC. The third version have 11 questions, 4 of them being bonus questions. The untested score model could as such give a minimum of 0 points and a maximum of 18 points to a project.

4.4.1. Internal Expert Assessment Testing

Internal testing of UDC3 validity is first done through expert assessments, evaluating the score model against the codes the 31 interview transcripts from Sample A and B. The initial score model used (third UDC3 version) gave total points from 9 to 17, with a mean of 13.5. The 21 projects could not always be assessed separately, as some informants had participated in several success projects. As Table 12 shows, we then refer to combined project experiences. All success cases should produce high scores.

To provide a higher success prediction accuracy, we adjusted the score model based on transcripts to increase scores. Points are tabled across questions, revealing that bonus question Ba (measuring CSC on Competence building as part of an organizations UD strategy) seems less important than the other bonus questions. As this question is directly based on a CSC the decision was still made to keep it.

Table 12. Initial Internal Expert Score Model

Project	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Ba	Bb	Bc	Bd	Score
1	2	2	1	1	1	2	2	1	1	1	0	14
2	2	2	2	2	2	1	1	0	1	1	1	15
3	1	0	2	1	1	1	2	1	1	1	1	12
4,8,9,21	1	1	1	2	2	1	2	0	1	1	1	13
5,11	1	2	1	2	1	2	2	0	1	1	1	14
6	1	0	0	2	1	2	1	0	1	1	0	9
6,7	0	0	0	2	2	2	2	0	1	1	0	10
8	1	1	2	1	1	2	1	0	1	1	0	11
10	1	2	0	1	2	2	1	0	1	1	1	12
1,12	1	2	2	2	2	2	2	1	1	1	1	17
13	2	0	2	2	2	1	1	0	1	1	1	13
14	2	1	2	2	2	2	1	1	1	1	1	16
15	2	2	1	1	2	2	2	1	1	0	1	15
16	2	0	2	1	2	2	2	0	1	1	1	14
17,18	2	1	2	1	2	2	1	1	1	0	1	14
19	1	2	1	2	2	1	2	1	1	0	1	14
20	2	2	2	2	2	2	1	0	1	1	1	16
Average	*1.4*	*1.2*	*1.4*	*1.6*	*1.7*	*1.7*	*1.5*	*.4*	*1*	*.8*	*.8*	*13.5*

Table 13. Final Internal Expert Score Model

Project	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Ba	Bb	Bc	Bd	Score
1	2	2	1	1	1	2	2	1	1	1	0	14
2	2	2	2	2	2	1	1	0	1	1	1	15
3	1	2	2	1	1	1	2	1	0	1	1	13
4,8,9,21	1	2	1	2	2	1	2	0	1	1	1	14
5,11	1	2	1	2	1	2	2	0	1	1	1	14
6,7	1	2	0	2	2	2	2	0	0	1	0	12
8	1	2	2	1	1	2	1	0	1	1	0	12
10	1	2	0	1	2	2	1	0	1	1	1	12
1,12	1	2	2	2	2	2	2	1	1	1	1	17
13	2	2	2	2	2	1	1	0	0	1	1	14
14	2	2	2	2	2	2	1	1	1	1	1	17
15	2	2	1	1	2	2	2	1	1	0	1	15
16	2	2	2	1	2	2	2	0	0	1	1	15
17,18	2	2	2	1	2	2	1	1	1	0	1	15
19	1	2	1	2	2	1	2	1	1	0	1	14
20	2	2	2	2	2	2	1	0	1	1	1	16
Average	*1.5*	*2*	*1.4*	*1.7*	*1.8*	*1.8*	*1.6*	*.4*	*.8*	*.9*	*.8*	*14.3*

In order to check impact on overall scores Question Q2 (on Requirements specification including UD) is the main question providing the lowest score, and is switched with the highest scoring bonus question, Bb (measuring personal Interest and Enthusiasm). The next iteration of internal expert assessment incorporating these changes increases the mean to 14.3, with scores ranging from 12 to 17 (see Table 13).

