Eyal Eshet

Examining Human-Centered Design Practice in the Mobile Apps Era

Turku Centre *for* Computer Science

TUCS Dissertations
No 212, June 2016

Examining Human-Centered Design Practice in the Mobile Apps Era

Eyal Eshet

To be presented, with the permission of the Faculty of Social Sciences, Business and Economics, for public criticism in the Auditorium Armfelt, Arken, on June 10, 2016 at 12:00.

Åbo Akademi University
Faculty of Social Sciences, Business and Economics
Gezeliusgatan 2 A
20500 Turku, Finland

2016

Supervised by

Docent Dr. Franck Tétard
Faculty of Social Sciences, Business and Economics
Åbo Akademi University
Turku, Finland

Professor Harry Bouwman
Faculty of Technology, Policy, and Management
Delft University of Technology
Delft, The Netherlands

Reviewed by

Professor Morten Hertzum
Department of Computer Science
University of Copenhagen
Copenhagen, Denmark

Professor Jan Gulliksen
School of Computer Science and Communication
Royal Institute of Technology
Stockholm, Sweden

Opponent

Docent Dr. Timo Jokela
Aalto University
Joticon Oy
Helsinki, Finland

ISBN 978-952-12-3392-0
ISSN 1239-1883

Turku 2016

Abstract

Human-Centered Design (HCD) is a well-recognized approach to the design of interactive computing systems that supports everyday and professional lives of people. To that end, the HCD approach put central emphasis on the explicit understanding of users and context of use by involving users throughout the entire design and development process. With mobile computing, the diversity of users as well as the variety in the spatial, temporal, and social settings of the context of use has notably expanded, which affect the effort of interaction designers to understand users and context of use. The emergence of the mobile apps era in 2008 as a result of structural changes in the mobile industry and the profound enhanced capabilities of mobile devices, further intensify the embeddedness of technology in the daily life of people and the challenges that interaction designers face to cost-efficiently understand users and context of use. Supporting interaction designers in this challenge requires understanding of their existing practice, rationality, and work environment.

The main objective of this dissertation is to contribute to interaction design theories by generating understanding on the HCD practice of mobile systems in the mobile apps era, as well as to explain the rationality of interaction designers in attending to users and context of use. To achieve that, a literature study is carried out, followed by a mixed-methods research that combines multiple qualitative interview studies and a quantitative questionnaire study.

The dissertation contributes new insights regarding the evolving HCD practice at an important time of transition from stationary computing to mobile computing. Firstly, a gap is identified between interaction design as practiced in research and in the industry regarding the involvement of users in context; whereas the utilization of field evaluations, i.e. in real-life environments, has become more common in academic projects, interaction designers in the industry still rely, by large, on lab evaluations. Secondly, the findings indicate on new aspects that can explain this gap and the rationality of interaction designers in the industry in attending to users and context; essentially, the professional-client relationship was found to inhibit the involvement of users, while the mental distance between practitioners and users as well as the perceived innovativeness of the designed system are suggested in explaining the inclination to study users *in situ*. Thirdly, the research contributes the first explanatory model on the relation between the organizational context and HCD; essentially, innovation-focused organizational strategies greatly affect the cost-effective usage of data on users and context of use. Last, the findings suggest a change in the nature of HCD in the mobile apps era, at least with universal consumer systems; evidently, the central attention on the explicit understanding of users and context of use shifts from an early requirements phase and continual activities during design and development to

follow-up activities. That is, the main effort to understand users is by collecting data on their actual usage of the system, either before or after the system is deployed.

The findings inform both researchers and practitioners in interaction design. In particular, the dissertation suggest on action research as a useful approach to support interaction designers and further inform theories on interaction design. With regard to the interaction design practice, the dissertation highlights strategies that encourage a more cost-effective user- and context-informed interaction design process. With the continual embeddedness of computing into people's life, e.g. with wearable devices and connected car systems, the dissertation provides a timely and valuable view on the evolving human-centered design.

Acknowledgements

This book that you read now tells a story that has come to fruition with the help and support from many people and organizations. Hence, it is my great pleasure to start the story by introducing and thanking them.

First, my supervisor, **Docent Dr. Franck Tétard**, introduced the topic of Human-Centered Design to me early in my master's studies. This topic has captured my focus of interest ever since. Franck has been a committed adviser to me with my master's thesis and naturally throughout the long doctoral research journey. Without Franck's encouragement for the doctoral research, this story would not even get started. In addition, Franck has been greatly supportive to me throughout my higher education lecturing career.

I am enormously grateful to my co-supervisor, **Prof. Harry Bouwman**. Harry's vast work experience, attitude, and social skills have had the most enormous impact on my career as a researcher. Harry has established and continuously developed my research competences and quality. I have always looked forward to the discussions with Harry, his critical and constructive comments as well as the sharing of stories on our own personal lives. Harry's fingerprints are highly visible throughout this book.

I have been fortunate to work in IAMSR under the directorship of **Emeritus Prof. Christer Carlsson** and **Prof. Pirkko Walden.** Christer and Pirkko created and have promoted a research environment that is enjoyable and supportive to work in. I especially appreciate your ubiquitous availability to help with any question or matter. I am also grateful for the financial support you provided me throughout the years in IAMSR.

I would like to offer my thanks to **Assistant Prof. Mark de Reuver** at Delft University of Technology for the collaboration and critical comments. Your analytical remarks and strictly focused view have inspired me ever since and are evident in this book.

I am honored to have **Prof. Morten Hertzum** and **Prof. Jan Gulliksen** as the reviewers of this work. Your extensive experience, constructive and encouraging comments greatly helped to improve the quality of this dissertation.

I would like to show my sincere gratitude to **Docent Dr. Timo Jokela** for accepting the tasks of assessing my dissertation and acting as my opponent in the defence.

My special thanks go to **Docent Dr. Eija Karsten**. Eija's comments on my early research plan have made me aware of the choice of wording, which is reflected in this work. In addition, Eija has supported me in my higher education career by discussing on-, reflecting on-, and co-teaching the User-Centered Design course.

I would also like to thank **Kimmo Tarkkanen** at Turku University. Kimmo share my interest in the topics of usability, UX, and UCD, and hence, have provided valuable remarks on my work. In addition, the Work Informatics User Experience lab that Kimmo is in charge of has been invaluable to my delivery of the course on usability testing.

I am fortunate to have been working with supportive colleagues at IAMSR, who have shared their research perspectives and more importantly have made my daily life more enjoyable. Thank you: **Nazrul Islam, Xiaolu Wang, Shahrokh Nikou, Jozsef Mezei, Markku Heikkilä, Anna Sell, Guopeng Yu, Usman Warraich, Jie Guo, Camilla Walden, Joanna Carlsson, Ville Harkke, Yong Liu, and Robin Wikström**.

The administrative staff at Åbo Akademi, both in my former and current faculties, deserves big thanks for cheerfully allowing me to focus on the research work. Special thanks go to **Christel Engblom, Tove Österroos, Irmeli Laine, and Joanna Anckar**.

This work would have been impossible without the financial support from multiple organizations and foundations. Thus, I am greatly thankful and would like to express my sincere gratitude to: Turku Centre of Computer Science (TUCS), Stiftelsen för Åbo Akademi, Liikesivistysrahasto, Dagmar och Ferdinand Jacobssons fond, Marcus Wallenbergs Stiftelse för Företagsekonomisk Forskning, KAUTE-säätiö, Oskar Öflunds Stiftelse, Otto A. Malms Donationsfond, TeliaSonera tutkimus- ja koulutussäätiö, and Tieto- ja viestintätekniikan ammattilaiset (TiViA) Tietotekniikan Tutkimussäätiö.

Last and most importantly, I would like to thank my beloved family. My dear wife **Satu** and my son **Ben** are the main source of joy in every moment of my life. My dear mom **Hadassa**, my late father **Reuven**, and my brother **Matan** have inspired me throughout my life and have always supported my endeavors. Special thanks also to my mother-in-law **Liisa**. This book is dedicated to all my beloved and caring family.

Eyal Eshet
Åbo, 29.4.2016

Preface

"There's always room for a story that can transport people to another place." J. K. Rowling

The story of this dissertation predates the scientific plot. So before you turn to page one, allow me to transport you to the context that motivated this work.

My professional background is in software design, mainly in a technology firm that provides tailored software solutions to business clients. These solutions took the form of a Content Management System (CMS), Knowledge Management System (KMS), Customer Relationship System (CRM), and corporate websites. My main tasks involved designing and implementing parts of the solutions, backend and frontend, along with few colleagues. The client provided general requirements while inspirations for the design was in the hands of our team. Following an agile process, the quick iterations with clients and their positive feedback kept us busy and gave a stimulating pressure to go on without much reflection on the process. Until one sunny day.

About a year before that day and concurrently with the work, I enrolled for a master's degree program in Information Systems. During the first year of the program, I attended a course on User-Centered Design (UCD), followed by a complementary course on usability testing. The learning experience from these courses, combined with the parallel work experience, led to an increased interest in UCD and more broadly in Human-Computer Interaction (HCI). On the professional level, I got an opportunity to spread the interest on that sunny day.

At the firm, a consultant was hired to revise our work practices. Each employee was assigned to reflect on the work routines and suggest improvements. Envisaging a usability champion status, I advocated UCD and proposed ways to integrate it into our work, which got the team inspired. The next day, we already planned usability test and discussed ways to reach end-users. But in the long term, it mostly remained on the planning table; the initial enthusiasm and support for the UCD philosophy did not translate into established organizational courses of action.

Although frustrating, it did not affect my personal interest in UCD; rather, my lens turned to the implementation of UCD in organizations. The first offspring from this particular scope of interest is my Master's thesis on the practice of usability engineering for a mobile system in an academic context. Encouraged by my thesis supervisors Dr. Franck Tétard and Prof. Christer Carlsson, I later decided to use my background experience and devote my time to a larger scientific exploration of the UCD practice, which resulted in this dissertation.

Contents

List of Tables and Figures

Part I

Research Summary

Chapter 1.

Introduction

This chapter presents the core issues in this research. I start by explaining the research problem that motivates this work, after which the key concepts are clarified and the knowledge gaps in the literature are identified. The gaps lead to the formulation of the research objective and questions. Thereafter, I describe the scope of this dissertation and the methodological approach taken to address the research question. Next, the relevancy and contribution of this work are discussed, before closing by with an outline of the dissertation.

1.1. Problem statement

Human-Centered Design (HCD) is an established approach to the design of usable and useful interactive systems. According to its core principles, achieving usability and usefulness requires an *explicit understanding of users and context of use by actively involving users throughout the design and development process*. In contrast to stationary computing devices (e.g. desktop) that are typically used in single context, mobile computing devices (e.g. mobile phone) are used in variety of multi-contextual settings (Henfridsson and Lindgren, 2005). Consequently, understanding the varied context of mobile device use during the design and development process puts a strain on interaction designers, in particular on the cost-effective collection and analysis of user requirements and the evaluation of design proposals. Rapid developments in mobile technologies and a restructuring of the mobile industry in recent years brought about greater diversity of users. This diversity challenges interaction designers' effort to involve relevant users during the design and development of mobile systems.

Until recently, the design and development of mobile systems (i.e. services or applications) was largely controlled by telecommunication network operators and handset manufacturers, while mobile devices were primarily used for basic communication functions. On July 2008, a structural transformation of the mobile industry started with the introduction of the app store model for distributing systems, which democratized the development of mobile systems (relabeled as 'mobile apps'). Combined with the profound new capabilities of mobile devices that allow for new ways of interaction and ubiquitous consumption of information, the focus in system development has quickly shifted from stationary computing towards mobile computing, particularly in the

form of mobile apps for touch-based smartphones and tablet computers. This new period of mobile computing is referred to as the *mobile apps era*.

The ubiquitous nature of mobile systems, especially for consumers, during the mobile apps era resulted in mobile devices being increasingly embedded in people's everyday lives. Essentially, understanding users in such fluid and unpredictable usage contexts requires new interaction design competences (Hinman, 2012) as well as user studies that extend to both the spatial and the temporal dimensions, such as longitudinal ethnographic studies (Tamminen et al. 2004). Moreover, rapid developments in device-embedded sensors and wireless technology allow practitioners to collect a plethora of data on contextual usage behavior in real-time. Though, efficiently extracting meaningful insights from a continuous flow of 'Big Data' is challenging. Last, while the mobile apps era marks a milestone for system design and development practitioners, it also led to an increasingly competitive and dynamic market (Bergvall-Kåreborn and Howcroft, 2011) that put more pressure on the effective, efficient and timely understanding of users within an organizational project.

To sum up, the fundamental expansion to the diversity of users and the variety of context of use as well as the recent mobile revolution raise questions regarding how interaction designers attend to users and context of use in the mobile apps era. Gaining insights on the work practices and rationality of interaction designers is crucial to scientific efforts on supporting practitioners and more generally to the development of interaction design theories.

1.2. Literature overview

Understanding the problem in this research necessitates a closer look at the body of knowledge, particularly within the Human-Computer Interaction (HCI) field, where the HCD approach was originally devised, developed and continue to serve as an established framework for the design practice. By reviewing the existing literature, I clarify key concepts and discuss the knowledge gaps that this work aims to address.

To start with, the word 'design' invokes different interpretations as it is used in plenty of diverse fields, e.g. applied arts, architecture, engineering, and business process. The design field in this work is labeled *interaction design*, as in:

> *"Designing interactive products to support the way people communicate and interact in their everyday and working lives" (Sharp et al. 2007, p.8).*

Following Simon's (1969) general view of design as *"courses of action aimed at changing existing situations into preferred ones"* (p.111), design is more specifically interpreted here in terms of an *activity* or a *process* for producing interactive systems that enhance the everyday and working lives of people.

Consequently, practitioners who are involved in producing these systems need an understanding of the people, i.e. users, who use the systems (Norman and Draper, 1986). The practitioners who are involved in understanding users operate under different roles, nowadays mainly interaction designer, user experience (UX) designer, usability engineer, and user researcher (Sharp et al. 2007). For brevity and in light of the 'interaction design' label of the field, in this work the practitioners are denoted as *interaction designers*.

While HCD is a well-established approach to improve the usability and usefulness of interactive systems, interaction designers may follow other approaches. The HCD approach was conceived during the 1980s (Norman and Draper, 1986), though already in the 1970s, advocates of the Participatory Design (PD) approach allowed and encouraged factory workers to actively participate in the design of computer systems that aimed at facilitating their work tasks (Schuler and Namioka, 1993). Since then, extensive efforts, particularly by HCI scholars and practitioners, have contributed practical approaches for the design of interactive systems. For instance, Nielsen's (1993) Usability Engineering, Beyer and Holtzblatt's (1997) Contextual Design, Cooper's (1999) Goal-Directed Design, and more recently User Experience (UX) design (Hassenzahl and Tractinsky, 2006) and Interaction Design (Sharp et al. 2007). While the computing landscape has dramatically changed along these years, all the approaches agree on and emphasize a core principle of HCD, i.e. *user involvement throughout the design and development process*. Especially for design evaluations, the involvement of users should occur in the context of use (Gulliksen et al. 2003). Being formalized by the International Standardization Organization (ISO, 1999; ISO, 2010), the HCD approach is most recognized in advocating these principles, and thus, I refer to 'HCD' throughout this work, such as in 'HCD methods'.

Practically, interaction designers involve end-users through the employment of HCD methods and techniques for user- and field- research. The approaches mentioned before lay the foundations for some of the seminal HCD methods, while the literature on design research comprise collections of more methods (e.g. Laurel, 2003; Randall et al. 2007). These methods were largely devised during the era of stationary computing. More recent research efforts contributed methods with a specific focus on understanding users for the design of interactive systems in mobile computing (for reviews of these methods, see e.g. Kjeldskov and Graham, 2003; Hagen et al. 2005; Coursaris and Kim, 2011). However, in the mobile apps era, the increased diversity of users, their usage of mobile devices for various needs, e.g. business, entertainment, communication, wellbeing, and education, in a variety of and dynamic contexts, for instance work office, private home, public street, sunny beach, dark bar, local shop, and foreign museum, significantly increase the challenge to involve users in the context of use. Insights into scientific approaches to address these challenges are

dispersed. This work contributes to the literature by providing a contemporary view on the use of HCD methods and techniques in academic projects during the mobile apps era.

Apart from documenting the landscape of HCD methods, supporting interaction designers requires understanding their existing practice, i.e. the use of HCD methods in industrial context. Consequently, various studies (e.g. Hudson, 2000; Rosenbaum et al., 2000; Gunther et al., 2001; Vredenburg et al. 2002; Gulliksen et al. 2004; Venturi et al., 2006; Bygstad et al., 2008) have continuously examined the state of HCD practice from different perspectives, including the application of field research methods (Monahan et al. 2008) that emphasize the understanding of context of use. However, the studies have not focused specifically on the design of mobile systems, let alone in the mobile apps era. Hence, this research provides a descriptive account of the HCD practice with mobile systems in the mobile apps era that constitutes a timely contribution to the HCI literature when mobile computing becomes a common practice. However, to better understand the rationality for the HCD practice, a closer examination of how practitioners make sense of the equivocal 'context of use' notion is required.

'Context' is an ambiguous label that has different connotations in different fields (Bradley and Dunlop, 2005). In HCI, 'context' and 'context of use' are commonly used interchangeably to denote the circumstances in which people use, or are expected to use, the interactive system (ISO, 2010). Since human action is always contingent on the situated circumstances (Suchman, 2006), understanding the specific aspects that affect the use of a system is of utmost importance to interaction designers. In light of the change from a single context to multi-contexts with the use of mobile devices and the enhanced sensorial capabilities of mobile devices, i.e. context-aware and ubiquitous computing, an increased scientific interest attempted to theoretically delineate the concept of 'context' (e.g. Greenberg, 2001; Dourish, 2004), complemented by theoretical models on the context of use in mobile computing (Bradley and Dunlop, 2005; Jumisko- Pyykkö and Vainio, 2010). Especially given the ambiguity of the concept (Pintilie, 2015) and its all-inclusive definition (Alexander, 1964; Dey, 2001), the perception of 'context' can play a role on the approach interaction designers take to study users and context. However, at the time of research, there were no insights on interaction designers' perception of 'context', particularly in the mobile apps era. This research provides a preliminary understanding on practitioners' way of conceiving 'context' in specific projects, which helps to explain their rationality for the HCD practice.

Commonly, HCD work takes place within organizational projects, which are complex social systems with multi-level impact on the involvement of users. Accordingly, the organizational strategy (Grudin, 1991a), its culture and work

practices (Iivari, 2005), as well as the historical focus of organizations (Emam and Madhavji, 1995) influence the ability to involve users. Moreover, organizational projects often engage stakeholders at various levels within an organization as well as in external partner organizations; the distinct backgrounds and worldviews of stakeholders (Suchman, 2002a) as well as their different expectations (Krippendorf, 2006) and criteria to evaluate project success (Baxter and Sommerville, 2011) influence the motivation of those with decision-making power to support HCD work (Gulliksen et al. 2004; Venturi et al. 2006), especially with temporal and financial resources (Vredenburg et al. 2002; Bak et al. 2008) and with capabilities (Rosenbaum et al. 2000; Ji and Yun, 2006). Projects are also characterized by the specific interactive system being designed and the nature of its users, which has an impact on the identification of and access to users (Axtell et al. 1997). Studies on user involvement in organizational projects during the mobile apps era are scant. Given the diversity of users in the mobile apps era and the variety in the context of mobile system use, more insights are needed. This research examines HCD work with mobile systems in industrial projects, putting a focal lens on the forces that affect user involvement, especially in the context of use.

On the organizational level, the impact of the strategy on the HCD work is further examined. Organizations have specific strategies that govern, among other things, their business operations and the allocation of resources to the different operations. Interaction design is one of these operations, which requires the availability of competent interaction designers and resources to understand end-users. Given the increasingly competitive environment in the mobile apps era as well as the increased flow of data on usage behavior, design-related competences and resources become more prominent for the effective and efficient understanding of changes in consumer demands. However, apart from highlighting strategic factors, such as the lack of HCD resources and capabilities, thus far the relationship between the strategic management and the design practice has not been studied. This research examines how different organization strategies directly and indirectly affects aspects of the HCD practice, which helps to explain the HCD practice on a broader perspective of the organizational management.

To sum up, existing literature present knowledge gaps with regard to understanding user involvement in context of use in the mobile apps era. First, insights on scientific approaches to address the challenges of user diversity and variety of context of use are largely dispersed. Second, given the challenges in the mobile apps era, insights on the state of HCD practice in the industry are largely from the era of stationary computing, while insights into the rationality to involve users, specifically in the context of use, are scant. Last, existing studies provide a theoretical understanding of the ‘context of use’ concept, though it is unclear how interaction designers perceive ‘context of use’, especially in light of

the increased variety of multi-contextual settings in which mobile systems are used.

1.3. Research objective and questions

Based on the described problems and knowledge gaps, the objective of this research is:

> To contribute to theories on interaction design by explaining the HCD practice in the mobile apps era as well as the rationality of interaction designers in attending to users and context of use, taking interaction designers' organizational work context into consideration

Derived from the objective, the questions for this research are:

RQ1. What scientific HCD methods are available for understanding users and context of use in the mobile apps era?

Answer to this question would provide a scientific point of reference to insights on the actual use of HCD methods by interaction designers in the industry, which is a major concern in the next question:

RQ2. How do interaction designers perceive and approach the context of use during the design and development of mobile systems in the mobile apps era?

While the first questions were largely concerned with a *descriptive* account on *how* HCD is practiced in scientific and organizational settings, the last question is *explanatory* in nature, focusing on *why* interaction designers do what they do, in other words:

RQ3. What are the core factors that inhibit and encourage interaction designers in their effort to involve users in real-life contexts of use during the design, development, and post-deployment of mobile systems in the mobile apps era?

Attending to the objective and answering the questions requires two major levels of analysis: (1) HCD practice, i.e. HCD methods and techniques; and (2) practitioners, particularly in HCD roles, who are involved in the design and development of mobile systems in an industrial context.

1.4. Scope and approach

This research is largely grounded in the field of Human-Computer Interaction (HCI), which is defined as "*a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them*." (Hewett et al. 1992). Given that scholars in the field have been instrumental in developing and formalizing the

HCD approach, the HCI literature provides the most extensive body of knowledge on the inquired topic.

The HCD approach is examined within specific sociotechnical mobile computing systems. First, the label 'mobile' refers to the mobility of human rather than the system. Mobility is loosely defined as the ability of people to move between locations that greatly vary in their physical-, social-, and temporal- dimensions (Henfridsson and Lindgren, 2005). As people move, they carry their mobile computing devices along with them and use them in a variety of these multi-dimensional settings. Hence, mobile computing is regarded in terms of carried-on devices (Dix et al. 2000). Technically, the research is concerned with touch-based smartphones and tablet devices that became widespread in the mobile apps era. In particular, the research is focused on systems (i.e. services, applications) that run on these devices, including native platform applications (i.e. mobile apps), browser-based mobile web applications (e.g. HTML5) and any hybrid solution. These applications are referred in this work as *mobile systems*. Given the limited insights on the HCD of these systems at the outset of the research, the research started with a broad social perspective on systems, that is, both for work and for leisure activities. Later on, the research adopted a more narrow scope on non-work consumer systems, specifically for media- and finance- related tasks.

To answer the research questions, the work starts by surveying existing HCI literature on the HCD practice of mobile systems in the mobile apps era. This study constitutes the groundwork by providing a review of scientific HCD methods for studying users and context of use in the design of mobile systems and by uncovering possible directions for the empirical inquiries.

The empirical research largely followed a mixed-methods research methodology (Tashakkori and Teddlie, 2003) that combines qualitative interviews and quantitative questionnaire conducted in three sequential phases. The first phase consists of exploratory semi-structured interviews with various practitioners who are involved in the design and development of mobile systems. The interviews aimed at a preliminary examination of the HCD practice in the industry, taking the insights from the preceding literature study into account. In particular, the qualitative study focused on eliciting practitioners' challenges with regard to the application of HCD. Interviews are useful for exploration, especially in the case of emerging phenomenon with no existing insights (Lazar et al. 2010). Moreover, conducting interviews with multiple informants in different cases address the replication logic (Yin, 2003), which help in identifying patterns. The phase resulted in the identification of more focused themes and the development of hypotheses for further investigation.

In the second phase, the themes and hypotheses were examined and tested more strictly and quantitatively with a questionnaire. Aimed at explaining the state of HCD practice in the mobile apps era, the questionnaire was designed with 'context of use' as a focal lens to also provide initial insights into practitioners' perception of the 'context of use' notion. A questionnaire instrument is considered useful for explaining behaviors, testing hypotheses and also exploring uncharted waters (Johnson and Turner, 2003; Lazar et al. 2010). While the study provided answers to its questions, the findings also raised specific questions regarding the impact of the organizational work context on interaction designers' rationality for the HCD work that required deeper explanation.

Hence, the last phase consists of in-depth semi-structured interviews that aimed at explaining practitioners' rationality with regard to conducting user studies in naturalistic context, with an emphasis on their organizational work context. In-depth interviews are useful for such deep probing into a specific topic of interest (Johnson and Turner, 2003; Lazar et al. 2010). To increase the reliability of findings, the phase consisted of two studies conducted in different countries, each by involving multiple informants in different organizations. The insights from this phase complemented and combined with inferences from previous phases to formulate the coherent understanding, i.e. meta-inferences, of this dissertation work.

The mixed-methods methodology research approach taken in this work, including a methodological discussion of each study, are discussed in more details in Chapter 3.

1.5. Relevance and contribution

Since the emergence of mobile computing, HCI researchers involved in interaction design contributed scores of methods, techniques, and tools to make sense of users in an increasingly heterogeneous and dynamic context of use (for reviews, see for instance, Kjeldskov and Graham, 2003; Hagen et al. 2005; Coursaris and Kim, 2011). Ultimately, these research efforts have to support interaction designers in their effort to produce systems that enhance the everyday and working lives of people. However, Rogers (2004) observed that research-oriented solutions are hardly used by interaction designers. Highlighting differences in the notion of 'complexity' between science and interaction design, Stolterman (2008) argues that researchers' insufficient understanding of the nature of design practice causes this discrepancy. To align the HCI research effort on interaction design with the needs of interaction designers, scholars (e.g. Stolterman, 2008; Goodman et al. 2011) call for devoting more research efforts to the understanding of existing interaction design practice, such as the work activities, experiences and work contexts of interaction designers. This research responds to this call by shedding light on the HCD work of interaction designers

as well as their rationality for applying core HCD principles, taking their work context into account. By that, this dissertation contributes to theorizing interaction design.

With the fundamental impact of mobility on the nature of system usage, interaction designers need to adjust their strategies with regard to understanding users. Essentially, making sense of users in multi-contextual situations requires longitudinal studies that extend beyond fixed locations. Given the decreasing time-to-market due to the competitive environment as well as agile development approaches, an effective and efficient understanding of users is of strategic importance to organizations. By in-depth and in-breadth examination of practitioners and their work context, this work helps to explain strategies and factors that contribute to a more effective and efficient user- and context-informed design. Consequently, this research directly contributes to organizations and practitioners involved in interaction design.

However, having a user- and context-informed design does not guarantee a useful and usable system from the user perspective. That is, this research merely examines the design practice in terms of interaction designers' general attentiveness to users and context, while assessment of the actual system usage, i.e. its user experience, as well as the relations between the design practice and the user experience is beyond the scope of this research. Moreover, this research examines HCD practice only regarding the involvement of users in context of use, and hence a detailed description on the application of specific HCD methods is not included.

1.6. Outline

Following this introduction, chapter 2 presents the theoretical grounds for this research as well as related studies. I start by positioning the research within the interrelated fields of interaction design and HCI. This is followed by a focus on interaction design approaches, particularly HCD, and more narrowly on the core principles of the approaches. From there, I discuss mobile computing and its effect on the core principles of HCD and the implications for interaction designers. Next, I establish the significance of the mobile apps era as a paradigm shift for interaction designers that requires research attention.

I then continue to the situated interaction design practice by elaborating on interaction design as a profession that scopes the work of interaction designers, after which I discuss interaction designers' work context, or in Suchman (2002b) words the 'site of technology production'. Last, I review other studies that are relevant to the understanding of the HCD practice as well as rationale of interaction designers in conducting HCD. More importantly, I explain the

knowledge gaps in the insights from existing research, which gave rise to the research questions and inspire this research exploration.

Chapter 3 presents the overall research methodology and individual studies. Firstly, I discuss three major epistemological worldviews in social research that help me orient this research's worldview and associated methodology. Thereafter, I describe the mixed-methods research methodology and explain its application in this research. Last, I provide a methodological overview of the qualitative and quantitative studies conducted within this research project, including the interactions between the studies.

Chapter 4 discusses the research results. I start by providing an overview of the main findings from each paper, following by synthesizing the results into coherent meta-inferences from the whole research project. The meta-inferences are then discussed regarding their relations to theories and practice (chapter 2).

Chapter 5 concludes the dissertation. I provide answers to the research questions, before discussing the implications of these answers on interaction design theory and research, as well as on its practice. I also discuss the limitations of this work and suggest paths for further research, taking a view on the future of mobile computing into account.

Chapter 2.

Theoretical background and related studies

This chapter presents the theoretical framework of this research and related work on the topic. I start by situating this dissertation within the boundaries of interaction design practice and the scientific HCI field, a research scope labeled here 'design-oriented scientific research'. Being the most noteworthy contribution of 'design-oriented scientific research', the HCD approach is examined along other seminal design approaches, followed by a narrower focus on the core HCD principles of the approaches. Next, mobile computing and its significant impact on core HCD principles are discussed, particularly in light of the mobile apps era and its paradigm change for interaction designers. I then elaborate on the professionals who are involved in interaction design as well as their organizational work context. Last, existing studies that are relevant for the questions raised in this research are discussed and the knowledge gaps that further motivated this research exploration are explained.

2.1. Interaction design

'Design', a core concept in this research, is a frequently used everyday label that invokes different connotations. To start with, the Oxford Dictionary[1] defines 'design' in terms of "*a plan or drawing produced to show the look and function or workings of a building, garment, or other object before it is made*", and also as "*the art or action of conceiving of and producing a plan or drawing of something before it is made*". The former leans towards an object or outcome from an activity, such as with a blueprint in architecture, a function model in system engineering, and a sewing pattern in fashion; the latter refers to an actual activity or process, for instance crafting a pottery in arts and crafts, shaping spaces in interior design, and defining the architecture and components in systems design. Blevis et al. (2006) assert, "*that many people in the popular culture think of design as decoration*" (p.5), whereas the notions held by those who are involved in professional design ranges from objects and features to

[1] http://www.oxforddictionaries.com

ecologies and futures. The different interpretations illustrate the ambiguity of the label 'design'. Hence, I shall first clarify 'design' for the context of this work.

The scope of this dissertation is the practical field named *interaction design*, which is concerned with the design of digital artifacts for people. Coined by the industrial designers Bill Moggridge and Bill Verplank in the mid-1980s, 'interaction design' instituted a new type of design activity. Rather than the design of physical objects, *interaction design is concerned with software-based computing systems*, such as PC, spreadsheet program, and microwave control system (Cooper et al. 2007). These systems allow the creation of unprecedented complex behavior, e.g. a microwave button that triggers multiple functions, such as setting the cooking program, adjusting time, and setting a timer, depends on the state of the system. Essentially, *interaction design is the process of defining and designing the complex behavior of systems* (Cooper et al. 2007; Saffer, 2010). While the designed behavior in systems may be complex, the interaction with the system should accommodate to people needs and desires. And so inherent in the *interaction design process is a human-centered endeavor* aiming at enhancing the desirability, and reducing the complicatedness, in the everyday interaction of people with computing devices and systems (Sharp et al. 2007).

The intellectual body of knowledge on interaction design draws, by large, on research within the Human-Computer Interaction discipline (Stolterman and Löwgren, 2004), which likewise is concerned with the design of effective and desirable computing systems for humans.

2.2. Human-Computer Interaction

Human-Computer Interaction (HCI) is an interdisciplinary field with a focus on the utility, usability, and user experience of systems. As the HCI label implies, the field is inherently broad, drawing insights from research in various fields, such as computer science, cognitive psychology, sociology, and anthropology (Myers et al. 1996; Benyon, 2014). Emerged in the early 1980s, the collaboration between the different fields was seen as essential in achieving the mutual aim of "*producing technological systems that are better for humans*" (Karat and Karat, 2003, p.533). More specifically, HCI was originally concerned with improving the utility and usability of computer systems (Preece et al. 1994). *Utility* refers to the extent to which the system functions are useful to the users. *Usability* is concerned with the extent to which the system can be used by users with effectiveness, efficiency and satisfaction in a specific context of use (ISO, 2010). As computing systems became more personal (e.g. with mobile computing), HCI research has put more emphasis on the holistic *user experience* - the emotional, psychological, and social responses of people before, during, and after the use of a system (Forlizzi et al. 2008; ISO, 2010). To achieve the

utility, usability, and user experience ends, design has played an increasing role in HCI research.

Interaction design emerged as an integral part of HCI research. During the early days of HCI, research was largely focused on producing computer systems with more "natural" interactions, e.g. direct manipulation and speech recognition, as well as observing the use of these systems (Karat and Karat, 2003). Insights on design approaches were mainly drawn from software engineering (Benyon, 2014). With computing systems being ever more accessible to people, e.g. with the emergence of graphical user interfaces, the Internet, and mobile computing, as well as the acknowledgement of utility, usability, and user experience as desired outcomes, the importance of the design process and design thinking in achieving these ends has significantly increased (Laurel and Mountford, 1990; Winograd, 1996; Forlizzi et al. 2008), which led to close collaboration between academic and industry-based design researchers and practitioners (Karat and Karat, 2003; Forlizzi et al. 2008). Consequently, HCI researchers became increasingly involved in the interaction design practice, while interaction design has become a strategic research interest in HCI (Myers et al. 1996; Fallman, 2003; Karat and Karat, 2003; Forlizzi et al. 2008).

The tight interrelationship between HCI and interaction design is further emphasized by the use of the terms 'HCI practice' (Gray et al. 2014) and 'interaction design research' (Fallman, 2008; Stolterman, 2008); the former denotes the interaction design practice, while the latter refers to research-oriented interaction design as well as the study of the interaction design profession and practice. This academic-based research into the practice of interaction design is described with different labels, e.g. 'science of design' (Cross, 2001), 'design studies' (Fallman, 2008), and 'design research' (Roedl and Stolterman, 2013). In this work, I use the term 'design-oriented scientific research' (adapted from Fallman, 2003) to denote the academic-based design, which is mainly concerned with the production of design knowledge, as distinct from the industry-based interaction design, which may involve design research methods but is not driven by scientific research questions and is primarily concerned with the products as an outcome.

Design-oriented scientific research is aimed at producing knowledge that supports interaction designers and theorizes the interaction design practice. Supporting interaction designers in attending to the complexity involved in designing usable software systems has long been established as major concerns of HCI research (Preece et al. 1994). More specifically, design-oriented scientific research has been increasingly interested in establishing the fundamental concepts and principles for a humanistic design process (Karat and Karat, 2003) as well as the development and assessment of humanistic design methods and tools that aim at improving the design process, such as methods to

understand users, inform the design, and evaluate the use of systems (Myers et al. 1996; Forlizzi et al. 2008). To assist scholars in increasing the practical relevancy of these methods and processes, design-oriented scientific research is also aimed at theorizing the complexity of the interaction design practice, particularly the activities interaction designers are engaged in, their experiences as well as their work context (Stolterman, 2008; Goodman et al. 2011).

This research is positioned within the design-oriented scientific research of computer systems, aiming at contributing to interaction design theories. I am aware that design-oriented scientific research extends beyond the vague boundaries of HCI, for instance to Computer Supported Cooperative Work (CSCW) that is mainly concerned with supporting the work of multiple people using computer systems (Grudin, 1994), and to Information Systems (IS) with its main interest on the application of enterprise computer systems in organizations. This research draws mostly on the HCI body of knowledge for its extensiveness and broad perspective on design-oriented scientific research. At the core of this research is arguably the most influential contribution of design-oriented scientific research – the Human-Centered Design approach and its core principles.

2.3. Human-Centered Design

Human-Centered Design (HCD, widely known as UCD to exchange 'human' for 'user') is a formally recognized design approach and attitude with a focal lens on users and the context of use. Emerged through the 1980s (Norman and Draper, 1986) in the domain of workplace computing, the approach has been popularized during the Internet era and after much efforts from scholars and practitioners alike was formalized by the International Organization for Standardization (ISO, 1999). Later on, the standard was adapted in response to the widespread of personal and consumer-based systems, e.g. by extending the notion of usability to aspects of the holistic user experience (ISO 9241-210, 2010). The standard describes a framework for complementing any methodology and process for the design and development of computer systems with a human, or user, perspective. On a high-level, the approach consists of four interdependent activities (see Figure 1). Acknowledging the mental and cognitive differences between designers and users (Norman, 1986), the HCD approach should follow key principles, largely based on Gould's (1988) early insights and the works by Shackel (1991) and Macleod and Bevan (1993). Most fundamentally, the design should be based upon an *explicit understanding of users and context of use* by *active involvement of users throughout design and development* as well as in *follow-up evaluations of actual system usage* (ISO 9241-210, 210). By that, HCD puts users, or user data, as a source to generate design ideas and as the main criteria to evaluate the usefulness, usability, and user experience of solutions (Karat, 1996).

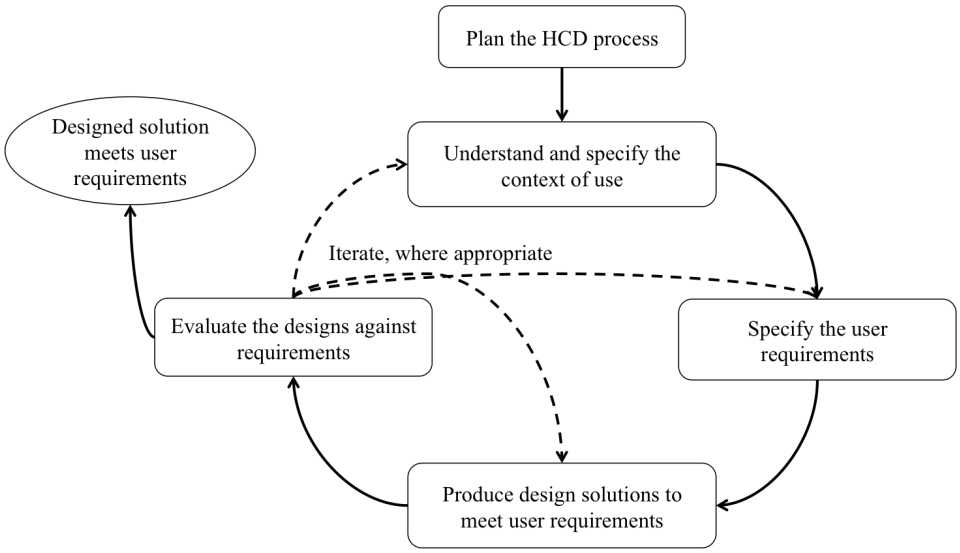

Figure 1: High-level human-centered design activities (ISO 9241-210, 2010)

A relatively similar human concern is advocated by a variety of design approaches. Among the seminal efforts are participatory design (Schuler and Namioka, 1993), usability engineering (Nielsen, 1993; Mayhew, 1999), contextual design (Beyer and Holtzblatt, 1997; Holtzblatt et al. 2005), goal-directed design (Cooper, 1999), scenario-based design (Rosson and Carroll, 2001), User Experience (UX) design (Hassenzahl and Tractinsky, 2006) and obviously Interaction Design (Sharp et al. 2007). More recently, efforts have been made (e.g. Da Silva et al. 2011; Gothelf and Seiden, 2013) to align the HCD approach with the constant increasing pace of software development (Millen, 2000) and its new methodologies, such as Agile (Martin, 2002) and Lean startup (Ries, 2011). While the approaches represent different attitudes and focal lens of activity, as the names imply, they are all committed to the HCD attitude of designing computing systems for human use. Essentially, the approaches agree on the need to involve users and explicitly understand the context of use during the design and development process, which are considered the *sine qua non* of HCD (Gulliksen et al. 2003). These principles are the central interest of this research; hence a closer examination on the notions of 'user involvement' (also called 'user participation', e.g. Gulliksen et al. 2003) and 'context of use' is warranted. Note that the focus in this work on HCD, rather than other design approaches, is motivated by the fact that HCD is the only standardized, and most established, design approach.

To start with, the word 'user' implies a mere focus on those who use the system, though it actually concerns all stakeholders that the system may directly or indirectly affect (Krippendorf, 2006; ISO 9241-210). Depending on the type of

interactive system being designed and the nature of its users, different types of user groups may be relevant, such as various groups of users who interact with and operate the system (i.e. end-users), people who technically and content-wise administer the system, and organizational management that have an interest in the financial rewards from the system. Accordingly, a prerequisite to the user involvement is the identification of all the stakeholders.

Attitudes on the concept and nature of user involvement greatly vary (Kujala, 2003). Conceptually, Barki and Hartwick (1989) distinguish between 'user involvement' and 'user participation'; the former refers to the users' psychological level of attachment with the system, while the latter denotes the users' functional level of performing different activities during the design. However, the terms are commonly used synonymously (Iivari and Iivari, 2011). A more practical categorization of user involvement is based on the type of involvement as suggested by (Damodaran, 1996): in *informative* involvement, users provide and/or receive information; in *consultative* involvement, users comment on a predefined service or range of facilities; and in *participative* involvement, users influence decisions relating to the whole system. Moreover, the types of involvement can be direct or indirect (Grudin, 1991b; Iivari and Iivari, 2011); direct denotes the involvement of actual users, while indirect refers to representative users or surrogate in case the direct users are unknown or when the user population is too large and diverse to be accommodated in the design. Iivari and Iivari (2011) describe surrogate as intermediaries that represent the actual users, such as UCD/usability specialists. Last, user involvement must have an impact on the design (Grudin, 1991b).

Practically, user involvement can be characterized on different continuums: from passive involvement, for instance by ethnographic observations and video analysis (Blomberg et al. 1993) to active by conducting workshop with users (Schuler and Namioka, 1993); from an ad-hoc consultative involvement in usability evaluation of solutions (Gothelf and Seiden, 2013) to longitudinal participative collaboration with users throughout the duration of the project, for instance in participatory design (Schuler and Namioka, 1993); from taking place in artificial environment, e.g. a usability lab testing (Nielsen, 1993), to a naturalistic work or use context as with contextual inquiry (Beyer and Holtzblatt, 1997); and from a remote collaboration with users by conducting a survey and remote usability testing to a face-to-face collaboration with users through interviews (Sharp et al. 2007). To a great extent, the nature of user involvement is dependent on the project circumstances (Sharp et al. 2007).

The formal principle on 'user involvement' emphasizes an active involvement of users in their use environment during different phases of the design and development process (Gulliksen et al. 2003; ISO 9241-210, 2010). Firstly, the stakeholder user groups must be the direct users or indirect representative of the

intended user groups of the system (Gulliksen et al. 2003; ISO 9241-210, 2010). Secondly, users should be involved actively by taking part in design and evaluation or act as a source of data, that is, involved to at least informative or consultative levels. Thirdly, users should be involved throughout the design, development, and post-deployments phases of a project. Gould (1988) emphasized the importance of early and continuous user focus to collect fundamental information for specifying requirements and to inform the design. Bevan and Macleod (1994) highlighted user involvement in evaluations to test design proposals. Users should also be involved in follow-up evaluations to obtain user feedback during the post-deployment phase, as input for redesign (ISO 9241-210, 2010). Lastly, the participation of users in the design and development process, especially with regard to evaluations, must take place in the actual context of use (Bevan and Macleod, 1994; Gulliksen et al. 2003; ISO 9241-210, 2010). Next, I discuss the notion of 'context of use', starting by clarifying the concept of 'context'.

Context is a highly abstract concept; it is omnipresent in our daily conversations, yet can mean anything (Pintilie, 2015). Context is also ubiquitous in our daily interaction with the world, since human cognition and action is always situated within, and contingent on, the circumstances of the interaction (Suchman, 2006). Within HCI, theoretical discussions on 'context' commonly break it down into two dimensions: internal processes, which relate to human goals, motives, and personal stories-so-far; and external resources, such as artifacts, people, and other settings of the situational environment (Nardi, 1996; Greenberg, 2001; Bradley and Dunlop, 2005). Essentially, both the internal and external aspects of context relate to a particular activity and are dynamically defined within this activity (Nardi, 1996; Dourish, 2004). Hence, context is not a property of the world, but rather the way a human is making sense of the world, that is, something can become contextually relevant only in the course of action (Svanæs, 2001; Dourish, 2004). In HCI, actions are commonly those related to the *use* of an interactive system, hence labeled as '*context of use*'.

'Context of use' broadly refers to internal and external contextual aspects that affect the interaction with a system (ISO 9241-210, 2010). The formal ISO standard acknowledges that the usability and user experience of a system is dependent upon the context in which the system is used. While context is dynamic, computing systems have long been used by limited classes of users, e.g. trained office workers and technology-oriented people, typically in a single external context, such as at workplace and at home, to support relatively routine tasks, such as typewriting, computations, and automation of work processes. Based on the experience from designing and using systems for routine tasks, i.e. activities, a set of high-level dimensions has emerged to support the identification of likely relevant contextual aspects. These dimensions help in describing the context of use, which comprises both internal processes, *the users*

and their intended tasks, as well as external resources*, the equipment (hardware, software and materials) and the physical, social, cultural and organizational environment,* in which the system is, or is intended to be, used (ISO 9241-210, 2010).

Generating explicit understanding of the context of use, a fundamental activity and principle of HCD, requires the involvement of users in the intended use context, especially in evaluations of design proposals. This type of user involvement *in situ* is often labeled 'field study' (as opposed to a lab study). The various human-centered approaches mentioned before provide an extensive source of practical methods and techniques to involve users in different settings, including in field studies. In addition, being a focal research interest within HCI, scores of human-centered tools to inform the design of interactive systems are documented in the ever-increasing body of knowledge (e.g. Preece et al. 1994; Laurel, 2003; Randall et al. 2007; Benyon, 2014).

With mobile computing, the variety of users and context of use significantly expand, which affect the efforts in attending to users and context of use.

2.4. Mobile computing

A fundamental concept in mobile computing is mobility. In fact, mobility is an attribute of human, not of computing or devices. Mobility is loosely defined as the ability of people to move between locations that greatly vary in their spatial, temporal, and social settings (Henfridsson and Lindgren, 2005). As they move, people carry their computing devices with them. The ability to use these devices during the movement and in varied multi-contextual settings distinguishes mobile computing from stationary computing, which is typically used in a single context of use. Dix et al. (2000) further identify three categories of mobile computing devices: (1) carried-on devices, such as personal digital assistant (PDA) and wearable technology; (2) autonomous devices, such as robots; and (3) devices embedded in another moving object, such as a computer in a car. This research is concerned with mobile computing as carried-on devices (hereafter, referred to as mobile devices). During the 1990s, mobile devices such as mobile phones and PDAs became more affordable, resulting in their increasing adoption by people and organizations. The ability to use computing on the move, independent of time and place, prompted research interest into mobility and the implications of mobile devices use (Dahlbom and Ljunberg, 1998). Besides the effect on individuals, organizations, and the society, mobile computing significantly affects the core principles of interaction design.

With mobile devices, the diversity of 'users' and variety of 'context of use' are significantly expanded. Typically, stationary computing (e.g. mainframe and desktop computers) devices are used in single, relatively homogenous context,

such as home and office, with limited contextual considerations. Moreover, possible contextual changes and their influence on the design are fairly predictable (Hinman, 2012). However, the inherent mobility characteristic in the use of mobile devices creates a variety of multi-contextual settings. Moreover, mobility results in a context of use that is dynamic and unpredictable (Forman and Zahorjan, 1994). Being highly affordable, mobile computing significantly increases the diversity of users and their tasks as well as the variety of mobile devices (Johnson, 1998). Reflecting upon the notions of 'users' and 'context of use' as discussed in the previous chapter, mobile computing and the ability to ubiquitously use mobile devices significantly expand the internal context, e.g. more diversified users and tasks, as well as the variety of the external context, e.g. technical, physical, social and cultural considerations in multi-contextual settings. This encouraged further research on theorizing the context of use in mobile computing.

From the perspective of ubiquitous and context-aware computing (Dey, 2001), research efforts have long concentrated on approaches to the representation of context for the engineering of context-aware systems (Abowd and Mynatt, 2000). Synthesizing prior research and theories on context from different disciplines, Bradley and Dunlop (2005) proposed a model to analyze context for the design of context-aware systems. The model emphasizes the understanding of the *meaningful* context, i.e. aspects that are implicitly related to user's goals, in relation to the *incidental* context, i.e. the situational context (relatively similar to the use of *internal* and *external* context). From an HCI perspective, Jumisko-Pyykkö and Vainio (2010) synthesized existing literature and proposed a more descriptive model of the context of use in mobile computing. The model presents a scientific classification of contextual aspects into components and sub-components. To highlight the dynamic nature of context, the model includes properties with a continuum aspect (e.g. rhythmic-random pattern, static-dynamic dynamism) that extends the description of components. The authors acknowledge the relational aspect of context, asserting that the degree to which the components are relevant to the usage is not assumed to be equal and is case-dependent. From a theoretical and conceptual perspective, the models provide an extensive framework for examining the context of use in mobile computing. Though, from a practical view, the expansion in the nature of 'users' and 'context of use' has considerable implications on the interaction design practice.

In essence, the explicit understanding of users and context of use in the design and development of mobile computing systems requires studies that extend over multiple spaces and temporal episodes. First, mobile systems denote the software or programs that run on mobile devices (mobile systems are elsewhere termed applications, programs, and services, depends on the venue). Being carried on, the use of mobile systems, especially for non-work activities, is being increasingly entwined with people's everyday work and private lives (Dix et al.

2000). Fundamentally, making sense of such rich context of use requires studies on people's daily activities by employing longitudinal ethnographic methods (Greenberg, 2001; Tamminen et al. 2004). Long-term studies can address, to some extent, the unpredictable nature of daily life by capturing the internal and experiential context (e.g. user goals, expectations, motivations) and their relation to the external situated context (Hassenzahl and Tractinsky, 2006) as well as understanding internal resources, such as the meanings people give to the technologies they use (Dourish, 2004). Moreover, system evaluations should take place where relevant mobile usage activities occur in real-world settings over longer periods than are customary in traditional laboratory sessions to capture real experiential outcomes (Hassenzahl and Tractinsky, 2006). However, within the course of a project, conducting longitudinal ethnographic-like studies to inform the design and evaluate design proposals as well as the real usage of systems is a laborious task. Essentially, interaction designers who are involved in mobile system design need more cost-efficient methods and tools. This challenge has emerged as a focal research interest among scholars and interaction design practitioners alike.

Numerous methods have been proposed to support interaction designers in their effort to understand people and technology in multi-contextual settings. For instance, to understand user needs, Millen (2000) proposes rapid ethnography; Ginsburg (2010) suggests 'shadowing' users combined with field interviews; Hinman (2012) proposes to employ a brainstorm in the field; and various practitioners suggest different diary approaches, such as experience sampling method (Consolvo and Walker, 2003), mobile probes (Hulkko et al. 2004) and a mobile-adapted diary study (Brandt et al. 2007). For evaluations of mobile systems, Kjeldskov and Stage (2004) suggest a usability laboratory augmented with certain characteristics of real-life situations; Kjeldskov et al. (2005) propose rapid reflection; Ginsburg (2010) recommends to approach people in coffee shops and on the street for testing under time constraints; and Kanstrup et al., (2010) demonstrate a living laboratory approach that resembles a realistic context. In addition, Baur et al. (2011) emphasize the ability to log actual usage data combined with self-reporting of usage. An extensive list of methods for the evaluation of user experience aspects was assembled by Vermeeren et al. (2010) (available in http://www.allaboutux.org/). Recent studies (Kjeldskov and Graham, 2003; Hagen et al. 2005; Coursaris and Kim, 2011) synthesized and summarized the growing literature on methods for understanding users in mobile computing. However, this body of knowledge does not tell us much about the state of interaction design practice in the industry. Moreover, the mobile and telecommunication industry has experienced a structural transformation since 2008 with far-reaching implications on mobile software practitioners.

2.5. The mobile apps era

In the mobile apps era, the use of mobile systems has become truly ubiquitous. For most of the mobile industry history (as of 2016), telecommunication network operators and handset manufacturers controlled the development and distribution of mobile systems. Moreover, the use of mobile devices was mainly characterized by basic communication, games, and time-management functions. On July 10, 2008, Apple opened the App Store, a mobile platform, complemented by a software development kit (SDK), for distributing mobile systems (i.e. mobile apps) that directly connects between third-party mobile app providers and end users; the handset manufacturer, i.e. Apple, controls the platform, but merely focuses on the quality of apps. The App Store also introduced a business model that allows app providers to generate revenues from the download and use of their apps. Shortly, other mobile OS providers (e.g. Google Android, Microsoft Windows Phone) created similar app stores, resulting in the democratization of mobile software design and development. At about the same time, the capabilities of mobile devices were profoundly transformed, most remarkably attributed to technology developments in device-embedded sensors, processors, and wireless technology. These developments allow for more natural ways to interact with the device, e.g. by touch-based gestures and by using voice-based natural language, as well as ubiquitously interact with other people, consume and generate information. In a short time, apps for touch-based smartphones and later also tablet devices became the focus of system development. The phrase "there's an app for that®"[2] symbolizes the multi-functionality of modern mobile devices. The mobile apps era has had a profound impact on interaction design.

With mobile devices becoming evermore embedded in the mundane lives of people, interaction designers need new competences to effectively elicit the relevant from the ordinary. In the mobile apps era, interaction designers are faced with three major challenges to the understanding of users and context of use: Firstly, *competences* in design for stationary computing are not directly transferable to mobile computing. As the mobile apps era opened the domain of mobile software development to the masses, most practitioners have no experience with the intricacies involved in designing for mobile. Making sense of the rich contextual settings in the use of mobile systems is considered to be "quite possibly the most essential skill necessary in creating great mobile experiences" (Hinman, 2012, p.vi). However, it is also a major challenge for interaction designers (Bentley and Barrett, 2012). Hinman (2012) argues that designers need to acquire new competences in, as well as methods and tools for, making sense of users and contexts. Moreover, usage is not merely limited to the

[2] "There's an app for that®" is a registered trademark of Apple Inc. (http://www.apple.com/legal/intellectual-property/trademark/appletmlist.html)

mobile experience, but is further complicated due to the increased user experience of systems on multiple devices (e.g. smartphone, tablet, desktop, TV) and on multiple platforms (e.g. iOS, Android, OSX, Windows), whether concurrently, asynchronously, collaboratively with others, or in ad-hoc situations. Involving users to understand such contexts of use within the course of a project is strenuous.

Secondly, the expansion in the diversity of users and variety of contextual settings of use requires more *resources* to explicitly understand users and context of use. The emerged competitive market for mobile apps put significant pressure on the resources to understand users. In no time, the app store platform and its financial incentives led to an increasingly competitive and dynamic market (Bergvall-Kåreborn and Howcroft, 2011). In addition, the use of Agile approaches for the design and development of software system has become common practice. A core principle of Agile methodologies concerns the short delivery cycles of incremental improvements to interactive systems. Given the need for longitudinal ethnographic methods in understanding users and context in the design of mobile systems, the competitive pressure and the incorporation of user involvement with the short Agile cycles, increase the challenge to effectively and efficiently elicit valuable data to timely inform the design (Seffah et al. 2005).

Lastly, the *abundance of data* on mobile usage poses a challenge to make sense of the data. The increase in embedded-sensors in touch-based devices, combined with wireless connectivity, allow the collection of a mass of rich data on usage behavior in real-time. This so-called 'Big Data' is further intensified with insights provided from an increasing amount of market research firms. However, the efficient and effective extraction of meaningful insights from so much data is a challenge that requires sophisticated tools. Moreover, although usage data may be greatly valuable for incremental improvement of systems, it implies that a system is already in functional use. Thus, usage data does not address the HCD principle on understanding of users and context to establish user requirements prior to system development.

While interaction design in the industry draws upon this intellectual knowledge from design-oriented scientific research, the practice of design has its own intellectual culture (Cross, 2001). With regard to the fundamental HCD principle of involving users in context during design and development, the design culture is critically distinct from science, not least in relation to the organizational environment in which interaction design takes place. This calls for a closer examination of relevant knowledge on the context of interaction design practice in the industry.

2.6. The situated Interaction Design practice

Interaction design as a profession incorporates loosely defined roles and different educational backgrounds. Professionals who are involved in the design of usable and desirable systems have continuously adapted their job labels to reflect their educational backgrounds (Boivie et al. 2006) and evolving range of activities (Karat and Karat, 2003). In fact, by the end of the 1990s, a bewildering amount of 52 names have been counted for the profession, for instance, HCI specialist and cognitive scientist (Boivie et al. 2006). Nowadays, the professionals who are involved in interaction design mostly use the labels of interaction designer, UX designer, usability engineer, information architect, and user researcher, though the boundaries for the range of activities in design roles are ill defined (Sharp et al. 2007). Furthermore, interaction design practitioners have different educational backgrounds, e.g. in psychology, computer science, marketing, and industrial design. Although such pluralization of views contributes to the interdisciplinary strength of the field, it nonetheless plays a role on practitioner's values towards human-centeredness and the consequent approach to involve and to understand users. The human-centered approach is further influenced by interaction designers' ability to reflect-in-action.

Interaction design is a reflective activity that is largely inherent in a 'designerly', rather than scientific, culture. The ultimate goal of design is the production of artifacts that aim to improve an existing situation (Cross, 2001; Fallman, 2003). To that end, designers do not simply follow a straightforward problem-solving process of analyzing the problem by involving users, synthesizing design solutions, and evaluating the solutions with users. Instead, interaction designers are commonly involved in unordered, informal and iterative activities to make sense of the problem as well as the solution (Fallman, 2003). This process was described as "the 'designerly' ways of knowing, thinking, and acting" (Cross, 2001, p.55), that is, the knowledge and expertise are largely gained through their experience with, and through designing for, the artificial world, rather than being inherent in science. Schön (1983) established this view on the design process as a reflective dialogue with the design situation, arguing that designers are inclined to conduct experiments, e.g. by involving users or carrying out field studies, when the available knowledge is insufficient to understand the problematic situation they face. Given the different educational backgrounds, the 'designerly' and reflective action further emphasizes the knowledge and skills of designers (or 'abilities' as suggested by Stolterman and Löwgren, 2004) as instrumental on their tendency for attending to users and context of use as well as the approach to do so. Essentially, the reflective action as well as the knowledge and skills are situated within specific settings.

Interaction design takes place within organizational settings with specific strategies. Organizations have strategies that aim to establish effective and

efficient work routines to generate value, in many cases a long-term value to shareholders. Organizational strategy can be conceptualized using two paradigms, outside-in and inside-out (De Wit and Meyer, 2010). Outside-in approaches are guided by the competitive business environment of the organization and focused on its strategic positioning using aspects such as cost leadership and differentiation (Porter, 1985), operational excellence, product leadership, and customer intimacy (Treacy and Wiersema, 1993) as well as innovation (Christensen, 1997). Inside-out perspectives are focused on the availability of resources and capabilities within the organization as a source for its competitive advantage (Barney, 1991; Mata et al. 1995). Regardless of the approach, organizational strategies govern the allocation of resources, e.g. competent human capabilities and financial resources, to its necessary operations, including to interaction design. Consequently, organizational strategies also affect the involvement of users, being an integral part of the interaction design process. However, strategies are often created, maintained, and implemented by organizational management that may have different perception of interaction design. The influence of decision makers on interaction design calls attention into the social complexities of organizations.

Interaction design is commonly practiced within the context of an organizational project with multiple stakeholders. Projects are complex social systems that require the collaboration of many stakeholders at various ranks within the organization as well as with external business partners. Stakeholders have distinct educational and professional backgrounds that shape their views (Suchman, 2002a). Moreover, stakeholders have different motivations and expectations that have to be fulfilled (Krippendorf, 2006). Schön (1983) observed that practitioners, including designers, are being "frequently embroiled in conflicts of values, goals, purposes, and interests" (p.17). The different views of stakeholders increase the potential for conflict between the decision criteria as defined by the profession and the criteria that is enforced by those with decision-making power (Simon, 1969). The potential for conflict is particularly relevant for interaction design, since it is increasingly provided as a consultancy service in a professional-client relationship (Sharp et al. 2007). Conflicts can emerge between a professional view of design as a human-centered endeavor and a business perspective on achieving financial objectives, affecting the process for, and outcomes from, design, particularly considering that design outcomes are limited to propositions, which others implement to the final artifacts, i.e. the systems people use (Krippendorf, 2006).

Last, the interaction design process, especially the application of HCD, is dependent on the employed software development process. In software engineering, a software development process is a "framework for the tasks that are required to build high-quality software" (Pressman, 2005, p.21). In an effort to organize and improve the cost-efficient development process of software,

different approaches, or models, have been devised throughout the evolution of computing. Among the seminal models are the Waterfall model (Royce, 1970), the Spiral model (Boehm, 1988), the Rapid Application Development (RAD) model (Martin, 1991), the Unified Process (UP)(Jacobson et al. 1999), and more recently Agile development models such as Scrum (Schwaber and Beedle, 2001) and Extreme Programming (Martin, 2002). While the approaches agree on the core activities, they differ in the process of implementing the activities (Pressman, 2005). Nowadays, multiple models are employed by organizations, acknowledging that there is no silver bullet (Brooks, 1987), or a universal software development process that is suitable to all project cases. Being complementary to software engineering, HCD principles, e.g. the involvement of users, and activities, e.g. the early understanding of context of use, are contingent on the situated software development process and the extent to which the process allows the integration of HCD methods. For instance, Agile approaches encourage the constant incremental delivery of software based on user feedback and insights, though lack in the support for early focus on and validation of user needs (Seffah et al. 2005).

To sum up, HCD is a standardized and most established approach to the design of interactive systems for people use. Along with other popular interaction design approaches, it emphasizes the need to involve users during the entire project lifecycle. Moreover, users should be involved in the context of use, especially for design evaluations. However, the elimination of time and space constraints in the use of mobile devices has a significant effect on the design of mobile systems. Essentially, mobile systems are used in the context of everyday life and so understanding users and context of use in design requires the long-term involvement of users throughout their daily habits. The mobile apps era demonstrates to a greater extent the embeddedness of technology in the social and professional life of people. The challenges that interaction designers face at the mobile apps era call for reexamination of the HCD practice, essentially with regard to designers' attentiveness to the involvement of users in context of use. Recent developments in mobile technology, such as the rise of sensor-enabled wearable technology and in-car technology (Meeker, 2013), put further demands on the work of interaction designers and emphasize the timely importance of this research. In addition, within organizational settings, interaction designers are part of complex social systems with different personal views, conflicts of interests, and various software development processes that affect their practice. Next, I review relevant studies on the interaction design practice in the industry.

2.7. Relevant insights on the HCD practice

Insights on the interaction design process regarding the utilization of HCD methods for involving user in context highlight a gap between the theory and the design practice. Throughout the history of HCD, multiple studies have examined

the state of HCD practice from different perspectives, for instance, a general view on the utilization of HCD methods and techniques (Hudson, 2000; Vredenburg et al. 2002; Gulliksen et al. 2004); the strategic positioning of HCD within the organization (Rosenbaum et al. 2000; Ji and Yun, 2006; Venturi et al. 2006); the integration of HCD with software development processes (Gunther et al. 2001; Bygstad et al. 2008; Hussain et al. 2009); a focused view on usability evaluations (Bak et al. 2008); and a focal lens on the utilization of field methods (Monahan et al. 2008). Overall, the studies indicate that the involvement of users takes place, by large, in artificial environments, e.g. a usability lab, using methods such as usability evaluation, interview, lo- and hi-fidelity prototyping. Moreover, expert inspection methods that are characterized by indirect involvement using surrogates or mediators and do not directly involve users, such as heuristic evaluation, are also common. Rather than structured, interaction designers tend to use methods informally, i.e. 'quick and dirty' (Hudson, 2000; Venturi et al. 2006). Among field-oriented methods and approaches, interaction designers commonly use contextual inquiry, user observation, participatory design, and field evaluations. Along with usability testing, field-oriented methods are perceived by practitioners as highly effective, though such methods are utilized significantly less frequent (Rosenbaum et al. 2000; Vredenburg et al. 2002; Gulliksen et al. 2006; Monahan et al. 2008). A cost-benefit tradeoff plays a key role on the HCD practice in industrial context.

Interaction designers are often faced with financial and temporal constraints that limit their ability to understand users and context. The obstacle to use field-oriented methods and techniques is largely attributed to the perceived costs of these methods and the lack of budget and time allocated during the project (Rosenbaum et al. 2000; Vredenburg et al. 2002; Ji and Yun, 2006; Bak et al. 2008; Bygstad et al. 2008). Resources for interaction design are also expressed in terms of competent personnel (Rosenbaum et al. 2000; Ji and Yun, 2006). The allocation of these resources is directly linked to the organizational management, indicated by the frequent observation that awareness and support for HCD within an organization, particularly among managers, greatly encourage the work of interaction designers, whereas the lack of support inhibit their efforts (Rosenbaum et al. 2000; Gunther et al. 2001; Gulliksen et al. 2004; Iivari, 2006; Ji and Yun, 2006; Venturi et al. 2006). Though, awareness is not limited to managers; the different views held by software developers and interaction designers, for instance regarding the importance of usability (Ji and Yun, 2006) and usability testing (Bak et al. 2008), also affect the design practice. As may be expected, the experience of design professionals also plays a role on their inclination for certain practice (Hertzum and Jacobsen, 2001; Gulliksen et al. 2006; Suwa and Tversky, 2001). Overall, these factors point to the strategic importance of interaction design within the organization. Though, the studies examined the HCD work in general. A closer look on the specific task of user involvement indicates on forces that are also external to the organization.

The involvement of users is influenced by a complex multi-layer factors and actors. Using the layered model of software development process (Curtis et al. 1988), the factors can be analyzed on the layers of business environment, company, project, team, and individual practitioner. On the highest level, constant changes in technology and consumer demands requires ongoing user research (Page, 2005), but also introduces challenges to involve users with the lack of available systems (Balaji et al. 2005). On the organizational layer, user involvement is mainly influenced by the strategic importance of HCD within the company, particularly the allocation of temporal and financial resources and capabilities (Grudin, 1991b), the organizational culture (Iivari, 2004), and restrained access to internal users (Poltrock and Grudin, 1994). On the project layer, the project type, e.g. contract-, product-, and in-house development affect the timing of user involvement (Grudin, 1991a), while the short-term relationship between client and professional design companies as well as the internal politics creates difficulties to user involvement (Gasson, 1999; Bruno and Dick, 2007). In addition, projects are focused on specific interactive software systems with different nature and different diversity of users, which affect the effort to identify and access relevant users (Axtell et al. 1997).

On the team level, the integration of user involvement into the short agile cycles of release is challenging (Sy, 2007), while divergent views on user involvement within the team requires compromises (Iivari, 2005). On the lowest level of individual practitioner, user involvement is mainly rationalized by practitioners' attitudes on users and user involvement (Hertzum, 2008), as well as by practitioners' background experience and education (Iivari, 2005). In addition, internal and external dynamics, i.e. changes to societal conditions, affect user involvement on most layers.

Regarding user involvement in context of use during the design of mobile systems, insights mainly highlight the need for resources, and the nature of the designed system, its users and context of use as having impact on user involvement. Resource constraints are most commonly mentioned as a factor that affects the conduct of field studies (Monahan et al. 2008; Ahtinen et al. 2007; Baxter and Sommerville, 2011). For instance, Kangas and Kinnunen (2005) report on a mobile system that was tested in a lab environment due to limited budget, though the use cases for the system are strongly context-dependent. The type of the mobile system, e.g. an administrative tool for road maintenance workers (Ahtinen et al. 2007) or in-car infotainment system that interconnects with mobile devices (Henfridsson and Lindgren, 2010), plays a key role on the motivation for conducting field studies, though the constant switches in the context extends and complicates the context of the designed system, which requires attention to each specific local context (Henfridsson and Lindgren, 2010). The diversity of users of mobile devices is observed as a challenge to the identification of relevant users (Kujala and Kauppinen, 2004;

Page, 2005). Last, the security and privacy of users as well as the dynamic of the mobile use environment is a challenge to contextual ethnographic studies (Balaji et al. 2005; Blom et al. 2005).

These insights indicate on the increasing challenge to involve users in context during the design of mobile systems. Next, I elaborate on the limitations of these insights.

2.8. Knowledge gaps

Further examination of the interaction design practice is required in light of three major gaps in the body of knowledge (at the outset of this research on late 2010): (1) insights into scientific approaches to address the challenge of involving users in context of use during the design of mobile systems in the mobile apps era are largely dispersed; (2) insights into the specific interaction design practice of mobile systems in the industry, let alone in the mobile apps era, are scant. These gaps are further discussed.

There is an active research interest on devising HCD methods for the design of mobile systems, though insights are dispersed. Mobile computing has stimulated scholars to conceive and practice new and adapted methods to support interaction designers in the effort to understand users and context (as reviewed by Kjeldskov and Graham, 2003; Hagen et al. 2005; Coursaris and Kim, 2011). The mobile apps era opened new opportunities to the effort of interaction designers, e.g. streamlined process to distribute mobile systems, worldwide masses of potential audience, ubiquitous usage of mobile systems, and sensors that generate real-time usage data. This encouraged scholars to look for ways to efficiently utilize the new possibilities. Such methods and techniques are highly relevant to interaction design practitioners and researchers alike, though they are rather scattered in the numerous academic outlets for reporting on design-oriented scientific research. Thus, this work synthesizes and summarizes the explorations with HCD methods and techniques that emerge during the mobile apps era as well as providing a contemporary view on the HCD practice in academic projects.

There is limited research attention on examining the state of interaction design practice with mobile systems in the industry. Existing studies on the state of HCD (e.g. Hudson, 2000; Rosenbaum et al. 2000; Vredenburg et al. 2002; Gulliksen et al. 2004; Ji and Yun, 2006; Venturi et al. 2006; Bak et al. 2008; Bygstad et al. 2008) provide relevant views on the design of interactive systems in general, though the studies did not specifically examine the design of mobile systems. Monahan et al. (2008) focused on the use of field methods in design, though the study participants were not limited to those involved in mobile computing. Nevertheless, the study outlines interview, observation, and

contextual design as the most commonly used methods to understand users and context, with resource constraints being a major factor affecting designers' inclination to involve users in the field. Given the fundamental effect of mobile computing on the core HCD principles of user involvement and context of use (see section 2.4), relatively little is known about the interaction design of mobile systems, let alone in the mobile apps era. This research fills this gap by presenting a timely and descriptive account on the state of HCD practice in the industry.

Understanding the state of interaction design practice requires complementary insights into interaction designers' motivation for practice. To start with, 'context' has been extensively theorized and modeled (see section 2.3); though, given the common usage of the 'context' label and the ambiguous nature of the concept, the perceptions of 'context' by those involved in design may differ from its scientific understanding. Such perceptions can affect the approach to address the context of use. However, at the time of research, no knowledge exists on the perception of 'context' as held by practitioners who are engaged in design, especially when considering the crowds of practitioners who joined the mobile bonanza during the mobile apps era. As part of examining the HCD practice, this research study practitioners' perception of 'context' in order to bridge this knowledge gap.

Moreover, the organizational context in which interaction design takes place requires more research attention. The increasing time constraints for understanding users in the mobile apps era coupled with the increased flow of data on usage behavior requires competences for the effective and efficient understanding of changes in the business environment and consumer demands. Existing studies merely highlight strategic factors, such as the lack of HCD resources and capabilities, as affecting the understanding of users. Thus far, the relationship between the strategic management and the design practice has not been studied. This research examines how different organizational strategies, i.e. cost-focused and innovation-focused, directly and indirectly affects aspects of the HCD practice. Such insights complement the understanding of the HCD practice on a broader level of the organizational management.

Lastly, the diversity of users in the mobile apps era and the variety in the context of use require more insights into the specific task of involving users within organizational projects. The multi-layer forces that affect user involvement within industrial projects (see section 2.7) explain to large extent the difficulties to apply a fundamental HCD principle in the real world. In the mobile apps era, a recent study (Bauer et al. 2014) on context aware systems indicates that designers commonly face "difficulty in finding ways to explore the user's interaction with the system in context" (ibid, p.434). The findings suggest that this challenge is facilitated to some extent as designers gain professional

experience (with context-aware systems). Given the impact of the mobile apps era on interaction designers' efforts to apply the core principles of user involvement and context of use, the core factors that affect their rationality to involve users, especially to involve users in field studies, are yet to be examined. This research complements the state of HCD work with mobile systems in industrial context with a qualitative lens on the forces that affect user involvement, especially in the context of use.

Having clarified the knowledge gaps that motivated this research, in the next chapter I discuss the methodological approach and scientific inquiries I took to address these gaps.

Chapter 3.

Research Methodology

In this chapter, I first introduce the main epistemological worldviews in social research before explaining Mixed-Methods Research, the overall methodology that embraces diverse paradigmatic investigations and provided high-level guidelines for this project. Following that, I explain the application of a mixed-methods approach in this research and provide an overview of the studies that were conducted.

3.1. On epistemological worldviews

Internal to every research exploration are the researcher(s) epistemological worldviews that impact the way new knowledge is gained and inferred. Creswell and Clark (2011) maintain a 'worldview' as the philosophical assumptions and set of beliefs, "the epistemology behind the study or how researchers gain knowledge about what they know" (p. 38). Worldviews are at the broadest abstract level in planning a research, informing the theoretical foundations of the research that in turn guide the selection of a methodological approach and finally the methods that are used to collect and analyze the data (Crotty, 1998). Hence, making one's worldviews explicit is essential to the understanding of the holistic research exploration. Note that the term 'worldview' is often used synonymously with the term 'paradigm', which is defined as "the basic belief system or worldview that guides the investigator, not only in choices of method but ontologically and epistemologically fundamental ways" (Guba and Lincoln, 1994, p. 105). In this work, the terms 'worldview' and 'paradigm' are used interchangeably.

Generally, scientific research can be roughly categorized into three dominant epistemological worldviews – positivist, constructivist and pragmatist (Creswell and Clark, 2011). While other worldviews exist, I elaborate on these three, as they are most relevant for this research. The *positivism* worldview has foundations in the 'hard' sciences, such as mathematics, physics and chemistry, which are strong in their ability to quantify. Positivists assume determination - the existence of basic laws, or ultimate facts, that control natural events (Wardlow, 1989; Creswell and Clark, 2011). It was believed that quantitative is

the only way to produce valid data, and the higher degree of quantification ultimately leads to universal theories (Guba and Lincoln, 1994). Hence, a quantitative approach is historically associated with the positivist worldview and with the verification of theories. Practically, a quantitative approach uses "questions that lend themselves to numerical answers" (Patton, 2002, p.13). Using a narrow set of variables that are believed to be interdependent, though analytically distinct, positivist researchers study a particular natural phenomenon. They collect quantitative empirical data and measure the interrelations of the variables by using mathematical formulas, manifested in the form of statistical methods, to inform the theory on the inquired phenomenon (Creswell and Clark, 2011). Acknowledging certain difficulties with positivism, such as the researcher's lack of objectivity and the nature of reality as being constructed rather than determined, the worldview was developed to reflect a more critical view of realism and the falsification of theories (Guba and Lincoln, 1994). Nowadays, positivism is commonly labeled 'postpositivism', though the dominant inquiry approach remains quantitative (Teddlie and Tashakkori, 2003).

In contrast, the *constructivism* worldview is based on the understanding of a natural phenomenon as socially constructed through the subjective views, values and meanings of various participants (Creswell and Clark, 2011). Rather than focus on a set of determined variables, constructivists develop and refine theoretical constructs 'bottom-up' by interacting with participants, who share their contextual and social experiences-so-far. Ultimately, the inferred constructs inform a holistic understanding of the phenomenon (Guba and Lincoln, 1994; Creswell and Clark, 2011). By this, the constructivism worldview addresses some of the main shortcomings of positivism as described before. The constructivism worldview (also labeled as 'interpretivism' or 'naturalism') is associated with the qualitative methodological approach and with theory generation (Teddlie and Tashakkori, 2003; Creswell and Clark, 2011). In contrast to quantitative approach and its numerical focus, a qualitative approach tells stories, describes experiences, and explains meanings by using quotations, observations, and document excerpts as its data (Patton, 2002).

Finally, the *pragmatist* worldview is mainly concerned with practicality - addressing the research question with the most appropriate methods, rather than being subject to a specific worldview and methodological approach (Teddlie and Tashakkori, 2003; Creswell and Clark, 2011). Pragmatists reject the epistemological incompatibility between positivism and constructivism that is held by purists of the worldviews and use a combination of both quantitative and qualitative approaches in a pluralistic research with multiple stages. This problem-centered and real-world practice view is commonly associated with mixed-methods research (Teddlie and Tashakkori, 2003; Johnson and Onwuegbuzie, 2004).

Taking a pragmatist view that is informed by HCI literature, particularly regarding the HCD approach for system design (ISO, 2010), in this research I employed a mixed-methods approach by combining qualitative interviews and a quantitative questionnaire to examine and explain the HCD practice in the design and development of mobile systems. While interview and questionnaire are associated with qualitative approach and quantitative approach, respectively, each method can be internally mixed, that is, interviews can have quantitative data and questionnaires can have qualitative questions depending on the research aim and questions.

3.2. Mixed-Methods Research

Mixed-Methods Research (MixMR) is an approach that involves multiple methods, essentially a combination of quantitative and qualitative, to study a particular phenomenon (Tashakkori and Teddlie, 2003). Acknowledging the dynamic and multi-structural aspects that influence events in the real world, Mingers (2001) encourage researchers to make use of a 'strong methodological pluralism' by employing a variety of research methods and paradigms to understand real-life problems. Moreover, Mingers (2001) notes that a research inquiry often realized as a process that poses different problems at different phases, each requires an appropriate method. Hence, a mixture of suitable approaches would result in a more holistic understanding. Tashakkori and Teddlie (2003) established MixMR as the 'third methodological movement', following quantitative as the first 'movement' and qualitative as the second 'movement'. Teddlie and Tashakkori (2003) further clarify a common confusion between *multimethod* research and *mixed-methods* research; both denote a research endeavor with multiple methods to collect empirical data, though the first indicates on methods that may be within the same worldview (i.e. quantitative or qualitative), while the latter necessitates the employment of both quantitative and qualitative research methods.

MixMR allows researchers to address both confirmatory and exploratory questions, develop strong inferences and provide diversity of views (Teddlie and Tashakkori, 2003). Firstly, quantitative methods are mostly associated with theory verification, while qualitative methods are typically employed for theory generation. By combining them in the inquiry of a specific phenomenon, the researcher is able to confirm hypotheses and explore questions more in-depth. Secondly, given the shortcomings and weaknesses of certain methods, e.g. lack of breadth or depth, understanding the complexity of social phenomena requires complementary methods. By using complementary mixed-methods, researchers develop and expand on inferences from one phase of the research to another and ultimately develop meta-inferences that integrate all the findings. These meta-inferences are considered to be stronger than inferences from a single study or worldview and are an essential quality of MixMR. Lastly, the combination of

methodological worldviews may lead to converging views, but also to contradicting inferences and an overall incoherent picture of the explored phenomena. Rather than a weakness, the diversity of views is considered an added value of MixMR that leads to new understandings of the phenomena, re-examination of the underlying assumptions, and/or new study for further explorations of the phenomena. The rationality for, and strengths of, MixMR makes it an appropriate methodology for this research project.

To start with, this research aims at exploring and explaining a particular social phenomenon - the interaction design practice in light of the shift to mobile computing and its fundamental impact on the core HCD principle on user involvement. This phenomenon takes place in real-life environment that is socially complex and dynamic, involving multiple stakeholders on various levels, e.g. design and project teams, organizational management, business environment partners, as well as end users, all have an influence on the course of HCD action. Moreover, the complexity and dynamic nature of the HCD context is fueled by rapid technological developments that require appropriate actions. As a recent emerging phenomenon (the research started in 2010, two years after the commencement of the mobile apps era), explaining the HCD practice necessitates, at the minimum, an initial exploratory study followed by a broader confirmatory study. Therefore, understanding the HCD practice with mobile systems requires a MixMR approach by involving a diversity of worldviews and methods, both in-depth and in-breadth.

Situational aspects of the research circumstances also influence the selection of a mixed-methods approach. Firstly, the researcher(s) involved need to have enough resources (especially time), appropriate competences and possible collaboration (Mingers, 2001; Teddlie and Tashakkori, 2003; Creswell and Clark, 2011). The research takes place within a dissertation project, which provides sufficient time resources for multiple studies. Moreover, the author had previous experience with conducting a qualitative study, which are generally more time-consuming. Possible collaboration was considered for the quantitative studies, particularly with advanced inferential analysis techniques. Secondly, there should be adequate intellectual body of knowledge that is relevant to the phenomenon of interest, including theories and research methods (Mingers, 2001). The HCD approach and its principles are well established in the HCI literature with both quantitative and qualitative methods being used to understand the work of relevant professionals. Thirdly, the context of the researched phenomenon, e.g. particular individuals, type of activity, profession, organization, industry or country, has to be considered (Mingers, 2001; Venkatesh et al. 2013). The design and development of mobile systems is very popular in Finland, and therefore, local organizations were considered as a suitable starting point. Since the interaction design practice involves many stakeholders within organizational and project settings, it is essential to meet

with various practitioners who are most insightful on HCD-related activities and decisions. Hence, the practitioner scope of the research includes those in roles that are related to interaction design, business management, and software development. Later in this chapter, I explain how the context of the studied phenomenon evolved, particularly with regard to activity, industry and country.

Last, examining the specific purposes for using MixMR serves as a decision tool to assess whether the research objective and questions fit with either one or multiple purposes. Venkatesh et al. (2013) summarized the seven purposes of MixMR: complementarity, completeness, developmental, expansion, corroboration/confirmation, compensation, and diversity. Complementarity is most commonly used as the overall purpose for conducting a mixed-methods approach (Bryman, 2006). Based on the research objective and questions as stated in chapter 1, *complementarity* is also the main purpose for the mixed-methods approach in this research, specifically:

- to obtain complementary in-breadth and in-depth understanding of the HCD practice with mobile systems that helps to explain its nature

Bryman (2006) emphasizes the common use of multiple purposes in the application of mixed-methods approach. Hence, the more detailed purposes for the mixed-methods approach in this research include:

- Developmental – develop hypotheses on the HCD practice in one study and test them in a sequential study
- Expansion – explain the broad view on the HCD practice that is obtained from a quantitative study with detailed understanding that is inferred from a qualitative study
- Confirmation – assess the credibility and validity of findings obtained from a quantitative study of the HCD practice with a qualitative study (i.e. triangualtion of methods)
- Diversity – Obtain divergent views on the HCD practice from various practitioners who are involved in the HCD practice and decisions (i.e. triangulation of perspectives)

To sum, the MixMR approach is appropriate to address the objective and questions in this research, while contextual considerations were found to be more favorable than limiting. Next, I present two principles of MixMR that guided the application of the approach in this research.

3.2.1. Principles of Mixed-Methods Research

The literature on MixMR outlines two fundamental principles of the approach:

1. Mixture of worldviews - a research approach that combines qualitative and quantitative paradigms as well as their findings in a single or multi-phased research inquiry (Teddlie and Tashakkori, 2003; Johnson et al. 2007; Creswell and Clark, 2011; Venkatesh et al. 2013)

2. Mixture of methods - a research approach that employs qualitative and quantitative research methods that have complementary strengths and no overlapping weaknesses (Johnson and Turner, 2003; Onwuegbuzie and Teddlie, 2003)

These principles are used in describing the application of MixMR in the next section.

3.2.2. Applying Mixed-Methods Research

An outline of the mixed-methods approach as applied in this research is presented in Figure 2. Johnson and Onwuegbuzie (2004) emphasize the recursive and interactional nature of the process, in which phases "are not necessarily linear or unidirectional" (p.21). The approach taken in this research reflects this dynamic and iterative process, in which Figure 2 merely provides a high-level snapshot of the process. Hence, the remains of this chapter elaborate on the process by illuminating the interactions between the studies.

The diagram and notational system in Figure 2 comply with the guidelines for reporting mixed-methods by Creswell and Clark (2011). In particular, the notational system conforms to the mixed-methods research nomenclature as first developed by Morse (1991, 2003) and includes the following components:

- Quan = quantitative
- Qual = qualitative
- Uppercase QUAN/QUAL denotes dominancy in the approach
- Arrow (→) indicate on a sequential data collection (e.g. Qual → Quan)
- Plus (+) is a sign for concurrent data collection (e.g. QUAN + Qual)

The mixed-methods approach in this research is sequential with equal roles for the qual and quan phases. Hence, the uppercase QUAN/QUAL as well as the plus (+) sign are not used. Also note that study 1 is a systematic literature analysis that precedes the mixed-methods phases and aims at providing basis and direction for the overall research, though the study per se is not part of the mixed-methods phases.

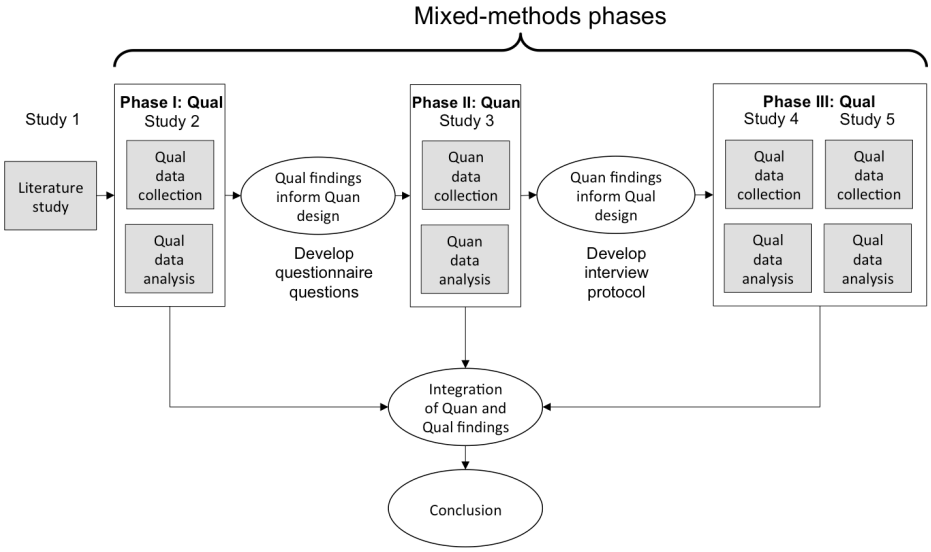

Figure 2: Outline of the mixed-methods approach applied in this research

A methodological overview of the conducted studies is presented in Table 1, while a more elaborated methodological discussion of each study follows in section 3.3.