Table 14. Characterizing Factors (Mentions:N), + Promoting - Obstructing

	Main-Category	Sub-Category	Sub-Sub-Category
Personal	+Competence (29:34)	+DfA Mindset (27:34)	
		+Experience (18:34)	
	-Lack Competence (24:34)	-Lack Mindset (20:34)	
		-Inexperience (6:34)	
	+Personal Qualities (29:34)	+Enthusiastic (25:34)	
		+Interested (25:34)	
		+Empathic (15:34)	
		+Teachable (13:34)	
		+Innovative (10:34)	
	-Lack Personal Qualities (18:34)	-Uninterested (13:34)	
		-Negative (9:34)	

Based on improved scores, three fairly equally sized prediction levels is proposed: 0-5 points to indicate a project which "is likely to struggle to achieve universal design", if the score is 6-11 points this indicate a project with uncertain success/fail predictions, and from 12-18 to indicate a project which is "expected to achieve excellent universal design quality".

The final tool design (UDC3 version 4 and forward) contains the following questions: Question 1 measures the CSC organizational anchored UD 2) Awareness and 3) Priority. Question 2 measures the CSC personal qualities 14) Interest and 15) Enthusiasm for UD. Question 3 measures processual CSC 11) Time & Budget and 12) Equipment & Human resources. Question 4 measures the personal CSC 13) DfA Mindset while generally asking for team UD competence. Question 5 covers the processual CSC on UD and UX 6) Needs Integration and 7) Continuous Focus. Question 6 measures the UD quality control CSC 10) Internal UD evaluations (such as code inspections and validations, UD checkpoints and UX inspections) and 9) User Testing (such as real, frequent, early and direct user feedback). Question 7 covers the processual CSC cross-disciplinary 8) Team Collaboration. Bonus points are added for a) the strategic organizational CSC 4) Competence building, b) the CSC UD in 5) Requirement specification, and in addition c) the non-CSC promoting factor Iterative & Flexible process and d) the non-CSC promoting factor External UD Quality Evaluation.

4.4.2. External Self-Assessment from Failed Cases

Expert assessments are preliminary investigations into the accuracy of the UDC3 score model, as they are performed by a researcher against gathered data they are not real-life self-assessment tests. As the second evaluation step, UDC3 is tested by end-users from failed projects. The aim is to check the score model, and the understandability of the questions and the design.Ideally, all projects in the failed sample should get between 0 and 5 points.

Table 15. Failed Sample Scores

Project	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Ba	Bb	Bc	Bd	Score
A	1	1	0	1	0	1	2	0	0	1	0	6
B	0	2	0	0	0	0	2	0	1	0	0	5
C	1	1	0	1	0	0	1	0	0	0	0	4
D	0	2	0	1	0	0	1	0	0	0	0	4
D	0	1	1	1	0	0	2	0	0	0	0	5
E	1	2	1	2	2	0	2	0	1	0	0	11
F	0	0	0	1	0	0	1	0	0	0	0	2
G	1	2	0	1	0	1	2	0	0	1	0	8
G	0	2	0	1	0	0	2	0	0	0	0	5
H	1	2	0	0	0	0	2	0	0	0	0	5
I	1	0	0	0	0	0	2	0	0	0	0	3
J	1	2	0	1	1	0	0	0	0	0	0	5
Average.	*.6*	*1.4*	*.2*	*.8*	*.3*	*.2*	*1.6*	*0*	*.2*	*.2*	*0*	*5.25*

Table 15 presents the scores. The project average is 5.25 points. Three projects received a total score in the 6-11 points group, and nine projects are in the 0-5 group. It seems questions 2 and 7 (reflecting CSC about personal qualities and team collaboration) may not be the strongest fail predictors. Assessors of the same projects largely end up with similar scores. Project D receives 4 and 5 points respectively, even if some of the questions have a one-points difference. Project G has identical scores on eight questions, but ends at 5 versus 8 points as one of the assessors gives a one-point (partial fulfillment) on three of the questions while the other gives 0. Overall, the consistently much lower scores in this sample compared to the success cases tentatively confirms our score model.