Table 1: Methodological overview of the studies

Study	***Aims***	***Data collection***	***Data analysis***
Study 1	• Understand what scientific HCD methods are used in the design of mobile systems • Find research gaps and avenues for further research	Procedure: • Systematic literature search Product: • 79 reviewed papers	Procedure: • Summarizing and synthesizing • Descriptive statistics Product: • Outline of employed HCD methods • Descriptive account of emerging methods
Study 2	• Explore the HCD practice in the industry by obtaining divergent views • Understand challenges in the application of HCD • Develop hypotheses	Procedure: • Semi-structured interview • Participants who are engaged in mobile system design in Finland (N=20) Product: • Interview transcripts	Procedure: • Cross-case synthesis to understand patterns and challenges to the application of HCD Product: • Outline of HCD-related themes to inform further research

Study 3	• Understand the state of HCD practice from a 'context of use' lens by obtaining divergent views • Test hypotheses on the relation between organizational strategy and HCD practice • Expand the understanding on practitioners' perception of context	Procedure: • Web-based questionnaire • Random sample of participants (N=150) Product: • Numerical and textual data	Procedure: • Descriptive statistics • Confirmatory factor analysis • Inferential statistics for conceptual model testing using Structural Equation Modeling with SPSS-AMOS Product: • Descriptive account of the HCD practice and practitioners' perception of context of use • Confirmation of hypotheses on the relation between organizational strategy and HCD practice
Study 4	• Understand the context of HCD practice • Expand the depth of understanding on factors that affect HCD practitioners, specifically the involvement of users in context of use • Validate findings obtained from study 3	Procedure: • Participants who are involved in mobile system design for media and finance in the Netherland (N=26) • Semi-structured interview Product: • Interview transcripts	Procedure: • Coding and thematic analysis following grounded theory approach with Atlas.ti CAQDAS • Cross-case synthesis Product: • Explanatory model on factors that affect HCD practice
Study 5	• Replicate findings from study 4 in a different country • Develop the understanding on factors that affect HCD practitioners, specifically the involvement of users in context of use	Procedure: • Participants who are involved in mobile system design for media and finance in Finland (N=15) • Semi-structured interview Product: • Interview transcripts	Procedure: • Coding and thematic analysis following grounded theory approach with Atlas.ti CAQDAS • Cross-case synthesis • Own analysis framework Product: • Explanatory model on factors that affect HCD practice • Account of HCD practice with regard to core HCD principles

Since MixMR emphasizes the appropriation of the research inquiries to the presented problem, there is no universal process for MixMR. Hence, I use the MixMR principles (section 3.2.1) as a basis to describe the application of the mixed-methods approach in this research.

(1) Mixture of worldviews: Combining the qualitative and quantitative paradigms in a mixed-methods research starts with the design strategy, which requires two major considerations - temporal and paradigmatic (Mingers, 2001; Johnson and Onwuegbuzie, 2004; Venkatesh et al. 2013). Regarding the time order, the strategy follows either a concurrent or sequential design. In a concurrent design, studies are employed at one phase with the findings from studies informing each other. With a sequential design, studies are carried out in successive phases with the findings from one phase feeding into the sequential phase. In both cases, quantitative and qualitative worldviews can take a fairly equal role in the overall approach or one worldview may dominate the approach, e.g. an intensive ethnographic study with supporting statistical data (Mingers, 2001; Johnson and Onwuegbuzie, 2004; Johnson et al. 2007).

Figure 3 presents the matrix of design strategies for MixMR as adapted from Johnson and Onwuegbuzie (2004), annotated with labels (in parentheses) by Creswell and Clark (2011). Johnson and Onwuegbuzie (2004) encourage a creative approach, such as with complex designs that include more studies than is presented. For instance, Creswell and Clark (2011) explain the multiphase design strategy in which concurrent and sequential strategies are combined within a single research program.

		Time order	
		Concurrent	Sequential
Paradigm emphasis	Equal role	Qual + Quan (convergent)	Qual → Quan (Exploratory) Quan → Qual (Explanatory)
	Dominant role	QUAL + Quan QUAN + Qual (Embedded)	QUAL → Quan Qual → QUAN QUAN → Qual Quan → QUAL

Figure 3: Mixed-methods design strategy (adapted from Johnson and Onwuegbuzie, 2004)

In addition, the design requires decisions on the level of interaction between the quantitative and qualitative approaches and how the two approaches are related, or mixed (Creswell and Clark, 2011). The level of interaction can be *independent* or *interactive*; in the former, the research questions, data collection and analysis are independent for qualitative and quantitative studies, while the integration takes place merely in drawing the overall conclusions; in the latter, there is a direct interaction between the studies at different phases during the research process. Creswell and Clark (2011) listed the different stages of integration and the mixing strategy:

- Mixing during interpretation – after both qualitative and quantitative data is collected and analyzed. The inferences from each approach are compared and synthesized to draw combined conclusions. This stage is intrinsic to all mixed-methods approaches.
- Mixing during data analysis - after the analysis of each approach, a matrix (or diagram or any analysis tool) is used to explicitly merge the two sets of data into a combined analysis. Often, this requires the transformation of one type of data into the other, i.e. qualitize quantitative data or quantitize qualitative data.
- Mixing during data collection – in this mixing strategy, the two approaches are connected by using the findings from one set of data to inform the design of the other type of data.
- Mixing at the level of design – occurs within a traditional quantitative or qualitative research approach by embedding one form of data within a large design or by using a theoretical framework to join the data sets.

Taking the temporal, paradigmatic, interaction, and mixing considerations into account, the design strategy should follow the most effective way to address the research problem and questions (Johnson and Onwuegbuzie, 2004; Creswell and Clark, 2011; Venkatesh et al. 2013). Obviously, the research context, as discussed before, also plays a role, e.g. temporal consideration, available funding, the availability of particular participants or the need to synchronize the research with a specific type of activity.

In this research, a sequential exploratory design was adopted, followed by an explanatory design that consists of three distinct phases: Qual → Quan → Qual. As depicted in Figure 2, the research started with a systematic literature study (study 1) that despite being external to the mixed-methods data collection, lay the groundwork for understanding the landscape of HCD methods that are used in the design of mobile systems. To explore the application of HCD in the industry and better understand the challenges of practitioners, the mixed-methods approach started with an exploratory qualitative phase (study 2). This phase resulted in the identification of specific themes, i.e. knowledge gaps: (1) practitioners' perception of, and ways to approach, the context of use; and (2)

the impact of organizational strategy on the HCD practice. These themes guided a refocus of the MixMR approach and the emergence of RQ2 and RQ3 (see section 3.3.2 for more details). Johnson and Onwuegbuzie (2004) emphasize such recursive and interactional nature of MixMR, in which "even the question and/or purpose can be revised when needed" (p.21).

Understanding these themes required examination of the HCD on a broader level. Hence, the mixed-methods approach followed with a quantitative phase (study 3) that provided a descriptive account of the first theme as well as confirmation of hypotheses based on the latter theme. Findings from the quantitative phase also called for more in-depth insights on the work context of interaction designers as well as the situated rationality for their HCD practice. Thus, the mixed-methods research continued with an explanatory qualitative phase (study 4) that helped to expand the understanding of the HCD practice with contextual data. For replication logic regarding the qualitative findings, the mixed-methods approach concluded with a similar qualitative inquiry in another country with slightly different cultural characteristics (study 5). At face value, this approach may suggest a paradigmatic emphasis on qualitative methods, though in practice the quantitative approach played an equally important role.

As indicated, the level of interaction between the qualitative and quantitative phases is *interactive* – characterized by direct interaction between the phases in a way that each research phase informs the design of the successive phase. Consequently, the mixing of qualitative and quantitative approaches occurs primarily during the data collection stage of integration by linking the findings from one approach to the design and inferences of the successive approach. Naturally, the mixing also takes place during the interpretation stage by integrating (or linking) the qualitative and quantitative findings into 'meta-inferences', which are "theoretical statements, narratives, or a story inferred from an integration of findings from qualitative and quantitative strands of mixed-methods research" (Venkatesh et al. 2013, p.38). As such, meta-inferences are a core objective of mixed-methods approach, though their structural outcome varies depending on the context of the studied phenomena and the type of insights gained from the studies. The process of developing meta-inferences also varies and depends on the strategy. For sequential MixMR design, especially with developmental or expansion purposes, Venkatesh et al. (2013) recommends following the 'bridging' approach that aims at developing a consensus between the findings and better understand the boundaries of the findings (Venkatesh et al. 2013). The meta-inferences are discussed in the results chapter (Chapter 4).

The main rationale for this complex sequential design strategy is informed by the research problem and context. Firstly, in 2010, the time of starting the research, design for mobile computing was an emerging field with only scant

empirical insights on the HCD practice and the professionals who are involved in the practice. Hence, I started with an exploratory qualitative study and conducted successive studies that build on the findings. Secondly, conducting sequential studies is appropriate to the phenomenon of interest; projects for mobile system design take place continually, which allows data collection at a preferred stage of the research. Thirdly, a single researcher is primarily involved in the research, which makes it practically difficult to rigorously conduct concurrent studies. Finally, the research is performed as part of a dissertation work, which temporally allows for the application of sequential studies.

(2) Mixture of methods: Methods denote the actual procedures to gather the empirical data. The six most commonly employed methods in mixed-methods research are: questionnaire, interview, focus group, test (standardized or experimental), observation, and secondary data (e.g. documents, physical and archived data) (Johnson and Turner, 2003; Venkatesh et al. 2013). In this research, the mixed-methods approach included a combination of interview and questionnaire methods. In what follows, I rationalize the employment of these methods in light of their complementary strengths, while touching upon their weaknesses. A more elaborated discussion on the data collection and analysis in each study, as well as the interaction between studies, is presented in section 3.3.

For the initial exploratory Qual phase (study 2), I selected the semi-structured interview method, since interviews are useful for exploration, particularly with an emerging phenomenon, and encourage reflection on past experiences (Johnson and Turner, 2003; Lazar et al. 2010). Hence, interviews were appropriate to study the HCD practice with mobile systems, an uncharted phenomenon at that time, and to gather practitioners' experiences, particularly on their challenges to apply HCD. Moreover, an interview can easily be repeated multiple times, thus attending to the replication logic (Yin, 2003) and the diversity purpose of this MixMR approach. Consequently, I gathered views on the design of multiple types of systems and from various practitioners who are involved in the HCD practice. The data was analyzed with a cross-case synthesis matrix (Yin, 2003), a helpful instrument to identify patterns and themes. While interviews are useful for identifying themes, they are less appropriate for generalizing themes, i.e. explaining them with probability samples.

For the sequential Quan phase (study 3), I selected the questionnaire method. Questionnaire is a common instrument for explaining behaviors of certain populations, for testing hypotheses with probability samples that provide rather valid estimates for the studied population or phenomenon as well as for exploring uncharted waters (Johnson and Turner, 2003; Lazar et al. 2010). Informed by the themes from the preceding Qual phase (study 2), data was collected globally through an online questionnaire. A descriptive analysis of the data helped to explain the state of the HCD practice in the design of mobile

systems as well as to explore how practitioners perceive the concept of 'context of use' in mobile computing, an area of interest that was not studied before. Last, with inferential statistics of the questionnaire data, a conceptual model, consisting of a set of hypotheses on the relations between the organizational strategy, the competitive business environment and the HCD practice, was tested. The hypotheses were tested with Structural Equation Modeling (SEM) technique by using SPSS Amos[3]. While this study addressed the questions and confirmed results from the Qual phase (study 2), it highlighted the limitation of questionnaires in merely providing the big picture, or a 'snapshot' overview of the studied phenomenon (Lazar et al. 2010).

Hence, I turned again to semi-structured interviews for the successive Qual phase (studies 4 and 5), as interviews allow deep probing into a specific topic of interest (Johnson and Turner, 2003; Lazar et al. 2010), e.g. the work context of practitioners. Since work contexts may significantly differ, various practitioners in different organizations were approached. Thus, the replication logic was again a considered strength of the interview method. With the aim to elicit patterns in the rationality of practitioners HCD work, the rich data was first analyzed based on a grounded theory approach (Strauss and Corbin, 1990) following the open-axial-selective coding process, complemented by a cross-case synthesis matrix for identifying patterns among cases. For another level of replication logic, a second semi-structured interview study (study 5) was conducted with all controlled variables being similar to study 4, bar the country in which practitioners work. By using multiple interviews, divergent views were obtained on the contextual phenomenon to address the 'diversity' purpose of this mixed-methods approach.

While interview and questionnaire have obvious complementary breadth and depth strengths that helped in understanding the studied phenomenon, the methods also share weaknesses. In particular, in both interview and questionnaire the data collection is based on practitioners' recall of their doings, which is a step removed from their actual behavior (Lazar, p. 179). Moreover, in both methods participants are prone to bias from reactive effects, such as by deliberately provide answers to please the researcher or answers that put them in brighter colors (Johnson and Turner, 2003). Hence, selecting more ecological methods, such as case study observation, contextual inquiry, and action research would have been useful in gaining insights into practitioners' way of doing. However, ecological methods require more efforts in establishing collaboration with participants and their organization, significantly more time resources to conduct a single case, and appropriate timing with suitable commercial projects. Such resources and conditions were not available at the time of the research.

[3] http://www-03.ibm.com/software/products/en/spss-amos

Having described the application of the overall MixMR methodology in this research, in the next section I elaborate on methodological considerations in each conducted study.

3.3. Methodological overview of studies

This section presents the design of each study from a methodological perspective. In particular, I discuss reliability and validity issues by elaborating on the data collection and analysis procedures and demonstrate the interaction between studies by highlighting how insights from one study were used as an input to the successive study. Naturally, some aspects may overlap with the application of the MixMR approach as presented before in this chapter. Moreover, findings from studies are further elaborated in Chapter 4 and in the enclosed publications (Part II).

3.3.1. Study 1

Study aim: Groundwork for understanding the scientific HCD approaches that are used in the design of mobile systems, and identify avenues for further research

Data collection: Literature review is a common method to synthesize and summarize existing research on a specific area of interest in order to create foundations and guide further research (Webster and Watson, 2002). Accordingly, data was gathered during September-October 2011 through an extensive literature study following six major steps: (1) Setting the scope – research papers published between the years 2008-mid 2011 in the fields of HCI, mobile and ubiquitous computing and that describe application development for Google Android or Apple iOS platforms with a HCD perspective. (2) Selecting outlets – based on a list of outlets in existing studies (Kjeldskov and Graham, 2003; Hagen et al. 2005) as well as ranking lists of HCI outlets (Arnetminer, 2009; Borchers, 2008). (3) Keyword search – The keywords 'iphone' and 'android' were found to be the most appropriate in locating studies that describe mobile system design or development. Search was performed on academic digital databases (ACM, Elsevier, ScienceDirect, IEEE, Springer, Google Scholar). (4) Initial evaluation – papers were assessed by reading through the title and abstract (if needed, also introduction) and discarding those that do not match the scope. (5) Thorough evaluation - reading through the whole paper and discard those with no HCI perspective, e.g. technical papers and demos. (6) Backward-and-forward search on the qualified papers (Webster & Watson, 2002). The literature study resulted in the review of 79 research papers.

Data analysis: the data was summarized and synthesized by using a concept-centric matrix (Webster and Watson, 2002). The matrix was developed based on a conceptual framework of HCD methods as adapted from existing studies.

Input to successive study: The findings provide a landscape of the HCD practice with mobile systems that is used as a point of reference and as a basis for further investigations. In particular, the observed shift in the nature of evaluations, from lab-based to more naturalistic settings, as well as the increased use of analytics for evaluations, informed the design of the successive study.

The results give answer to RQ1. A complete description of the study and its findings is provided in Paper 1.

Limitation: A literature study of academic papers is limited to what has been documented from academic-oriented projects, by large. The HCD practice that is conducted within an academic study significantly differs from the HCD practice in the industry (Stolterman, 2008). Consequently, this literature study more closely represents the situation in academic-oriented studies and call for similar inquiries in the industry.

3.3.2. Study 2

Study aim: Initial exploration of the HCD practice with mobile systems in the industry to identify challenges in the application of HCD methods

Data collection: Attending to the limited academic-scope of a literature study, the author conducted semi-structured interviews with 20 practitioners who are involved in the design and development of different mobile systems in ten firms that are located in Finland. The data was collected between January–June 2012. Aiming for diversity of perspectives, I approached practitioners in roles related to design, business management, and software development, by using the social capital of the involved researchers and an online search for organizations that match the study scope. The number of interviews was determined based on available time resources combined with the saturation rule with regard to new and salient findings.

The interview script was based on a protocol that defined high-level themes for discussion as well as open-ended questions. After each interview, the protocol was updated based on a brief findings summary (Miles and Huberman, 1994) to inform successive interviews. In addition, questions were customized based on the role of practitioner. Informed by the findings from the literature study, the discussion put emphasis on the use of naturalistic settings during design. Practically, the interview focused on walking through a particular mobile system project with an emphasis on the following themes:

- Organizational and project settings
- HCD methods used in different phases of the project lifecycle
- Challenges and aspects that contribute to the application of HCD

In addition, data was collected on practitioners' education and work experience background as well as their attitudes on the concept of mobility.

In total, seven interviews were individual and six interviews with two to three practitioners who work for the same firm and know each other. Eleven interviews were conducted *in situ* face-to-face, while two interviews were remote by using Skype[4]. Interviews lasted between 65-105 minutes (avg. 80 min) and were audio-recorded for further analysis. After the interview, participants received a university-labeled gift as gratitude. Although interviews were used as the main source of evidence, the author also examined relevant documentation, e.g. service/UX design process, where available.

Data analysis: The subjects of observation in this study were practitioners within a specific organization and project settings. Initially, after each interview the salient issues and themes were summarized (Miles and Huberman, 1994), which helped in guiding successive interviews. Next, all interviews were transcribed and read through to re-examine the themes. The transcription followed a denaturalized approach (Oliver et al. 2005) that focuses on the meaning of wording. After that, a cross-case synthesis matrix (Yin, 2003) was used, to explore and analyze the findings based on an array of attributes, primarily:

- Metadata about the organization and project (e.g. business field, strategy, type of projects, HCD competence, software development model)
- HCD practice (e.g. methods and tools used in different design and development lifecycle)
- Challenges to the application of HCD and generally in daily work

Input to successive study: By examining the HCD practice in multiple types of systems as well as gathering insights from practitioners in diversified roles, the analysis highlighted themes that required broader investigation, particularly:

- Practitioners' perception of the context in which mobile systems are used
- Practitioners' approaches to understand the context in which mobile systems are used during the design and development of mobile systems
- The role of the emerging and competitive mobile business environment as well as the organizational strategy and project cases on the application of HCD in the design of mobile system

[4] http://www.skype.com

Limitation: By and large, the study focused on the challenges of practitioners in applying HCD methods during the design and development of mobile systems in industrial context. However, due to the refocus of the MixMR approach based on the new themes as well as time constraints, the findings from this exploratory study were not published, but rather informed, and were embedded in, the sequential Quan study. Thus, although not directly providing answers to any of the research questions, study 2 was instrumental in directing the successive studies by formulating and informing RQ2 and RQ3.

3.3.3. Study 3

Study aim: Following the qualitative insights, this study aimed at: (1) Examining the state of HCD practice with mobile systems in the industry by using the 'context of use' concept as a focal point; (2) Exploring practitioners' perception of 'context of use'; and (3) Testing hypotheses on the relation between the business environment, organizational strategy and HCD practice.

Data collection: Data was gathered by an online web-based questionnaire during February-March 2013. For divergent views, the questionnaire targeted practitioners who are involved in mobile system design and development in roles related to usability/interaction design, project management, and software development. A convenient amount of 150 responses were collected from globally distributed practitioners. Due to difficulties in estimating the populations of practitioners in the targeted roles, the sampling is non-probabilistic, though such practice is valid in HCI studies (Lazar et al. 2010). Potential respondents were approached by direct email through an online search of suitable companies, via mailing lists of professional communities, by posting in discussion forums and in social media channels. A free summary of the findings as well as a possibility to win relevant software licenses was used as incentives.

The questionnaire was pilot-tested following a three-stage process (Dillman, 2006). The questions were largely adapted from existing studies and formulated with the insights gained from the qualitative interviews (Study 2). Explorative questions, e.g. on practitioners' perception of 'context of use', were informed by existing theoretical models on the concept of 'context of use'. To contextualize the HCD practice to some degree and to facilitate the recollection of past experiences, the questionnaire started with specific questions on the type of system and type of users. For testing the hypotheses, a conceptual model was developed consisting of multiple constructs to examine the effect of the organizational strategy and the business environment on the HCD practice. In addition, the conceptual model takes design resources (time and financial constraints), organizational practices, and design competences into account as

mediating effects, since prior studies observed these constructs as having effect on the HCD practice. Established measurement items (i.e. observed variables) were used for the constructs (i.e. latent variables), while possible order effects were reduced with randomization of answer options.

Overall, the questionnaire had the following four themes:

- Perception of the context in which mobile systems is used
- HCD practice of a particular system, including effectiveness of specific methods and factors affecting the HCD practice
- Evaluation of data gathered with HCD methods
- Organizational strategy, business environment, and work practices

In the closing section, respondents were asked about their demographic and organizational settings. On average, completing the questionnaire took 14 minutes, although due to skip logic in the implementation, certain questions were not presented to all respondents. This also led to an unequal number of respondents for the skipped questions. The complete questionnaire is enclosed in Appendix 1.

Data analysis: The data was analyzed with descriptive statistics as well as inferential statistics. Descriptive statistics helps to describe the collected data by summarizing it in a way that conveys meaning and facilitates its interpretation. The analysis mainly relied on the statistical measures of frequency, sum, average, and percentage, to examine the state of HCD practice and to explore practitioners' perception of the 'context of use' concept.

For testing the conceptual model on the relation between the business environment, organizational strategy and the HCD practice, the Structural Equation Modeling (SEM) technique was conducted by using SPSS Amos software. SEM denotes a family of statistical procedures to test conceptual models that represent hypotheses on the relations among constructs, i.e. observed and latent variables, and their directionalities, i.e. which construct assume to affect the other in each relation (Hoyle, 1995; Kline, 2011). The latent variables in the model are described before in the data collection procedure, while the observed variables are included in the questionnaire (Appendix 1). A confirmatory factor analysis was used in assessing the validity of the observed variables being a measurement model for the latent variables.

According to Kline (2011), the testing of conceptual models with SEM can be done in three different contexts: for confirmatory purposes by accepting or rejecting the model based on how the data correspond to the model; by testing alternative models and accepting the one that correspond with the data; or more commonly, with an exploratory approach for model generation, by re-modifying a conceptual model and re-testing until the model corresponds with the data,

makes theoretical sense and is comprehensible. In this study, the approach was largely exploratory since the relation between the constructs, especially the business environment and organizational strategy effect on the design practice, has not been tested before. Accordingly, the initial model was modified, most notably by dropping the business environment construct, which affected the reliability of the whole model. A re-test of the modified model showed an improved fit, or strength, of the relationships between the remaining constructs. This also resulted in a more parsimonious model.

Input to successive study: Insights from the descriptive analysis highlight a gap between academic-oriented design practice (as observed in study 1) and the industry-based design practice with regard to conducting user studies in the context of use. In essence, practitioners in the industry are less likely to consider the naturalistic context of use by conducting field studies, although perceive such studies to be more effective. This observation required a more ecological approach to better understand the work context of practitioners and their rationality for conducting user studies in naturalistic context (RQ3).

Insights from the testing of the conceptual model showed that the organizational strategy, especially with innovative focus, does have a great effect on the HCD practice, both directly and through mediators. Though, due to the exploratory nature of the model, it serves as a preliminary explanatory model that proved to be useful and hence, requires further development. Moreover, these findings urged a more in-depth examination regarding the role of the organizational context on the application of HCD.

The results from the descriptive analysis address RQ2. A complete description of the study and its findings is provided in Paper 2. The results from testing the model contribute to answer RQ3. A more elaborated description of the findings is provided in Paper 3.

Limitation: some of the questions in the questionnaire, notably the ones with statements and rating-scale answers, are qualitative in nature. In other words, these questions require an open answer on the attitude and perception of individual respondents rather than merely selecting a quantitative numerical rating from a set of pre-defined options. Obviously, the rich nature of qualitative assessment is lost in the forced transformation from qualitative to quantitative data. However, in order to test hypotheses with probability samples, the application of quantitative analysis methods requires this transformation to numerical format. To improve the construct validity of the numerical data, the questions and answers were grounded in established latent variables, i.e. factors or constructs, as well as in established observed measures, i.e. indicators. A confirmatory factor analysis was used to test the validity and reliability of the

constructs, that is, to confirm the inter-correlation of the observed measures and their relationship with the construct (Brown, 2015).

3.3.4. Study 4

Study aim: explain the core factors that affect practitioners in their effort to approach users in naturalistic context of use.

Data Collection: Semi-structured in-depth interviews were carried-out with 26 practitioners in roles related to design, management, and software development, who are employed by 14 companies in the Netherlands. The data was collected between September-October 2013. Practitioners were selected from the social capital of the involved researchers and by an online search for organizations that match the study scope. With regard to mobile systems, the scope included mobile app, mobile web application, or a hybrid of them, that is designed to run on mobile devices, specifically touch-based smartphone and tablet computer. Due to the broad variety of categories for mobile systems (e.g. games, wellbeing, education) with different use cases, the scope of systems was limited to two consumer categories: media and finance. These categories are popular among consumers, while their perceived contexts of use differ, from a more generic context for media to a more specific context for finance.

An interview protocol defined the topics for discussion and was focused on walking through a particular mobile system project while paying special attention to the involvement of users and naturalistic context as well as the rationality for doing, or not doing that. Participants received the list of topics in advance, which included the following themes:

- Perception of mobile users
- Perception of the environment in which mobile services are used
- Methods used to elicit data about users, incl. motivation to use them
- Means to interpret the data and generate design ideas
- Means to evaluate the design practice and project

Data was also collected on the professional background and work responsibilities of practitioners as well as the organizational project settings.

Twenty interviews were individual interviews and three interviews with two practitioners who work together on a similar project. 16 interviews were conducted *in situ* face-to-face, while seven interviews were remote by using Skype. Due to the intensity of interviews (23 in four weeks at different locations), an implicit reflection after each interview, rather than an explicit summary, was used in informing a successive interview. On average, interviews lasted 62 min. and were audio-recorded.

Data analysis: Similar to study 2, the subjects of observation were practitioners within a specific organization and project settings. Interviews were first transcribed following a denaturalized approach (Oliver et al. 2005). Thereafter, transcriptions were sent to the interviewees for validation. After initial reading through the transcripts to identify themes, the data was analyzed following a grounded theory approach (Strauss and Corbin, 1990). In practice, the inductive analysis followed a three-steps process: (1) *open coding* of relevant excerpt instances to identify preliminary categories on the factors that affect practitioners in their effort to approach prospective users and naturalistic context of use. As recommended by Miles and Huberman (1994), the categories are based on a preliminary list of codes, in this case informed by the body of knowledge on the HCD practice and more specifically on user involvement; (2) *axial coding* to look for dimensions and relations between the identified categories; and (3) *selective coding* to identify the core concepts that explain the factors that affect practitioners. Although presented as distinctive and linear, the three steps are practically interwoven and highly recursive. For instance, preliminary open coding attempts have led to an abundance of codes, which complicated its axial categorization and required a fresh start with a new coding strategy. Coding attempts were guided by a discussion on the strategy while the analysis was gradually assessed with few transcripts at a time. The coding and analysis was conducted using Atlas.ti[5] (Muhr, 1991) software. Thereafter, a cross-case synthesis technique (Yin, 2003) was used to identify patterns in the work and rationality of practitioners, based on an array of attributes (see Table 3 in Appendix 2).

Input to successive study: The data collection for the successive replication study (study 5) started immediately after data was collected for this study. Consequently, the transcription and analysis process took place concurrently with the data collection for study 5. As such, reflection on the interviews in this study as well reading through the transcripts helped to inform the interview protocol for the successive interviews. In particular, more attention was put on the business environment and its influence on the involvement of users in context.

Note that due to the preliminary difficulties in finding an apt coding strategy, as described before, one of the coding attempts was first performed on the data that was collected from study 5. In this attempt, the coding strategy proved to be more satisfactory. Therefore, the analysis of the data in this study by following the same coding strategy actually took place after the data analysis in study 5. Ultimately, the analysis of the two studies was combined into a unified view.

The findings contribute to address RQ3 and are further elaborated in Paper 5.

[5] http://www.atlasti.com/

3.3.5. Study 5

Study 5 is merely a replication of study 4 in a different country. Hence, I highlight only the methodological considerations and findings that differ from study 4.

Study aim: replicate study 4 to expand on, and improve the validity of, the core factors that affect practitioners in their effort to approach users in naturalistic context of use. Moreover, to the study aims at exploring the suitability of an experimental framework to provide deeper insights into the application of HCD throughout the project lifecycle.

Data collection: Semi-structured in-depth interviews were carried-out with 15 practitioners who are employed by 11 companies in Finland. The data was collected between October 2013-March 2014. The scopes for practitioner roles, mobile systems and categories were similar to the scopes in study 4. As explained before, the transcription and analysis process in study 4 took place during the data collection for study 5. This helped to inform the interview protocol (as described in study 4) for the interviews conducted within study 5, in particular by probing more in-depth into organizational and project case settings.

Thirteen practitioners were interviewed individually and two practitioners who work in the same company were interviewed together, though shared their experience from different projects. Fourteen interviews were conducted *in situ* face-to-face, with one interview over Skype. Interviews lasted 61 min. on average and were audio-recorded.

Data analysis: The transcription and analysis followed largely a similar process as described in Study 4. However, after the cross-case synthesis phase, the data was further analyzed with an experimental tabular framework that incorporates three core principles of the HCD approach (study target users, in real-life context, and over time) as well as three project phases (requirements, evaluation, post-deployment) to apply the principles. The framework was based on the data elicited from the cross-case synthesis and aimed at assessing more in-depth the application of core HCD principles throughout the project lifecycle.

The main findings, regarding the factors that affect practitioners in applying the core HCD principles address RQ3, and are described in study 4 and more in details in Paper 5. Findings from the use of the experimental framework are reported in Paper 4 and contribute to the validity of the answer to RQ2.

Chapter 4.

Results

In this research I set out to examine the HCD practice of interaction designers in light of the shift to mobile computing in the mobile apps era. In particular, a focal lens is placed on the involvement of users in context of use during the design and development of mobile systems, a core principle of the HCD approach. This chapter outlines the insights from this research endeavor. In the first part, I present the major findings in each of the original publications in light of the discussed theories and existing studies. Thereafter, the findings from the mixed-methods studies are integrated into meta-inferences. (For detailed results, please see the respective article enclosed in Part II of the dissertation).

4.1. Insights from original publications

Table 2 presents an overview of the studies and their relations to research questions as well as to the publications where findings are reported.

Table 2: Relations between studies, research questions, and publications

Study	*Research Question*	*Publication where findings are reported*
Study 1	RQ1	Paper 1: Eshet, E. (2012). Human-Centered Design in Mobile Application Development: Emerging Methods. International Journal of Mobile Human-Computer Interaction, 4(4).
Study 2	RQ2	Findings from study 2 were not published. See section 3.3.2 for more details.
Study 3	RQ2 RQ3	Paper 2: Eshet, E. and Bouwman, H. (2014). Addressing the Context of Use in Mobile Computing: A Survey on the State of the Practice. Interacting with Computers, 27(4), pp. 392-412. Paper 3: Eshet, E., de Reuver, M. and Bouwman, H. (2016). The role of organizational strategy in the design of mobile systems: A study of mobile practitioners. Under revision in: Communications of the Association for Information Systems

Study 4	RQ3	Paper 5: Eshet, E. and Bouwman, H. (2016). Context: the final frontier in the practice of user-centered design? Under revision in: Interacting with Computers.
Study 5	RQ2 RQ3	Paper 4: Eshet, E., & Bouwman, H. (2016). Approaching Users and Context of Use in the Design and Development of Mobile Systems. In Design, User Experience, and Usability: Users and Interactions. Lecture Notes in Computer Science, 9187, pp. 508-519. Springer International Publishing. Paper 5: Eshet, E. and Bouwman, H. (2015). Context: the final frontier in the practice of user-centered design? Under revision in: Interacting with Computers

---

Paper 1**:** *Eshet E. (2012). Human-Centered Design in Mobile Application Development: Emerging Methods. International Journal of Mobile Human Computer Interaction, 4(4), pp. 1-21.*

Apart from outlining new methods to the involvement of users and understanding the context of use, the literature study (study 1) contributes the first view on the scientific HCD approaches and practice in the mobile apps era. The findings indicate on a shift towards evaluations in naturalistic environment and the utilization of rich data on actual system usage.

First, taking an earlier literature study on the use of HCD methods in mobile computing (Kjeldskov and Graham, 2003) into account, insights from the literature study that started this research indicate on a notable increase in the use of various field evaluation methods, i.e. those studies that take place in representative, or the actual, context of use. Conversely, evaluations in a lab environment were used to a slightly lower degree from the earlier literature study by Kjeldskov and Graham (2003). In light of the theoretical discussion on mobile computing (section 2.4), the shift towards evaluating design proposals in actual context of use is expected, particularly by those involved in interaction design from a scientific perspective.

This shift is enabled and stimulated by the transformation of the mobile industry and device capabilities during the mobile apps era. In many of the field evaluations that were reviewed in the literature study (study 1), researchers benefited from the app store model and the affordability of smartphones to involve users with their own devices. The use of own devices elevates the cost-efficiency and real-life dimension of field-oriented evaluations; own devices eliminate the need for specific testing devices, a common burden in the pre mobile apps era, and acclimatization to the device, since users are familiar with the device and its configuration; masses of users can be involved over longer

period of times during their usage 'in the wild', i.e. without the control of moderators, which increases the accuracy of collected data (Henze & Boll, 2010; McMillan et al., 2010) and uncover unpredictable use of systems (Kim et al. 2011). Combined with the technological capabilities of mobile devices in the mobile apps era, field evaluations with own device bring new possibilities to understand relevant aspects of the dynamic, heterogeneous and unpredictable context of use.

Second, insights from the literature study (study 1) also emphasized the increased utilization of actual usage data. In practice, researchers experienced with tools embedded in their implemented systems to log actual user interaction with the system and interpret usage patterns (e.g. McMillan et al. 2010). This type of passive user involvement liberates interaction designers from the resource consuming task of being *in situ*, e.g. in user observation, and at the same time gaining valuable insights on users. Since the usage of data logging requires a system in use, it is not suitable to gaining early understanding of users and context to inform the requirements. For that phase, studies reported on the use of largely traditional methods, such as interview, survey, and user observation, though their utilization was significantly less frequent than the use of evaluation methods. While tools for logging mobile device usage were previously observed (Hagen et al. 2005), the data that can be collected by the sensor capabilities of current mobile devices is significantly more context-rich and immense. Consequently, the availability of large amount of data on users and context requires further research to help practitioners make efficient and effective use of the data. In essence, how the different sources and types of data can be conceptualized in a way that supports design? And how the data can be efficiently analyzed for design (e.g. tools, techniques)?

Paper 2**:** *Eshet, E. and Bouwman, H. (2014). Addressing the context of use in Mobile Computing: A survey on the state of the practice. Interacting with Computers, 27(4), pp. 392-412.*

This paper contributes the first account on the state of interaction design practice with mobile computing as well as the first examination of practitioners' perception of the complex 'context of use' notion. Major findings from the quantitative study (study 3) emphasize a state of HCD practice that echoes the practice with stationary computing, practitioners' focus on the internal context, the increasing position of interaction design as a professional consultancy service, and the increased utilization of agile for the software development process.

First, mobile computing *per se* was not a factor that encouraged interaction design professionals to involve users in context. Insights from study 3 show that

professionals who are engaged in the design and development of mobile systems most often used established methods, such as interviews, lab usability testing and user observation. Field evaluations, as well as other context-oriented methods, such as contextual inquiry, participatory design, and diary study were used significantly less frequently, although perceived as effective. This indicates on some attention to the context of use during an early phase of gathering and specifying requirements, while in evaluations there is a lack of consideration for context. Strikingly, the results are fairly similar to insights from existing studies on the state of HCD practice (e.g. Venturi et al., 2006; Monahan et al. 2008), although these studies did not focus on mobile computing. The interaction design practice was mainly affected, as previously observed (e.g. Vredenburg et al. 2002), by temporal and financial constraints as well as by practitioners' experience with certain HCD methods. Evidently, the inclination to examine users in context of use is more convoluted than merely a shift to mobile computing.

Second, practitioners' attitudes on various aspects of the 'context of use' notion emphasized interest in the internal context. The most important contextual aspects to the design of mobile systems were observed to be users goals, followed by usage behavior and daily activities of users. These aspects are mostly related to the internal context, or 'meaningful' as viewed by Bradley and Dunlop (2005). On the contrary, aspects that are part of the situated external context, such as the physical, spatial, and technological environment were perceived as less important. Notably, the social influence on users was perceived as the least important aspect; this view is in contrast with the conclusive role of the social environment on the acceptance and use of mobile services as observed by user studies in different settings (e.g. Tamminen et al. 2004; Wigelius and Väätäjä, 2009) and by consumer surveys (e.g. Lu et al. 2003; Shin, 2007). This discrepancy may be explained by the difficulty to understand social aspects in definite terms, including their design implications, unlike more objective situational aspects such as technical or temporal-spatial (Kjeldskov and Paay, 2010). Nevertheless, the study provides the first view on how practitioners perceive the ambiguous 'context of use' concept, particularly considering the impact of mobile computing on context of use. Essentially, understanding practitioners' view helps to explain their intentions for user involvement in context, and thus is fundamental in explaining the actual design practice.

Third, interaction design is increasingly provided as a professional consultancy service. The majority of respondents in the quantitative study (study 3) worked as service providers in a professional-client relationship, for instance in software companies and usability/UX consulting. Monahan et al. (2008) observed fairly similar figures. This situation exemplifies the complex social and business environment of design services (see section 2.6) that increases the potential for conflict with the views and practice of interaction designers. Hence, the position

of design service within the business environment and its influence on the involvement of users in context requires further research attention.

Last, agile methods are increasingly used as the software development process, which affect the nature and potential for involving users in context. Considering the complementary character of HCD to the software development process (as discussed in section 2.3), evidence from the questionnaire study (study 3) indicate on a sharp increase from a prior study (Bygstad et al. 2008) in the use of agile methods, mainly Scrum. The specific attention in agile methods on short incremental improvement, i.e. sprint cycles, based on customer feedback affects the involvement of users in context, especially in early requirement phase; this study indicates that companies that use Scrum are less likely to use context-oriented methods, e.g. user observation and contextual inquiry, than companies with own adapted software development process. Context-oriented methods are generally more time consuming, while the inherent sprint cycles in the Scrum process encourage more time-consciousness.

Paper 3**:** *Eshet E., De Reuver M. and Bouwman H. (2015). The role of organizational strategy in the design of mobile systems: A study of mobile practitioners. Submitted to Communications of the Association for Information Systems (CAIS).*

This paper contributes the first explanatory model, rather than qualitative or descriptive account, to connect the organizational context and innovation strategies with the interaction design practice of mobile systems. Taking the immense availability of user-, usage-, and contextual- data in the mobile apps era into account, the connection with design is particularly focused on the efficient and effective usage of this data. Insights from the quantitative study (study 3) indicate that an open innovation strategy greatly influence the cost-efficiency of data usage.

Organizational strategies that focus on innovation have a great effect on the interaction design practice. Grounded in the theoretical assumptions as discussed before (section 2.6), the explanatory model indicates on a significant relation between innovation-focused strategies and the cost-efficiency usage of data on users and context in the design of mobile systems. This finding substantiates insights from innovation management regarding open innovation and knowledge management as well as insights from HCI (Rosenbaum et al. 2000; Venturi et al, 2006) that emphasize the facilitation of internal communication within an organization as a key to HCD practice. Moreover, the explanatory model indicates that the effective usage of data is significantly affected by the competences and experiences of practitioners as well as by organizational practices, i.e. the encouragement to create and openly share ideas within the

organization. In contrast to innovation-focused strategies, cost-focused strategies found to have no direct influence on the effective usage of data, though a negative effect on competences and experiences as well as on organizational practices. On a practical level, the findings highlight the importance of having competent practitioners with relevant skills and experience as a critical asset that can give organizations a competitive advantage, as well as having an open innovative strategy that encourages the exchange of data and knowledge within project teams and organizations in order to achieve a better-informed design.

Paper 4**:** *Eshet E. and Bouwman, H. (2015). Approaching users and context of use in the design and development of mobile systems. In: Aaron Marcus (Ed.), Design, User Experience, and Usability: Users and Interactions, Lecture Notes in Computer Science 9187, 508–519, Springer.*

This paper contributes a preliminary qualitative examination on the involvement of users in context during the design, development, and usage of consumer mobile systems for media and finance. The results from the qualitative study (study 5) emphasize the infrequent involvement of users in naturalistic context during early design phase and suggest on the professional-client type of business relationship as playing a role on target user involvement.

While the study was qualitative in nature, the results show a low tendency to involve users in naturalistic context, especially during early requirements phase. Given the possibility to evaluate with users' own devices in the mobile apps era, the findings highlight pilot testing as the exclusive approach for evaluations *in situ*. This evaluation approach helps to reveal actual usage behavior of users, which is perceived by practitioners as a highly important objective (as discussed in the insights from Paper 2). Having a broader quantitative approach, existing studies (e.g. Rosenbaum et al. 2000; Monahan et al. 2008) indicated on the low utilization of context-oriented methods, while paper 3 in this research emphasized the low attention to context especially during evaluations.

Qualitatively, the findings suggest that the business environment has an influence on the involvement of users during a mobile system design project. Practitioners in an internal design team, i.e. in-house, approached target users to some extent during their projects. However, practitioners in a professional-client type of relationship, i.e. consultancy, often relied on input from social peers and especially from project internal stakeholders, i.e. the client, while target users were hardly approached. Evidently, the client plays a role on inhibiting practitioners to approach users; first, by a reluctance to share data on own customers; and second, by strictly limiting the project resources. Generating explicit understanding of users and context merely via the client's understanding of users add another level of obscurity, especially considering the business

perspective of the client. In light of the preliminary stage of the findings, further research was required to verify the business environment effect as well as more broadly to explain the conditions that affect the involvement of users and the utilization of context-oriented methods.