12 of the 20 approached assessors responded, per e-mail. All responses were mirrored back to the assessors, in order

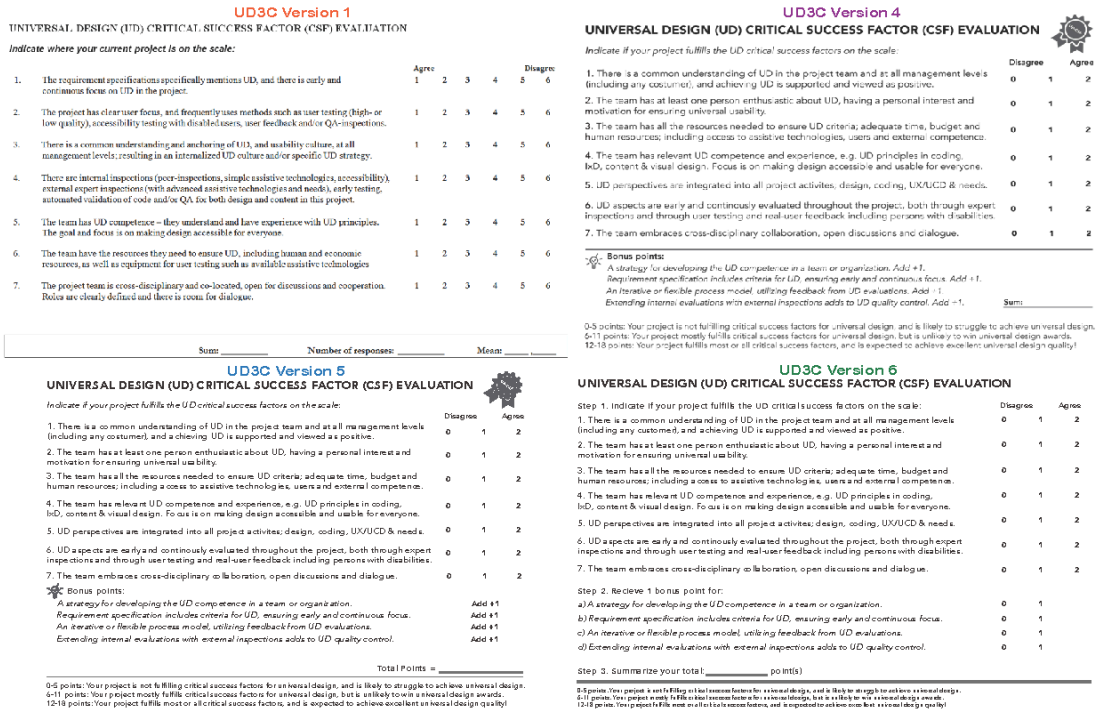


Figure 3. UD3C Tool Design Iterations: Overview of Tested Versions

to disclose possible misunderstandings and to ensure our calculations are correct. Through this mirroring process, it became clear that several assessors had overlooked the bonus questions. One informant had misinterpreted the summarizing line and used it as the total for the bonus questions only. These misunderstandings were clarified, and final scores corrected for all projects. Based on the end-user feedback, question formulations were discussed and clarified and the visual layout was altered to make the scoring model easier to understand (creating UDC3 version 5, and improving to UDC3 version 6).

4.4.3. External Self-Assessment from Focus Group

As a third evaluation step, UDC3 (version 6) was brought to a focus group interview, furthering the interview study by adding 3 final informants across 2 new successful projects using the same interview guide. Informants 32, 33 and 34 (one designer and two developers) from success projects 22 and 23 participated in the focus group. The focus group interview was transcribed and added into NVivo, and fit well in the final factor categories. Differing from the other interviews, this group interview ended with a self-assessment of the two newly added projects using the UDC3. The understandability of the improved UDC3 design in version 6 design was confirmed.

Table 16. Success Sample Scores from Focus Group

Project	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Ba	Bb	Bc	Bd	Score
22	0	2	0	1	1	0	1	1	1	0	0	7
22	0	2	0	1	1	1	1	0	0	0	1	7
23	2	2	1	1	2	0	2	1	1	1	1	14
Average	*0.7*	*2*	*0.3*	*1*	*1.3*	*.3*	*1.3*	*.7*	*.7*	*.3*	*.7*	*9.3*

Results are presented in Table 16. Project 23 receives 14 points, while both project 22 assessors ends at 7 points - placing it in the middle success prediction. The informants explain that the award given to this project emphasized and rewarded the efforts made with regards to UD - rather than the end-quality. Thus, the middle level prediction of success seems to be quite fitting for this particular project, and the score model is acceptable despite an 9.3 average.