Paper 5**:** *Eshet E. and Bouwman, H. (2015). Context: the final frontier in the practice of user-centered design? Under revision in: Interacting with Computers.*

This paper contributes an in-depth view on the situated circumstances that encourage and inhibit interaction designers to involve target users and to do so in actual context, during the design of mobile systems. As in paper 4, the examined cases are limited to consumer mobile systems for media and finance. The findings from the qualitative studies (study 4 and study 5) corroborate that the professional-client relationship significantly inhibited the involvement of target users, whereas the involvement of users in real-life context is often rationalized by the mental and cognitive distance between practitioners and users as well as the perceived innovativeness of the designed system. Interestingly, these project-specific factors are not particular to the design of mobile computing systems.

Most significantly, interaction designers in consultancy position were faced with an economic constraint; they aimed at satisfying the client and secure their 'bread-and-butter' while the client crucially limited their resources to involve users. To paraphrase on Simon (1969), interaction designers in a consultancy position are faced with a dilemma between being loyal to the decision criteria as defined by the profession and the criteria that is enforced by those with decision-making power, i.e. the client. In addition to the insights mentioned in Paper 4, a common short-term contract between interaction design consultancy and its client inhibits interaction designers from involving and understanding users during the actual usage of the system to inform a possible redesign. Without direct user involvement, designers often rely on indirect and more obscured user data, e.g. through the client. The findings also highlight a great variety in the type of relationship between professional interaction design consultancies and clients, such as the degree of openness in relationship and the level of integrativeness in the operations, which affected the involvement of users. Following the discussion of 'design' and its various interpretations (section 2.1), these findings suggest that clients may perceive the design service in terms of the expected outcome rather than a human-centered process.

The consequence reliance on external, rather than direct, user data can be characterized, following Krippendorf's (2006) view, as a third-order understanding of target users. Krippendorf asserts that understanding of users (and more generally, stakeholders) is inherent in a second-order understanding, i.e. the understanding of users' understanding of something. A third-order

understanding, through the client's understanding of users understanding of something adds a critical level of obscurity to the necessary reflection-in-action with target users in context. Thus, the third-order understanding is a deviation from core HCD principle on user involvement. The interaction designers that were participated in studies 4 and 5 often have notions of, and mostly dissatisfaction with, this deviation. Given the increasing role of interaction design as a consultancy (observed in paper 2), the third-order understanding may happen rather often. Vaughan (2005) observed that a repeated 'deviated' practice run the risk of becoming a 'normalized' practice behavior, i.e. within the organization, the deviant behavior ceased to be considered a deviant and is regarded as business as usual. Aiming to support interaction designers, emphasizing this insight draws attention to the business environment complexity and the risk of 'normalization of deviance' in interaction design; moreover, it provides a deeper understanding on the rationality of interaction designers' HCD work, especially with regard to user involvement.

Overall, the business environment complexity in the work of interaction designers has been emphasized in prior studies. Overall, existing studies (e.g. Grudin, 1991a; Trenner and Bawa, 1998; Iivari, 2004; Iivari, 2005; Iivari, 2006; Iivari and Iivari, 2011; Sharon, 2012) observed that the involvement of users is more challenging in software companies and product development projects than in-house development. Jokela and Abrahamsson (2004) touch upon the professional-client relationship in their single case study on agile development, emphasizing that a close collaboration with the client does not guarantee more extensive HCD work, since the extent of HCD activities are mainly dependent on the client's interest in usability, or its usability capability maturity. Bruno and Dick (2007) discuss the difficulty to 'sell' user involvement to clients as well as the contract-based short-term relationships between professionals and clients. Hence, the findings from studies 4 and 5 regarding the professional-client relationship merely reconfirm prior findings and emphasize the economic constraint as the main inhibiting factor on user involvement. Moreover, the project-level challenges to user involvement suggest that measuring the strength and weaknesses of the HCD in organizations by using different usability capability maturity (UCM) models (Jokela et al. 2006) may not be sufficient. UCM models should have a broader project focus to account for all project stakeholders in various project types.

Essentially, the mental and cognitive distance between target users and interaction designers is observed to play a key role on the involvement of users *in situ*. In particular, unfamiliarity with users, their habits and activities encouraged the explicit understanding of users *in situ* during the early requirements phase. Examples include users in different continent, age group, and specific profession. In contrast, when the mental distance is not far apart, such as with systems for consumers or universal type of users, interaction

designers were less inclined to explicitly study the context as they indicated on their familiarity with the needs of such users. In addition to the mental distance, the insights indicate that the perceived innovativeness of the designed system as well as the project size (in terms of investment) is also influencing the likelihood of studying users in context.

The mental distance is related to Schön's (1983) reflective action, in which practitioners are inclined to conduct reflective experiments, such as study users in context, when the available knowledge is insufficient to understand the problematic situation they face. Suchman (2002b) also touches upon the distance factor in her discussion on local improvisation, asserting that a greater distance, e.g. geographical, cultural, and experiential, requires a greater effort in appropriating technologies into users' local circumstances. However, this is the first study to suggest on the nature of system and users as a key to explain the involvement of users in context.

4.2. Meta-inferences

The results highlight various aspects with regard to user involvement in context during the design and development of mobile systems in the mobile apps era. Integrating the insights from the multiple studies brings two meta-inferences to the fore: (1) the changing nature of user involvement in the mobile apps era; and (2) the business environment complexity and the mental distance between practitioners and users, as a deeper level explanation of interaction designers' rationality for HCD work. Next, I explain these meta-inferences.

First, this research indicates on a shift in user involvement toward evaluations with real-life system usage. From the outset, this research project aimed at explaining the HCD practice in the mobile apps era. Accordingly, the multiple studies in this research provide various indicators to the changing nature of user involvement and more broadly of the HCD practice. Insights from paper 1 indicate that the streamlined possibilities to obtain rich data from the actual usage of systems in real-time, as well as the increased utilization of the data to inform and improve the design. Constant incremental improvement of released systems is a fundamental principle of Agile methods, which are becoming increasingly popular in the industry as indicated by the insights from paper 2. Moreover, paper 2 emphasizes the low likelihood of agile practitioners to utilize established context-oriented methods, e.g. user observation and contextual inquiry, due to the short sprint cycles. Recent approaches to product development, such as Lean startup (Ries, 2011) take a step further than agile in shortening the time-to-market with its Minimum Viable Product (MVP) strategy, which means deploying the core minimal "version of a new product which allows a team to collect the maximum amount of validated learning about customers with the least effort." (Ries, 2011).

Combining the shortening time to involve users during design with the possibility to obtain actual usage data (paper 1); the focus of practitioners on understanding actual usage (paper 2); and the increased position of design service as consultancy (paper 2), which limits the possibilities for user involvement during design, suggests that the focus on explicit understanding of users and context in HCD, at least with universal consumer systems, is shifting towards the post-deployment phase of system usage. In the established HCD approach (Figure 1), the first activity of 'understanding and specifying the context of use' is fundamental for the sequential activities. With the inferences from this research, this activity gains its main focus in follow-up studies after the system has been put into some form of actual usage, such as with pilot testing (paper 4). Consequently, this shift puts emphasis on the efficient and effective usage of the obtained data. To this end, this research indicates on innovation-focused organizational strategies as useful and paramount to cost-oriented strategies (paper 3). Moreover, the observed shift in user involvement encourages further research on the conceptualization and utilization of user and context data during the actual usage of systems, as stated before.

Although this research paid particular attention to the design of mobile computing systems, the major contributions have less to do with mobile computing *per se*.

The business environment complexity, the mental and cognitive distance between interaction designers and users, and the perceived innovativeness of the designed system are valuable theoretical contributions. This research set out to contribute to interaction design theories by explaining the rationality of interaction designers regarding the studied phenomenon. Existing studies (see section 2.7) provide helpful insights on factors that affect interaction designers and explain their behavior to some extent. By applying a focal lens on the involvement of users in context as a fundamental principle of HCD, this research contributes a deeper understanding on the rationality of interaction designers to the involvement of users in context during design. Essentially, the insights draw attention to specific project-level conditions in the practice of HCD: the business environment settings and its complexity as well as the project settings, particularly regarding the nature of users and the innovativeness nature of the system being designed.

These causal conditions may explain the marginal usage of context-oriented HCD methods as observed in Paper 2. Since the observed project-level factors are not idiosyncratic to mobile computing, they can also shed light on prior studies that indicated on the low utilization of context-oriented HCD methods (e.g. Rosenbaum et al. 2000; Vredenburg et al. 2002), explained largely with the cost-benefit trade-off. Furthermore, the business environment complexity and the mental distance between interaction designers and target users can be highly

relevant in explaining the gap between science and practice, as also observed in this research.

Whereas the literature study (paper 1) indicates on an increase in the utilization of field evaluations, i.e. in naturalistic environments, the survey (paper 2) indicates that the broader design practice in the industry remained relatively similar to the practice with stationary computing. Moreover, the involvement of users was characterized by traditional methods, such as interview, lab usability testing, and observation, whereas newer methods, such as the different dairy methods suggested by design-oriented scientific research, are hardly used. The differences between science and practice are well discussed (Simon, 1969; Schön, 1983), also within the design community (Cross, 2001; Fallman, 2003; Krippendorf, 2006; Stolterman, 2008), and essentially derived from the disparate objectives and expected outcomes in science and practice, as well as the different ways in which scholars and practitioners deal with complexity. This research contextualizes this gap in the interaction design of mobile systems, particularly with the involvement of users in context.

In science, the observed situated conditions influence the interaction design practice to significantly lower extent, if any; firstly, simulating the business environment in academic research is difficult; and secondly, attentiveness to users, regardless of their mental distance from practitioners, is a cornerstone expected from any reported design endeavor. Hence, the observed conditions help to explain the rationality of interaction designers with regard to user involvement in context and constitute the major contribution of this dissertation. Having said that, the business environment complexity and the nature of users and system were developed from qualitative studies on the design of universal consumer systems, which require further examination with a broader quantitative study and different types of sociotechnical systems.

Chapter 5.

Discussion and conclusions

In this chapter I first outline the main findings in light of the research questions. After that, the contribution of the findings to theory and its implications on the inquired research domain, its practice, and education are explained. Thereafter, the research limitations are discussed. Last, I conclude with a view on future domain work.

5.1. Addressing the research questions

This research aimed at explaining the HCD practice in the mobile apps era. Considering the fundamental expansion in the diversity of users and variety of contexts of use with mobile computing, as well as the structural transformation in the mobile and telecommunication industries and the profound enhancement of mobile device capabilities in the mobile apps era, this research was particularly interested in examining possible changes to HCD practice as well as explaining the rationality of interaction designers in attending to users and context of use. This interest was articulated in the main research questions (section 1.3), which guided the studies with multiple methods and paradigms within a mixed-methods research approach (Chapter 3). The research resulted in various findings and meta-inferences that are discussed in details in Chapter 4. In what follows, I briefly indicate how the findings address the main research questions.

RQ1. What scientific HCD methods are available for understanding users and context of use in the mobile apps era?

The extensive literature study (study 1), being the first to synthesize and summarize the scientific-oriented HCD practice in the mobile apps era, addresses this question. The findings particularly emphasize the emerging approaches and possibilities to obtain and make use of real-time and rich data on actual system usage. In addition, given the app store distribution model and the affordability of devices, the findings highlight the new cost-efficient possibility to involve users in real-life context, i.e. conduct evaluations with users by utilizing their own device. Arguably, this possibility contributed to a shift in the

scientific-oriented HCD toward evaluations in real-life environment. These findings demonstrate the constant adjustment of HCD to cope with new challenges and opportunities that technological developments bring. The results are discussed in more details in Paper 1 and in Chapter 4.

RQ2. How do interaction designers perceive and approach the context of use during the design and development of mobile systems in the mobile apps era?

This question is addressed by the empirical quantitative study (study 3), which provides the first quantitative examination on the perception of 'context' by interaction designers as well as the first account on the state of HCD practice in the mobile apps era. Findings from the study emphasize interaction designers' focus on aspects of the internal context, such as user goals and the resulting behavior with the system and more generally in everyday activities. In contrast, aspects that are considered as part of the external situated context, e.g. physical, spatial, technological, and social, received less attention from interaction designers. The perception of context arguably plays a role on interaction designers' rationality and inclination to study the situated context; essentially, the findings highlight practitioners' lack of attentiveness to real-life context of use, especially in evaluations. Moreover, the findings indicate that mobile computing and the mobile apps era (as of 2013) did not have a major effect on the involvement of users *in context*, as the findings largely reflect the state of HCD practice in the age of stationary computing. Consequently, it suggests that interaction designers, as well as their stakeholders within a project, have not yet realized the demands of designing for mobile computing. The findings are further discussed in Paper 2 and in Chapter 4.

RQ3. What are the core factors that inhibit and encourage interaction designers in their effort to involve users in real-life contexts of use during the design, development, and post-deployment of mobile systems in the mobile apps era?

This explanatory question is addressed by the quantitative study (study 3) and the qualitative studies (study 4 and study 5). First, by testing a conceptual model on the relations between organizational strategy and the design practice, the findings indicate that innovation-focused strategies greatly affected the cost-efficiency usage of data on users and context during the design of mobile systems. With innovation-focused strategies, the findings reemphasize the importance of practitioners' competences and experience as well as having organizational practices that encourage the creation and sharing of ideas within the organization. In contrast, the findings indicate that cost-focused strategies have a negative effect on practitioners' competences and experiences as well as on organizational practices. The findings provide the first explanatory model that

relates aspects of the interaction design practice with the organizational context. These insights are elaborated in Paper 3 and in Chapter 4.

Findings from the qualitative studies call attention to the business environment complexity as a core barrier to user involvement, especially in contract-based projects. Moreover, the findings suggest on a link between the nature of users and the designed system and the rationality of interaction designers regarding the involvement of target users in real-life context of use. Essentially, the professional-client relationship inhibited the involvement of target users, at least in the design of consumer mobile systems; being a consultancy that provides design services, interaction designers faced significant limitations to involve users enforced on them by those with decision-making power, i.e. the client. However, the findings emphasize that a mental distance between the user group and the interaction designers encouraged the utilization of user studies in naturalistic context. Additionally, studies of users in the context of use are also encouraged when the designed system is perceived to be innovative. This research confirms prior studies' observation on the business environment complexity and suggests a new explanation to the rationality for conducting field studies during design, namely the unfamiliarity with the users and the innovativeness of the designed system. A further discussion of the findings is provided in Paper 4, Paper 5 and in Chapter 4.

5.2. Contribution to theory

This research contributes to interaction design theories by providing a first view on the design practice from a mobile computing perspective rather than a stationary computing perspective, let alone in the mobile apps era. Given the significant impact of mobile computing and the mobile apps era on core HCD principles and interaction designers, this research indicates on a shift in the scientific-oriented HCD practice toward studies in real-life environments, particularly with evaluations, whereas the broad interaction design practice has not shifted. The gap between science and practice is well documented (Simon, 1969; Schön, 1983; Krippendorf, 2006; Stolterman, 2008), to which this research contributes a specific lens in the case of user involvement in context during the interaction design of mobile systems. Furthermore, the research emphasizes the constant evolving nature of HCD (Karat and Karat, 2003), in which the focus on understanding users in context is shifting from an early and continual HCD activity to a follow-up activity, that is, obtaining actual system usage data, especially with consumer mobile systems. Such usage-driven HCD significantly differs from the established HCD approach (ISO 9241-210, 2010); it requires further research into its applicability in various cases and on its economical aspects. Overall, the findings on the state of HCD in science and in the industry provide a timely view and point of reference during a shifting period

from stationary computing to mobile computing, particularly regarding the emergence of wearable computing.

Moreover, this research provides the first insights into the perception of 'context of use' held by practitioners who are engaged in design. While the notions of 'context' and 'context of use' were extensively theorized, including for mobile computing (e.g. Nardi, 1996; Dourish, 2004; Bradley and Dunlop, 2005; Jumisko- Pyykkö and Vainio, 2010), practitioners' understanding of context of use was not yet examined at the time of research. Considering the fundamental effect of mobile computing on the actual context of use, this research shows that interaction designers put more emphasis on internal aspects of the context, such as user goals, and on usage behavior and daily habits, whereas external context aspects that affect the behavior were considered to be less important. The perception of designers may suggest on their inclination toward a follow-up rather than early involvement of users in context, particularly with the new possibilities to rapidly collect rich usage data. Further research may substantiate the relation between "the 'designerly' ways of knowing, thinking, and acting" (Cross, 2001, p.55) with regard to the explicit understanding of users and context of use.

This research presents a preliminary attempt to connect the design practice with the organizational context and innovation strategies on an explanatory level rather than a qualitative or descriptive account in prior research (e.g. Rosenbaum et al. 2000; Venturi et al, 2006). The research shows that innovation-focused strategies have a positive effect on the usage of data on users and context in the design of mobile systems, while cost-oriented strategies have no effect. Theoretically, this insight contributes to understanding interaction design in the broader organizational context in which it takes place (as discussed in section 2.6), and the need for explanatory studies that goes beyond a limited focus on design in order to better understand interaction design and to inform its theories.

Last, this research provides evidence on the core factors that explain the work rationality of interaction designers with regard to user involvement. Besides confirming the challenges to involve users in a professional-client relationship, the research highlights the mental distance between users and interaction designers and the perceived innovativeness of the designed system as key factors that encourage the involvement of users in context, particularly in an early HCD activity. Responding to Stolterman's (2008) call for in-depth studies on the existing design practice, these insights contribute to better understand designers' rationality for practice and inform theories on the interaction design practice. This rationality suggests that neither mobile computing and its effect on the context of use nor new HCD methods and tools significantly encourage practitioners to involve users in real-life contexts of use. Rather, the HCD-orientation of an organization (or its usability capability maturity), its business

environment and usability capability maturity of stakeholders, and the nature of users and system in a particular project may be more accurate predictors for the extensiveness of applying the core HCD principle of involving users in context.

5.3. Implications for research and practice

This research is part of design-oriented scientific research efforts (as clarified in section 2.2), and hence, its main research implications are for scholars active in this discipline. As described in the theoretical chapter (section 2.2), design-oriented scientific research put emphasis on theorizing the complexity of interaction design practice as well as on supporting the work of interaction designers; in the previous section, I show how this research contributes to the former, though this research also has implications for scholars who are aimed at producing knowledge for the latter.

Essentially, this research argues for more sensitivity to the context of interaction design practice from researchers who aim at supporting interaction designers. Significant design-oriented scientific research efforts are focused on devising and evaluating new and adapted HCD methods and tools (Myers et al. 1996; Forlizzi et al. 2008), mostly with the aim to improve the interaction design practice. However, many of the efforts do not find their place in the HCD toolkit used by interaction designers (Rogers, 2004), arguably due to researchers' unawareness to the complex work context of interaction designers and their existing practice (Wixon, 2003; Stolterman, 2008; Goodman et al. 2011). This research emphasizes the business environment complexity and its effect on a core HCD activity in an effort to bring more awareness and consideration to it by researchers who intend to support interaction designers' HCD work. Obviously, this complexity cannot be easily simulated in academic research.

Hence, researchers who develop, adapt, or assess HCD methods and tools should engage more often in action research by closely collaborating with interaction designers, as suggested by Schön (1983). This tight collaboration may yield multiple contributions: firstly, to interaction design theories, by observing the practice in different contextual settings; secondly, to the knowledge base on HCD methods, by describing the practice in various industrial contexts; and thirdly, to the interaction designers involved, by intervening in, and improving their course of action. Apart from being engaged in action research, interaction designers and others who are involved in interaction design can further benefit from this research. In addition, more ecological insight is needed on the narratives between designers and clients as well as more broadly on all types of projects, e.g. using case studies, in order to provide UCD practitioners with established strategies.

Despite the business environment complexity, this research (Paper 5) emphasizes various strategies to the relationship between professional interaction design consultancies and clients, which encourage the explicit understanding of users and context of use. Firstly, by having an open type of relationship, interaction designers can gain access to the client's customers, the end users in most cases, which ease the burden on recruiting specific target users. Secondly, with an open and long-term relationship, interaction designers may gain access to actual system usage data. Thirdly, embedding interaction designers within the client's project team is an indicator for the client's understanding of the importance of interaction design. Consequently, it allows interaction designers to focus on doing their professional work rather than try to convince the client to provide budget for their work. With regard to the actual HCD work, this research (Paper 2) provides evidence for practitioners on a cost-effective strategy in attending to users and context by including a broader spectrum of HCD methods, each having strengths on specific contextual aspects, internal and external, throughout the entire project.

With the focal lens on the organizational context, this research has implications also for organizational management. The strong influence of innovation-focused strategies on the cost-efficient usage of data on users and context (Paper 3) emphasizes the importance of establishing a work environment that fosters an open exchange of ideas, data, and knowledge within project teams and organizations. In light of the increased availability of rich data on users, this research also highlights the importance of having relevant HCD skills for data gathering and crunching, in order to obtain knowledge on evolving usage patterns in a cost-efficient and timely manner.

Last, this research has implications on the education of interaction designers. Essentially, students in interaction design schools should acquire competencies and tools that enable them to deal with various business environment situations. The strategies described before provide some bases that obviously require further development as well as more insights in future research. In addition, the increasing importance and amount of usage data to inform design requires relevant competences to the gathering and analysis of data for interaction design purposes.

5.4. Limitations

The limitations of each study are discussed in more details in the published papers (Part II) and in the methodology chapter (section 3.3). Here, I merely reflect on the limitations of the research project as a whole.

Firstly, the sample used in informing the studies can hardly be randomized, which affects the external validity of inferences. As explained before (section

2.6), practitioners who are involved in interaction design use multiple titles and loosely defined roles with no available lists that cover the population. Thus, it is not possible to have a random sample of the population. The questionnaire study was based on non-probabilistic sampling. Although such sampling is common and valid in HCI research (Lazar et al. 2010), generalization cannot be guaranteed. The sample in the interview studies was naturally more limited, both with regard to the country of practitioners, i.e. Finland and the Netherlands, and the type of systems, i.e. media and finance systems for consumers. Hence, the findings from the interview studies may represent the reality within such boundaries. Since these boundaries were not specifically examined in the questionnaire study, integration of the insights from the mixed methods is limited. Developing the insights from this research beyond these boundaries, to various countries and regions as well as to various system categories (e.g. health, enterprise, games, B2B, C2C) is highly warranted.

Secondly, regarding the mixed-methods research approach, the applied interview and questionnaire methods both rely largely on informants' recollections of past events. As Lazar et al. (2010) put it, recalling past experiences is "one step removed from reality" (p.179). Consequently, the recollection-informed 'reality' may be biased or inadvertently inaccurate. This drawback was considered and alleviated in the questionnaire study (see Paper 2) and in the interview studies (see Paper 5) by focusing on recent and specific project experiences, including ongoing events, rather than on the interaction design practice in general. Nevertheless, generating a deep understanding on the work of professionals requires triangulation on the sources of evidence (Yin, 2003). In particular, future insights from sources on the reality as-is, such as from direct observation of interaction designers, documentation (e.g. professional-client contracts, meeting memoranda, and communiqués), and archival records (e.g. HCD-related data, produced outcome) would be valuable to the further development of the insights from this research.

Thirdly, the results reflect the situation at a single point in time, though the studied phenomenon is continuous. Findings from the questionnaire show a state of HCD practice that reflects past experiences from a certain point of time, while findings from the interview studies also capture ongoing experiences to some extent. However, the HCD practice with regard to a specific system is continuing. Particularly regarding the shift to the explicit understanding of user and context of use in follow-up studies, the focus on recent and ongoing projects from one point of time limits the understanding of possible future HCD-related events. Thus, studying the HCD practice warrants longitudinal studies into the actual usage of systems.

Lastly, this research merely indicates on the potential of interaction designers to be user- and context- informed during the design, not on the extent of the actual systems to create the desired situations for their users. This research was mainly concerned with explaining the HCD practice in the mobile apps era and the rationality of interaction designers for this practice. While attending to users and context of use are core HCD principles, it does not guarantee the success performance of the actual system by its users. On the other hand, the non-involvement of users in context does not necessarily results in inferior performance of systems; relying solely on the intuition of interaction designers and their clients could pay-off in some cases. Nevertheless, a link between the HCD work during design and the actual user experience performance of system is warranted in future research to better explain the need for HCD work in various cases. To that end, holistic longitudinal studies that capture the system design, development, and usage to further extent are needed.

5.5. Future HCD research

The mobile apps era is a step in the increasing embeddedness of technology in everyday lives of people. This embeddedness continues at the time of writing, for instance with wearable computing (e.g. watch, wristband, ring) and in-car computing, which likely leads to new use cases and usage patterns. In this research I merely focused on the interaction design of mobile computing systems. While the findings are timely valuable, further research should pay attention to the interaction design of emerging technologies and more holistically on the design of cross-channel experiences on various form factors.

Future studies should build on the findings from this research to further develop the understanding of interaction designers and their HCD practice. Firstly, this research merely provides preliminary evidence on the relation between organizational strategy and a specific aspect of HCD, the cost-efficient usage of data on users and context. More evidence is needed both in developing this link, as well as in establishing new explanatory connections between interaction design and the organizational context, for instance to the major business operation of organizations and to the business environment of organizations. Generating such insights would further the understanding of design in organizational context and would allow practitioners more cost-efficiently to allocate design resources in specific circumstances.

Secondly, the shift in explicit understanding of users and context toward the usage phase of projects requires studies into the HCD practice during the post-deployment phase of systems. Grounded in the HCD approach, design-oriented scientific research has traditionally had its central attention on upfront research to collect and form user requirements as well on the evaluation of design proposals. Insights from this research emphasize the need to expand the

boundaries of HCD scope to include the post-deployment phase, where a large amount of data (sometimes labeled 'Big Data') on user and context can be collected. With the growing importance of incremental improvement of systems, theorizing the available data on user and context and devising means to cost-efficiently analyze and gain explicit understanding of users and context during the actual usage phase, e.g. as demonstrated by McMillan et al. (2010), would be valuable in supporting interaction designers.

Thirdly, addressing the business environment complexity requires deeper insights into its intrinsic roots. This research provides preliminary insights on strategies that encourage a more HCD-oriented approach in cases of interaction design consultancy and professional-client relationship. These insights require more substantiation and development in various situations. First, the third-order understanding may not be limited to consultancies, but may also affect in-house design teams, especially in case they operate as profit centers. More crucially, overcoming the third-order understanding of users requires studies that explain the sources of the problem. For instance, given the ambiguous notion of 'design' (as discussed in section 2.1), client organizations that obtain professional design service may perceive 'design' largely in terms of the expected outcome, whereas the explicit understanding of users and context may be conceived as a different professional service or merely a technical knowledge possessed by interaction designers. Hence, a study on the perception of 'design' and expectations from the professional-client relationship, by various stakeholders who are engaged in the relationship, could shed light on one source of the problem. Another study could build on existing usability capability maturity models study (Jokela et al. 2006) to help explain possible divergent views on the design service between client and in-house organizations and to develop a usability capability maturity model that can be used in assessing projects and their complex social settings rather than the usability capability maturity of a single organization.

Lastly, the mental and cognitive distance between users and practitioners is an important line of research that requires more empirical evidence. Similar to the business environment complexity, insights on the mental distance between target users and design practitioners as affecting the inclination to study users in context are preliminary and are not idiosyncratic to mobile computing. The mental distance condition affects the implementation of core HCD principle and hence, further studies are needed to provide insights from various cases, particularly in industrial settings.

References

Abowd, G. D., & Mynatt, E. D. (2000). Charting Past, Present, and Future Research in Ubiquitous Computing. ACM Trans. Comput.-Hum. Interact., 7(1), 29–58. http://doi.org/10.1145/344949.344988

Ahtinen, A., Nurminen, J. K., & Häkkilä, J. (2007). Developing a Mobile Reporting System for Road Maintenance: User Research Perspective. In Proceedings of the 4th International Conference on Mobile Technology, Applications, and Systems and the 1st International Symposium on Computer Human Interaction in Mobile Technology (pp. 1–7). New York, NY, USA: ACM. http://doi.org/10.1145/1378063.1378065

Alexander, C. (1964). Notes on the Synthesis of Form. Harvard University Press.

Arnetminer. (2009). HCI Conference and journal ranking. Retrieved from http://arnetminer.org/page/conference-rank/html/HCI.html

Axtell, C. M., WATERSON, P. E., & CLEGG, C. W. (1997). Problems integrating user participation into software development. International Journal of Human-Computer Studies, 47(2), 323–345. http://doi.org/10.1006/ijhc.1997.0143

Bak, J. O., Nguyen, K., Risgaard, P., & Stage, J. (2008). Obstacles to usability evaluation in practice (pp. 23–32). Presented at the Proceedings of the 5th Nordic conference on Human-computer interaction: building bridges (NordiCHI '08), ACM Press. http://doi.org/10.1145/1463160.1463164

Balaji, T. S., Landers, B., Kates, J., & Moritz, B. (2005). A Carrier's Perspective on Creating a Mobile Multimedia Service. Commun. ACM, 48(7), 49–53. http://doi.org/10.1145/1070838.1070865

Barki, H., & Hartwick, J. (1989). Rethinking the Concept of User Involvement. MIS Quarterly, 13(1), 53–63. http://doi.org/10.2307/248700

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. Journal of Management, 17(1), 99–120. http://doi.org/10.1177/014920639101700108

Bauer, J. S., Newman, M. W., & Kientz, J. A. (2014). What Designers Talk About When They Talk About Context. Human–Computer Interaction, 29(5-6), 420–450. http://doi.org/10.1080/07370024.2014.896709

Baur, D., Hering, B., Boring, S., & Butz, A. (2011). Who needs interaction anyway: exploring mobile playlist creation from manual to automatic. In Proceedings of the 16th international conference on Intelligent user interfaces (pp. 291–294).

Baxter, G., & Sommerville, I. (2011). Socio-technical systems: From design methods to systems engineering. Interacting with Computers, 23(1), 4–17. http://doi.org/10.1016/j.intcom.2010.07.003

Bentley, F., & Barrett, E. (2012). Building Mobile Experiences. MIT Press.

Benyon, D. (2014). Designing Interactive Systems: A comprehensive guide to HCI, UX, and Interaction Design (3rd ed.). Pearson Education.

Bergvall-Kåreborn, B., & Howcroft, D. (2011). Mobile Applications Development on Apple and Google Platforms. Communications of the Association for Information Systems, 29(1), 565–580.

Bevan, N., & Macleod, M. (1994). Usability measurement in context. Behaviour & Information Technology, 13(1-2), 132–145.

Beyer, H., & Holtzblatt, K. (1997). Contextual design: defining customer-centered systems. Morgan Kaufmann.

Blevis, E., Lim, Y.-K., & Stolterman, E. (2006). Regarding Software as a Material of Design (pp. 1–18). Presented at the Wonderground, Lisbon: Design Research Society.

Blomberg, J., Giacomi, J., Mosher, A., & Swenton-Wall, P. (1993). Ethnographic field methods and their relation to design. In D. Schuler & A. Namioka (Eds.), Participatory design: Principles and practices (pp. 123–155).

Blom, J., Chipchase, J., & Lehikoinen, J. (2005). Contextual and Cultural Challenges for User Mobility Research. Commun. ACM, 48(7), 37–41. http://doi.org/10.1145/1070838.1070863

Boehm, B. W. (1988). A spiral model of software development and enhancement. Computer, 21(5), 61–72. http://doi.org/10.1109/2.59

Boivie, I., Gulliksen, J., & Göransson, B. (2006). The lonesome cowboy: A study of the usability designer role in systems development. Interacting with Computers, 18(4), 601–634. http://doi.org/10.1016/j.intcom.2005.10.003

Borchers, J. (2008). HCI journals that are included in the ISI Journal Citation Reports. Retrieved from http://hci.rwth-aachen.de/isi-journals

Bradley, N. A., & Dunlop, M. D. (2005). Toward a multidisciplinary model of context to support context-aware computing. Hum.-Comput. Interact., 20(4), 403–446. http://doi.org/10.1207/s15327051hci2004_2

Brandt, J., Weiss, N., & Klemmer, S. R. (2007). txt 4 l8r: lowering the burden for diary studies under mobile conditions. In CHI '07 extended abstracts on Human factors in computing systems (pp. 2303–2308). New York, NY, USA: ACM. http://doi.org/10.1145/1240866.1240998

Brooks, J., F.P. (1987). No Silver Bullet Essence and Accidents of Software Engineering. Computer, 20(4), 10–19. http://doi.org/10.1109/MC.1987.1663532

Brown, T. A. (2015). Confirmatory Factor Analysis for Applied Research, Second Edition. Guilford Publications.

Bruno, V., & Dick, M. (2007). Making Usability Work in Industry: An Australian Practitioner Perspective. In Proceedings of the 19th Australasian Conference on Computer-Human Interaction: Entertaining User Interfaces (pp. 261–264). New York, NY, USA: ACM. http://doi.org/10.1145/1324892.1324948

Bryman, A. (2006). Integrating quantitative and qualitative research: how is it done? Qualitative Research, 6(1), 97–113. http://doi.org/10.1177/1468794106058877

Bygstad, B., Ghinea, G., & Brevik, E. (2008). Software development methods and usability: Perspectives from a survey in the software industry in Norway. Interacting with Computers, 20(3), 375–385. http://doi.org/10.1016/j.intcom.2007.12.001

Christensen, C. M. (1997). The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Harvard Business Press.

Consolvo, S., & Walker, M. (2003). Using the experience sampling method to evaluate ubicomp applications. Pervasive Computing, IEEE, 2(2), 24–31.

Cooper, A. (1999). The Inmates are Running the Asylum–Why High-Tech Products Drive Us Crazy and How 2 to Restore the Sanity. Indianapolis: Sams.

Cooper, A., Reimann, R., & Cronin, D. (2007). About Face 3: The Essentials of Interaction Design (3Rev Ed edition). Indianapolis, IN: John Wiley & Sons.

Coursaris, C. K., & Kim, D. J. (2011). A Meta-Analytical Review of Empirical Mobile Usability Studies. J. Usability Studies, 6(3), 11:117–11:171.

Creswell, J. W., & Clark, V. L. P. (2007). Designing and conducting mixed methods research.

Cross, N. (2001). Designerly Ways of Knowing: Design Discipline Versus Design Science. Design Issues, 17(3), 49–55. http://doi.org/10.1162/074793601750357196

Crotty, M. J. (1998). The Foundations of Social Research: Meaning and Perspective in the Research Process. London ; Thousand Oaks, Calif: SAGE Publications Ltd.

Curtis, B., Krasner, H., & Iscoe, N. (1988). A Field Study of the Software Design Process for Large Systems. Commun. ACM, 31(11), 1268–1287. http://doi.org/10.1145/50087.50089

Dahlbom, B., & Ljungberg, E. (1998). Mobile informatics. Scandinavian Journal of Information Systems, 10, 227–234.

Damodaran, L. (1996). User involvement in the systems design process-a practical guide for users. Behaviour & Information Technology, 15(6), 363–377. http://doi.org/10.1080/014492996120049

Da Silva, T. S., Martin, A., Maurer, F., & Silveira, M. S. (2011). User-Centered Design and Agile Methods: A Systematic Review. In AGILE (pp. 77–86).

De Wit, B., & Meyer, R. (2010). Strategy Synthesis: Resolving Strategy Paradoxes to Create Competitive Advantage (3 edition). Australia: Cengage Learning.

Dey, A. K. (2001). Understanding and Using Context. Personal and Ubiquitous Computing, 5(1), 4–7. http://doi.org/10.1007/s007790170019

Dillman, D. A. (2006). Mail and Internet Surveys: The Tailored Design Method -- 2007 Update with New Internet, Visual, and Mixed-Mode Guide (2nd ed.). Wiley.

Dix, A., Rodden, T., Davies, N., Trevor, J., Friday, A., & Palfreyman, K. (2000). Exploiting space and location as a design framework for interactive mobile systems. ACM Trans. Comput.-Hum. Interact., 7(3), 285–321. http://doi.org/10.1145/355324.355325

Dourish, P. (2004). What we talk about when we talk about context. Personal Ubiquitous Comput., 8(1), 19–30. http://doi.org/10.1007/s00779-003-0253-8

Emam, K. E., & Madhavji, N. H. (1995). A field study of requirements engineering practices in information systems development. In , Proceedings of the Second IEEE International Symposium on Requirements Engineering, 1995 (pp. 68–80). http://doi.org/10.1109/ISRE.1995.512547

Fallman, D. (2003). Design-oriented Human-computer Interaction. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 225–232). New York, NY, USA: ACM. http://doi.org/10.1145/642611.642652

Fallman, D. (2008). The interaction design research triangle of design practice, design studies, and design exploration. Design Issues, 24(3), 4–18.

Forlizzi, J., Zimmerman, J., & Evenson, S. (2008). Crafting a Place for Interaction Design Research in HCI. Design Issues, 24(3), 19–29. http://doi.org/10.1162/desi.2008.24.3.19

Forman, G. H., & Zahorjan, J. (1994). The challenges of mobile computing. Computer, 27(4), 38–47. http://doi.org/10.1109/2.274999

Gasson, S. (1999). The reality of user-centered design. Journal of Organizational and End User Computing (JOEUC), 11(4), 5–15.

Ginsburg, S. (2010). Designing the iPhone user experience: A user-centered approach to sketching and prototyping iPhone apps. Addison-Wesley Professional.

Goodman, E., Stolterman, E., & Wakkary, R. (2011). Understanding interaction design practices. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1061–1070). New York, NY, USA: ACM. http://doi.org/10.1145/1978942.1979100

Gothelf, J., & Seiden, J. (2013). Lean UX: Applying Lean Principles to Improve User Experience. O'Reilly Media, Inc.

Gould, J. D. (1988). How to design usable systems. In M. Helander (Ed.), Handbook of Human-Computer Interaction (pp. 757–785). Amsterdam, The Netherlands: Elsevier.

Gray, C. M., Stolterman, E., & Siegel, M. A. (2014). Reprioritizing the Relationship Between HCI Research and Practice: Bubble-up and Trickle-down Effects. In Proceedings of the 2014 Conference on Designing Interactive Systems (pp. 725–734). New York, NY, USA: ACM. http://doi.org/10.1145/2598510.2598595

Greenberg, S. (2001). Context as a dynamic construct. Human–Computer Interaction, 16(2-4), 257–268.

Grudin, J. (1991a). Interactive Systems: Bridging the Gaps Between Developers and Users. Computer, 24(4), 59–69.

Grudin, J. (1991b). Systematic Sources of Suboptimal Interface Design in Large Product Development Organizations. Human–Computer Interaction, 6(2), 147–196. http://doi.org/10.1207/s15327051hci0602_3

Grudin, J. (1994). Computer-supported cooperative work: History and focus. Computer, (5), 19–26.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. Handbook of Qualitative Research, 2(163-194).

Gulliksen, J., Boivie, I., & Göransson, B. (2006). Usability professionals—current practices and future development. Interacting with Computers, 18(4), 568–600. http://doi.org/10.1016/j.intcom.2005.10.005

Gulliksen, J., Boivie, I., Persson, J., Hektor, A., & Herulf, L. (2004). Making a difference - a survey of the usability profession in Sweden. In Proceedings of

the third Nordic conference on Human-computer interaction (NordiCHI'04) (pp. 207–215). ACM Press. http://doi.org/10.1145/1028014.1028046

Gulliksen, J., Göransson, B., Boivie, I., Blomkvist, S., Persson, J., & Cajander, Å. (2003). Key principles for user-centred systems design. Behaviour & Information Technology, 22(6), 397–409. http://doi.org/10.1080/01449290310001624329

Gunther, R., Janis, J., & Butler, S. (2001). The UCD Decision Matrix: How, When, and Where to Sell User-Centered Design into the Development Cycle. Retrieved from http://www.ovostudios.com/upa2001/

Hagen, P., Robertson, T., Kan, M., & Sadler, K. (2005). Emerging research methods for understanding mobile technology use. In Proceedings of the 17th Australia conference on Computer-Human Interaction: Citizens Online: Considerations for Today and the Future (pp. 1–10).

Hassenzahl, M., & Tractinsky, N. (2006). User experience - a research agenda. Behaviour & Information Technology, 25(2), 91–97. http://doi.org/10.1080/01449290500330331

Henfridsson, O., & Lindgren, R. (2005). Multi-contextuality in ubiquitous computing: Investigating the car case through action research. Information and Organization, 15(2), 95–124. http://doi.org/10.1016/j.infoandorg.2005.02.009

Henfridsson, O., & Lindgren, R. (2010). User involvement in developing mobile and temporarily interconnected systems. Information Systems Journal, 20(2), 119–135. http://doi.org/10.1111/j.1365-2575.2009.00337.x

Henze, N., & Boll, S. (2010). Push the Study to the App Store: Evaluating Off-screen Visualizations for Maps in the Android Market. In Proceedings of the 12th International Conference on Human Computer Interaction with Mobile Devices and Services (pp. 373–374). New York, NY, USA: ACM. http://doi.org/10.1145/1851600.1851671

Hertzum, M. (2008). On the Process of Software Design: Sources of Complexity and Reasons for Muddling through. In J. Gulliksen, M. B. Harning, P. Palanque, G. C. van der Veer, & J. Wesson (Eds.), Engineering Interactive Systems (pp. 483–500). Springer Berlin Heidelberg.

Hertzum, M., & Jacobsen, N. E. (2001). The Evaluator Effect: A Chilling Fact About Usability Evaluation Methods. International Journal of Human-Computer Interaction, 13(4), 421–443. http://doi.org/10.1207/S15327590IJHC1304_05

Hewett, T. T., Baecker, R., Card, S., Carey, T., Gasen, J., Mantei, M., … Verplank, W. (1992). ACM SIGCHI Curricula for Human-Computer

Interaction. New York, NY, USA: ACM. Retrieved from http://old.sigchi.org/cdg/index.html

Hinman, R. (2012). The Mobile Frontier (1st ed.). Rosenfeld Media.

Holtzblatt, K., Wendell, J. B., & Wood, S. (2005). Rapid Contextual Design: A How-to Guide to Key Techniques for User-centered Design. Elsevier.

Hoyle, R. H. (1995). Structural Equation Modeling: Concepts, Issues, and Applications. SAGE Publications.

Hudson, W. (2000, May 3). User-Centered Survey Results. CHI-WEB@ACM.ORG. Retrieved from http://listserv.acm.org/scripts/wa-ACMLPX.exe?A2=ind0005A&L=CHI-WEB&F=&S=&P=9056

Hulkko, S., Mattelmäki, T., Virtanen, K., & Keinonen, T. (2004). Mobile probes. In Proceedings of the third Nordic conference on Human-computer interaction (pp. 43–51). New York, NY, USA: ACM. http://doi.org/10.1145/1028014.1028020

Hussain, Z., Slany, W., & Holzinger, A. (2009). Current State of Agile User-Centered Design: A Survey. In A. Holzinger & K. Miesenberger (Eds.), HCI and Usability for e-Inclusion (Vol. 5889, pp. 416–427). Springer Berlin / Heidelberg.

Iivari, J., & Iivari, N. (2011). Varieties of user-centredness: an analysis of four systems development methods. Information Systems Journal, 21(2), 125–153. http://doi.org/10.1111/j.1365-2575.2010.00351.x

Iivari, N. (2004). Enculturation of User Involvement in Software Development Organizations - an Interpretive Case Study in the Product Development Context. In Proceedings of the Third Nordic Conference on Human-computer Interaction (pp. 287–296). New York, NY, USA: ACM. http://doi.org/10.1145/1028014.1028059

Iivari, N. (2005). Usability Specialists – "A Mommy Mob", "Realistic Humanists" or "Staid Researchers"? An Analysis of Usability Work in the Software Product Development. In M. F. Costabile & F. Paternò (Eds.), Human-Computer Interaction - INTERACT 2005 (pp. 418–430). Springer Berlin Heidelberg.