The end-user assessments were followed by an open discussion of the value of the UDC3 and input on further supporting tool ideas. The main feedback from the focus group was on the value of UDC3 as a tool for facilitating discussions; communicating to management levels both organizational and processual aspects that would facilitate or disrupt UD efforts on project level. The focus group expressed a desire to use the tool in a workshop with project owners and team members, where one could sit down and discuss goals, opportunities and needs. They perceive UDC3 as facilitating a checklist-review approach at project start up, ensuring awareness of strengths and weaknesses related to UD in the project. The focus group was asked about the desired form of the UDC3 tool, and whether an online version would be preferred. They were provided a sketched paper prototype exemplifying an online UDC3 tool. The participants rejected the need for digitalization, and expressed they would prefer a paper-based tool for workshop-discussions.

The focus group further expressed three ways in which the UDC3 tool could be furthered; 1) the need for more detail on some of the criteria; e.g. related to the team having "relevant UD competence and experience"; 2) the fit of the tool for integration with Jira, CFS or other project management tool in order to boost UD quality control during project development; 3) create an informative website overviewing the criteria "topics" and presenting real-life best practice examples related to the criteria - including, but not limiting to, examples of specified requirements including UD. The website audience is assumed to be persons with a given or assumed responsibility for UD in their organizations or on their projects and persons involved in the project planning.

4.4.4. External Self-Assessment from Phone Interviews

Forth and finally, the UDC3 tool was tested for as many as possible of the remaining 21 projects in the final success sample as well as potential new success cases. This was done through a phone interview study, where 27 informants were contacted. 16 informants are interviewed, representing 14 projects of which 13 projects from the remaining success sample and one new project also fulfilling the success sample criteria. We wanted to verify that the questions and score model are understandable and appears valid for measuring success. 18 of the 20 provided assessments across the 14 projects resulted in scores within the top tier of 12 to 18 points, see Table 17. The mean score for the 20 evaluations is 14.2.

Table 17. Success Sample Scores from Phone Interviews

Project	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Ba	Bb	Bc	Bd	Score
1	2	2	0	2	1	1	2	0	1	1	1	13
1	2	2	2	2	2	2	2	1	1	1	1	18
1	1	2	2	1	1	1	2	0	1	1	0	12
2	2	2	2	1	2	1	2	0	1	1	1	15
3	2	2	2	2	1	1	2	1	1	1	0	15
3	1	2	1	2	1	2	2	1	1	1	1	15
4	2	2	1	2	2	1	2	0	1	1	0	14
6	2	2	2	1	2	0	2	0	0	1	0	12
7	2	2	2	1	2	0	2	0	0	1	0	12
8	1	2	0	2	1	0	0	0	1	0	0	7
8	2	2	0	2	2	1	2	1	1	1	0	14
9	2	2	2	2	2	2	2	1	1	1	1	18
12	1	2	0	2	1	0	1	0	0	1	0	8
13	2	2	2	2	2	2	2	1	1	1	1	18
14	2	2	0	2	1	1	2	1	0	1	1	13
15	2	2	1	1	2	2	2	1	1	1	0	15
15	2	2	2	2	2	0	2	1	1	1	0	15
16	2	2	1	2	1	2	2	0	1	1	1	15
20	2	2	2	2	2	2	2	1	1	1	1	18
24	2	2	2	2	2	1	2	1	1	1	1	17
Average	*1.8*	*2*	*1.3*	*1.8*	*1.6*	*1.1*	*1.9*	*.6*	*.8*	*1*	*.5*	*14.2*

Four projects are given the maximum score - i.e. is rated higher in self-assessments than in expert assessments. The last two end up in the middle tier from 6-11 points, in which projects "mostly fulfill" CSC. Project 8 is assessed by two different informants - and while informant 23 scores it to 14 points, informant 7 only gives 7 points. Other assessors also rate somewhat differently; informant 10 rates project 1 to 18 points, while informant 8 rates it as 13 points and informant 6 as 12 points. On the other hand, informants 11 and 12 both rate project 3 similarly at 15 points, and informants 14 and 15 both rate project 15 to 15 points.