Iivari, N. (2006). "Representing the User" in software development—a cultural analysis of usability work in the product development context. Interacting with Computers, 18(4), 635–664. http://doi.org/10.1016/j.intcom.2005.10.002

ISO. (1999). ISO 13407:1999 Human-centred design processes for interactive systems. Geneva: International Organization for Standardization.

ISO. (2010). ISO 9241-210:2010 Ergonomics of human-system interaction-Part 210: Human-centred design for interactive systems. Geneva: International Organization for Standardization.

Jacobson, I., Booch, G., Rumbaugh, J., Rumbaugh, J., & Booch, G. (1999). The unified software development process (Vol. 1). Addison-wesley Reading.

Ji Yong Gu, & Yun Myung Hwan. (2006). Enhancing the Minority Discipline in the IT Industry: A Survey of Usability and User-Centered Design Practice. International Journal of Human-Computer Interaction, 20(2), 117–134. http://doi.org/10.1207/s15327590ijhc2002_3

Johnson, B., & Turner, L. A. (2003). Data collection strategies in mixed methods research. In A. Tashakkori & C. Teddlie (Eds.), Handbook of Mixed Methods in Social & Behavioral Research (pp. 297–319).

Johnson, P. (1998). Usability and Mobility; Interactions on the move. In Proceedings of the First Workshop on Human-Computer Interaction with Mobile Devices. Retrieved from http://www.dcs.gla.ac.uk/~johnson/papers/mobile/HCIMD1.html

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed Methods Research: A Research Paradigm Whose Time Has Come. Educational Researcher, 33(7), 14–26. http://doi.org/10.3102/0013189X033007014

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a Definition of Mixed Methods Research. Journal of Mixed Methods Research, 1(2), 112–133. http://doi.org/10.1177/1558689806298224

Jokela, T., & Abrahamsson, P. (2004). Usability Assessment of an Extreme Programming Project: Close Co-operation with the Customer Does Not Equal to Good Usability. In F. Bomarius & H. Iida (Eds.), Product Focused Software Process Improvement (pp. 393–407). Springer Berlin Heidelberg.

Jokela, T., Siponen, M., Hirasawa, N., & Earthy, J. (2006). A survey of usability capability maturity models: implications for practice and research. Behaviour & Information Technology, 25(3), 263–282. http://doi.org/10.1080/01449290500168079

Jumisko-Pyykkö, S., & Vainio, T. (2010). Framing the Context of Use for Mobile HCI. International Journal of Mobile Human Computer Interaction, 2(4), 1–28. http://doi.org/10.4018/jmhci.2010100101

Kangas, E., & Kinnunen, T. (2005). Applying user-centered design to mobile application development. Commun. ACM, 48(7), 55–59. http://doi.org/10.1145/1070838.1070866

Kanstrup, A. M., Bjerge, K., & Kristensen, J. E. (2010). A living laboratory exploring mobile support for everyday life with diabetes. Wireless Personal Communications, 53(3), 395–408.

Karat, J. (1996). User Centered Design: Quality or Quackery? Interactions, 3(4), 18–20. http://doi.org/10.1145/234813.234814

Karat, J., & Karat, C.-M. (2003). The evolution of user-centered focus in the human-computer interaction field. IBM Systems Journal, 42(4), 532–541.

Kim, S., Robson, C., Zimmerman, T., Pierce, J., & Haber, E. M. (2011). Creek Watch: Pairing Usefulness and Usability for Successful Citizen Science. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 2125–2134). New York, NY, USA: ACM. http://doi.org/10.1145/1978942.1979251

Kjeldskov, J., & Graham, C. (2003). A review of mobile HCI research methods. In Human-computer interaction with mobile devices and services (pp. 317–335). Springer.

Kjeldskov, J., Graham, C., Pedell, S., Vetere, F., Howard, S., Balbo, S., & Davies, J. (2005). Evaluating the usability of a mobile guide: the influence of location, participants and resources. Behaviour & Information Technology, 24(1), 51–65.

Kjeldskov, J., & Paay, J. (2010). Indexicality: Understanding mobile human-computer interaction in context. ACM Trans. Comput.-Hum. Interact., 17(4), 14:1–14:28. http://doi.org/10.1145/1879831.1879832

Kjeldskov, J., & Stage, J. (2004). New techniques for usability evaluation of mobile systems. International Journal of Human-Computer Studies, 60(5–6), 599–620. http://doi.org/10.1016/j.ijhcs.2003.11.001

Kline, R. B. (2011). Principles and Practice of Structural Equation Modeling. Guilford Press.

Krippendorff, K. (2006). The Semantic Turn: A New Foundation for Design. CRC Press.

Kujala, S. (2003). User involvement: A review of the benefits and challenges. Behaviour & Information Technology, 22(1), 1–16. http://doi.org/10.1080/01449290301782

Kujala, S., & Kauppinen, M. (2004). Identifying and Selecting Users for User-centered Design. In Proceedings of the Third Nordic Conference on Human-computer Interaction (pp. 297–303). New York, NY, USA: ACM. http://doi.org/10.1145/1028014.1028060

Laurel, B. (2003). Design research: Methods and perspectives. MIT press.

Laurel, B., & Mountford, S. J. (Eds.). (1990). The Art of Human-Computer Interface Design. Boston, MA, USA: Addison-Wesley Longman Publishing Co., Inc.

Lazar, J., Feng, J. H., & Hochheiser, H. (2010). Research Methods in Human-Computer Interaction. John Wiley & Sons.

Locke, E. A. (2007). The Case for Inductive Theory Building. Journal of Management, 33(6), 867–890. http://doi.org/10.1177/0149206307307636

Lu, J., Yu, C.-S., Liu, C., & Yao, J. E. (2003). Technology acceptance model for wireless Internet. Internet Research, 13(3), 206–222. http://doi.org/10.1108/10662240310478222

Macleod, M., & Bevan, N. (1993). MUSiC video analysis and context tools for usability measurement. In Proceedings of the INTERACT '93 and CHI '93 Conference on Human Factors in Computing Systems (p. 55). New York, NY, USA: ACM. http://doi.org/10.1145/169059.169072

Martin, J. (1991). Rapid Application Development. Indianapolis, IN, USA: Macmillan Publishing Co., Inc.

Martin, R. C. (2002). Agile Software Development, Principles, Patterns, and Practices (1st edition). Upper Saddle River, N.J: Pearson.

Mata, F. J., Fuerst, W. L., & Barney, J. B. (1995). Information Technology and Sustained Competitive Advantage: A Resource-Based Analysis. MIS Quarterly, 19(4), 487–505. http://doi.org/10.2307/249630

Mayhew, D. J. (1999). The Usability Engineering Lifecycle: A Practitioner's Handbook for User Interface Design. Morgan Kaufmann. McMillan, D., Morrison, A., Brown, O., Hall, M., & Chalmers, M. (2010). Further into the Wild: Running Worldwide Trials of Mobile Systems. In P. Floréen, A. Krüger, & M. Spasojevic (Eds.), Pervasive Computing (pp. 210–227). Springer Berlin Heidelberg.

Meeker, M. (2013). KPCB Internet Trends 2013. Retrieved from http://www.kpcb.com/insights/2013-internet-trends

Miles, M. B., & Huberman, A. M. (1994). Qualitative Data Analysis: An Expanded Sourcebook. SAGE Publications.

Millen, D. R. (2000). Rapid ethnography: time deepening strategies for HCI field research. In Proceedings of the 3rd conference on Designing interactive systems: processes, practices, methods, and techniques (pp. 280–286).

Mingers, J. (2001). Combining IS Research Methods: Towards a Pluralist Methodology. Information Systems Research, 12(3), 240–259. http://doi.org/10.1287/isre.12.3.240.9709

Monahan, K., Lahteenmaki, M., McDonald, S., & Cockton, G. (2008). An investigation into the use of field methods in the design and evaluation of interactive systems. In Proceedings of the 22nd British HCI Group Annual Conference on People and Computers: Culture, Creativity, Interaction - Volume 1 (pp. 99–108). Swinton, UK: British Computer Society.

Morse, J. M. (2003). Principles of Mixed Methods and Multimethod Research Design. In A. Tashakkori & C. Teddlie (Eds.), Handbook of Mixed Methods in Social & Behavioral Research (pp. 189–208).

Muhr, T. (1991). ATLAS/ti — A prototype for the support of text interpretation. Qualitative Sociology, 14(4), 349–371. http://doi.org/10.1007/BF00989645

Myers, B., Hollan, J., Cruz, I., Bryson, S., Bulterman, D., Catarci, T., … Ioannidis, Y. (1996). Strategic Directions in Human-computer Interaction. ACM Comput. Surv., 28(4), 794–809. http://doi.org/10.1145/242223.246855

Nardi, B. A. (1996). Context and consciousness: activity theory and human-computer interaction. The MIT Press.

Nielsen, J. (1993). Usability engineering (Vol. 125184069). Boston: Academic Press.

Norman, D. A. (1986). Cognitive engineering. In D. A. Norman & S. W. Draper (Eds.), User centered system design: New perspectives on human-computer interaction (pp. 31–61).

Norman, D. A., & Draper, S. W. (1986). User centered system design. Hillsdale, NJ.

Oliver, D. G., Serovich, J. M., & Mason, T. L. (2005). Constraints and Opportunities with Interview Transcription: Towards Reflection in Qualitative Research. Social Forces; a Scientific Medium of Social Study and Interpretation, 84(2), 1273–1289.

Onwuegbuzie, A. J., & Johnson, R. B. (2006). The validity issue in mixed research. Research in the Schools, 13(1), 48–63.

Onwuegbuzie, A. J., & Teddlie, C. (2003). A framework for analyzing data in mixed methods research. In A. Tashakkori & C. Teddlie (Eds.), Handbook of Mixed Methods in Social & Behavioral Research (pp. 351–383).

Page, C. (2005). Mobile Research Strategies for a Global Market. Commun. ACM, 48(7), 42–48. http://doi.org/10.1145/1070838.1070864

Patton, M. Q. (2002). Qualitative research and evaluation methods. Sage. Thousand Oaks, CA.

Pintilie, S. (2015). The Ethos of Context-aware Computing. Interactions, 22(4), 20–21. http://doi.org/10.1145/2770882

Poltrock, S. E., & Grudin, J. (1994). Organizational Obstacles to Interface Design and Development: Two Participant-observer Studies. ACM Trans. Comput.-Hum. Interact., 1(1), 52–80. http://doi.org/10.1145/174630.174633

Porter, M. E. (1985). Competitive Advantage: Creating and Sustaining Superior Performance. Simon and Schuster.

Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S., & Carey, T. (1994). Human-computer interaction. Addison-Wesley Longman Ltd. Pressman, R. S. (2005). Software Engineering: A Practitioner's Approach. Palgrave Macmillan.

Randall, D., Harper, R., & Rouncefield, M. (2007). Fieldwork for Design. London: Springer London.

Ries, E. (2011). The lean startup: how today's entrepreneurs use continuous innovation to create radically successful businesses. New York: Crown Business.

Roedl, D. J., & Stolterman, E. (2013). Design Research at CHI and Its Applicability to Design Practice. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1951–1954). New York, NY, USA: ACM. http://doi.org/10.1145/2470654.2466257

Rogers, Y. (2004). New theoretical approaches for human-computer interaction. Annual Review of Information Science and Technology, 38(1), 87–143. http://doi.org/10.1002/aris.1440380103

Rosenbaum, S., Rohn, J. A., & Humburg, J. (2000). A toolkit for strategic usability. In Proceedings of the SIGCHI conference on Human Factors in Computing Systems (CHI'00) (pp. 337–344). ACM Press. http://doi.org/10.1145/332040.332454

Rosson, M. B., & Carroll, J. M. (2001). Usability engineering: scenario-based development of human-computer interaction. Morgan Kaufmann.

Royce, W. W. (1970). Managing the development of large software systems. In proceedings of IEEE WESCON (Vol. 26, pp. 328–388). Los Angeles.

Saffer, D. (2010). Designing for interaction: creating smart applications and clever devices (2nd edition) (second). Berkeley, CA, USA: Peachpit Press.

Schön, D. A. (1983). The Reflective Practitioner: How Professionals Think In Action (1 edition). New York: Basic Books.

Schuler, D., & Namioka, A. (1993). Participatory design: Principles and practices. CRC PressI Llc.

Schwaber, K., & Beedle, M. (2001). Agile Software Development with Scrum (1st ed.). Upper Saddle River, NJ, USA: Prentice Hall PTR.

Seffah, A., Desmarais, M. C., & Metzker, E. (2005). HCI, Usability and Software Engineering Integration: Present and Future. In A. Seffah, J. Gulliksen, & M. C. Desmarais (Eds.), Human-Centered Software Engineering — Integrating Usability in the Software Development Lifecycle (pp. 37–57). Springer Netherlands.

Shackel, B. (1991). Usability-context, framework, definition, design and evaluation. Human Factors for Informatics Usability, 21–37.

Sharon, T. (2012). It's our research: getting stakeholder buy-in for user experience research projects (1st ed). Waltham, MA: Morgan Kaufmann.

Sharp, H., Rogers, Y., & Preece, J. (2007). Interaction design: beyond human-computer interaction (2nd edition). Wiley.

Shin, D.-H. (2007). User acceptance of mobile Internet: Implication for convergence technologies. Interacting with Computers, 19(4), 472–483. http://doi.org/10.1016/j.intcom.2007.04.001

Simon, H. A. (1969). The sciences of the artificial (Vol. xii). Cambridge, MA, US: The MIT Press.

Stolterman, E. (2008). The nature of design practice and implications for interaction design research. International Journal of Design, 2(1), 55–65.

Stolterman, E., & Löwgren, J. (2004). Thoughtful Interaction Design: A Design Perspective on Information Technology. MIT Press.

Strauss, A., & Corbin, J. M. (1990). Basics of qualitative research: Grounded theory procedures and techniques. Thousand Oaks, CA, US: Sage Publications, Inc.

Suchman, L. (2002a). Located accountabilities in technology production. Scandinavian Journal of Information Systems, 14(2).

Suchman, L. (2002b). Practice-Based Design of Information Systems: Notes from the Hyperdeveloped World. The Information Society, 18(2), 139–144. http://doi.org/10.1080/01972240290075066

Suchman, L. (2006). Human-machine reconfigurations: Plans and situated actions. Cambridge University Press.

Suwa, M., & Tversky, B. (2001). Constructive perception in design. In J. Gero & M. L. Maher (Eds.), Computational and cognitive models of creative design V (pp. 227–239). University of Sydney, Australia: Key Centre of Design Computing and Cognition.

Svanæs, D. (2001). Context-aware technology: a phenomenological perspective. Human–Computer Interaction, 16(2-4), 379–400.

Sy, D. (2007). Adapting Usability Investigations for Agile User-centered Design. J. Usability Studies, 2(3), 112–132.

Tamminen, S., Oulasvirta, A., Toiskallio, K., & Kankainen, A. (2004). Understanding mobile contexts. Personal Ubiquitous Comput., 8(2), 135–143. http://doi.org/10.1007/s00779-004-0263-1

Tashakkori, A., & Teddlie, C. (Eds.). (2003). Handbook of Mixed Methods in Social & Behavioral Research. Thousand Oaks, CA: Sage.

Teddlie, C., & Tashakkori, A. (2003). Major issues and controversies in the use of mixed methods in the social and behavioral sciences. In A. Tashakkori & C. Teddlie (Eds.), Handbook of Mixed Methods in Social & Behavioral Research (pp. 3–50).

Treacy, M., & Wiersema, F. (1993). Customer intimacy and other value disciplines. Harvard Business Review, 71(1), 84–93.

Trenner, L., & Bawa, J. (1998). The Politics of Usability: A Practical Guide to Designing Usable Systems in Industry. Springer Science & Business Media.

Vaughan, D. (2005). Organizational rituals of risk and error. Organizational Encounters with Risk, 33–66.

Venkatesh, V., Brown, S. A., & Bala, H. (2013). Bridging the Qualitative-Quantitative Divide: Guidelines for Conducting Mixed Methods Research in Information Systems. MIS Quarterly, 37(1), 21–54.

Venturi, G., Troost, J., & Jokela, T. (2006). People, Organizations, and Processes: An Inquiry into the Adoption of User-Centered Design in Industry. International Journal of Human-Computer Interaction, 21(2), 219–238. http://doi.org/10.1207/s15327590ijhc2102_6

Vermeeren, A. P. O. S., Law, E. L.-C., Roto, V., Obrist, M., Hoonhout, J., & Väänänen-Vainio-Mattila, K. (2010). User experience evaluation methods: current state and development needs. In Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries (pp. 521–530). New York, NY, USA: ACM. http://doi.org/10.1145/1868914.1868973

Vredenburg, K., Mao, J.-Y., Smith, P. W., & Carey, T. (2002). A survey of user-centered design practice. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 471–478). New York, NY, USA: ACM. http://doi.org/10.1145/503376.503460

Wardlow, G. (1989). Alternative modes of inquiry for agricultural education. Journal of Agricultural Education, 30(4), 2–7.

Webster, J., & Watson, R. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. MIS Quarterly, 26(2), xiii–xxiii.

Wigelius, H., & Väätäjä, H. (2009). Dimensions of context affecting user experience in mobile work. In Human-Computer Interaction–INTERACT 2009 (pp. 604–617). Springer.

Winograd, T. (Ed.). (1996). Bringing Design to Software. New York, NY, USA: ACM.

Wixon, D. (2003). Evaluating Usability Methods: Why the Current Literature Fails the Practitioner. Interactions, 10(4), 28–34. http://doi.org/10.1145/838830.838870

Yin, R. K. (2003). Case Study Research: Design and Methods, 3rd Edition (3rd ed., Vol. 5). CA, USA: Sage Publications, Inc.

Appendix 1

Printout of the online questionnaire used for data collection in study 3

Mobile context of use

Welcome to the survey on **addressing context of use in mobile application development**.

The objective of the research project is to design a tool that would help practitioners in better addressing relevant aspects of the mobile context of use at an early development phase. Through your participation, we hope to better understand the needs of practitioners and take them into consideration when designing the tool. Accordingly, this survey is focused on how practitioners perceive the mobile context of use and put it into practice during their application (i.e. app) development process.

The survey may be filled out by practitioners involved in the design and development of mobile apps. Participation in the survey is completely voluntary and its completion would take about 15-20 minutes.

The survey is part of a research project for my doctoral thesis at the Institute for Advanced Management Systems Research (IAMSR) in Åbo Akademi University, Finland. It is conducted with funding from Turku Centre for Computer Science (TUCS).

A summary of the results and findings will be available to respondents of the survey. These findings will hopefully help you improve your development practices and better address the needs of your users. In addition to the summary, you can participate in a draw for:

- 5 licenses for Balsamiq Mockups balsamiq
- 5 licenses for AgileZen agilezen

In order to send you the summary or prize, an email is required. The email address will only be used for receiving the summary or prize.

We would like to assure you that the information you provide through your participation in this study will be kept confidential according to the research ethics and rules of Åbo Akademi University. Furthermore, the survey is completely anonymous - collected data will be presented statistically with no possibility to extract any personal data.

Thank you for your willingness to participate. Should you have any comments or concerns about your participation in this study, please contact Eyal Eshet at the details listed below.

Eyal Eshet
Doctoral candidate
eeshet@abo.fi

Åbo Akademi University
Institute for Advanced Management Systems Research (IAMSR)
Department of Information Technologies
Joukahainengatan 3-5
20520 Åbo
Finland

START HERE ▶

Part 1: Addressing the mobile context of use

▶▶▶ When answering the questions, please think back to your most recent experience in designing or developing a new mobile app.

Mobile app = a software program designed to run on mobile devices, such as a phone or a tablet computer

1. What software development method was being used for the mobile app development? *

'Use' means that one follows the main structure and principles of the method

- ○ Own adapted method
- ○ Rational Unified Process (RUP)
- ○ Scrum
- ○ Extreme Programming (XP)
- ○ Microsoft Solutions Framework
- ○ Other?
- ○ I am not sure/I don't know

2. Which of the following best describes the type of task your app enables? *

- ○ Utility task - simple task, minimum input, viewing content
- ○ Productivity task - manipulation and organization of detailed data
- ○ Immersive experience - games, full screen media-rich content
- ○ Other?

3. Who are the main users of your app? *

User = the person who interacts with the mobile app.

- ○ Consumers
- ○ Customers of a company
- ○ Internal employees
- ○ Other?

4. How important were the following user context aspects to the design of your mobile app? *

	Not at all important 1	Slightly important 2	Moderately important 3	Very important 4	Extremely important 5
Variety of computing devices used by target users	○	○	○	○	○
Daily tasks of target users	○	○	○	○	○
Mobile usage behavior of target users	○	○	○	○	○
Demographic knowledge on target users	○	○	○	○	○
Goals of target users	○	○	○	○	○
Physical environment of target users	○	○	○	○	○
Location of target users	○	○	○	○	○
Social influence of family, peers, and colleagues on actual users	○	○	○	○	○
Mobile device characteristics used by target users	○	○	○	○	○

▶ If you would like to add context aspects that were important to the design of your mobile app, please do so below.

5. How did you gather data about the aspects you perceived as important? *

Select all the methods that you used during the app development process, prior to the release of the app.

- ☐ Diary study
- ☐ Usability testing
- ☐ Contextual inquiry
- ☐ Interviews
- ☐ User study by external agency
- ☐ Field evaluation
- ☐ Data from previous projects
- ☐ Market research data
- ☐ Participatory design
- ☐ Survey
- ☐ Focus group
- ☐ User observation
- ☐ Other?
- ☐ I did not gather data

6. Please indicate the purpose for conducting the methods you used. *

Select all that apply.

	Understanding context	Requirements gathering	Evaluation	Inspiring concept creation
User observation	☐	☐	☐	☐
Field evaluation	☐	☐	☐	☐
User study by external agency	☐	☐	☐	☐

7. Please estimate the effectiveness of the data gathering methods you used. *

Effectiveness = being successful in producing the desired result.

	Not at all effective 1	Slightly effective 2	Moderately effective 3	Very effective 4	Extremely effective 5
User observation	○	○	○	○	○
Field evaluation	○	○	○	○	○
User study by external agency	○	○	○	○	○

8. How do the following factors influence your choice of method to use for gathering data?

	Not at all influential 1	Slightly influential 2	Moderately influential 3	Very influential 4	Extremely influential 5
Software development method used *	○	○	○	○	○
Competences of available staff to carry out the method *	○	○	○	○	○
Experience with method from previous projects *	○	○	○	○	○
Project development phase *	○	○	○	○	○
Project time constraints *	○	○	○	○	○
Project budget *	○	○	○	○	○
Type of target users (e.g. consumers, client, internal) *	○	○	○	○	○
Decisions by higher management *	○	○	○	○	○

▶ **If you would like to add factors that influence your choice of data gathering method, please do so below.**

9. How many people in general have been involved in data gathering methods? *

No. of employees

10. How are data gathering methods being funded? *

Funding includes data gathering methods that are outsourced.

- ☐ Annual budget
- ☐ Bill-back by project
- ☐ Part of R&D budget
- ☐ Other?

Part 2: Use and evaluation of the collected data

11. What methods have you used to analyze the data you gathered in the process of developing the app? *

Select all that apply.

- ☐ Requirements engineering techniques
- ☐ Task analysis
- ☐ Personas
- ☐ Scenarios of use
- ☐ Affinity diagram
- ☐ User stories
- ☐ Use case analysis
- ☐ Contextual analysis
- ☐ Human factors analysis
- ☐ Other?
- ☐ I am not sure/I don't know

12. To what level do you agree or disagree with the following statements? *

	Strongly disagree 1	Mostly disagree 2	Slightly disagree 3	Undecided 4	Slightly agree 5	Mostly agree 6	Strongly agree 7
The data we gather is efficiently used in my company *(Efficiency = achieving the maximum productivity with minimum wasted effort)*	○	○	○	○	○	○	○
The data we gather is effectively used in my company *(Effectiveness = being successful in producing the desired result)*	○	○	○	○	○	○	○
The data we gather significantly improve our understanding of possible contexts of use	○	○	○	○	○	○	○
The data we gather is crucial to the success of our mobile app	○	○	○	○	○	○	○
Data gathering methods are well integrated into our software development method	○	○	○	○	○	○	○
Data gathering methods are mostly included in a formal project plan	○	○	○	○	○	○	○

13. How do the following factors influence the expected result from the data gathering methods you have used?

	Not at all influential 1	Slightly influential 2	Moderately influential 3	Very influential 4	Extremely influential 5
Project development phase *	○	○	○	○	○
Competences of available staff *	○	○	○	○	○
Decisions by higher management *	○	○	○	○	○
Project time constraints *	○	○	○	○	○
Software development method used *	○	○	○	○	○
Type of target users (e.g. consumers, client, internal) *	○	○	○	○	○
Project budget *	○	○	○	○	○
Experience with method from previous project *	○	○	○	○	○

▶ **If you would like to add factors that influence the expected results from data gathering methods, please do so below.**

Part 3: Company

Next some questions about your work place.

14. Do you work primarily in a company or as a freelance? *

- ○ Company
- ○ Freelance

15. What is the industry sector, which your company (or you as a freelance) belongs to? *

In case you work for multiple companies, please select the main job.

- ○ Electronics
- ○ Software
- ○ Computers
- ○ Usability/UX consulting
- ○ Publishing
- ○ Government
- ○ Design
- ○ Education
- ○ Gaming
- ○ Telecommunications
- ○ Health and medical services
- ○ Financial services
- ○ Technology research
- ○ Other?

16. What is the size of your company? *

No. of employees

17. What department in your company is responsible for gathering data on user context? *

Select all that apply.

- ☐ Design department
- ☐ Marketing department
- ☐ Customer service department
- ☐ Development department
- ☐ Communications department
- ☐ Other?
- ☐ I am not sure/I don't know

18. Does management take action to foster a user-centered culture in the company? *

For instance, by offering training, improving practices, allocating resources, or increasing awareness to user-centeredness.

- ○ Yes
- ○ No

▶▶▶ The following questions (19-21) are optional.

The questions focus on the strategy of your company. We would appreciate if you can answer them as it would greatly help us to understand your work environment.

19. How important are the following aspects to your company's strategy?

	Not at all important 1	Slightly important 2	Moderately important 3	Very important 4	Extremely important 5
Producing a continuous stream of innovative products/services	○	○	○	○	○
Being unique in our industry (e.g. with regard to product/service)	○	○	○	○	○
Developing our brand as part of the marketing strategy	○	○	○	○	○
Being cost-leaders with our products/services	○	○	○	○	○
Focusing on incremental improvement of our own product/service	○	○	○	○	○
Focusing on well defined market segment(s)	○	○	○	○	○
Emphasizing economies of scale and scope with our products/services	○	○	○	○	○
Creating and managing durable customer relationship	○	○	○	○	○
Optimizing our operations to minimize development costs	○	○	○	○	○

20. How well do the following statements describe the practices at your company?

	Strongly disagree 1	Mostly disagree 2	Slightly disagree 3	Undecided 4	Slightly agree 5	Mostly agree 6	Strongly agree 7
Employees are encouraged to contribute to the team	○	○	○	○	○	○	○
Employees are given regular feedback on their performance	○	○	○	○	○	○	○
Employees are encouraged to bring new ideas to work practice	○	○	○	○	○	○	○
Employees should participate more in decisions made by top management	○	○	○	○	○	○	○

21. How well do the following statements describe the competitive environment of your company?

	Strongly disagree 1	Mostly disagree 2	Slightly disagree 3	Undecided 4	Slightly agree 5	Mostly agree 6	Strongly agree 7
The actions of local and foreign competitors in our major markets are changing quite rapidly	○	○	○	○	○	○	○
Technological changes in our industry are rapid	○	○	○	○	○	○	○
The market competitive conditions are highly unpredictable	○	○	○	○	○	○	○
Product preferences of customers change quite rapidly	○	○	○	○	○	○	○
Changes in customers needs are quite unpredictable	○	○	○	○	○	○	○
Competition in our industry is cutthroat	○	○	○	○	○	○	○
There are many competitive rivalries in our industry	○	○	○	○	○	○	○
Our competitors are relatively strong	○	○	○	○	○	○	○
Price competition is a hallmark of our industry	○	○	○	○	○	○	○

Part 4: Demographics
Briefly about yourself.

22. Which country are you based in? *

– Select country –

23. How long do you have experience with the user-centered design approach? *

No. of years

24. What is your main role in mobile app projects? *

- Service designer
- Graphic designer
- Software developer
- UX designer
- UI designer
- System engineer
- Project manager
- Human factor specialist
- Project owner
- Other?

Thanks for taking part!

25. If you would like to receive a summary of the results or participate in the prize draw, let us know an email where we can reach you.

Email

- Send me a summary of the results
- Include me in the prize draw for Balsamiq Mockups (5 licenses)
- Include me in the prize draw for AgileZen (5 licenses)

26. We would highly appreciate feedback on the questionnaire or its topic. If you would like to comment, please do so below.

Appendix 2

Table 3: Cross-case synthesis matrix (for the analysis of data in studies 4 and 5)

Section	Attribute	Description	Value
1. Project meta-data	Participant ID		ID
	Category	Category of the developed system	Media/finance
	Description	Brief description of project	
	Form factor	Multiple values are possible	Phone, tablet, mobile web, cross-platform
	Org. position	Position of the practitioner's organization in the project	Subcontractor (with type of client)/in-house
	Target users	Definition of target users by the practitioner	
2. How practitioners address the mobile context of use?	User involvement	What types of users are involved, in what practice and in which phase	User categories as emerged from analysis: • Unknown • Project-internal groups (developers, designers, client) • Social peer groups (friends, colleagues, family) • Random people (street, bar) • Target/representative users Practice: As stated by participants Phase: • Requirements • Evaluation • Usage
	Contexts	What types of contexts, in what practice and in which phase	Context categories as emerged from analysis: • Artificial (lab, office) • Artificial augmented (lab) • Representative (home, street) • Naturalistic (real life or closely imitating) Practice: As stated by participants Phase: as in user involvement
	Over time	In which phase and for how long was the practice carried out (only for practices that were not ad hoc)	Phase: as in user involvement Length: • Limited time (as stated) • Continual

3. Why practitioners address the mobile context the way they do?	Encourage	Factors that *encourage* the involvement of target users in real-life contexts of use over time	Core concepts as emerged from analysis
	Inhibit	Factors that *inhibit* the involvement of target users in real-life contexts of use over time	Core concepts as emerged from analysis
4. Indicators that can further explain practitioners' motives	Concerns	Concerns that practitioners sought to understand	Core categories as emerged from analysis: • Users 'meaningful' context (needs, goals, habits, behavior) • 'Incidental' context (spatial-temporal, social, culture, legal, domain) • System (functionality, technical challenges, input/output, gestures) • Business environment (business goals, client/other stakeholders, marketing, competition)
	Project objectives	Regarding system state and final outcome	System state: • New • Redesign • Incremental improvement Outcome objective categories as emerged from analysis: • Increase usage • Generate revenues • Add functionality • Add customers • Intangible benefits (long-term, reputation, help users) • Unclear
	Project evaluation	Project evaluation criteria	Criteria categories as emerged from analysis: • Client satisfaction • User/customer satisfaction • Stay on budget • Revenues • Usage figures • None
	Notes	Other relevant contextual data about the practitioner and/or project	

Part II
Original Publications

The contribution of the author to the original publications

1. Single author.
2. Main author. Designed the questionnaire study with the co-author. Conducted the questionnaire and analysis of data. Wrote most of the paper.
3. Main author. Designed the questionnaire study with the second co-author. Conducted the questionnaire. Wrote most of sections 1, 2, 3, 5, 6
4. Main author. Designed the interview study with the co-author. Conducted the interviews and analysis of data. Wrote most of the paper.
5. Main author. Designed the interview studies with the co-author. Conducted the interviews and analysis of data. Wrote most of the paper.

Paper 1

Eshet, E. (2012). Human-Centered Design in Mobile Application Development: Emerging Methods. International Journal of Mobile Human-Computer Interaction, 4(4).

Human-Centered Design in Mobile Application Development: Emerging Methods

Eyal Eshet, Turku Centre for Computer Science (TUCS), Institute for Advanced Management Systems Research, Åbo Akademi University, Åbo, Finland

ABSTRACT

Mobile platforms (e.g., Google Android, Apple iOS) and their closely integrated app stores transformed the mobile industry and opened the market for mobile application developers. Consequently, applications for smartphones quickly soared to phenomena levels. As mobile technology continues to evolve and shape human interaction with technology, human-centered design (HCD) methods adapt to the capabilities of technology and to the needs of mobile application development. This study presents a preliminary review of 79 research papers on the practice of HCD in mobile application development for the smartphone touch era. The aim of the study is to highlight emerging methods and their implications for mobile application development. The methods discovered by this study assist mobile application developers to better understand their target users. Further research is needed, particularly in exploring what user research and evaluation methods are the most effective in the context of mobile application development.

Keywords: Design and Evaluation Methods, Human-Centered Design, Literature Review, Mobile Application Development, Mobile Platforms, Smartphone, User Research Methods

INTRODUCTION

Research in Human-Computer Interaction (HCI) for mobile computing devices has yielded valuable techniques to understand mobile users and improve interaction with mobile devices. Most of the techniques emerged from traditional Human-Centered Design (HCD) methods, adapted to specific characteristics of mobile technology and its usage behavior; for instance, using the device while walking on a treadmill to augment a usability lab with a mobile-like situation (Kjeldskov & Stage, 2004), or self-reporting methods utilizing the mobile device, as in mobile probes (Hulkko et al., 2004) and mobile diaries (Brandt et al., 2007). However, the smartphone touch era that commenced with the introduction of the iPhone in 2007 (Fling, 2009) constitutes a major shift in mobile usage behavior (context of use and user experience) and mobile technology (mobile platforms and app stores). These aspects have an impact on HCD methods and on developers of mobile applications (hereafter, developers) for the smartphone touch era (hereafter, smartphone).

Context of use is commonly described with five aspects: the user, its task space, technol-

DOI: 10.4018/jmhci.2012100101

ogy, physical environment, and social aspects (Hiltunen et al., 2002). The diversity of mobile users and the physical context of mobile usage are almost boundless, while the technology in a smartphone greatly expands the task space and social settings. Consequently, developers need cost-effective techniques to understand usage behavior of smartphone users and to evaluate the product in real context.

Smartphones are also increasingly integrated in our lifestyle. The close relationship with the device implies a need to complement the largely task-oriented HCD with user experience (UX) facets such as hedonistic, aesthetic, emotion, mood and expectations (Hassenzahl & Tractinsky, 2006). For developers, it is essential to understand what UX aspects are relevant, their connection to application design, and how they can be evaluated.

The most significant impact on developers of mobile applications is derived from the transformation of the mobile ecosystem (Basole & Karla, 2011). In particular, mobile platforms have taken a dominant position in the ecosystem with new entrants (Apple iOS and Google Android) swiftly taking over the lead positions. Mobile platforms could not achieve their phenomena level without their closely integrated app stores, which opened the market for masses of developers. Though, platform providers solely govern the content and operation of their app stores, leaving developers with a lack of control of their products' distribution (Fling, 2009).

This study extends the contributions of previous studies (Coursaris & Kim, 2006; Coursaris & Kim, 2011; Hagen et al., 2005; Kjeldskov & Graham, 2003). It presents a review of 79 papers on the practice of HCD methods in the context of mobile application development for smartphones. The study aims to discover emerging HCD methods and their implications for mobile application development. Consequently, the main unit of analysis is a framework of HCD methods based on the HCD process as described by ISO (2010). The study would help to direct future needs for development and research questions, while developers can benefit by utilizing and improving the methods.

The study discovered four emerging HCD methods – *living lab*, *digital ethnography*, *in the wild* evaluation, and *data logging*. These methods demonstrate the dynamic nature of HCD methods in adapting to the capabilities of new technology and in attending to the increased role of technology in our life. New methods provide contextual data that can help developers better understand the lifestyle of their target or current users. Future research can focus on what are the most effective methods for mobile user research and for evaluation, what data to collect, how to conduct evaluations of social-oriented application, and how sensors embedded in smartphones impact HCD methods.

The next section discusses previous studies in the field of mobile HCI and application development for smartphones. Then we describe the procedure of conducting the study, followed by the conceptual framework for the review. Thereafter, the paper continues with presentation and explanation of the results, followed by a discussion of the results. Limitations of the study are made clear before concluding with opportunities for future research.

RELATED WORK

Various studies focused on reviewing HCI aspects in the development of mobile software prior to the smartphone touch era. Kjeldskov and Graham (2003) contributed an early overview of applied research methods for Mobile HCI. They classified papers based on methodology (e.g., case study, field study, action research, survey) and research purpose (e.g., understand, engineer, evaluate). Their review highlights a clear tendency for building and testing mobile systems in laboratory settings. Consequently, they argue for more natural setting research in the form of basic and action research that consider the actual needs and use of mobile systems.

Hagen et al. (2005) reviewed new methodological approaches that address mobile chal-

lenges and organized them in three categories: (a) mediated data collection; (b) simulations and enactments; and (c) combinations of methods. The authors identified a trend for self-reporting techniques for data collection (e.g., diaries, probes, device logs) in order to gain a better understanding of mobile use. This trend is driven by mobile technology developments, such as camera and network connectivity, that have made self-reporting a viable and valuable practice. In addition, they argue that longitudinal studies are necessary to understand and measure mobile usage behavior.

Coursaris and Kim conducted a review (2006) and a follow-up (2011) of empirical mobile usability studies, focusing on evaluation methods such as survey, interview, focus group, device log, and lab/field observations. The authors identify four contextual factors that influence mobile usability (user, task, environment, and technology) as well as the usability dimensions commonly (and less so) measured, and organize them within a framework that provides the basis for their analysis. The results reveal a clear tendency for examining the task and technology factors, while insufficient research was done on user characteristics and the influence of environment on mobile usability. Task-oriented studies mainly involve closed tasks with a pre-defined outcome, while open and unstructured tasks can be more suitable for measuring mobile usability. Technology-oriented studies are focused on the user interface, while the complex technological architecture that enables mobile phones can have a significant impact on its usability. In addition, laboratory tests continue to be the preferred method for evaluation.

A recent exploratory study by Bergvall-Kåreborn et al. (2010) examines the practices of mobile application developers, particularly with the Apple iOS and Google Android platforms. Although the study is not HCI-oriented, it highlights key factors (personal, social, economical, and organizational) that influence mobile application developers. In essence, the mobile application market is highly competitive with a short shelf life of applications. Thus, developers work under pressure to shorten the time-to-market in order to gain a competitive edge with novel ideas. There is also an element of uncertainty as the control of Apple and Google over their respective platforms creates difficulties both for the development and distribution of applications. For instance, app stores lack facilities for bi-directional communication between developers and users.

This study draws on these previous reviews and concentrates on HCD methods in the development of mobile applications for smartphones.

LITERATURE SEARCH PROCEDURE

At the core of this study is a literature review of journal and conference proceedings papers published between the years 2008 and mid-2011 mainly within the fields of HCI, mobile, and ubiquitous computing. Publication years reflect the emergence of the smartphone's touch era, while the fields are the most relevant and commonly focus on the practical implementation of solutions. At the time of writing, mobile platforms by Google (Android) and Apple (iOS) best demonstrate the smartphones' touch era with Google Play and App Store as their app stores, respectively. On that account, the scope of the study is limited to papers describing application development for these platforms.

Previous studies by Kjeldskov and Graham (2003) and Hagen et al. (2005) formed the outset for the list of journals and conferences reviewed for this study (Appendix B). Thereafter, HCI journals and conferences were selected based on ranking lists (Arnetminer, 2009; Borchers, 2008). Lastly, a search through databases and search engines (ACM, Elsevier, ScienceDirect, IEEE, Springer, Scholar) assisted in discovering journals and conferences for the relevant fields.

The search procedure for papers started with a full text search using various keywords (e.g., 'iphone,' 'android,' 'mobile application,' 'user centered design,' 'smartphone') and combinations. This proved to be problematic

as researchers may use different words, for instance 'mobile application' can be 'mobile service' or 'mobile solution.' In addition, the nature of the conceptual framework, focusing on HCD methods throughout the entire mobile application development life cycle, makes it impractical to search for each and every method (considering the inconsistency of terminology in describing a method).

Consequently, an updated search procedure was limited to the technology-oriented keywords 'iphone,' 'android,' and 'droid.' These words are more specific in the relevant fields and likely to be used in studies describing application development for the selected mobile platforms. The keywords were used in a particular search within each journal and conference proceedings (on the publisher's website or by using a search engine). Papers were first evaluated by the title and abstract. If needed, the introduction and the context in which the keywords are mentioned were also checked. Qualified papers, those that relate to the development of mobile applications for the selected platforms, were printed out.

Regarding conference papers, all types of papers were considered (e.g., full, short, in progress) since each paper has the potential to find a practice-oriented contribution. Later on, papers with no HCI perspective such as technical focused, short demos and multiple papers on the same application were filtered out (25 papers in total). Lastly, a backward- and forward-search procedure (Webster & Watson, 2002) was conducted on the selected papers, which resulted in the discovery of four more relevant papers not within the main reviewed fields. Altogether, 69 conference papers and 10 journal papers were reviewed.

CONCEPTUAL FRAMEWORK

The study aimed at exploring new HCD practices in the context of mobile application development for smartphones. Consequently, the main unit of analysis is HCD methods.

The starting point for the study is the HCD process as detailed in ISO 9241-210 (ISO, 2010), which replaces ISO 13407:1999. Apart from being a well-cited standard (the predecessor), the process provides a simple framework to analyze strengths and shortcomings in the process. The first step in an HCD process is planning HCD, followed by four interdependent phases (*italics* for how phases are hereafter referred to in the paper): (1) understand and specify the *context of use*; (2) specify the user *requirements*; (3) produce *design* solutions to meet user requirements; and (4) *evaluate* the design against requirements. Each of these high-level activities encompasses a set of HCD methods, also known as usability methods, which help practitioners achieve the goal of the activity.

However, the ISO standard does not cover the actual methods and tools. An attempt to organize HCD methods was developed by Maguire (2001), who classified the methods based on the same five key activities described by the ISO standard. Table 1 presents the framework of HCD methods used by this study.

The framework utilizes Maguire's framework as a foundation for methods classification with the following modifications:

- The initial phase of HCD planning was discarded as the study focuses on the actual development and practices that bring out the end-user perspective.
- Under the Evaluation phase, 'participatory evaluation,' 'assisted evaluation,' and 'controlled user testing' were replaced by informal/unknown-, lab-, and field- evaluations. A lab/field classification is more relevant for mobile development.
- Based on the methods by Usability Net (2006), the post-release phase was added. The phase is briefly mentioned in ISO (2010) as 'Long-term monitoring,' which is fundamental to the HCD process.
- Contextual inquiry (appears under the Requirements phase in UsabilityNet, 2006) is classified under the context of use phase, as the method is inherently context-oriented.