On the understandability of questions, several comment that they don't have a shared understanding of UD across their project teams, and wonder what UD definition we use. Three of the 16 informants, notably those working on continuous in-house projects in rather large organizations, express they hold limited and discipline-specific knowledge, making it hard to assess all CSC aspects asked for. Several requested clarification of question 3 (Q3) and bonus question Ba. Their comments indicate Q3 asking about resources is a compounded item; measuring many things in one single question. The highest possible score, 2 points, is typically given

if assessors agreed that *most* of the resources to ensure UD was present. As Q3 gives the second lowest average score, splitting the item could make its contribution to the overall score low. We want to make the assessment efficient, and not ask too many questions. Thus, the item was kept as a single, compound item.

Bonus question Ba measures the CSC on competence building as part of an organizational UD strategy. Many informants were not aware of such a strategy. Since this item measures a CSC on organizational level, it may be a question not all target users of the UD3C tool are able to answer. It has the lowest average bonus questions score across all the expert and end-user assessments, both for failed and success samples, and seems less important than the other questions. If cut, the prediction model should be adjusted so that the top tire is from 11-17 points, while the fail prediction should remain on 0-5 (as BA does not provide points to any assessed failed cases). For now, only minor changes was made; a few typos were corrected and the alignment of bonus point rows were improved, creating the final UD3C version 7 (see Figure 4).

On the usefulness of the tool, seven informants mention using UD3C to create a shared understanding of UD and increase UD focus; sharing knowledge on what is needed to succeed with UD in real-life and not only limited to satisfying the WCAG standards. About half of the informants stated they would find the assessment useful at the start of a project; for defining requirements, checking whether needed resources are available and planning the process. They believe introducing UD3C early on would increase user-testing and quality control.

Eight informants mention that the evaluation tool could also be used later, as retrospective or midway evaluations. Such evaluations are considered useful âĂIJas long as there is time left in the project to make improvementsâĂİ.

Five informants envision the tool used by product owners and project managers. Six see the tool as useful in the context of influencing decisions related to UD in a project, e.g. taking the project scores and success predictions to the management or stakeholders in order to get more resources allocated to user-centered activities. Some feel that the level of detail of the tool would be most useful in this context.

4.4.5. Summarizing Assessment Findings

We wanted to make sure that the UD3C tool consistently gives high scores to the success cases, across the different assessment methods used. We compare the 46 assessment scores (23 provided from experts and 23 from end-user informants) across the 24 included success projects in Table 18. Transcript-based expert assessments fit well with self-assessments scores. The mean score for the 42 assessments is 13.9, tentatively confirming UD3C measures a high CSC compliance in success projects.

Table 18. Comparison of Experts and User Scores

Project	Expert Scores	User Scores
1	12, 17	12, 13, 18
2	15	15
3	13	15, 15
4	14	14
5	14	N/A
6	12	12
7	12	12
8	12, 14	7, 14
9	14	18
10	12	N/A
11	14	N/A
12	17	8
13	14	18
14	17	13
15	15	15, 15
16	15	15
17	15	N/A
18	15	N/A
19	14	N/A
20	16	18
21	14	N/A
22	N/A	7, 7
23	N/A	14
24	N/A	17
Average:	14.2	13.6

5. DISCUSSION

In our first research question we identify the characterizing factors of ICT-projects that have successfully achieved UD. Our NVivo data reflects experiences and reflections from 34 informants across a total of 23 successful projects, increasing the validity and generalizability of earlier findings. Using NVivo, the extended data set is iteratively re-categorized, reflecting new insights. The rich qualitative data provide the means to explore factor relationships in more depth going forward.

We feel confident in the strength of our findings as a local sample to the Oslo area in Norway. Tentative factors from Sample A are verified across a larger N, with similar or increased mentions for all categories, and the extended data also encompass new insights. In order to further strengthen the validity of our findings, they need to be more systematically compared to related research. In a tentative comparison, the important factors identified in this study coincide well with e.g. Fuglerud and Sloan (2013), Røssvoll and Fuglerud (2013), Schulz et al. (2014), and Scott, Spyridonis and Ghinea (2015).

The result from our first research question is a categorized overview of 84 factors, 53 promoting and 24

UD3C EVALUATION - UNIVERSAL DESIGN CRITICAL CRITERIA COMPLIANCE

Step 1. Indicate if your project fulfills the UD critical success factors on the scale:	**Disagree**		**Agree**
1. There is a common understanding of UD in the project team and at all management levels (including any customer), and achieving UD is supported and viewed as positive.	**0**	**1**	**2**
2. The team has at least one person enthusiastic about UD, having a personal interest and motivation for ensuring universal usability.	**0**	**1**	**2**
3. The team has all the resources needed to ensure UD criteria; adequate time, budget and human resources; including access to assistive technologies, users and external competence.	**0**	**1**	**2**
4. The team has relevant UD competence and experience, e.g. UD principles in coding, IxD, content & visual design. Focus is on making design accessible and usable for everyone.	**0**	**1**	**2**
5. UD perspectives are integrated into all project activites; design, coding, UX/UCD & needs.	**0**	**1**	**2**
6. UD aspects are early and continously evaluated throughout the project, both through expert inspections and through user testing and real-user feedback including persons with disabilities.	**0**	**1**	**2**
7. The team embraces cross-disciplinary collaboration, open discussions and dialogue.	**0**	**1**	**2**

Step 2. Recieve 1 bonus point for:

a) A strategy for developing the UD competence in a team or organization.	**0**	**1**
b) Requirement specification includes criteria for UD, ensuring early and continuous focus.	**0**	**1**
c) An iterative or flexible process model, utilizing feedback from UD evaluations.	**0**	**1**
d) Extending internal evaluations with external inspections adds to UD quality control.	**0**	**1**

Step 3. Summarize your total: _____ point(s)

0-5 points: Your project is not fulfilling critical success factors for universal design, and is likely to struggle to achieve universal design.
6-11 points: Your project mostly fulfills critical success factors for universal design, but is unlikely to win universal design awards.
12-18 points: Your project fulfills most or all critical success factors, and is expected to achieve excellent universal design quality!

Figure 4. Final UD3C Tool (Universal Design Critical Criteria Compliance, Version 7)

obstructive across four levels; Societal, Organizational, Processual and Personal. They are further classified hierarchically into 22 main categories, containing sub-categories and sub-sub-categories. Our findings gives new insight into factor relationships, and suggest that measures must to be taken at several sector levels in order for a single project to succeed (Societal, Organizational, Processual and Personal). At this stage in our research, the CSC findings point to how organizational (management and client) anchoring of UD is a particularly important influence on the other factors, as it ensures focus and priority beyond what the legislation is able to do on it's own. Further, the characteristics of successful project processes highlight a link between collaborative user-centered approaches, usability efforts and universal design success. The rich qualitative data provide the means to explore factor relationships in more depth going forward.

Our second research question investigates which of the identified characterizing factors seems most critical for achieving UD success. We continue our analysis of the empirical data from informants who have, by this study's requirements, done just that; succeeded with UD implementation for an ICT-solution. We are able to condense the wide range of characterizing factors into 15 Critical Success Criteria, of which three on organizational level, eight related to the processual ICT-project level, and three depending on the project team persons. These are: Societal (1) Legislative Support, Organizational anchoring of UD (2) Awareness and (3) Priority and strategic (4) Competence Building, Processual (5) Requirement Specification and UD/UX (6) Needs Integration and (7) Continuous Focus, (8) Team Collaboration, (9) User Testing and (10) Internal quality controls and enough (11) Time & Budget and (12) Equipment & Human Resources, and Personal (13) DfA Mindset and individuals (14) Interested in and (15) Enthusiastic about UD.

5.1. How to Utilize Findings for Project Tools?

Our third research question focuses on how we can utilize these findings to build project-level support for planning, evaluating and managing UD in ICT-development. We suggest creating a project assessment tool attempting to predict UD success early on based on compliance to the identified critical factors - both to support the practice

field and to bridge the gap between research and industry. By utilizing a questionnaire-based form, we formulate 11 questions to measure 14 CSC considered relevant.