Table 1. Framework of HCD methods (adapted from Maguire, 2001)

Context of use	Requirements	Design	Evaluation	Post-release*
Identify stakeholders	Stakeholder analysis	Brainstorming	Informal evaluation /unknown settings	Post-release testing*
Context of use analysis	User cost-benefit analysis	Parallel design	Lab evaluation	Subjective assessment*
Survey of existing users	User requirements interview	Design guidelines and standards	Field evaluation	User surveys*
Field study/user observation	Focus groups	Storyboarding	Heuristic or expert evaluation	Remote evaluation*
Diary keeping	Scenarios of use	Affinity diagram	Satisfaction questionnaire	
Task analysis	Personas	Card sorting	Assessing cognitive workload	
Contextual inquiry*	Existing system/ competitor analysis	Paper prototyping	Critical incidents	
	Task/function mapping	Software prototyping	Post-experience interview	
	Allocation of function	Wizard of oz		
	User, usability, and organization requirements	Organizational prototyping		
* UsabilityNet (2006)				

RESULTS

This section presents the utilization of HCD methods by the reviewed papers, focusing on the emerging HCD methods - those that extend the initial framework of HCD methods. Following that are figures regarding the reviewed outlets (journals and conferences).

Utilization of HCD Methods

Table 2 presents the classification of HCD methods from 79 reviewed papers. Reference numbers correspond to the list of research papers in Appendix A. Methods marked with an asterisk (*) extend the framework of HCD methods and are further explained in the next section. In addition, varied methods are included in multiple phases to reflect their actual utilization in the literature.

Certainly, practiced methods in the literature do not always fulfill the extent of the method as described by Maguire (2001). Hence, methods are classified to the most appropriate, in order to adhere as much as possible to Maguire's framework. Accordingly, studies with a defined target audience are classified as 'Identify stakeholders'; Context descriptors are classified as 'Context of use analysis'; and any design requirements are grouped under 'Usability requirements.'

Emerging HCD Methods

Table 2 highlights three methods (marked with an asterisk) that are not included in the initial framework of HCD methods (Table 1) – *digital ethnography*, *data logging*, and *in the wild* evaluation. In addition, Kanstrup et al. (2010) experimented with a *living lab* approach. These methods are further explained in this section.

Table 2. Utilization of HCD methods in mobile application development

HCD phase	HCD method	References	%
Context of use	Identify stakeholders	2,3,7,8,9,12,14,19,23,24,25,27,2 9,35,40,41,43,49,50,51,53,60,62, 63,66,67,73,74,77,79	38
	Context of use analysis	22,24,50,54,63	6
	Survey of existing users	2,3,8,9,19,21,27,41,43,51,58,73,77	16
	Field study/user observation	7,16,25,45,50,53,62,63,74	13
	Diary keeping	7,29	3
	Task analysis		
	Contextual inquiry	7,25,40,41,50,63	8
	Digital ethnography*	19,51	3
Requirements	Stakeholder analysis		
	User and cost-benefit analysis		
	User requirements interview	7,9,16,19,28,35,40,41,49,51,53,67,73,74	18
	Focus groups	2,56,60	4
	Scenarios of use	15,16,19,21,22,29,34,41,47,49,50,53,58,61,75,76	20
	Personas	19,41	3
	Existing system/competitor analysis	1,8,23,27,30,33	8
	Task/function mapping		
	Allocation of function		
	User, usability, and organization requirements	1,2,20,23,25,27,28,29,33,35,44,50,51,54,56,58,61,62,63,6 5,66,68,74,77,79	32
Design	Brainstorming	12,25,49,53	5
	Parallel design	52,67,76	4
	Design guidelines and standards	52,53,78	4
	Storyboarding	49,58	3
	Affinity diagram	19,33,41	4
	Card sorting		
	Paper prototyping	2,4,9,17,19,41,49,56,58,74,78	14
	Software prototyping	9,12,19,25,40,62,67	9
	Wizard of oz		
	Organizational prototyping		

continued on following page

Table 2. Continued

HCD phase	HCD method	References	%
Evaluation	Informal evaluation/ unknown settings	6,9,16,23,27,38,47,65,70,73,78	14
	Lab evaluation	3,4,8,9,10,14,34,35,40,46,49,56,58,64,67,69,76	22
	Field evaluation	8,11,17,18,20,21,24,25,32,33,40,41,43,45,47,51,52,53,57,60,61,62,63,67,68,74,75,79	35
	Heuristic or expert evaluation		
	Satisfaction questionnaire	1,2,3,4,5,8,11,14,17,18,19,20,24,34,35,45,46,49,51,52,58,61,62,63,64,67,68,75,76,79	38
	Assessing cognitive workload		
	Critical incidents		
	Post-experience interview	19,24,25,31,40,41,43,47,58,62,74,79	15
	User observation	19,25,31,33,62	6
	Diary study	5,50,62	4
	Automatic data logging*	5,17,20,24,32,45,50,52,79	11
	Remote evaluation	19	1
	Focus group evaluation	33,46,60	4
Post-release	Post-release testing		
	Subjective assessment	27,31,48,78	5
	User surveys	27,66	3
	Remote evaluation		
	In the wild*	13,26,48,57,66,78	8
	Automatic data logging*	13,48,57,66	5
* Emerging method			

Digital Ethnography

"Ethnography is about telling social stories" (Murthy, 2008, p. 838). Stories that help us understand the life and motivations of a cultural group of people. Nowadays, with the help of ubiquitous technology and the Web, certain groups of people are leaving an immense and revealing footprint of their life by creating, consuming, and sharing information online. Hence, it is well reasoned to complement ethnography studies with digital ethnography, which utilizes online media (e.g., blog, discussion forum, social network, chat room) for the collection and analysis of relevant information regarding a specific group of people. As a research method, there are certain issues to consider, such as bias, ethics, and the impact of researcher selectivity (Murthy, 2008), although, for practitioners digital ethnography can be a lightweight technique to gain understanding of their target audience. Chowdhury and Wynn (2011) reviewed member profiles and group discussions in a popular online hospitality community, as these members were the target users of the mobile application. Noz and An (2011) inspected online forums of their predefined target users - cat owners.

For more information on digital ethnography as a research method see Murthy (2008), and

for business practice see Masten and Plowman (2003). The classification of digital ethnography in this paper, separated from field studies, gives prominence to its growing potential particularly with the ubiquitous of mobile devices.

In the Wild and Data Logging

Arguably the most remarkable aspect introduced by app stores is the potential to reach millions of users instantaneously. Masses of users have the potential to offer invaluable data on application use and unprecedented understanding of mobile usage behavior on a global scale. The in the wild approach denotes utilizing actual application users as participants in a contextual and worldwide evaluation without direct control of moderators – thus, in the wild. Note that in the wild evaluation commonly takes place once the application has been distributed to the public, though, the term is also used in describing certain field evaluations prior to application release (Durrant et al., 2011; Kim et al., 2011).

In the wild evaluations can run for longer terms in case the application is already released. The real-life situations can reveal unexpected use of the application (Kim et al., 2011), while the potential number of global application users can result in better accuracy of data (Henze & Boll, 2010; McMillan et al., 2010). However, it only tells the story of active users, excluding insights about non-users – those who uninstalled (Shirazi et al., 2011) or abandoned the application. A large base of users also expands the range of devices utilized, which can help in fixing issues caused by platform fragmentation (e.g., multiple devices for Android).

The paradox with the approach is that an application needs to attract a certain number of users in order to be effective. Particularly for crowdsourcing and user-generated data applications (e.g., with social media), initial data is necessary to draw a critical mass that generates content and creates a social effect (Porat et al., 2011; Zimmerman et al., 2011). Consequently, for certain types of applications (e.g., real-time events, crowdsourcing), the in the wild approach is in fact the first possibility to conduct effective evaluation (Shirazi et al., 2011).

Conducting in the wild evaluations with smartphones brings about new possibilities for quantitative and qualitative feedback.

Quantitative Techniques

Automatic data logging entails a logging tool embedded in the application and a server-side database for data storage (e.g., Ferris et al., 2010). The type and degree of the logged data varied. McMillan et al., (2010) demonstrated the potential of a carefully designed logging and visualization framework for interpreting usage patterns and feed information for an in-depth qualitative analysis (e.g., specific participants to interview, what to inquire). The practice of automatic logging of interaction events is not new (Hagen et al., 2005; Maguire, 2001), though rich sensors embedded in smartphones allow for gathering of relevant contextual data that may help to explain a specific interaction and usage behavior. The second quantitative technique utilizes the application distribution platform's rating system and statistical data on downloads to get a prompt appreciation of its success (e.g., Zhai et al., 2009).

As demonstrated by McMillan et al. (2010), it is essential to complement the logged quantitative data with subjective assessment to get a deeper understanding of users' motives and goals.

Qualitative Techniques

Qualitative techniques are classified in Table 1 as Subjective assessment under the Post-release phase. McMillan et al. (2010) utilized Facebook, a popular social network, as a communication channel both with and between users. Based on quantitative data and insights gathered from Facebook, the researchers conducted phone interviews with selected users (for a small incentive) to better understand their mobile behavior. Incentives for qualitative data were also implemented as part of their application, a

mobile game, where users submitted feedback in order to earn game points. Other studies also integrated an optional feedback mechanism (e.g., Ferris et al., 2010; Miluzzo et al., 2010), combined with an online message board (Miluzzo et al., 2010) or online social tool such as a blog (Ferris et al., 2010). While these techniques depend on developers' creativity and will to invest, app stores offer their own review system with instant and valuable feedback from users (Miluzzo et al., 2010; Zhai et al., 2009).

Living Lab

Kanstrup et al. (2010) used the living lab approach with smartphones to explore ways of supporting the everyday life of diabetics. A living lab is an environment that resembles a realistic context (to various degrees) with users, in which studies are conducted for medium- or long-term, aiming to explore new developments and drive innovations (Følstad, 2008). The living lab experiment by Kanstrup et al. (2010) encompasses all phases of HCD over a period of two years, in which stakeholders (diabetics, developers, service providers, and researchers) closely collaborated in order to learn, explore, and drive new mobile service innovations. In essence, this type of living lab can be described as an entire HCD in the wild, although retaining some degree of control by practitioners.

Outlets

Table 3 shows the yearly distribution of reviewed papers on outlets (journals and conferences). Note that data was collected up to mid-2011. Still, the increased interest in developing and researching mobile applications is obvious. As noticed, most of the papers come from CHI (37%) and MobileHCI (15%) conferences.

The actual utilization of HCD methods by outlets is presented in Table 4. The figures represent the number of times HCD methods were utilized by an outlet's publications at each HCD phase as percentage of the total number of times HCD methods were conducted by all outlets at the same HCD phase.

For instance, the total number of times HCD methods were conducted at the context of use phase is 64. The share of CHI publications at this phase is 47% (30 times). Only outlets with more than one publication are presented.

Apart from highlighting the outlets' focal areas regarding mobile application development and the HCD process, utilization figures can be compared with the share of an outlet in the study (Table 3). Accordingly, CHI publications account for 37% of outlets in the study while utilizing half or more of the total number of HCD methods at all phases, except in the context of use phase. Being an HCI-oriented venue, more emphasis is expected at CHI on the HCD aspect of software development. On the contrary, MobileHCI (also HCI-oriented) publications have under-utilized HCD methods (9% on average) compared to their share in the study (15%). The utilization of HCD methods can be beneficial for researchers who focus on a certain HCD phase. However, most outlets in the study have only two or fewer publications, a low number from which to infer.

DISCUSSION

The HCD approach provides a solid framework of high-level activities for developing interactive systems based on the end-user perspective, though the methods to achieve the goals of each activity continually evolve. Their evolution addresses developments in technology, which becomes more embedded in our lifestyle. Consequently, peoples' relationship with the technology becomes more intimate. The emerging HCD methods reviewed in this study demonstrate how methods adapt in order to attend to the role of technology in our life.

Living lab is the most far-reaching approach to research the interrelationship between humans and technology. As living labs attempt to resemble a real-life living environment over a long period of time, the approach is heavy on resources and expertise skills that are not available for most developers. However, certain

Table 3. Yearly distribution of reviewed papers on outlets

Outlet (J=journal)	2008	2009	2010	Mid-2011	Total
CHI		4	9	16	29 (37%)
MobileHCI		4	8		12 (15%)
IUI			2	4	6 (7%)
UIST			3		3 (4%)
Personal and Ubiquitous Computing (J)			2	1	3 (4%)
DIS			2		2 (3%)
UbiComp			2		2 (3%)
NordiCHI			2		2 (3%)
OZCHI			2		2 (3%)
MUM		2			2 (3%)
IEEE Intelligent Systems (J)			2		2 (3%)
Mobile Networks and Applications (J)			1	1	2 (3%)
MoMM			1		1 (1%)
MobiCom			1		1 (1%)
ACM EICS		1			1 (1%)
ACM ASSETS	1				1 (1%)
ACM MobiOpp			1		1 (1%)
CSCW				1	1 (1%)
Pervasive			1		1 (1%)
Mobility		1			1 (1%)
IEEE Systems, Man, and Cybernetics		1			1 (1%)
IJMHCI (J)				1	1 (1%)
Wireless Personal Communications (J)			1		1 (1%)
Journal of Academic Librarianship (J)				1	1 (1%)

methods commonly practiced in a living lab can be suitable for conducting user research over time. For instance, the mobile application developed by Gerken et al. (2010) is a multimodal diary tool for remote field studies. Combined with the experience sampling method (Consolvo & Walker, 2003), these tools are useful for understanding the context of use.

Digital ethnography adds another channel for user research in the early context of use phase. Almost any imaginable social group in the physical world has a dedicated online discussion forum, blogs, social media group, or a website. Developers can take advantage of the virtual world footprint to gain insight into target groups without leaving the office. Case studies on digital ethnography can help improve the method in terms of data collection, data analysis, software tools available, challenges, and limitations of the method. Overall, developers are in need of a framework to know what methods are the most effective for mobile user research - gathering and analyzing context of use data, and what data is relevant to collect.

The *in the wild* approach demonstrates how evaluation methods come closer to assessing ubiquitous technology in lifelike situations. Hagen et al. (2005) suggested that technological

Table 4. Utilization of HCD methods in major outlets

Outlet (J=journal)	Context of use	Requirements	Design	Evaluation	Post-release
CHI	47%	53%	64%	50%	56%
MobileHCI	6%	11%	9%	8%	13%
IUI	0%	2%	3%	8%	6%
UIST	8%	2%	0%	5%	0%
Personal and Ubiquitous Computing (J)	5%	3%	0%	4%	0%
DIS	5%	3%	12%	1%	0%
UbiComp	11%	5%	0%	1%	0%
NordiCHI	3%	5%	0%	3%	0%
OZCHI	3%	0%	6%	4%	0%
MUM	3%	3%	3%	1%	0%
IEEE Intelligent Systems (J)	2%	3%	0%	2%	0%
Mobile Networks and Applications (J)	0%	0%	0%	0%	0%

capabilities of a smartphone should drive innovation for enhancing methods and tools to gather relevant contextual data on users. Drawing on their conclusion, combining the in the wild approach with an application-embedded tool to log contextual user behavior in real-life situations has great potential to enrich the understanding of mobile users and their information needs.

Logging tools are not new (Hagen et al., 2005), though the extent of data that can be logged by the smartphone's technology is immense, particularly contextual data. In addition, logging tools can also provide facilities for contextual qualitative feedback that are currently not well supported by app stores. With a massive amount of data, the question is again what data is relevant to collect with these tools? The answer is most likely a tradeoff between user needs and application needs. For instance, privacy and security of mobile users is an obvious concern. Users should be informed of what type of data is gathered and provided an option for opt in/out at any time.

For certain applications (e.g., crowdsourcing), in the wild approach impacts the entire HCD process. Crowdsourcing applications are based on masses of people, so an effective evaluation of them prior to release is difficult. Consequently, the traditional HCD process shifts into a "crowd-centered refine" process, in which design iterations take place between application upgrades (McMillan et al., 2010; Miluzzo et al., 2010). How can such applications be tested at an early phase and before release? On a lower scale, one way is to distribute the application for evaluation to selected users through a website (Li, 2010), while another alternative is to use an online crowdsourcing platform for software testing, such as uTest (http://www.utest.com/) or mob4hire (http://www.mob4hire.com/).

Overall, the in the wild approach requires further insights into how to effectively use quantitative and qualitative methods to inform the redesign of applications; for instance, how to recruit and communicate with users, and how the methods impact users and their actual use of the application.

While in the wild evaluations are central for social applications, data on the utilization

of evaluation methods (Table 2) also indicates a shift from the lab/field ratio observed earlier by Kjeldskov and Graham (2003). In this study, field evaluations (including user observations and diary study evaluations) account for 40% (32 of 79), while evaluations in a lab were conducted by 22% (another 14% of informal or in unknown settings). In the Kjeldskov and Graham (2003) review, figures indicate 8% for field evaluations and 29% for lab evaluations.

The shift is driven partly by the capacity to run applications on subjects' own devices (with discretion), which was practiced in this study in 32% (9 of 28) of field evaluations. Using subjects' own devices elevates the naturalistic dimension in evaluations (e.g., familiarization with the device, actual device configuration), allowing for more test subjects with fewer resources, and long-term test sessions (days or weeks). At the same pace that smartphones gain popularity, evaluations with one's own device can increase in practice, eventually becoming the standard. What are the implications on the planning, actual application testing, and analysis?

Another major element that reinforces the need for testing in the field is smartphone technology, sensors in particular. The increasing set of sensors embedded in smartphones (Lane et al., 2010) brings forth an abundance of opportunities for enhancing the user experience. Since sensors are context-aware (e.g., net connectivity, GPS, compass, accelerometer), applications that depend on sensory data should strive for realistic test environments. How do sensors embedded in smartphones impact HCD methods? How do application developers utilize sensory data throughout the HCD process?

LIMITATIONS

There are few limitations regarding the review and its quality. First, as in most literature reviews, the analysis data is limited to what has been documented in the reviewed papers, which may be only part of the whole picture. Second, due to the review process for journals and the relative infancy of the smartphone touch era, the vast amounts of papers are from conference proceedings, which may affect the quality and quantity of method reporting. Third, the descriptiveness of the methods as well as terminology used is inconsistent. Some papers are technical-focused, conforming to the main subjects of their conference. Thus, HCD methods may not be mentioned. And last, even though papers were scanned twice, the credibility of the results is only as good as the experience and interpretation skills of the author.

CONCLUSION

HCD methods need to constantly adapt to the development of technology, which shapes human interaction with the technology. This paper presents a preliminary review on emerging HCD methods in the context of mobile application development for smartphones. The study identified the following needs for development and research questions:

- **Methods for mobile user research:** What are the most effective methods to collect and analyze context of use in mobile application development? And what data is relevant to collect?
- **Tools for logging usage and contextual data:** What data is relevant to collect? How can smartphone users be efficiently informed (on the UI level) about what data the application collects?
- **In the wild methods:** How to effectively use in the wild quantitative and qualitative methods to inform the redesign of applications?
- **Evaluation of social applications:** How social-oriented applications can be effectively evaluated on an early conceptual level and later on a functional level?
- **Evaluations with subjects' own device:** How it affects the planning, testing, and analysis of field evaluations?
- **Utilization of sensors:** How sensors impact HCD methods? How developers utilize sensory data for their application throughout the HCD process?

REFERENCES

Arnetminer. (2009). *HCI Conference and journal ranking*. Retrieved October 15, 2010, from http://arnetminer.org/page/conference-rank/html/HCI.html

Basole, R. C., & Karla, J. (2011). On the evolution of mobile platform ecosystem structure and strategy. *Business & Information Systems Engineering*, *5*, 313–322. doi:10.1007/s12599-011-0174-4

Bergvall-Kåreborn, B., Howcroft, D., & Chincholle, D. (2010). Outsourcing creative work: A study of mobile application development. In *Proceedings of the International Conference on Information Systems* (paper 23).

Borchers, J. (2008). *HCI journals that are included in the ISI journal citation reports*. Retrieved October 15, 2010, from http://hci.rwth-aachen.de/isi-journals

Brandt, J., Weiss, N., & Klemmer, S. R. (2007). Txt 4 l8r: Lowering the burden for diary studies under mobile conditions. In *Proceedings of the Extended Abstracts on Human Factors in Computing Systems* (pp. 2049-2054). New York, NY: ACM.

Chowdhury, S. K., & Wynn, J. (2011). Cowabunga! A system to facilitate multi-cultural diversity through CouchSurfing. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 965-970). New York, NY: ACM.

Consolvo, S., & Walker, M. (2003). Using the experience sampling method to evaluate Ubicomp applications. *IEEE Pervasive Computing, 2*(2), 24-31.24–31. doi:10.1109/MPRV.2003.1203750

Coursaris, C. K., & Kim, D. J. (2006). A qualitative review of empirical mobile usability studies. In *Proceedings of the Americas Conference on Information Systems* (paper 352).

Coursaris, C. K., & Kim, D. J. (2010). A meta-analytical review of empirical mobile usability studies. *Journal of Usability Studies*, *1*(3), 117–171.

Durrant, A., Rowland, D., Kirk, D. S., Benford, S., Fischer, J., & McAuley, D. (2011). Automics: Souvenir generating photoware for theme parks. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 1767-1776). New York, NY: ACM.

Ferris, B., Watkins, K., & Borning, A. (2010). OneBusAway: Results from providing real-time arrival information for public transit. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 1807-1816). New York, NY: ACM.

Fling, B. (2009). *Mobile design and development*. Sebastopol, CA: O'Reilly Media.

Følstad, A. (2008). Living labs for innovation and development of information and communication technology: A literature review. *Electronic Journal for Virtual Organizations and Networks*, *10*, 99–131.

Gerken, J., Dierdorf, S., Schmid, P., Sautner, A., & Reiterer, H. (2010). Pocket Bee – A multi-modal diary for field research. In *Proceedings of the Nordic Conference on Human-Computer Interaction* (pp. 651-654). New York, NY: ACM.

Hagen, P., Robertson, T., Kan, M., & Sadler, K. (2005). Emerging research methods for understanding mobile technology use. In *Proceedings of the Australia Conference on Computer-Human Interaction* (pp. 1-10).

Hassenzahl, M., & Tractinsky, N. (2006). User experience – A research agenda. *Behaviour & Information Technology*, *25*(2), 91–97. doi:10.1080/01449290500330331

Henze, N., & Boll, S. (2010). Push the study to the app store: Evaluating off-screen visualizations for maps in the Android Market. In *Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp. 373-374). New York, NY: ACM.

Hiltunen, M., Laukka, M., & Luomala, J. (2002). *Mobile user experience*. Wien, Austria: IT Press.

Hulkko, S., Matelmäki, T., Virtanen, K., & Keinonen, T. (2004). Mobile probes. In *Proceedings of the Nordic Conference on Human-Computer Interaction* (pp. 43-51). New York, NY: ACM.

ISO. (2010). *Ergonomics of human-system interaction - Part 210: Human-centred design for interactive systems (ISO 9241-210:2010)*. Brussels, Belgium: European Committee for Standardization.

Kanstrup, A. M., Bjerge, K., & Kristensen, J. E. (2010). A living laboratory exploring mobile support for everyday life with diabetes. *Wireless Personal Communications*, *53*(3), 395–408. doi:10.1007/s11277-010-9953-3

Kim, S., Robson, C., Zimmerman, T., Pierce, J., & Haber, E. M. (2011). Creek watch: Pairing usefulness and usability for successful citizen science. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2125-2134). New York, NY: ACM.

Kjeldskov, J., & Graham, C. (2003). A review of mobile HCI research methods. In L. Chittaro (Ed.), *Proceedings of the 5th International Symposium on Human-Computer Interaction with Mobile Devices and Services* (LNCS 2795, pp. 317-335).

Kjeldskov, J., & Stage, J. (2004). New techniques for usability evaluation of mobile systems. *International Journal of Human-Computer Studies*, *60*(5-6), 599–620. doi:10.1016/j.ijhcs.2003.11.001

Lane, N., Miluzzo, E., Lu, H., Peebles, D., & Campbell, A. T. (2010). A survey of mobile phone sensing. *IEEE Communications*, *48*(9), 140–150. doi:10.1109/MCOM.2010.5560598

Li, Y. (2010). Gesture search: A tool for fast mobile data access. In *Proceedings of the Symposium on User Interface Software and Technology* (pp. 87-96).

Maguire, M. (2001). Methods to support human-centred design. *International Journal of Human-Computer Studies*, *55*, 587–634. doi:10.1006/ijhc.2001.0503

Masten, D., & Plowman, T. (2003). Digital ethnography: The next wave in understanding the consumer experience. *Design Management Journal*, *14*(2), 75–81.

McMillan, D., Morrison, A., Brown, O., Hall, M., & Chalmers, M. (2010). Further into the wild: Running worldwide trials of mobile systems. In P. Floréen, A. Krüger, & M. Spasojevic (Eds.), *Proceedings of the 8th International Conference on Pervasive Computing* (LNCS 6030, pp. 210-227).

Miluzzo, E., Lane, N. D., Lu, H., & Campbell, A. T. (2010). Research in the app store era: Experiences from the CenceMe app deployment on the iPhone. In *Proceedings of the International Workshop Research in the Large: Using App Stores, Markets, and other Wide Distribution Channels in UbiComp Research.*

Murthy, D. (2008). Digital ethnography: An examination of the use of new technologies for social research. *Sociology*, *42*(5), 837–855. doi:10.1177/0038038508094565

Porat, T., Rief, I., Puzis, R., & Elovici, Y. (2011). LoOkie – It feels like being there. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2149-2152). New York, NY: ACM.

Shirazi, A. S., Rohs, M., Schleicher, R., Kratz, S., Müller, A., & Schmidt, A. (2011). Real-time nonverbal opinion sharing through mobile phones during sports events. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 307-310). New York, NY: ACM.

Usability Net. (2006). *Methods table*. Retrieved January 25, 2011, from http://www.usabilitynet.org/tools/methods.htm

Webster, J., & Watson, R. (2002). Analyzing the past to prepare for the future: Writing a literature review. *Management Information Systems Quarterly*, *26*(2), xiii–xxiii.

Zhai, S., Kristensson, P. O., Gong, P., Greiner, M., Peng, S., Liu, L., & Dunnigan, A. (2009). Shapewriter on the iphone: From the laboratory to the real world. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2667-2670). New York, NY: ACM.

Zimmerman, J., Tomasic, A., Grrod, C., Yoo, D., Hiruncharoenvate, C., & Aziz, R. …Steinfeld, R. (2011). Field trial of Tiramisu: Crowd-sourcing bus arrival times to spur co-design. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 1677-1686). New York, NY: ACM.

Eyal Eshet is a PhD student at the department of Information Technologies of Åbo Akademi University, Finland. His dissertation research focuses on Human-Centered Design in mobile application development, particularly cost-effective methods for understanding users and context of use. He has a Master of Science (Economics and BA) from Åbo Akademi, specialized on electronic and mobile commerce, in which his final thesis analyzed the implementation of usability engineering methods in the design and development of mobile services at an academic institution. Eyal Eshet has over 5 years of work experience as software developer and UI design, which significantly contributes to his understanding of the circumstances connected with a software development process.

APPENDIX A

Reviewed Research Papers in Table 2

1. Ankolekar A., Szabo G., Luon Y., Huberman B.A., Wilkinson D. & Wu F. (2009). Friendlee: a mobile application for your social life. In *Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Services*. ACM.
2. Baecker O., Ippisch T., Michahelles F., Roth S. & Fleisch E. (2009). Mobile Claims Assistance. In *Proceedings of the International Conference on Mobile and Ubiquitous Multimedia*. ACM.
3. Baltrunas, L., Ludwig, B., Peer, S. & Ricci, F. (2011). Context relevance assessment and exploitation in mobile recommender systems. *Personal and Ubiquitous Computing*.
4. Baur D., Boring S. & Butz A. (2010). Rush: repeated recommendations on mobile devices. In *Proceedings of the International Conference on Intelligent User Interfaces* (pp. 91-100). ACM.
5. Baur, D., Hering, B. Boring, S. & Butz, A. (2011). Who needs interaction anyway? Exploring mobile playlist creation from manual to automatic. In *Proceedings of the International conference on Intelligent User Interfaces* (pp. 291-294). ACM.
6. Beer, W. (2010). GeoPointer – Approaching tangible augmentation of the real world. In *Proceedings of the International Conference on Advances in Mobile Computing & Multimedia* (pp. 221-225). ACM.
7. Bentley, F. & Chowdhury, S.K. (2010). Serendipitous Family Stories: Using findings from a study on family communication to share family history. In *Proceedings of the International Conference on Ubiquitous Computing* (pp. 359-360). ACM.
8. Bigham, J.P., Jayant, C., Ji, H., Little, G., Miller, A., Miller, R.C., Miller, R., Tatarowicz, A., White, B., White, S. & Yeh, T. (2010) VizWiz: Nearly Real-time Answers to Visual Questions. In *Proceedings of the Symposium on User Interface Software and Technology* (pp. 333-342). ACM.
9. Bohner R., D'Adamo N., Faeth A., Kaplan S.R. & Marsh W.E. (2009). Edible earth: dining on seasonal and local ingredients. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2811-2816). ACM.
10. Boring S., Baur D., Butz A., Gustafson S. & Baudisch P. (2010). Touch projector: mobile interaction through video. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2287-2296). ACM.
11. Bourke, S., McCarthy, K. & Smyth, B. (2011). The Social Camera: A Case-Study in Contextual Image Recommendation. In *Proceedings of the International Conference on Intelligent User Interfaces* (pp. 13-22). ACM.
12. Brown, Q., Bonsignore, E., Hatley, L., Druin, A., Walsh, G., Foss, E., Brewer, R., Hammer, J. & Golub, E. (2010). Clear Panels: A Technique to Design Mobile Application Interactivity. In *Proceedings of the Conference on Designing Interactive Systems* (pp. 360-363). ACM.
13. Buddharaju P., Fujiki Y., Pavlidis I. & Akleman E. (2010). A novel way to conduct human studies and do some good. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 4699-4702). ACM.
14. Buddharaju, P., Shastri, D., Mandapati, A., Vaidya, S. & Pavlidis, I. (2011). Who said monitoring is boring? In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2041-2046). ACM.
15. Callaway, C., Stock, O., Dekoven, E., Noy, K., Citron, Y. & Dobrin, Y. (2011). Mobile drama in an instrumented museum: Inducing group conversation via coordinated narratives.

In *Proceedings of the International Conference on Intelligent User Interfaces* (pp. 73-82). ACM.
16. Chang, T-H. & Li, Y. (2011). Deep Shot: A Framework for Migrating Tasks Across Devices Using Mobile Phone Cameras. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2163-2172). ACM.
17. Cheng, J., Bapat, A., Thomas, G., Tse, K., Nawathe, N., Crockett, J. & Leshed, G. (2011). GoSlow: Designing for slowness, reflection and solitude. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 429-438). ACM.
18. Choi, J., Jang, B. & Kim, G.J. (2010). Organizing and presenting geospatial tags in location-based augmented reality. *Personal and Ubiquitous Computing, 15*(6), 641-647.
19. Chowdhury, S.K. & Wynn, J. (2011). Cowabunga!: A system to facilitate multi-cultural diversity through CouchSurfing. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 965-970). ACM
20. Church K., Neumann J., Cherubini M. & Oliver N. (2010). SocialSearchBrowser: a novel mobile search and information discovery tool. In *Proceedings of the International Conference on Intelligent User Interfaces* (pp. 101-110). ACM.
21. Constandache, I., Bao, X., Azizyan, M. & Choudhury, R.R. (2010). Did you see Bob? Human localization using Mobile Phones. In *Proceedings of the International Conference on Mobile Computing and Networking* (pp. 149-160). ACM.
22. Coppola, P., Della Mea, V., Di Gaspero, L., Menegon, D., Mischis, D., Mizzaro, S., Scagnetto, I. & Vassena, L. (2010). The Context-Aware Browser. *IEEE Intelligent Systems, 25*(1), 38-47.
23. Dai, J., Bai, X., Yang, Z., Shen, Z. & Xuan, D. (2010). Mobile phone-based pervasive fall *detection. Personal and Ubiquitous Computing, 14*(7), 633-643.
24. Dearman, D., Sohn, T. & Truong, K.N. (2011). Opportunities Exist: Continuous discovery of places to perform activities. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2429-2438). ACM
25. Durrant, A., Rowland, D., Kirk, D.S., Benford, S., Fischer, J. & McAuley, D. (2011). Automics: Souvenir generating photoware for theme parks. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 1767-1776). ACM
26. Ehlen, P. & Johnston, M. (2011). Multimodal Local Search in Speak4it. In *Proceedings of the International Conference on Intelligent User Interfaces* (435-436). ACM
27. Ferris B., Watkins K. & Borning A. (2010). OneBusAway: results from providing real-time arrival information for public transit. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 1807-1816). ACM
28. Gehring S., Löchtefeld M., Schöning J., Gorecky D., Stphan P., Krüger A. & Rohs M. (2010). Mobile product customization. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 3463-3468). ACM
29. Gerken, J., Dierdorf, S., Schmid, P., Sautner, A. & Reiterer, H. (2010). Pocket Bee – a multi-modal diary for field research. In *Proceedings of the Nordic Conference on Human-Computer Interaction* (pp. 651-654).
30. Giradello A. & Michahelles F. (2010). AppAware: Which Mobile Applications Are Hot?. In *Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp. 431-434). ACM
31. Hahn, J. & Morales, A. (2011). Rapid Prototyping a Collection-based Mobile Wayfinding Application. *Journal of Academic Librarianship* (September 2011).

32. Hall, M., Bell, M., Morrison, A., Reeves, S., Sherwood, S. & Chalmers, M. (2009). Adapting Ubicomp Software and its Evaluation. In *Proceedings of the Symposium on Engineering interactive computing systems* (pp. 143-148). ACM.
33. Halpern, M., Tholander, J., Evjen, M., Davis, S., Ehlrich, A., Schustak, K., Baumer, E.P.S. & Gay, G. (2011). MoBoogie: Creative expression through whole body musical interaction. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 557-560). ACM.
34. Jang, H., Kim, S., Shin, W. & Myaeng, S-H. (2010). Personal Information Access Using Proactive Search and Mobile Hypertext. *IEEE Intelligent Systems, 25*(1), 27-36.
35. Kane, S.K., Bigham, J.P. & Wobbrock, J.O. (2008). Slide Rule: Making Mobile Touch Screens Accessible to Blind People Using Multi-Touch Interaction Techniques. In *Proceedings of the Conference on Computers and accessibility* (pp. 73-80). ACM.
36. Kanstrup, A.M., Bjerge, K. & Kristensen, J.E. (2010). A Living Laboratory Exploring Mobile Support for Everyday Life with Diabetes. *Wireless Personal Communications, 53* (3), 395-408.
37. Karrer T., Wittenhagen M. & Borchers J. (2009). PocketDRAGON: a direct manipulation video navigation interface for mobile devices. In *Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Services*. ACM.
38. Kemp R., Palmer N., Kielmann T. & Bal H. (2010). Opportunistic communication for multiplayer mobile gaming: lessons learned from PhotoShoot. In *Proceedings of the International Workshop on Mobile Opportunistic Networking* (pp. 182-184). ACM.
39. Ketabdar H., Roshandel M. & Yüksel K. A. (2010). MagiWrite: towards touchless digit entry using 3D space around mobile devices. In *Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp. 443-446). ACM.
40. Kim, S., Robson, C., Zimmerman, T., Pierce, J. & Haber, E.M. (2011). Creek Watch: Pairing usefulness and usability for successful citizen science. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2125-2134). ACM
41. Koh S., Kuo A., Lauterbach D., Liebman N. & McVittie A. (2009a). TreasureHunter: a system to increase the reuse of local used goods. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2835-2840). ACM.
42. Koh R.K.C., Tan H.X.L. & Duh H.B-L. (2009b). Information empowerment through mobile learning. In *Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Services.* ACM.
43. Lee,C-L., Lee, D., Cheng, Y-M., Chen, L-C., Chen, W-C. & Sandnes, F.E. (2010). On the implications of sense of control over bycicling: Design of a physical stamina-aware bike. In *Proceedings of the Conference of the Australian Computer-Human Interaction* (pp. 13-16). Australia: CHISIG.
44. Leichsenring, C., Tünnermann, R. And Hermann, T. (2011). feelabuzz: Direct Tactile Communication with Mobile Phones. *International Journal of Mobile Human Computer Interaction, 3* (2).
45. Li, Y. (2010). Gesture Search: A Tool for Fast Mobile Data Access. In *Symposium on User Interface Software and Technology* (pp. 87-96). ACM.
46. Lobunets, O. & Prinz, W. (2011). Evaluating a smart working environment with a digital card game prototype. In *Proceedings of the Conference on Computer supported cooperative work* (pp. 673-676). ACM.
47. Löchtefeld, M., Gehring, S., Schöning, J. & Krüger, A. (2010). PINwI – Pedestrian Indoor Navigation without Infrastructure. In *Proceedings of the Nordic Conference on Human-Computer Interaction* (pp. 731-734). ACM

48. McMillan D., Morrison A., Brown O., Hall M. & Chalmers M. (2010). Further into the Wild: Running Worldwide trials of Mobile Systems. In P. Floréen, A. Krüger, and M. Spasojevic (Eds.): *Proceedings of the Pervasive Computing* (LNCS 6030, pp. 210-227).
49. Mohammedali, M., Phung, D., Adams, B. & Vankatesh, S. (2011). A context-sensitive device to help people with Autism cope with anxiety. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 1201-1206). ACM.
50. Neustaedter, C. & Judge, T.K. (2010). Peek-A-Boo: The Design of a Mobile Family Media Space. In *Proceedings of the International Conference on Ubiquitous Computing* (pp. 449-450). ACM.
51. Noz, F. & An, J. (2011). Cat Cat Revolution: An interspecies Gaming Experience. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2661-2664). ACM.
52. Nugent, T. & Lueg, C. (2010). ReGroup: Using location sharing to support distributed information gathering. In *Proceedings of the Conference of the Australian Computer-Human Interaction* (pp. 372-375). Australia: CHISIG.
53. O'Murchu, N & Sigfridsson, A. (2010). TiY (tag-it-yourself). In *Proceedings of the Conference on Designing Interactive Systems* (pp. 57-60). ACM.
54. Ouilhet H. (2010). Google Sky Map: using your phone as an interface. In *Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp.419-421). ACM.
55. Pereira, O., Caldeira, J.M.L.P. & Rodrigues, J.J.P.C (2010). Body sensor network mobile solutions for biofeedback monitoring. *Mobile Networks and Applications, 16*(6), 713-732.
56. Petersen D., Stele J. & Wilkerson J. (2009). WattBot: a residential electricity monitoring and feedback system. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2847-2852). ACM
57. Pielot M., Poppinga B. & Boll S. (2010). PocketNavigator: vibro-tactile waypoint navigation for everyday mobile devices. In *Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp. 423-426). ACM.
58. Porat, T., Rief, I., Puzis, R. & Elovici, Y. (2011). LoOkie – It Feels Like Being There. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2149-2152). ACM.
59. Proß B., Schöning J. & Krüger A. (2009). iPiccer: automatically retrieving and inferring tagged location information from web repositories. In *Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Services*. ACM.
60. Reddy, S., Shilton, K., Denisov, G., Cenizal, C., Estrin, D. & Srivastava, M. (2010). Biketastic: Sensing and Mapping for Better Biking. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 1817-1820). ACM.
61. Reed, M. & Holtzman, H. (2011). Kiroscope: managing time perception and scheduling through social event coordination. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 1969-1978). ACM.
62. Rosner, D. & Ryokai, K. (2010). Spyn: Augmenting the creative and communicative potential of craft. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2407-2416). ACM.
63. Ryokai, K., Oehlberg, L., Manoochehri, M. & Agogino, A. (2011). GreenHat: Exploring the Natural Environment Through Experts' Perspectives. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2149-2152). ACM.
64. Shastri, D., Buffington, R., Fujiki, Y., Tsimayrtzis, P. & Pavlidis, I. (2010). O Job Can You Return My Mojo? Improving Human Engagement and Enjoyment in Routine Activities. In

Proceedings of the Conference on Human Factors in Computing Systems (pp. 2491-2498). ACM.

65. Sheridan, J., Bryan-Kinns, N., Reeves, S., Marshall, J. & Lane, G. (2011). Graffito: Crowd-based performative interaction as festivals. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 1129-1134). ACM.
66. Shirazi, A.S., Rohs, M., Schleicher, R., Kratz, S., Müller, A. & Schmidt, A. (2011). Real-time nonverbal opinion sharing through mobile phones during sports events. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 307-310). ACM.
67. Su J., Rosenzweig A., Goel A., de Lara E. & Truong K. N. (2010). Timbremap: enabling the visually-impaired to use maps on touch-enabled devices. In *Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp. 17-26). ACM.
68. Tintarev N., Flores A. & Amatrian X. (2010). Off the beaten track: a mobile field study exploring the long tail of tourist recommendations. In *Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp. 209-218). ACM.
69. Weiss M., Mattern F., Graml T., Staake T. & Fleisch E. (2009). Handy feedback: connecting smart meters with mobile phones. In *Proceedings of the International Conference on Mobile and Ubiquitous Multimedia*. ACM.
70. Wenig D. & Malaka R. (2010). Interaction with combinations of maps and images for pedestrian navigation and virtual exploration. In *Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp. 377-378). ACM.
71. Whipple J., Arensman W. & Boler M. S. (2009). A public safety application of GPS-enabled smartphones and the android operating system. In *Proceedings of the IEEE International Conference on Systems, Man, and Cybernetics* (pp. 2059-2061). IEEE.
72. White, J., Thompson, C., Turner, H., Dougherty, B. & Schmidt, D.C. (2011). WreckWatch: Automatic Traffic Accident Detection and Notification with Smartphones. *Mobile Networks and Applications, 16* (3), 285-303
73. White, S., Ji, H. & Bigham, J.P. (2010). EasySnap: Real-time Audio Feedback for Blind Photography. In *Proceedings of the Symposium on User Interface Software and Technology* (pp. 409-410). ACM.
74. Wu C-H., Wu T-F., Chou Y-H., Huang K-H., Wuang C-H., Chen M-C. & Deng Y-S. (2010). HappyFeet! Influencing at the turning points: walking or scooter ride for short-distance journey?. In *Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp. 463-465). ACM.
75. You C-W., Chen Y-L., Cheng W-H., Chen M-S. & Tsai S-A. (2010). SocialCRC: a social- and context-aware rendezvous coordination system. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 3391-3396). ACM.
76. Yu S-J. & Selker T. (2010). Who said what when?: capturing the important moments of a meeting. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 3283-3288). ACM.
77. Zenker B. & Ludwig B. (2009). ROSE: assisting pedestrians to find preferred events and comfortable public transport connections. In *Proceedings of the International Conference on Mobile Technology, Application & Systems*. ACM.
78. Zhai S., Kristensson P. O., Gong P., Greiner M., Peng S., Liu L. & Dunnigan A. (2009). Shapewriter on the iphone: from the laboratory to the real world. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 2667-2670). ACM.

79. Zimmerman, J., Tomasic, A., Grrod, C., Yoo, D., Hiruncharoenvate, C., Aziz, R., Thiruvengadam, N.R., Huang, Y. & Steinfeld, R. (2011). Field trial of Tiramisu: Crowd-sourcing bus arrival times to spur co-design. In *Proceedings of the Conference on Human Factors in Computing Systems* (pp. 1677-1686). ACM.