We evaluate the power of our proposed UDC3 (Universal Design Critical Criteria Compliance) tool to measure CSC compliance in four iterations, improving question formulations, tool design, scoring models for the questions and score thresholds for predictions on UD success. The tool is evaluated in a series of different manners; expert assessment, focus group and self-assessment via mail and phone interviews. Using multiple data sources in order to support the interpretations of the same type of data is knows as data source triangulation (Lazar, Feng and Hochheiser, 2010).

Through our prototyping, we explore the ability of UDC3 to predict UD success based on CSC compliance. The outcome of our third research question is two-fold: a suggestion on how empirical findings may be utilized to support project-level UD quality planning, and a prototyped UD3C tool tentatively measuring best practice and predicting UD success based on critical factors on team member selection, processual and organizational factors.

The UDC3 tool successfully measures the compliance of ICT-projects in our sample to identified UD CSC key factors for UD across multiple successful projects. We derive best practices from the CSC; key factors for UD across multiple successful projects. Best practice compliance is defined as adherence to the empirically identified CSC, and we treat "UD best practice" as a set of factors recommended to ICT-projects as particularly helpful or critical for ensuring UD. The best practices, and thus the questions, may of course be improved based on new knowledge.

The self-assessment tool predicts project success based on its current practices, aiming to guide and quality assure project practices beyond WCAG and similar guidelines. The UD3C tool is meant to be used by project members and management, and based on a total score UD success is indicated as likely (high score), unlikely (low score), or somewhere in between (medium score).

Perceived usability has been investigated through open-ended questions to 27 of our target users, and in-depth discussion with 17 of our target users. Based on user feedback, UD3C has the potential to support UD quality management during ICT development by providing the means to evaluate compliance iteratively during the project, however would be particularly useful as an early-phase project planning tool. The users indicate its value as a discussion facilitator; making UD goals and UD awareness more explicit and as such contribute to emphasize and communicate UD perspectives among stakeholders. Many perceive the tool as likely to inspire more user-centered projects.

As the tool can provide early indicators predicting the likelihood of achieving UD and make any lacking or obstructing factors visible, informants also feel the tool could be a great support in communicating to management. Specifically in securing adequate resource and time allocation, by defining and communicating key factors for UD success to organizational management and project owners.

We find it interesting that our work indicates research insights can be translated into a valid measurement of UD quality. If UD3C, or a similar assessment tool, can offer an easy verification of UD going beyond only technical accessibility checks, we believe this would be a major contribution to the practice field in relation to assessing UD quality. Perhaps the limitations of the current checklist-type UD evaluations focused on technical accessibility, and on already developed code, can be somewhat mitigated.

5.2. Limitations of Our Study

As the main focus of the study was to investigate project processes and practices, we did not expect to identify critical factors outside the project scope. In hindsight, it makes sense that all four of our identified levels influence project success. Most of our identified factors are closely linked to the level on which our informants are closest to; the processual level. This is followed by factors on organizational and personal levels, which is natural as this is both the context in which the informants execute their profession, and the focus of our interview guide. If our sample had been comprised of more informants in management positions (currently less than 12% of the our sample), one could speculate more factors on organizational levels would have been mentioned. If interviewing government agencies or institutions maintaining or guarding accessibility legislations, nationally or internationally, different perspectives on the context of UD of ICT success might appear.

As outlined in the success-sample selection and inclusion criteria, there are no clear objective measurements of what UD of ICT-solutions entails. Instead of working to define, derive or identify such measurements, this study has relied on evaluations of award committees on design awards related to accessibility, UD and design for all. As such, it may be critiqued that this study does not necessarily point to success criteria for achieving UD, but rather success criteria for getting an award, high rating, nomination or honorary mentions from award committees and UD evaluators.

It may also be speculated on whether or not interviewing only "successful" projects makes our main sample a non-representative population. Indeed, the granularity of the factors on the promoting side is notably

higher that the obstructive. This is not surprising due to the focus of our interview guide. If we had also asked our informants on their unsuccessful experiences, we could perhaps have identified the negative aspects in a similar detail.