APPENDIX B

List of Journals and Conferences

Journals

- *International Journal of Human-Computer Interaction* (HCI)
- *User Modeling and User-Adapted Interaction* (UMUAI)
- *International Journal of Human-Computer Studies* (IJHCS)
- *Interacting with Computers* (INTCOM)
- *International Journal of Human-Computer Interaction* (IJHC)
- *International Journal of Mobile Human Computer Interaction* (IJMHCI)
- *Communications of the ACM* (CACM)
- *Human Factors: The Journal of the Human Factors and Ergonomics Society* (HFES)
- *Human Factors and Ergonomics in Manufacturing & Service Industries* (HFEMSI)
- *ACM Transactions on Computer-Human Interactions* (TOCHI) †
- *ACM Interactions*
- *UPA Journal of Usability Studies* (JUS)
- *UPA User Experience Magazine* (UX)
- *Pervasive and Mobile Computing*
- *IEEE Pervasive Computing*
- *Mobile Networks and Applications*
- *Personal and Ubiquitous Computing* †
- *Wireless Personal Communications*
- *Expert Systems with Applications*
- *IEEE Internet Computing*
- *IEEE Intelligent Systems*
- *IEEE Wireless Communications*

Conference Proceedings

- Human Computer Interaction with Mobile Devices and Services (MobileHCI) † §
- Conference on Human Factors in Computing Systems (CHI) † §
- Participatory Design Conference (PDC) §
- Advanced Visual Interfaces (AVI) †
- Mobile Systems, Applications and Services (MobiSys)
- Mobile Technology, Applications, and Systems (Mobility)
- Workshop on Mobile Computing Systems and Applications (HotMobile)
- Mobile and Ubiquitous Multimedia (MUM) §
- Conference on Mobile Computing and Multimedia (MoMM)
- Conference on Mobile Computing and Networking (MobiCom)
- Symposium on User Interface Software and Technology (UIST) †

- Conference on Computer Supported Cooperative Work (CSCW) † §
- European Conference on Computer Supported Cooperative Work (ECSCW)
- Intelligent User Interfaces (IUI)
- Graphics Interface (GI)
- Supporting Group Work (GROUP)
- Eye Tracking Research & Application (ETRA)
- Haptics Symposium (HAPTICS)
- User modeling, Adaptation, and Personalization (UMAP)
- Human Factors and Ergonomics Society of Australia (OZCHI) §
- Nordic Conference on Human-Computer Interaction (NordiCHI)
- Workshop on Networking, Systems, Applications on Mobile Handhelds (MobiHeld)
- International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc)
- International Workshop on Mobile Opportunistic Networks (MobiOpp)
- Conference on Pervasive Computing (Pervasive)
- Designing Interactive systems (DIS) † §
- Conference on Ubiquitous Computing (Ubicomp) §

† Used by Kjeldskov and Graham (2003)
§ Used by Hagen et al. (2005)

Paper 2

Eshet, E. and Bouwman, H. (2014). Addressing the Context of Use in Mobile Computing: A Survey on the State of the Practice. Interacting with Computers, 27(4), pp. 392-412. doi: 10.1093/iwc/iwu002

Advance Access publication on 14 February 2014
doi:10.1093/iwc/iwu002

Addressing the Context of Use in Mobile Computing: a Survey on the State of the Practice

EYAL ESHET[1,*] AND HARRY BOUWMAN[2]

[1]*Turku Centre for Computer Science (TUCS), Department of Information Technologies, Åbo Akademi University, Joukahainengatan 3-5, 20520 Turku, Finland*
[2]*Delft University of Technology, Jaffalaan 5, Delft, 2628 BX, The Netherlands*
[*]*Corresponding author: eeshet@abo.fi*

Understanding the context of use is essential to the design of interactive systems. In contrast to the relatively stable and homogeneous use context in stationary computing, the context of use in mobile computing is dynamic and heterogeneous. Although mobile context has been studied from a theoretical perspective, empirical data on how practitioners address the mobile context of use is scant. With the emergence of more advanced mobile technologies, improved interfaces and the ubiquitous character of mobile apps, questions related to context of use and how designers and developers collect relevant data become even more pressing. This paper presents the results of a survey based on a convenience sample of 150 practitioners involved in mobile app design and development. Our results show that the mobile context of use is mainly considered in the early phase of requirements gathering and specification, while there is a lack of external context-related considerations in evaluations. Methods that are perceived as being more appropriate to address the mobile context are also perceived as being more effective, though they are used considerably less frequently. A key to addressing the mobile context is to improve the utility of such methods, taking the time and budget constraints of practitioners, as well as their experience, into consideration.

RESEARCH HIGHLIGHTS

- Understanding user goals, behavior and tasks is most important to mobile practitioners.
- They commonly engage in interviews and user observation in the early user-centered design phase.
- Evaluations often lack awareness of external context-related considerations.
- Time and budget constraints influence the choice and practice of methods.
- We report on cost-effective strategies to address the mobile context.

Keywords: ubiquitous and mobile computing, HCI design and evaluation methods, user centered design, empirical studies in interaction design

Editorial Board Member: Fabio Paternó

Received 18 June 2013; Revised 16 December 2013; Accepted 7 January 2014

1. INTRODUCTION

Understanding the context of use and user needs is crucial in system design. Early research (Gould and Lewis, 1985) in human–computer interaction (HCI) already emphasized the need to understand users, their work tasks and task circumstances as being essential to the design of usable systems. The importance of the context of use to system usability has been recognized by the International Standardization Organization (ISO 9241-11, 1998; ISO 13407, 1999, replaced by ISO 9241-210, 2010) and by HCI-related disciplines, such as ubiquitous computing (Dey, 2001), user experience (UX) design (Hassenzahl and Tractinsky, 2006) and interaction design (Rogers *et al.* 2007). The concept of context of use is stressed throughout the user-centered design (UCD) process: early on, in the elicitation of fundamental information to specify product requirements and inform the design (ISO, 2010), and later, when

conducting valid and reliable evaluations (Bevan and Macleod, 1994). Until recent years, computing devices were mainly used in stationary environments, such as the workplace, office, classroom or home. In such places, system use is characterized by fairly routine tasks, which became a key instrument for the analysis and evaluation of system usability (Hassenzahl and Tractinsky, 2006). As a result, stationary environments have a manageable number of context-related considerations, while changes in contextual aspects and implications for design are relatively predictable (Hinman, 2012).

However, the elimination of time and place restrictions in mobile computing engenders a context of use that is subject to rapid and unpredictable changes (Forman and Zahorjan, 1994). Mobile computing devices, such as mobile phones, are used in spaces and under circumstances that reflect people's everydayness. Consequently, contextual aspects frequently change in unpredictable ways, as mobile users go about their everyday interactions (Tamminen *et al.* 2004). Making sense of such transitional circumstances requires new tools to document, analyze and distinguish the relevant from the ordinary. In addition, system evaluations should take place in lifelike situations over time. While research efforts have yielded numerous methods designed to understand the use of mobile computing (e.g. Coursaris and Kim, 2011; Hagen *et al.* 2005; Kjeldskov and Graham, 2003), data on how practitioners address the context of use in mobile computing (hereafter, the mobile context of use) are, thus far, very limited. Because of rapid developments in mobile technologies in recent years, e.g. the commencement of the smartphone touch era (Fling, 2009), and the democratization of mobile software development, making sense of the context of use has become a more prominent issue for practitioners. Hinman (2012) argues that understanding the mobile context is 'quite possibly the most essential skill necessary in creating great mobile experiences' (p. vi), although practitioners are poorly equipped to address the mobile context. Hence, the question that drives our research is, 'how do mobile practitioners address, that is to say comprehend and approach, the context of use during their projects?'

This study uses a survey method to empirically examine how the mobile context of use is currently being addressed. The survey will be complemented by qualitative studies to gain further insights into the actual design practice of mobile applications, particularly focusing on how practitioners in the industry perceive and address the mobile context of use. Our target sample consists of practitioners in three project roles: usability/UCD specialists, software developers and project managers. We examine the understanding of certain contextual aspects among practitioners, the methods they use and for what purpose, the perceived effectiveness of methods and practitioners' overall evaluation of their strategy for addressing the mobile context of use. This study contributes to HCI literature on understanding the UCD practice and challenges, in an era when mobile and ubiquitous computing is becoming common practice. In addition, we provide guidelines for practitioners and suggestions for further research.

This paper is organized as follows: in Section 2, we examine the context of use concept and its implications for mobile computing, review prior industry surveys and introduce our research approach; in Section 3, we describe the research method; in Section 4, we present the results; in Section 5, we discuss the findings and limitations and in Section 6, we discuss the conclusion and suggest avenues for further research.

2. LITERATURE REVIEW

2.1. Context of use

Context is an essential and inescapable characteristic of daily life, which consciously and unconsciously affects our behavior. Indeed, human cognition and action is always situated within, and therefore contingent on, specific circumstances (Suchman, 2006), which include internal processes, for instance, motives and goals of people and external resources, such as artifacts, other people and specific environmental settings (Nardi, 1996). Attending to this multidisciplinary nature, Bradley and Dunlop (2005) see context as positioned within 'a process whereby a person consciously or unconsciously compares an external context with acquired personal experiences/knowledge (both of which may contain task, physical, social and temporal dimensions) to form goals for undertaking concise actions, possibly with other people and/or objects' (p. 424). Traditionally, in HCI, actions are those related to the use of an interactive system. As such, the term 'context of use' refers to the circumstances in which a system is, or will be, used. In this paper, we use the concepts of 'context' and 'context of use' interchangeably, similar to the way they are used in HCI literature. When designing a system, understanding the context of use is believed to be necessary for the development of intuitive systems.

Understanding the context of use is fundamental to the design of interactive systems. Although not labeled as such, aspects of the context of use were highlighted in early HCI research. Gould and Lewis (1985) emphasized the need to understand users, their work tasks and task circumstances as being essential to the design of usable information systems. Bannon (1986) emphasized the role of social and organizational environments in understanding work practices. Gould *et al.* (1988) established 'early and continual focus on users' as a key principle for the design of usable systems, stressing the need for direct contact with users in their workplace. Macleod and Bevan (1993) were arguably the first to use the concept of 'context of use' to include 'the users, tasks and environments for which a system is designed' (p. 55). Moreover, they provided a method for specifying the key characteristics of the concept. Their focus was on the role of context of use in system evaluation, arguing that reliable evaluations should be conducted with 'representative users performing representative work tasks in appropriate

circumstances' (Macleod and Bevan, 1993, p. 55). Their work has been instrumental in standardizing system usability.

Standards for system usability emphasize the context of use throughout the design practice. The ISO 9241-11: Guidance on Usability (ISO, 1998) underlines that the usability of a system depends on the context in which it will be used. ISO 13407 for *Human-Centered Design processes for Interactive Systems* (ISO, 1999, replaced by ISO 9241-210, 2010) specifies, among its principles and activities, that the design should be based on an explicit understanding of the context of use. Addressing the context of use takes place throughout the iterative design practice: at an early phase to collect fundamental information for specifying user and product requirements as well as informing the design (ISO, 2010), and at later phases to plan and carry out reliable and valid usability evaluations (Bevan and Macleod, 1994) and follow-up evaluations after system release. The standards were also inspired by UCD approaches (e.g. Beyer and Holtzblatt, 1997; Cooper, 1999; Nielsen, 1993; Rosson and Caroll, 2001; Schuler and Namioka, 1993), which provide a more practical account of addressing the context of use. Maguire (2001) introduced a systematic procedure to the analysis of the context of use. At the core of the method is a table that contains general components of the context of use—the system, user and stakeholders, task and environments (technical, physical, organizational). However, the primary focus of traditional UCD approaches is the domain of work in organizations, which is relatively stationary.

In stationary computing, the context of use is relatively stable and task-oriented. Research on system usability emerged from the need to improve the productivity of office workers (Karat and Karat, 2003). Workplaces are characterized by fairly static environment and a manageable amount of users who use a single computer and follow fairly routine tasks. Consequently, user tasks became a key to the analysis of users and evaluation of system usability (Hassenzahl and Tractinsky, 2006). Stationary environments, such as home, office or classrooms, share common characteristics: the nature of the system is fixed, with limited contextual considerations. In addition, possible changes in the context of use, and their influence on the design, are fairly predictable (Hinman, 2012). In contrast, mobile computing is dynamic and unpredictable in nature.

2.2. Context of use in mobile computing

The most profound difference between stationary and mobile computing is mobility. In their taxonomy of mobility, Dix *et al.* (2000) define three main categories of mobile computing: (i) carried-on devices, such as PDA and wearable computers; (ii) autonomous devices, such as robots and (iii) devices embedded in another moving object, such as a computer in a car. In this study, we are interested in the first category, hereafter simply referred to as the mobile system. As is apparent from the taxonomy, the mobility of the device is contingent upon its carrier. Being carried on, the use of mobile systems is entwined with people's everyday activities (Dix *et al.* 2000). The ability to use a mobile system anywhere and everywhere results in heterogeneous contexts of use, while using it on the move institutes a context of use that is dynamic and unpredictable (Forman and Zahorjan, 1994; Tamminen *et al.* 2004). The impact is not only on the environments in which the system can be used. Inherently, mobile computing also introduces new classes of users and tasks that further extend the variability of the context of use (Johnson, 1998). Indeed, mobility has a fundamental impact on prior assumptions of the context of use and, hence, on the approaches to address it.

The situated nature of mobile systems has led to increased interest in delineating the notion of context, particularly in light of ubiquitous and context-aware computing (e.g. Dey, 2001; Dourish, 2004; Greenberg, 2001). In an effort to do so, model-based approaches to the engineering of context-aware, multi-device user interfaces (e.g. Calvary *et al.* 2003; Paternó, 2005; Paternó *et al*. 2009) have highlighted certain high-level components of the context of use to support both the design of applications and their adaptation to the dynamic context in real time. Context is mainly defined in terms of the users, hardware and software platforms, and the physical environment where the system is used (Calvary *et al.* 2003; Paternó, 2005), along with the tasks and their temporal relations designed to support user goals (Paternó, 2005; Paternó *et al.* 2009). In addition, Paternó *et al.* (2009) emphasize the need to describe context aspects at different abstraction levels in the design of interactive applications for multiplatform devices.

Recent studies (Bradley and Dunlop, 2005 and Jumisko-Pyykkö and Vainio, 2010) have synthesized prior research to provide theoretical models of the mobile context of use. Bringing together the context theories from linguistics, computer science and psychology, Bradley and Dunlop (2005) proposed a multidisciplinary model of and a practical tool to analyze context. The model, which aims at supporting the design of context-aware systems, acknowledges the dynamic and unpredictable nature of context as well as the internal aspects and variability of users. A key principle of the model is the separation of context into *meaningful* context, which is implicitly related to user's goals, and *incidental* context, which is usually unrelated to primary user goals. This is similar to the foreground/background activities described by Svanæs (2001) and emphasizes the importance of understanding user goals.

Jumisko-Pyykkö and Vainio (2010), in their attempt to characterize the mobile context of use, present a descriptive model based on a review of major HCI literature. The model emphasizes the categorization of contextual aspects into components and sub-components, with properties of context that extend the description of components to highlight the dynamic nature of each component and of the mobile context as a whole. At the center of the model are the user and the mobile system, which are influenced by the components and their properties. However, the authors emphasize that the degree to which the components and their properties affect

the user is not assumed to be equal and varies on a case-by-case basis.

Overall, the models proposed by Jumisko-Pyykkö and Vainio (2010) and by Bradley and Dunlop (2005), combined with the earlier context of use analysis table by Maguire (2001), provide a relatively extensive framework for the examination of the mobile context of use. In Table 1, we combined and summarized the components from the models. Note that the context-related properties (at the bottom of Table 1) originally applied to the context components that were contributed by Jumisko-Pyykkö and Vainio (2010). Nevertheless, they can also help explain the dynamics of specific user and system components.

Although from a theoretical and conceptual perspective, many insights, normative rules and relevant aspects are discussed and proposed, the core question is 'how do mobile practitioners comprehend and approach the context of use?' Practitioners need tools to comprehend and make sense of the ordinary situations in which people use their mobile devices in order to better inform the design.

2.3. Practical implications of views on context for mobile computing

Addressing the mobile context of use requires studies that extend beyond fixed locations and task analysis. Essentially, the mobility nature calls for the application of field methods that span both spatial and temporal dimensions. Greenberg (2001) suggests using ethnographic methods in a longitudinal study, to capture predictable as well as unpredictable contextual episodes. Tamminen *et al.* (2004) provided an account of such a study and its contribution to informing system design. However, collecting data on people's everyday activities can be a daunting task. Limiting the scope of studies means focusing on the relevance out of the ordinary. The relevance of data can be determined only when we understand user intentions (Svanæs, 2006), and the meanings they give to the technologies they use (Dourish, 2004). Dourish (2004) also suggests involving users as active participants in design.

Field studies are not only important when it comes to informing the design. A usability laboratory cannot capture the vast amount of contextual aspects and the dynamic evolution of context as observed in day-to-day practice, so system evaluations should take place where ordinary and relevant activities occur. This requires methods and tools to capture and analyze the use of a system in real-world settings over longer periods than are customary in traditional laboratory sessions. Rather than merely looking at task performance, evaluations should try to measure subjective aspects that contribute to the holistic experience, as suggested by UX research. This perspective includes aspects such as hedonic, emotion and affect, which are internal states of humans and cannot be observed and analyzed similar to the completion of a task (Hassenzahl and Tractinsky, 2006). Practitioners need understanding and methods that can measure and operationalize subjective human needs in their design.

These challenges indicated above have led researchers and practitioners to conceive new approaches to address the mobile context of use. For instance, attending to the increasing time pressure in system development, Millen (2000) proposes a set of field techniques for conducting rapid ethnographic studies; Ginsburg (2010) suggests 'shadowing' users and conducting field interviews and Hinman (2012) proposes conducting brainstorming in the field. While these techniques require practitioners going into the field, diary studies allow users to self-document their interactions over longer periods of time. Various diary approaches have been suggested in mobile computing, such as experience sampling method (Consolvo and Walker, 2003), mobile probes (Hulkko *et al.* 2004) and a mobile-adapted diary study (Brandt *et al.* 2007). Examples of methods used to analyze the collected data are, for instance, interactive scenarios (Strömberg *et al.*, 2004), which are actively developed with potential users by means of role-playing and improvisation; rich scenarios (Bradley and Dunlop, 2005), which focus on the identification of user goals, meaningful context aspects and incidental situations; the indexicality concept (Kjeldskov and Paay, 2010), which is used to analyze the relationships between user context and UI representations; Ginzburg's (2009) user journeys and Hinman's (2012) nouns and relationships framework.

Approaches to a more lifelike evaluation of mobile systems include, for instance, a usability laboratory augmented with certain characteristics of real-life situations (Kjeldskov and Stage, 2004), long-term field evaluations with closed tasks (Kjeldskov *et al.* 2005), and with open tasks (Roto *et al.* 2006), expert inspection methods (Po *et al.* 2004), rapid reflection (Kjeldskov *et al.* 2005), approaching people in coffee-shops and on the street for testing under time constraints (Ginsburg, 2010), and a living laboratory approach that resembles a realistic context (Kanstrup *et al.*, 2010). Field evaluations are commonly conducted with conventional methods, such as user observation, interviews and questionnaires (Coursaris and Kim, 2011). In addition, the ability to install mobile software on the user's device opens new remote opportunities for logging data on their actual mobile usage combined with self-reporting on their use (Baur *et al.* 2011), but also raises some serious privacy concerns (Bouwman *et al.* 2013). Vermeeren *et al.* (2010) have assembled an extensive list of methods for the evaluation of user experience aspects (available in http://www.allaboutux.org/).

While there is a growing body of knowledge on research methods for addressing the context of use in mobile computing (e.g. Coursaris and Kim, 2011; Hagen *et al.* 2005; Kjeldskov and Graham, 2003), less is known about the actual design practice in the industry. In the mobile world, dominated by telecommunication network operators and handset manufacturers, relatively few practitioners were involved in the development of mobile systems, and the use of the systems was mainly characterized by basic communication functions. The recent structural transformation of the mobile industry, by opening the app store model for distributing software, marked a milestone for mobile software practitioners.

Table 1. A context of use model for mobile computing.

Component	Sub-component	Examples
1. User	1.1 User goals[b]	Goals and related, or independent, actions
	1.2 User name[a]	Type, role
	1.3 Experience, knowledge, skills[a]	Product and related experience, task knowledge, input device skills, language skills
	1.4 Personal attributes[a]	Age, gender, physical/cognitive capabilities and limitations, attitude and motivation
2. System[b]	2.1 Capabilities and limitations	Battery, processor, memory, sensors, input and output technologies, content server, network
3. Physical context[c]	3.1 Spatial location, functional place and space	City area, school, home, train Shopping, sport, work
	3.2 Sensed environment	Light, sound, weather conditions
	3.3 Movements and mobility	User's motion (e.g. sitting, walking), user's mobility (e.g. wondering, traveling, visiting), motion of user's environment (e.g. bus, train)
	3.4 Artifacts	Physical objects in the vicinity of the user
4. Temporal context[c]	4.1 Duration	Extent of use session or of the event that necessitates the use
	4.2 Time	Usage activity in relation to day, week, year, holiday, etc.
	4.3 Before-, during-, and after- usage session	Actions expected before and after taking pictures
	4.4 Actions related to time	Hurrying, waiting
	4.5 Synchronous-asynchronous actions	Voice vs. text-based communication
5. Task context[c]	5.1 Multitasking	Interactions with the real world (e.g. walking, talking, driving) alongside the interaction with the mobile device
	5.2 Interruptions	User's attention switches from the current task to the interrupting event (e.g. due to technical, social or physical causes)
	5.3 Task domain	Goal oriented tasks (e.g. work, guides, navigation) vs. action-oriented tasks (e.g. entertainment, gaming, sharing experiences)
6. Social context[c]	6.1 Persons present	Other people who are physically or virtually present, as individuals, group or public.
	6.2 Interpersonal interaction	Collaborative actions with presented persons (co-experiencing of multimedia mobile content, multitasking with person and mobile device)
	6.3 Culture	High-level values, norms and attitudes that influence how one interprets a situational event
7. Technical and information context[c]	7.1 Other systems, services, and networks	Dependency on social media content, roaming
	7.2 Interoperability	Between mobile and PC, between different mobile platforms
	7.3 Informational artifacts and access	Using objects and electronic devices, other than mobile, to achieve a similar goal (e.g. taking notes with a paper and a pen, watching videos on a TV or PC)
	7.4 Mixed reality systems	Augmented reality, gaming
Properties	Examples	
Level of magnitude (micro–macro)[c]	User's motion (micro) vs. user's mobility (macro), multitasking and interruptions (micro) vs. task domain (macro), persons nearby (micro) vs. culture (macro)	
Level of dynamism (static–dynamic)[c]	Using a similar mobile system while at bed or during a walk in the street affects the dynamism of context components	
Pattern (rhythmic–random)[c]	Temporally using a mobile system according to recognized usage pattern vs. random and unpredictable use, frequent vs. one-time use	
Typical combinations[c]	Especially of the physical and temporal components, such as visiting a festival or a museum, work vs. free time	

[a]Maguire (2001).
[b]Bradley and Dunlop (2005).
[c]Jumisko-Pyykkö and Vainio (2010).

2.4. The mobile apps era

Starting with smartphones (Fling, 2009), the mobile apps era has since been expanded to include tablet devices of various screen sizes. In the mobile apps era, the capabilities of mobile devices went through profound transformation, allowing new ways to interact ubiquitously with other people and consume information. While practitioners may be experienced in software and web development (i.e. for stationary computing), they are less experienced with the intricacies involved in developing software for mobile computing. Experienced practitioners are facing new challenges due to the extended capabilities of mobile devices (e.g. sensors, connectivity, interaction methods), the proliferation of devices and their increased embeddedness in the everyday lives of unparalleled numbers of users. Hinman (2012) argues that, even though understanding the mobile context is 'quite possibly the most essential skill necessary in creating great mobile experiences' (p. vi), practitioners are poorly equipped to address the mobile context. This serves as a basic assumption for our study.

2.5. Prior studies on the state of the practice

Existing studies on the state of the practice, as far as we are aware, have not focused specifically on the development of software for mobile computing, let alone in the smartphone touch era. Most of the studies on the UCD practice (e.g. Bygstad *et al.*, 2008; Gulliksen *et al.* 2004; Gunther et al., 2001; Hudson, 2000; Monahan *et al.* 2008; Rosenbaum *et al.*, 2000; Venturi *et al.*, 2006; Vredenburg *et al.* 2002) provide a descriptive account of the commonly used UCD methods and their perceived effectiveness from different perspectives. Monahan *et al.* (2008) emphasized the emergence of mobile computing by focusing on field methods and their utilization, but respondents were not limited to those involved in mobile computing, and their data were collected before the mobile apps era.

3. RESEARCH METHOD

3.1. Study approach

Although this study shares many of the interests of earlier surveys in understanding the practice of UCD, its approach is unique in three notable aspects: (i) we focus on UCD practice specifically involving mobile computing, (ii) we emphasize methods to address the context of use and (iii) we define the target audience as not merely including usability experts, but also practitioners in managerial positions and software developers, in order to gain a broader view of the practice in the industry. In addition, it is the first empirical UCD practice study to be conducted in the mobile apps era. Due to this novelty, our approach of the study toward these unique aspects was broad and exploratory. The survey method was selected because it is considered to be very useful for exploring such 'uncharted waters' and getting a 'snapshot' of the phenomena under study (Lazar *et al.*, 2010).

Moreover, the survey method is only a preliminary step in a broader research effort designed to understand mobile practitioners' design practice in the industry. As such, the survey contributes an overview that will be used to guide our planned qualitative examination of mobile practitioners' work, in particular with regard to the mobile context of use. In this survey study, our objective is to examine how practitioners perceive and approach the context of use during the design practice of mobile applications, which leads to the following research questions:

RQ1 What context aspects are perceived to be important by mobile practitioners when designing a mobile application?

RQ2 To what extent do the UCD methods used by practitioners during the design practice of mobile applications address the context of use?

The results of this study contribute to a preliminary descriptive account of UCD practices in the new mobile era, particularly with regard to the mobile context of use. For researchers, understanding current practices in mobile computing is essential for aligning the research efforts with the industry needs. The results will provide direction for further investigation of ways to approach the mobile context of use. Practitioners in the industry can gain knowledge on effective strategies to address the context of use in the design of mobile applications. Next, we explain how the study was designed and executed.

3.2. Sampling

Data were collected via a web-based questionnaire targeting practitioners who are involved in the design and development of mobile applications (i.e. apps). This was emphasized both in the survey invitation and in the introduction to the questionnaire. We focused on three project roles: (i) UCD/usability specialists (e.g. UX designers, interaction designers), (ii) project managers and project owners and (iii) software developers. The parametric size of such populations is difficult to estimate, as there are no databases that cover their profession. In particular, those involved in usability work use numerous job labels and educational backgrounds to achieve a similar goal. Thus, data were collected based on non-probabilistic sampling, a valid and common practice in HCI research (Lazar *et al.*, 2010), because it is often not possible to have a strict random sampling.

Potential respondents were contacted through multiple channels, particularly individual e-mail invitations and mailing lists of professional communities (HCI, UXPA, IXDA). In addition, a link to the questionnaire was posted on relevant and active discussion forums (e.g. LinkedIn groups, Google+ communities), and on Twitter, using relevant hash (#) tags. Recipients were asked to forward the invitation to other potential

respondents. To encourage people to respond, we sent reminders and distributed the survey link through trusted authorities in specific communities of the target population. As incentives, we offered the possibility to receive a summary of the findings and an opportunity to win software licenses for mockup drawing and project management.

3.3. Questionnaire design

The survey was pilot-tested following Dillman's (2006) three-stage recommendations, and its final version contained 24 questions. Most of the questions discussed in this paper were adapted from prior surveys, mainly those related to UCD practice. In addition, the author conducted interviews with mobile app practitioners in 10 Finnish firms during January–June 2012. The discussion in these interviews focused on the UCD process in mobile app design and the challenges practitioners face. As such, the interviews (unpublished) helped formulate the survey questions, which were divided into four sections:

(i) Addressing the mobile context—perceived importance of mobile context aspects; use, purpose and perceived effectiveness of data-gathering methods and factors affecting the choice and practice of methods;
(ii) Use and evaluation of the collected data;
(iii) Organizational settings and
(iv) Demographic data

In the closing section, we asked respondents for feedback on the questionnaire and its topic.

The first two sections addressed the respondent's experience from a recent mobile app project. For the sake of clarity, we provided a definition of mobile app as *a software program designed to run on mobile devices, such as a phone or a tablet computer*. The decision to focus on a specific project rather than on app development in general had two aims: to allow for a more descriptive analysis based on particular project and app settings, and to help respondents recall the experience from the project by starting the survey with app-related questions. In all sections, questions that are subject to an order effect were randomized. In addition, skip logic was implemented for selected questions, resulting in an unequal number of respondents for certain questions and question options. Overall, the extent and completion time of the survey was a major concern. The average completion time, excluding outliers, was 14 min, with a standard deviation of slightly <8 min.

The survey was available online for 4 weeks during February–March 2013, receiving a convenience amount of 150 responses. Limited information provided by the survey tool shows that the survey had about 1240 visitors who did not complete it. Noticeably, the number of visitors significantly increased following the distribution of the survey through social media and discussion forums, while the conversion rate was minor (if any). Based on the e-mails received and by closely monitoring the impact of distribution channels, it became clear that individual invitations and mailing lists were the most effective channels to distribute the survey.

3.4. Respondents profile

Responses came from 24 countries, mainly from practitioners based in Finland (39%), the USA (13%), the UK (7%) and Sweden (7%). Lower percentages of respondents came from the Netherlands, Israel, Switzerland, Denmark, Italy, Canada, India, Russia, Spain, France, Germany and Australia. Respondents were asked about their main role in mobile app projects (Figure 1). Most of the respondents work as UX designers (33%), project managers (15%), project owners (9%) and software developers (7%). Project roles in the 'other' category (21%) include various managerial positions (e.g. UX, design and technology), research roles (e.g. user, UX, scientific) and mixed roles, such as UX/UI design. Regarding their UCD background, 42% of respondents have 10 or more years of experience, while the average is 9 years (median = 7, mode = 10, 7 SD). This level of UCD experience gives us confidence that our respondents provided a reliable image of the design practice within their organization. Furthermore, their experience suggests that they are knowledgeable about developments in UCD, particularly with regard to mobile computing.

Respondents were asked about their employment type, industry and user-centeredness orientation. A majority (89%) of the respondents are primarily employed by a company, while the rest (11%) work as freelancers. Figure 2 presents the distribution of respondents by industry sectors. The list of sectors was adapted from prior survey studies (Monahan *et al.* 2008; Rosenbaum *et al.*, 2000; Venturi *et al.*, 2006). Similar to the data in Monahan *et al.* (2008), the largest single sectors are software (28%) and usability/UX consulting (21%). However, the majority of respondents come from diverse industries, of which the other sectors specified by respondents include marketing, combinations of listed sectors (design/UX and software), and sectors with a specific scope (e.g. music, adult, data security).

The respondents work in companies of different sizes. Data collected from those employed by a company ($N = 133$) show that about 26% of companies have 10 or fewer employees, 24% have 11–50 employees, 7% have 51–100 employees, 17% have 101–1000 employees and the remaining 26% have >1000 employees. The median size of companies is 60 and the mode is 5. At face value, the impression exists that the respondents are working typically in the setting in which we would expect them to be active—small, medium and large enterprises, mainly in the software business and usability/UX consulting. Although we cannot claim representativeness, we assume that the respondents represent a common sample for our population.

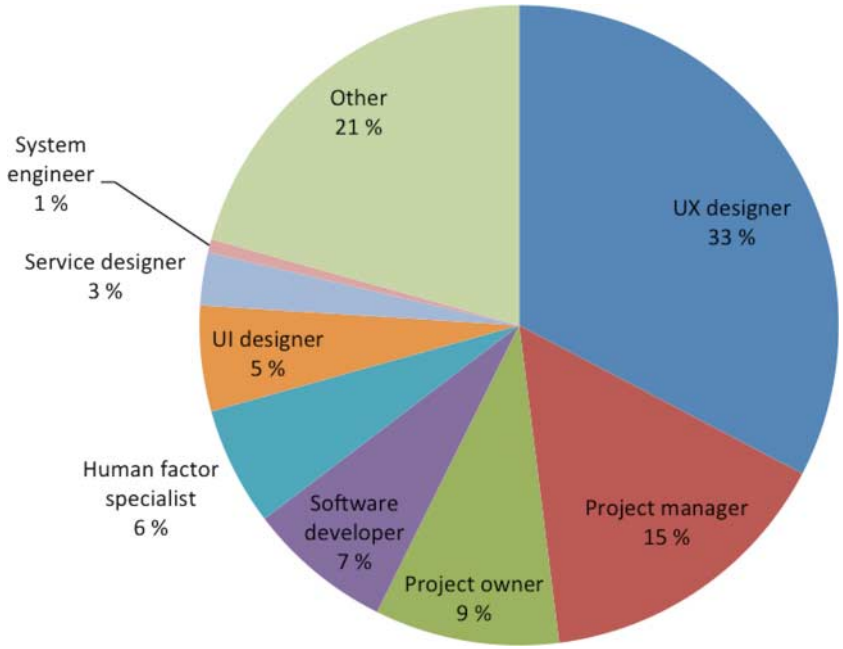

Figure 1. Respondents' role in mobile app projects ($N = 150$).

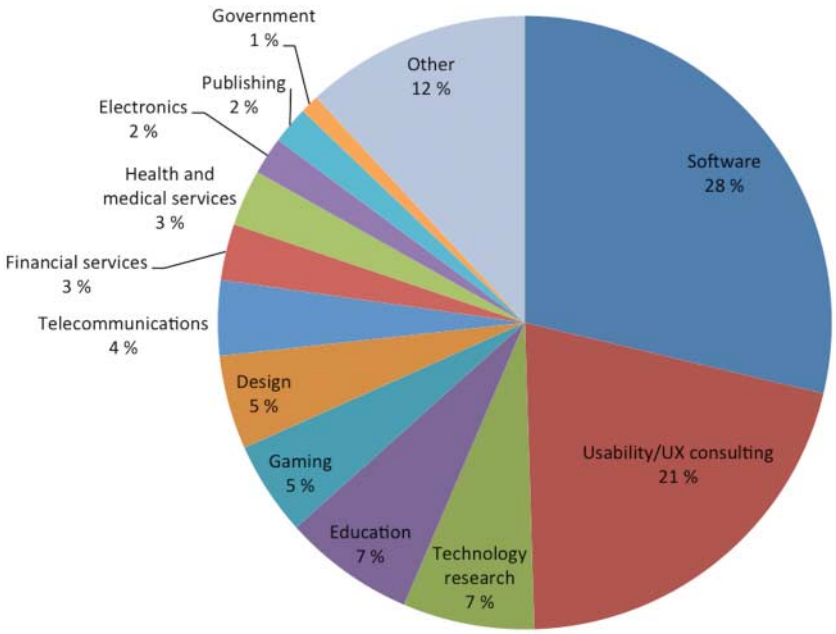

Figure 2. Respondents by industry sector ($N = 150$).

A majority of the respondents (74%, $N = 133$) think that their management takes action to foster a UCD culture. Design-oriented organizations (7 of 7 respondents) and usability/UX consulting (21 of 24) were the most UCD-oriented, while telecommunications (2 of 6) and financial services (1 of 3) were the least. Based on the options provided by Venturi *et al.* (2006), we looked at the funding sources for user studies. Similar to their findings, UCD work is funded primarily as part of the R&D budget (46%), followed by specific project funding (38%) and annual budgets (21%). A mere 10% has more than one source of funding. In the software industry, project funding (40%) is slightly more common than R&D budget (35%).

4. RESULTS

This section contains the study results and is divided into eight subsections: (i) profile of the mobile app projects that respondents were involved in, (ii) the perceived importance of certain context aspects by respondents, (iii) the usage and effectiveness of methods for gathering data, (iv) the purpose of methods, (v) factors that influence the choice and practice of methods, (vi) the number of practitioners involved in carrying out the methods, (vii) the usage of methods to analyze the collected data and inform the design and (viii) the respondents' evaluation of their overall strategy for addressing the context of use. This section provides a descriptive account on the research questions, while the questions are examined further in the discussion section.

4.1. Project profile

Specific circumstances of a project can influence the requirements for, and practice of, data gathering and analysis. In order to contextualize projects, respondents were asked about the software development method (SDM) being used, the type of app being developed and the main users of the app. These questions also helped respondents recall a recent and specific experience of developing a new mobile app.

Selection of SDMs commonly used in software development projects was adapted from Bygstad *et al.* (2008) and from prior (unpublished) interviews with mobile app development teams. The most frequently used formal SDM is Scrum (33%), while a larger group of respondents (39%) use a locally adapted method (Figure 3). In addition to the predefined options, respondents also specified Kanban and general agile approaches. In Bygstad's (2008) survey, which focused merely on the software and IT industry, most companies were also inclined to use their own adjusted method, while only 18% used agile methods. However, by looking at software companies in this survey, the larger portion (45%) uses an agile method (Scrum), followed by an adapted method (38%).

We asked about the type of app being developed, as this can affect the role and relevance of user data. Apps can be classified as utility, productivity and immersive (Ginsburg, 2010). Utility apps were developed by 39% of the respondents, 28% developed productivity apps, 18% focused on developing an immersive experience, such as games and 15% selected other. In the software industry, utility apps were slightly less common than productivity apps (29% and 36%, respectively), while the gaming industry is all about creating an immersive experience. Obviously, some apps would not clearly fit into this limited categorization. Among the other types of apps mentioned by respondents are shopping, social networking, healthcare, banking, communication, travel, music and apps that combine the predefined types. These purpose-based categories more closely reflect the categorization of apps in the app stores.

The type of target users can affect the availability and access to users. We asked respondents to choose between the three types of users that encompass the larger part of potential users: consumers, customers of a company and internal employees. The majority of respondents target the general mobile consumer market (72%), followed by apps for customers of a company (13%) and for internal employees (7%). Thus, the business domain is currently underutilized and we expect it will grow in the future. In the open text option, respondents mentioned a more clearly defined audience, such as students, travelers, football fans, website communities and health patients. The consumer market was the target for 78% of the utility apps and all the immersive experience apps. Most projects (74%) for customers of a company were designed as productivity apps, while apps for internal employees are distributed equally between utility and productivity (5 each).

4.2. Perception of context in the design of mobile apps

Attending to the complexity of the context of use phenomenon and how practitioners comprehend it requires a study of its own. In this study, we examine RQ1 with two questions on practitioners' perception of the phenomenon, as our interest was also in the actual development practices (RQ2). In the first question, we asked respondents to evaluate the importance of contextual aspects to the design of their mobile app. Obviously, attending to all the components included in Table 1 is not feasible, which is why we selected nine aspects that are assumed to be prominent, and used a 5-point scale (1 = not at all important, 5 = extremely important) for their evaluation. In the second question, respondents were asked to describe other contextual aspects that were important to their project.

Overall, the goals of users are perceived, by far, as the most important aspect for the design, followed by how these goals are operationalized in everyday situations—first with the mobile device and then in other daily tasks (Figure 4). Following Bradley and Dunlop (2005), these three aspects can be viewed as the *meaningful* context, while the other aspects are part of the *incidental* context. There appears to be a consensus among industry sectors with regard to the importance of understanding user goals, with fairly balanced scores, ranging between 4.00 and 4.63. The same consensus is clearly seen in the results based on different project profile settings. Respondents who developed apps for consumers ranked mobile device characteristics noticeably higher than daily tasks, likely due to the proliferation of mobile device flavors in the market. The least important aspect is social influence on users, which is the only aspect not directly concerning the actual users and their devices. This view is in contrast with the determining role of social influence on the acceptance and use of mobile services (e.g. Lu *et al.* 2003; Shin, 2007).

While the predefined aspects are relatively general, contributions from respondents were more project-specific. Contextual aspects mentioned as being important by respondents can be

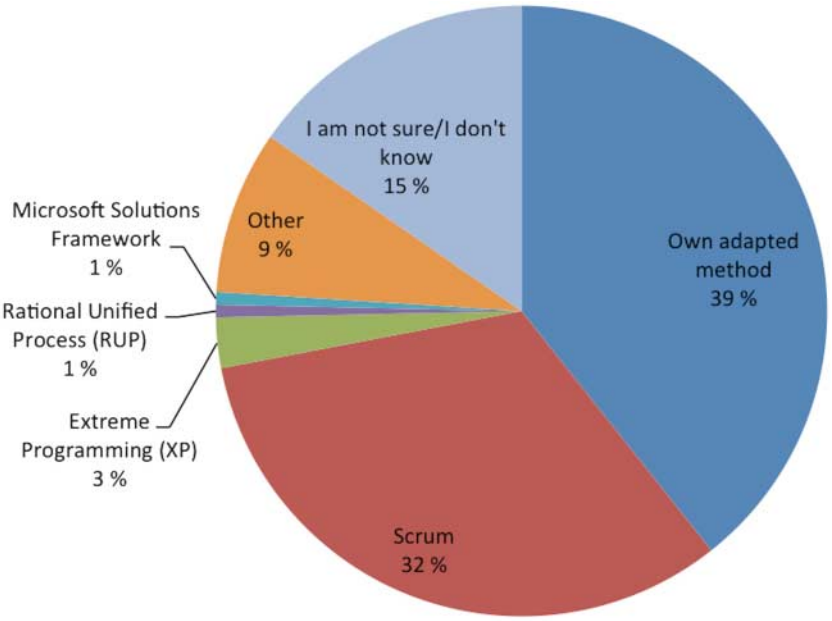

Figure 3. SDM used in mobile app development ($N = 150$).

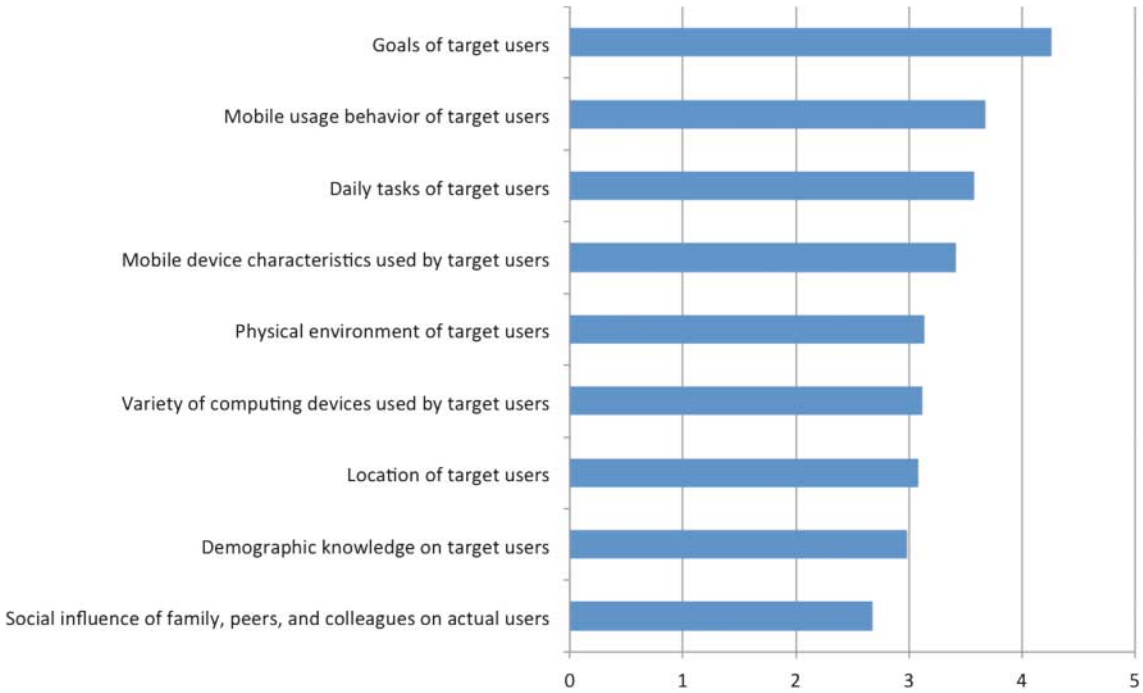

Figure 4. Importance of contextual aspects to the design of mobile app ($N = 150$).

broadly categorized into the components of context in Table 1 (see Table 2, the numbers in parentheses represent the component number in Table 1). Note that aspects such as consumers' purchase behavior are high-level usage descriptions that combine multiple context components. However, most aspects mentioned by the respondents emphasize a micro level of specificity that is relevant to a particular case. Thus, their perception of context highlights the unequal role of contextual components (Jumisko-Pyykkö and Vainio, 2010). Moreover, the range of aspects is an indication of the mesh of technology with ordinary life and the all-inclusive perception of the context of use concept by practitioners.