One of our external assessment investigations tested the prototype on a sample of "failed" cases to combat bias and make sure the UD3C tool can measure likelihood of failing. Here, we attempted to reach projects that had been reported to authorities or to media as failed, or that had been publicly critiqued by disabled end-users, their organizations or profiled UD experts. We were fairly successful in this regard, though we cannot prove all projects individually lack UD quality. As the prototyped UD3C evaluation tool gives the failed projects low scores, we argue that the validity of the tool as a success indicator is still strengthened.

The UDC3 tool needs more practical usage as a field intervention to check its usefulness. We see in Table 18 that the scores varies a bit from user to user. This was also the case for failed projects, as shown in Table 15. Since different informants can rate a project somewhat differently, the UDC3 tool should only be used as an indicator of compliance, and the ratings should be discussed as part of a project planning process. Though the validity seems strong enough that it is considered unlikely for a project complying well with CSC to end up in the fail prediction tier, and likewise a project not complying well to CSC to end up in the success prediction top-tier, they could both end up in the middle category. Thus, a project manager is encouraged to ask several or all project participants to rate the project and discuss both the overall results and differing scores. Through these discussions, we believe a clearer understanding of the CSC asked for and the actual compliance and potential improvements will be reached.

6. CONCLUSION

Using a qualitative, interpretive and exploratory research approach, we identify 84 characterizing factors for ICT-project achieving universal design (UD), and prototype a tool to measure compliance with critical criteria. Empirical data is collected from 34 informants across 24 successful projects, and from 10 informants across 10 failed projects. Through an iterative content analysis, alternating between bottom-up, emergent coding and top-down a-priori and directed perspectives, we identify 15 Critical Success Criteria (CSC) for UD. 14 CSC are internal to design- and development processes.

We hypothesize measuring these would help the quality control and management of UD in ICT-projects. A self-assessment project tool is iteratively designed and tested, labeled UDC3 - Universal Design Critical Criteria Compliance. We are able to formulate 11 questions to measure compliance to the 14 CSC. Based on self-assessment against statements reflecting the identified CSC, our UDC3 tool indicates the predicted likelihood for UD success. We evaluate the tool design and score model in four iterations: 1) iterative expert evaluations against 31 interview transcripts from 21 projects; 2) 12 end-user self-assessments emailed from 20 failed projects; 3) focus group interview discussions with 3 informants, and 3 end-user self-assessments from new 2 success projects; and 4) phone interview discussions with 16 informants and 20 end-user self-assessments from 14 success projects. We evaluate against both a success sample and a failed sample.

At the end of the iterative research process, we have prototyped a self-assessment evaluation tool with the ability to indicate the status of a project compliance to critical "best practice" and tentatively predict the likelihood of UD success. Based on the overall compliance scores to critical processual, organizational and personal success criteria., the tool tentatively predicts the likelihood of achieving UD in the resulting ICT-solution both and prior to, at the end of and during the project. If valid, as our study indicates, the UD3C assessment could be used as a benchmark for measurement of UD quality beyond technical accessibility.

A total of 46 informants have participated in the study, representing 24 success projects and 10 failed projects. Based on their feedback, the UD3C tool is considered valuable as an early project planning and communication tool within a team and towards stakeholders; in order to clarify UD understanding, promote end-user focus, and leverage resource decisions for improved UD success predictions.

The article A) overviews influential factors for securing UD in ICT development, and indicates which societal, organizational, processual and personal factors are the most critical, and B) provides a practical contribution through the UD3C tool, providing the means for projects to self-assess against best-practice.

6.1. Future Work

In our continued research, we will more systematically compare our findings to related research, in order to see if a consensus can be reached on UD best practices. This would further improve the generalizability and validity of our UD of ICT best practice findings. We will also investigate the relationships between identified success criteria in more depth, in an effort to gain insights from social and politic points of view.

Further, our informants suggests several other design and field intervention initiatives to support industry in

UD planning and quality control. Among suggested needs are best practice examples of requirement specifications containing UD needs, best practice examples of methodological approaches and more detailed discipline specific descriptions of relevant UD competence. Informants are also interested in checklist-oriented UD process-phase support integrated into existing project-management tools. We will continue our efforts in both industry and academia to explore the usefulness of interventions to support UD practices, including conducting field intervention to check the practical usefulness of UD3C.

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