Table 2. Classification of contextual aspects contributed by respondents.

Contextual aspect by respondents	Context component (from Table 1)
Adaptation ability to new UI	Input device skills and related experience (1.3)
Visual ability for 3D	Physical/cognitive capabilities (1.4)
Attitude towards mobile apps' security	Attitude and motivation (1.4)
GPS reliability	System capabilities (2.1)
Offline availability of data	System network capabilities (2.1)
Consumers' purchase behaviors	Mainly a combination of task context (5) with attitude and motivation (1.4) and the pattern property
Current activity of users	Mainly a combination of the temporal context (4) and task context (5)
Family and peer network relationships	Other persons physically or virtually present (6.1)
Recommenders' behavior and influence	Other persons physically or virtually present (6.1)
Integration of mobile device with car system	Interoperability (7.2)
Implementing a universal UX design on different devices	Informational artifacts and access (7.3)

4.3. Data-gathering methods in the design of mobile apps

4.3.1. Usage and effectiveness of methods

Addressing the contextual aspects that are perceived as important requires a user study in real-life situations, along with analytics on the use of devices. To start examining RQ2, we asked respondents to select the methods by which they gathered data, prior to the app release, about the aspects they perceived as important. A list of methods was adapted from prior studies (Monahan *et al.* 2008; Venturi *et al.*, 2006), focusing on data-gathering methods from actual or potential users (see Figure 5). Note that the word 'method' should be used with caution, as there is enough evidence that the design practice is relatively informal (Fallman, 2003; Rosenbaum *et al.*, 2000; Stolterman, 2008; Venturi *et al.*, 2006).

The most commonly used method is interviews (53%), followed by usability testing (50%) and user observation (43%). Apart from interviews and observations, other context-oriented methods, such as contextual inquiry, participatory design and diary study, were used less frequently compared with focus groups and surveys, which are limited in their consideration of context. Also, field evaluation was used significantly less often than usability testing. Half of the respondents also used data that were collected in previous projects, and one-third used available data from market research. Although these are not formal user-centered methods, they provide a better representation of the practices conducted to understand mobile users. Among other methods mentioned by respondents are the use of analytical tools (both on web and mobile), experts' evaluation, domain experts, benchmarking, and netnography (e.g. Facebook, Twitter). Overall, 85% of respondents used more than one method (mean ~4 methods, median 4; mode 5).

Respondents from usability/UX companies ($N = 32$) tend to favor more the studies in realistic environments and active involvement of users compared with respondents from software companies ($N = 44$). For instance, 44% of the usability/UX consultants used a contextual inquiry compared with only 9% of those in the software industry; the figures for participatory design are 25% and 9%; for user observation are 59% and 34%; for interviews are 62% and 48%; for field evaluation are 34% and 20%; and for usability testing are 59% and 45%, respectively. In contrast, 30% of the practitioners working in the software industry rely on focus groups, while only 16% in the usability/UX consulting companies. On average, respondents from the software industry use three methods to gather data, while respondents from UX consulting companies use four methods.

Because many in the software industry indicated they used Scrum as SDM, the propensity toward the less realistic environment is noticeable also among Scrum respondents ($N = 49$). For instance, they favored focus group (39%) over user observation (33%), while the figures for respondents using their own methods ($N = 59$) are 24% and 58%, respectively; Scrum respondents also conducted a contextual inquiry less often (14%) than those using their own methods (24%). In addition, in most cases, external user studies (52%) were outsourced by Scrum respondents. Essentially, respondents who use Scrum tend to be more time-conscious, likely due to the sprint cycles established in the Scrum process.

Having selected the methods, we asked respondents to evaluate their perceived effectiveness on a 5-point scale (1 = not at all effective, 5 = extremely effective). Note that a total of 11 respondents marked that they did not gather data, and hence were not asked to answer further questions about data gathering and analysis. Respondents could rate only the methods they previously selected. Consequently, the number of evaluators of each method is equal to the number of respondents for that method. The most effective methods for gathering data in mobile computing are perceived to be participatory design, usability testing and field evaluation, followed by user observation, interviews, contextual inquiry and diary studies (Figure 5). Noticeably, the perceived effectiveness of methods does not directly correspond to how often they are used. In addition, the

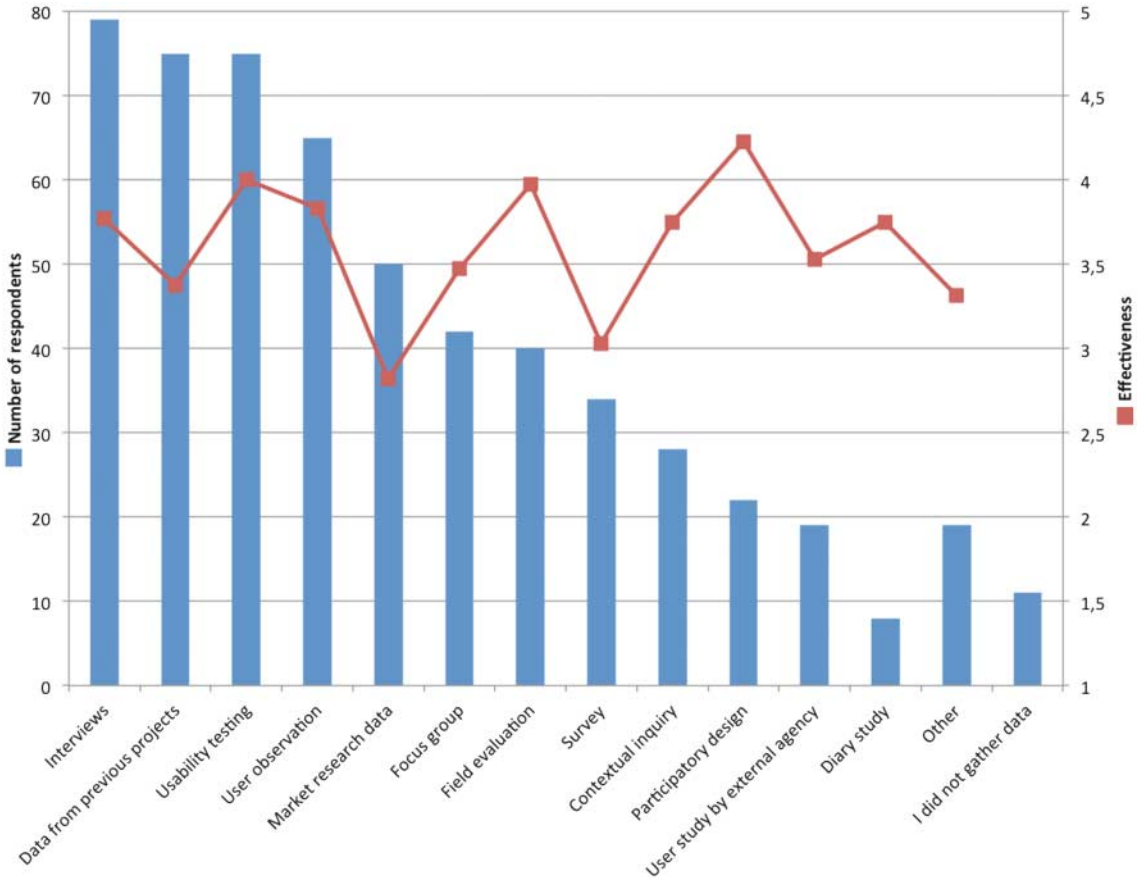

Figure 5. Usage ($N = 150$) and effectiveness ($N = 139$) of data-gathering methods.

most effective methods are characterized by active involvement of users throughout the UCD process and by attention to the external context (bar usability testing). Earlier studies (Monahan *et al.* 2008; Rosenbaum *et al.*, 2000; Vredenburg *et al.* 2002) also found various types of field methods and usability evaluations to be the most effective, while highlighting the discrepancy between the usage of methods and their rating of effectiveness. This suggests that other factors may play a role in method selection.

4.3.2. Purpose of methods

To start with, we asked respondents to choose the purposes for each method they previously selected. The options (see Figure 6) are based on Monahan *et al.* (2008) and to a large extent reflect the significance of the use context throughout the design practice. Understanding the purpose can help explain how respondents address the context of use throughout the UCD process. The total number of responses exceeds the actual usage of methods, because respondents could select multiple options (Figure 6). Understanding context is the main purpose for going to the field, for instance, with user observation, contextual inquiry and diary studies, as well as with external user studies. In addition, respondents often use data from previous projects and from market research to understand context. While this type of data is easily available, respondents did not find it very effective, especially in the case of market research data, most likely because of the general nature of the data rather than being specific for the project case. Overall, the fairly high percentages for 'understanding context' in most other methods indicate on the all-inclusive notion of the 'context' label.

To gather requirements, respondents primarily use interviews, focus groups, surveys and participatory design. Usability testing and field evaluations are obviously selected for evaluation purposes. Although both evaluation methods are perceived as equally and highly effective, field evaluation has a dual purpose and is increasingly used to interpret the context of use. The results are mostly in line with Monahan *et al.* (2008), highlighting the multipurpose nature of methods such as user observation, contextual inquiry, interviews, field evaluation and participatory design. These methods were also perceived as being fairly effective, although some are not frequently used.

4.3.3. Factors influencing the choice and practice of methods

To better understand why some methods are more commonly used, we asked respondents to evaluate selected factors with regard to their influence on the method being chosen. The

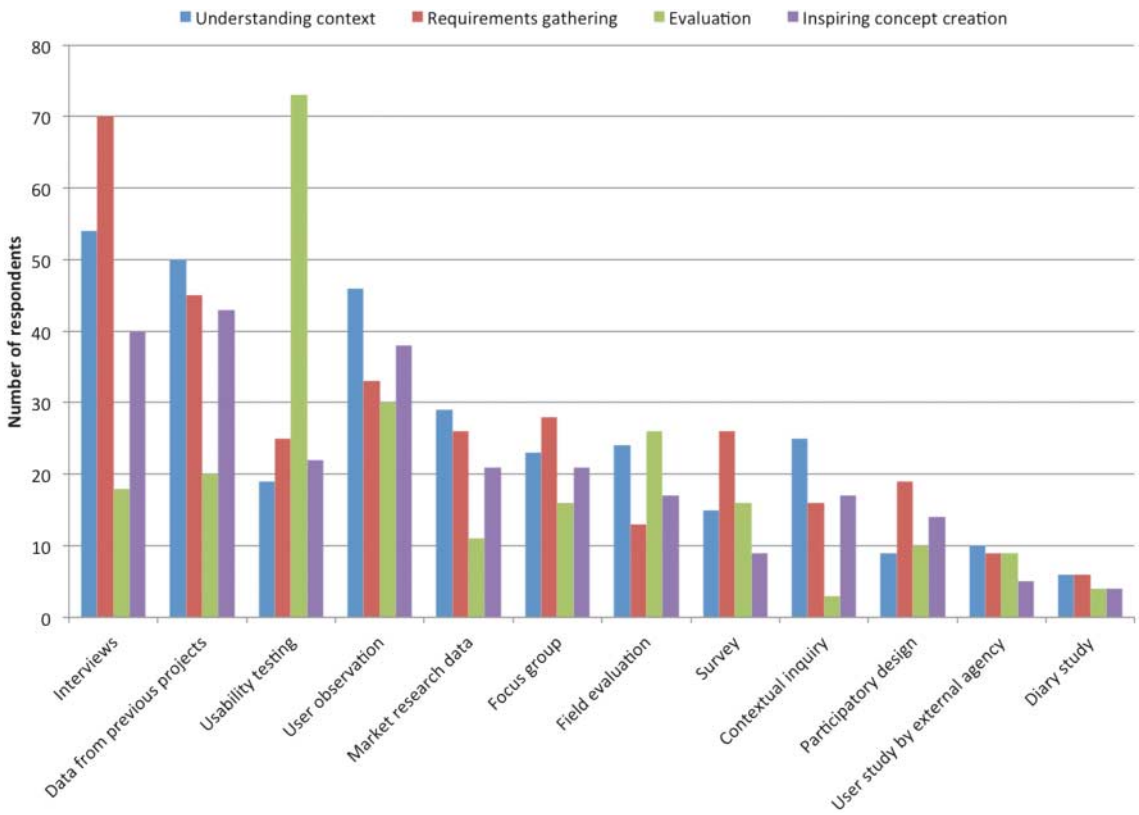

Figure 6. Purpose of data-gathering methods ($N = 139$).

factor options (see Figure 7) were derived from prior studies (e.g. Bygstad *et al.*, 2008; Monahan *et al.* 2008; Rosenbaum *et al.*, 2000) and from our prior (unpublished) interviews with mobile practitioners. A 5-point scale was used for the evaluation (1 = not at all influential, 5 = extremely influential). Overall, respondents choose methods based on their own experience, highly taking the project time and budget constraints into account (Figure 7). The same resource constraints were observed by previous studies (Monahan *et al.* 2008; Rosenbaum *et al.*, 2000) as the most influential factors. Clearly, employed SDM has the least influence, which is also evident from the relatively homogeneous ratings of respondents who used different SDMs. In the software industry ($N = 40$), project budget and the development phase are the most influential factors on method selection. Factors mentioned by respondents include client budget and schedule, geographical scope of users (global/local), research aim, a balanced set of qualitative and quantitative methods and availability of data from previous research.

In addition, we were interested in the factors that influence the expected results of data-gathering methods (i.e. impact on the actual practice). We used a similar set of factors as in the previous question (Figure 7). Like with the selection of methods, time constraints are again the most influential factor. However, during the implementation of the method, the competences of practitioners become slightly more instrumental than the allocated budget. This emphasizes the importance of understanding the intricacies of mobile context and the know-how in approaching it.

4.3.4. Number of practitioners

To complement the account of data collection, we asked respondents to specify the number of practitioners involved in data-gathering methods. A majority of respondents (62%) reported that 1–3 practitioners were involved in data gathering, with 24% involving 4–6 people, and the remaining 14% involving ≥10 practitioners (no counts for 7–9 practitioners). On average, six practitioners are involved in data gathering, while the median and mode are three. On average, usability/UX companies employ 1 practitioner more than in the software sector.

4.4. Usage of methods for data analysis and informing the design

Having respondents specify how they collect user data, we were interested in how they make sense of user data for designing the app. A list of common data analysis methods

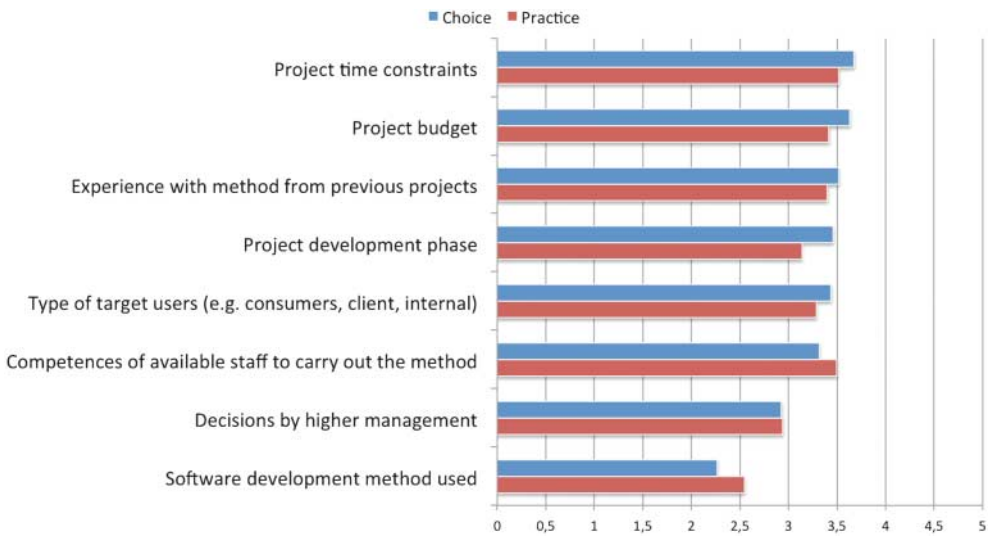

Figure 7. Factors influencing the choice and practice of methods ($N = 139$).

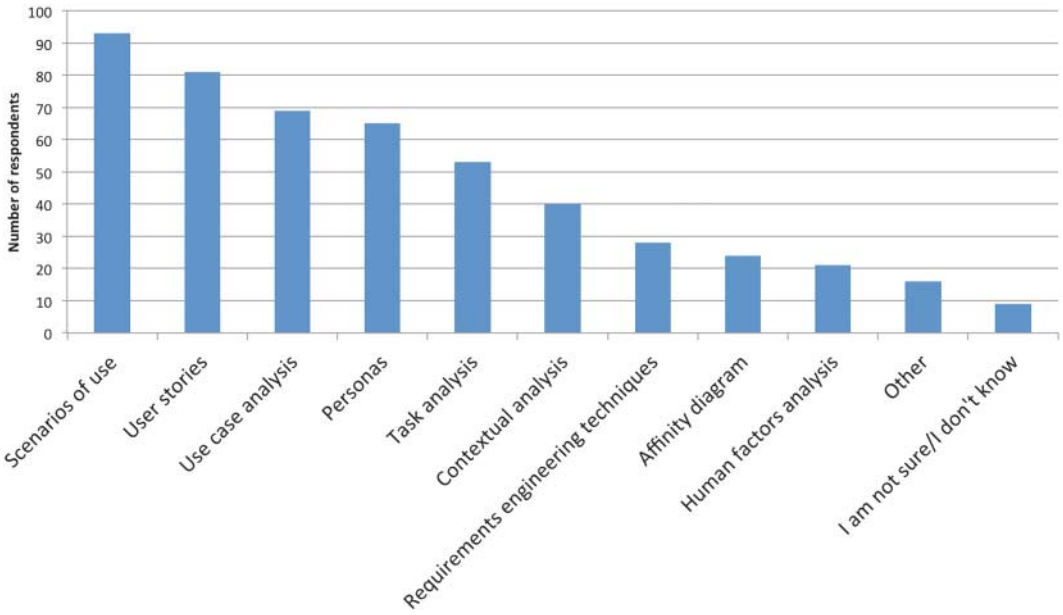

Figure 8. Usage of methods for data analysis and design ($N = 139$).

was adapted from Venturi *et al.* (2006). The most commonly used methods are scenarios, user stories, use case analysis and personas (Figure 8). Compared with Venturi *et al.* (2006), there is a clear reduction in the use of contextual analysis and requirements engineering, which may have to do with the time constraints of mobile practitioners. This is also emphasized by the popularity of the lightweight user stories. Respondents who used Scrum as SDM ($N = 45$) most frequently used user stories (71%). Comprehensive analysis methods, such as contextual analysis and affinity diagrams, are notably more prevalent in usability/UX companies ($N = 31$) compared with the software industry ($N = 40$). In addition, respondents from UX companies, on average, use four methods (from the list we provided and the methods specified by the respondents), while their counterparts in the software industry use three methods on average. A further analysis of project settings shows that task analysis is often used in projects for internal employees ($N = 8$, 62%) and in projects for productivity apps ($N = 40$, 50%). The former have a more clearly defined audience and set of tasks to support, while the latter requires greater attention to task navigation and execution on the UI. In addition to the methods provided, respondents also used user journey maps,

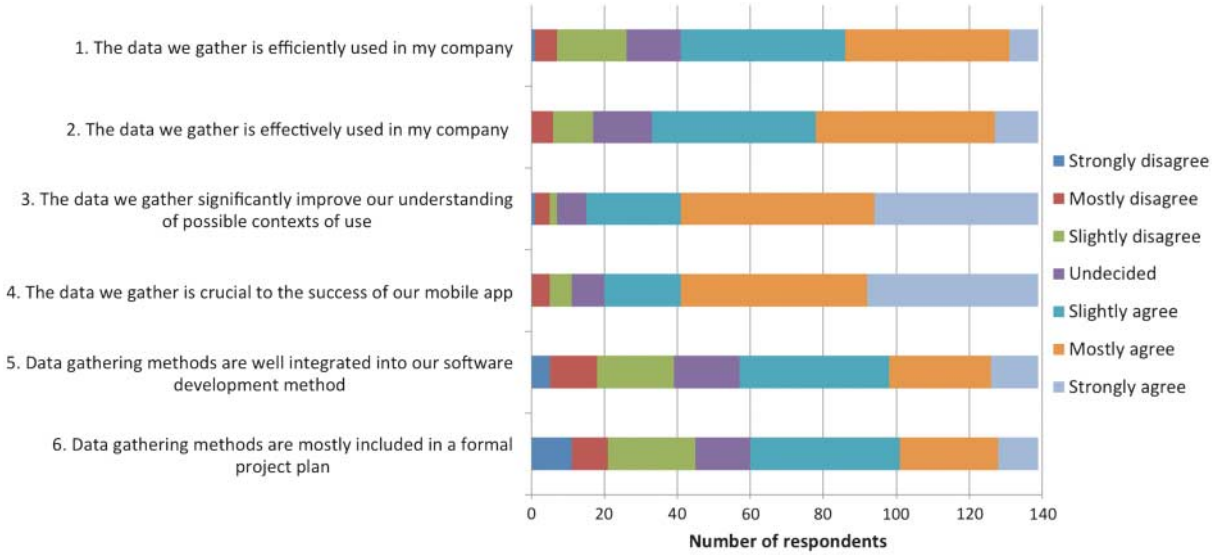

Figure 9. Evaluation of data-gathering strategy ($N = 139$).

impact maps and concept models that provide a more holistic view for the design space.

4.5. Evaluation of data collected and data-gathering strategy

During the design and development process, practitioners commonly use multiple methods to collect and analyze different types of data from various sources. Hence, we asked respondents to evaluate, through the extent they agreed with certain statements, their usage of the data they gathered (Figure 9). For the major part of the analysis, we divided the respondents of each statement into two groups: the 'agree-ers', those who strongly, mostly or slightly agree with the statement, and the 'disagree-ers', those who strongly, mostly or slightly disagree with the statement. The undecided were not included in the analysis.

With regard to the statements on the efficient and effective use of data (statements 1 and 2, Figure 9), respondents tend to slightly agree with the statements. Respondents from usability/UX companies ($N = 31$) appear to be more cost-effective in their usage of data compared with those in the software industry ($N = 40$). We further analyzed the data by dividing respondents into a cost-effective group, the 'agree-ers' on the efficiency and effectiveness usage of data ($N = 91$), and a cost-ineffective group, the 'disagree-ers' on the efficiency and effectiveness usage of data ($N = 13$). In the cost-ineffective group, about one-third of the respondents work in the software industry, although none of them belong to usability/UX companies. Respondents from the cost-effective group have, on average, 10 years of experience with UCD compared with 6 years for respondents in the cost-ineffective group.

Respondents from the cost-effective group on average, use four methods for data gathering and four for data analysis, while the figures for the cost-ineffective group are three and two, respectively. The cost-effective group has more freedom in selecting methods based on practitioners' experience, while the quality of the outcome depends on their competences. In contrast, the selection of methods by the cost-ineffective group, as well as the outcome, is influenced very much by decisions from higher management. Consequently, data-gathering methods used by the cost-effective group address the context of use throughout the entire UCD, while the cost-ineffective group mainly relies on late usability testing. Using more methods while adhering to time constraints may require more practitioners. Accordingly, an average of six practitioners are involved in data-gathering methods in the cost-effective group, compared to three in the cost-ineffective group.

With regard to methods for data analysis, the cost-ineffective group is noticeably lacking in the use of structured analysis methods, such as contextual analysis, affinity diagram, requirements engineering and task analysis, mainly counting on scenarios and lightweight user stories. In addition, only 23% of the respondents from the cost-ineffective group explicitly specify their target users with personas, compared with 56% in the cost-effective group. Methods specified by respondents, such as user experience journeys, impact maps and creating concept models, were also exclusively used by those in the cost-effective group, indicating a broader knowledge of methods for analysis and design.

There is a fairly high level of agreement among respondents that the gathered data significantly improve the understanding of the context of use (statement 3, Figure 9, $N = 124$ for 'agree-ers') and that the data are crucial to the success of the mobile app

(statement 4, Figure 9, $N = 119$ for 'agree-ers'). Because of the low number of 'diagree-ers', no further analysis was carried out between the groups.

Respondents agreed to a lesser extent with regard to the integration of data-gathering methods into the SDM being used (statement 5, Figure 9), although most respondents are positive on this issue. A cross-tabulation between the 'integrated' group—the 'agree-ers' who believe that their data-gathering methods are well integrated into the SDM ($N = 82$)—and the 'disintegrated' group—the 'disagree-ers' who believe that their data-gathering methods are not well integrated into the SDM ($N = 39$)—found no major differences in the SDM being used. Regarding the methods used to gather data, user observation was used by 54% of the respondents in the 'integrated' group, compared with 38% of those in the 'disintegrated' group, while the other methods show fairly similar usage frequencies. However, the 'disintegrated' group perceived the effectiveness of most methods to a lower degree than the 'integrated' group, which may indicate issues that influence the implementation of methods. Looking at the factors that affect the choice and use of methods, the 'disintegrated' group is mainly influenced by budget and time constraints, and by the development phase. In contrast, the 'integrated' group has greater flexibility to carry out methods based on their experience and know-how. Moreover, 82% of the respondents in the 'integrated' group specified that their management takes action to foster a UCD culture, against 66% of respondents in the 'disintegrated' group. To summarize, these insights suggest that the integration of methods into the SDM is largely influenced by managerial decisions and the institutionalization of usability practice in the company, rather than by the SDM being used.

Dividing respondents into those who included data-gathering methods in a formal project plan (statement 6, Figure 9, $N = 79$ for 'agree-ers') and those who are less likely to do so (statement 6, Figure 9, $N = 45$ for 'disagree-ers') shows quite similar trends to the 'integrated' and 'disintegrated' groups, respectively.

5. DISCUSSION

In this section, we examine the results in light of the research questions: the perceived importance of contextual aspects and the extent to which the methods address the context of use. In addition, we discuss the limitations of the study.

5.1. Perceived importance of context aspects

The term context is a commonly used label in everyday language to express meanings that are different from those used in HCI literature. Consequently, the common use of the term has implications for how practitioners understand the concept. As far as we know, this exploratory study is the first to highlight practitioners' perception of the mobile context of use. As such, we did not provide a definition of context, to prevent any bias. Studying the perception of practitioners is necessary to understand how they approach the context of use. In addition, it can help identify possible gaps between research and practice.

Using the context of use model (Table 1) to examine the respondents' perception of contextual aspects shows there is a clear inclination toward user aspects (goals, skills, attitude and motivation), as well as a combination of the task and temporal contexts with the pattern property (usage behavior, daily tasks, current tasks and purchase behavior). These aspects are directly related to the user's goals and actions, or the 'meaningful context' (Bradley and Dunlop, 2005). In addition, the system component is also influential, likely due to the rapid growth in mobile platforms and devices. The underlying external contextual aspects, such as the physical, social, technical and informational contexts, are generally perceived as being less important, although specific characteristics can be prominent depending on the case in question. Although external aspects are instrumental to determine goals and their consequent actions (Bradley and Dunlop, 2005), practitioners are more concerned with the actual practice rather than with the specific modifiers of practice. Understanding the intentions of users can only be achieved by questioning them during the course of action (Svanæs, 2001), while discerning meaningful usage behavior and daily tasks require a long-term study. Hence, practitioners' preferences support the need for ethnographic-like methods that span both space and time. However, the results show that these contextual aspects are only partly addressed.

The fragmentation of the mobile market can affect efforts to address the context of use. The proliferation of mobile devices in the market is a major concern for practitioners, particularly those who develop apps for the consumer market. The mobile market is increasingly fragmented in terms of devices' platforms, OS versions, screen sizes and resolutions. Supporting the development of native apps for multiple platforms requires the allocation of resources throughout the design and development process, which can have a negative impact on efforts to address the holistic context of use. Technical solutions, such as cross-platform development tools and HTML5, facilitate the development of apps for multiple platforms by using web technologies (Charland and Leroux, 2011). However, based on our prior (unpublished) interviews with mobile practitioners, native apps were preferred for the superior experience and performance they provide.

Finally, the social aspect was perceived as being the least important, which is in contrast with the prominence of social aspects to the mobile context as observed by specific user studies in different circumstances (e.g. Tamminen *et al.* 2004; Wigelius and Väätäjä, 2009) and by consumer studies (e.g. Shin, 2007). A likely reason for this discrepancy is that social aspects, unlike more objective aspects such as technical or temporal-spatial, are more difficult to comprehend in definite terms, including their design implications (Kjeldskov and Paay, 2010). It is also possible that the social scope we used in the question was simply

not relevant to the projects in question. Our scope is supported by consumer surveys, which refer to the social influence as a normative pressure from people who are important to the user (e.g. Shin, 2007) rather than merely people who are in the physical proximity to the user (e.g. Bradley and Dunlop, 2005). We suggest a further exploration of the social construct and how practitioners address social aspects.

Essentially, practitioners' perception of contextual aspects is an integral part of addressing the context of use that can help shed more light on the usage of methods. This study presents a combined model to examine the mobile context of use (Table 1) and a first view on how practitioners perceive the importance of certain context aspects. As such, the model and insights should be used as a basis for development in future studies and in better understanding the design practice of mobile practitioners. Moreover, examining practitioners' context perception in light of the major factors that influence their practice, namely time and budget constraints, suggests there may be an important gap that needs to be explored in future studies between the practitioners' actual and ideal design practice. Such information can further help explain the motivations for the current state of the practice.

5.2. Addressing the context of use

Overall, we found that addressing the context of use takes place at an early phase of gathering and specifying requirements, while there is a lack of consideration for the external context in evaluations. While interviews are a commonly used tool in field studies, they are most appropriate for fixed contexts rather than the dynamic mobile contexts. However, when combined with user observation, interviews can better capture the dynamic context, provided that observations are conducted over longer term. A more prominent lack of context is found in evaluations. The respondents' clear preference for usability testing over field evaluations means that situational aspects, such as spatial, social, technical aspects and experience over time, are not taken into consideration sufficiently during the evaluations of a mobile app. Therefore, we can conclude that the context of use is only partly addressed in mobile computing, particularly during the early phase. The results show that the methods most commonly used by mobile practitioners are fairly similar to those found in previous studies that did not focus on mobile computing (e.g. Monahan *et al.* 2008; Venturi *et al.*, 2006). A key to addressing the mobile context is to use methods that attend to the temporal aspect, in other words methods that span over time.

Ironically, the major obstacle to addressing the mobile context is that of time constraints. Respondents rarely used methods that allow for studies over time and space, such as participatory design, field evaluations and diary studies. Those respondents who did use these methods perceived them as being highly effective. However, resource constraints, especially in terms of time and budget, dominate the selection and use of methods. This is an indication of the cost–benefit trade-off mentioned earlier (Vredenburg *et al.* 2002), in which the efforts, especially in terms of time, to gather user and context data are offset implicitly against the expected benefits. As is evident from the results, previous experience with certain methods plays a determinant role in setting these value expectations. The cost–benefit trade-off is also evident in the methods being used for data analysis. The more comprehensive analysis methods are used significantly less frequently, although they were more common among those who had a cost-effective strategy. Bergvall-Kåreborn and Howcroft (2011), in a recent qualitative study of mobile developers, also emphasized the time pressure practitioners face on a daily basis, stating that it is largely influenced by the highly competitive market and the importance of being the first with a novel application. Consequently, we suggest attending to time constraints, as a first proposition in directing the improvement of methods that are perceived to be effective, such as field evaluations, contextual inquiry, participatory design and diary studies.

Some researchers may experience a sense of déjà vu. Indeed, Rosenbaum *et al*. (2000) already urged researchers to examine ways to increase the use of participatory design and other field studies. Hagen *et al.* (2005) highlighted the importance of longitudinal studies in understanding the actual use of technology. More recently, Monahan *et al.* (2008) extensively discussed necessary improvements to field methods, including in methodologies, tools for data collection and analysis, adaptability of methods to specific project cases, awareness of the value of field methods and the know-how needed to implement the methods. Our study is the first to confirm these shortcomings in the truly mobile era, also highlighting the gap between the design practice in scientific research and in industry.

This gap has been discussed (e.g. Goodman *et al.*, 2011; Stolterman, 2008) and is derived from the fundamentally different objectives and work circumstances of the two traditions. Stolterman (2008) points out, for instance, that scientific research traditionally aims at the formulation of theoretical, reproducible and generalizable knowledge, to explain the reality in a way that is unaffected by the researcher. By contrast, design practitioners aim at creating a unique and 'ultimate particular' reality that represents their own wishful beliefs; while in research a limited-scope study can contribute to the accumulation of knowledge, in the design practice the outcome must attend to the whole complexity of the design problem; consequently, in their work, design practitioners are more limited in their time, budget and information resources, which directly affects their design practice; Finally, researchers are evaluated based on their methodological conformance and performance, while designers are assessed based on the their end result.

Hence, to attend to the gap and scientifically support designers in their work practice, Stolterman (2008) advocates a 'careful and detailed studies of existing interaction design practice … research that examines, uncovers, analyzes, and interprets what interaction designers are already doing' (p. 62) in

actual commercial cases. An example of such study is described in Goodman *et al.* (2011). Based on the tools, techniques and concepts that are already being used by designers, Stolterman (2008) also records some possible types of contribution that are more likely to be used by designers. As mentioned above, our survey merely provides a 'snapshot' of the phenomena. Nevertheless, it highlights the need for tools that support designers in the rapid collection (including in evaluations) and interpretation of relevant data about the context of use. A possible direction for future studies is to examine the use of gamification during the design practice. Games with a purpose, or serious games, are useful in generating large amounts of data in a short time, and thus may facilitate the collection of relevant contextual data. We also stress the need to disseminate the experience with techniques and their how-to through social media channels and publicly accessible websites, which are more likely to be followed by practitioners in the industry.

As far as mobile practitioners are concerned, our results show that field-oriented methods, with active user participation, are generally perceived as being more effective. In particular, respondents who had a cost-effective strategy to address the mobile context-rated participatory design and diary studies as the most effective methods. Interestingly, these methods also attend to the temporal aspect of context by allowing studies over time. In addition, understanding the holistic context requires a combination of data-gathering methods, each may have strengths on specific contextual aspects. For instance, diary studies are often complemented with interviews for the purpose of interpretation. A similar triangulation of methods was observed in the data analysis methods, emphasizing the explicit specification of target users and their major tasks. For evaluation purposes, both usability testing and field evaluations are seen as highly effective. Overall, we found a cost-effective strategy to address the mobile context to include a broader spectrum of methods throughout the entire UCD process. Attending to the time constraints, companies can benefit by using more experienced practitioners in addressing the mobile context.

5.3. Limitations

Like with most surveys of this type, we cannot guarantee that the results represent a random sample of the population involved in the design and development of mobile apps. In particular, practitioners based in Finland dominate the results, although their answers were found to be fairly similar to those of the other respondents. In addition, software developers were underrepresented in the results. Nevertheless, based on the number of respondents, their UCD experience and position within the organization, and respondents' distribution in terms of business sectors and company sizes, we assume that our findings are generalizable.

Another shortcoming is that the results are based on the respondents' reflection rather than on actual practice. We facilitated this issue by focusing on respondents' experience with specific and recent projects. In addition, we targeted practitioner groups with a varied understanding of usability and its methods, which may have affected their answers. To gain more insight and increase the reliability of the results, we will further carry out qualitative studies with mobile practitioners in the industry.

We also acknowledge a shortcoming in attending to the main topic of context of use due to the limitations of using a survey-like study. First, UX perception and its specific methods were beyond the scope of this study, except as part of the UCD. We do believe that there is a need to explore the state of UX practice in mobile computing. Secondly, the survey findings are largely quantitative in nature, which limits the extent to which certain practice-related issues can be explained. In a follow-up qualitative study, we will take a closer look at mobile practitioners' '*activities*, *experiences*, and *contexts* of practice' (Goodman *et al.*, 2011).

6. CONCLUSION AND FUTURE WORK

This paper examined how the context of use is addressed in mobile computing. We used an online survey tool to collect data from 150 mobile practitioners, mainly in the roles of UX designer or project manager. The results of our study offer a valuable contribution to HCI knowledge, as they provide the first view on the state of UCD practices within mobile computing and, in particular, in a truly mobile era. Furthermore, we approached the study from the context of use perspective, being a core element of UCD as well as the main aspect distinguishing mobile from stationary computing. The context of use was analyzed based on an extensive model of the mobile context, which was adapted from prior studies. Our basic assumption was that mobile practitioners are not well equipped to address the intricacies of the mobile context.

Our results show that the perception among practitioners with regard to the mobile context is focused mainly on the goal-driven 'meaningful context'. Due to its prominent role, our further qualitative studies would examine how practitioners define and operationalize these goals in their design. In addition, practitioners commonly used UCD methods during the design and development of mobile apps, which echoes the practice observed in previous studies, even though they did not focus on mobile computing. That is to say, mobile practitioners, especially in software companies, rely on methods that are more suitable for a stable context rather than for a truly mobile context. Nevertheless, the methods that were commonly used at an early phase can be suitable to address the context of use, providing that they include a temporal perspective. However, a greater lack of context-related considerations is noticeable in evaluations, where usability testing dominates the practice. Overall, methods with active user involvement and field orientation were perceived as being more effective.

Taking this into account, together with the considerable resource constraints, especially in terms of time and budget, we reemphasize the need to improve the utility and awareness of ethnographic-like methods, as suggested in earlier studies.

Because it is a core element of system design, understanding the context of use is crucial to practitioners in the new mobile era. Examining the state of the practice in a survey study is only a first step that provides results on a very high level. In future research, we aim to continue this line of inquiry by conducting interviews with mobile practitioners. This ecological approach will seek a deeper understanding of the design practices and environments in specific industry cases, particularly focusing on issues related to practitioners' interpretation of mobile users and the mobile context of use.

ACKNOWLEDGEMENTS

The authors thank the reviewers and the editor for their invaluable constructive comments on earlier versions of the article. We also wish to thank Balsamiq Studios and Rally Software for giving away a few licenses of their software to motivate participation in the study.

FUNDING

This research was funded by Turku Centre for Computer Science (TUCS).

REFERENCES

Bannon, L. (1986) Issues in Design: Some Notes. In Norman, D.A. and Draper, S.W. (eds), User Centered System Design, pp. 25–29. Lawrence Erlbaum Associates, Hillsdale, NJ.

Baur, D., Hering, B., Boring, S. and Butz, A. (2011) Who Needs Interaction Anyway: Exploring Mobile Playlist Creation from Manual to Automatic. In Proc. 16th Int. Conf. Intelligent User Interfaces, Palo Alto, CA, USA, pp. 291–294. ACM.

Bergvall-Kåreborn, B. and Howcroft, D. (2011) Mobile applications development on Apple and Google platforms. Commun. Assoc. Inform. Syst., 29, 565–580.

Bevan, N. and Macleod, M. (1994) Usability measurement in context. Behav. Inform. Technol., 13, 132–145.

Beyer, H. and Holtzblatt, K. (1997) Contextual Design: Defining Customer-centered Systems. Morgan Kaufmann.

Bouwman, H., Reuver, M., de, Heerschap, N. and Verkasalo, H. (2013) Opportunities and problems with automated data collection via smartphones. Mobile Media Commun., 1, 63–68.

Bradley, N.A. and Dunlop, M.D. (2005) Toward a multidisciplinary model of context to support context-aware computing. Hum. –Comput. Interact., 20, 403–446.

Brandt, J., Weiss, N. and Klemmer, S.R. (2007) txt 4 l8r: Lowering the Burden for Diary Studies Under Mobile Conditions. In CHI'07 Extended Abstracts on Human Factors in Computing Systems, San Jose, CA, USA, pp. 2303–2308. ACM, New York, NY.

Bygstad, B., Ghinea, G. and Brevik, E. (2008) Software development methods and usability: perspectives from a survey in the software industry in Norway. Interact. Comput., 20, 375–385.

Calvary, G., Coutaz, J., Thevenin, D., Limbourg, Q., Bouillon, L. and Vanderdonckt, J. (2003) A unifying reference framework for multi-target user interfaces. Interact. Comput., 15, 289–308.

Charland, A. and Leroux, B. (2011) Mobile application development: web vs. native. Commun. ACM, 54, 49–53.

Consolvo, S. and Walker, M. (2003) Using the experience sampling method to evaluate ubicomp applications. Pervasive Comput. IEEE, 2, 24–31.

Cooper, A. (1999) The Inmates are Running the Asylum–Why High-Tech Products Drive Us Crazy and How to Restore the Sanity. Sams, Indianapolis, IN.

Coursaris, C.K. and Kim, D.J. (2011) A meta-analytical review of empirical mobile usability studies. J. Usability Stud., 6, 11:117.

Dey, A.K. (2001) Understanding and using context. Personal Ubiquitous Comput., 5, 4–7.

Dillman, D.A. (2006) Mail and Internet Surveys: The Tailored Design Method (2nd ed.). Wiley, New York, NY.

Dix, A., Rodden, T., Davies, N., Trevor, J., Friday, A. and Palfreyman, K., (2000) Exploiting space and location as a design framework for interactive mobile systems. ACM Trans. Comput.–Hum. Interact., 7, 285–321.

Dourish, P. (2004) What we talk about when we talk about context. Personal Ubiquitous Comput., 8, 19–30.

Fallman, D. (2003) Design-oriented Human–computer Interaction. In Proc. SIGCHI Conf. Human Factors in Computing Systems, Ft. Lauderdale, Florida, USA, pp. 225–232. ACM, New York, NY.

Fling, B. (2009) Mobile Design and Development: Practical Concepts and Techniques for Creating Mobile Sites and Web Apps. O'Reilly Media, Inc., Sebastopol, CA.

Forman, G.H. and Zahorjan, J. (1994) The challenges of mobile computing. Computer, 27, 38–47.

Ginsburg, S. (2010) Designing the iPhone User Experience: A User-centered Approach to Sketching and Prototyping iPhone Apps. Addison-Wesley Professional.

Goodman, E., Stolterman, E. and Wakkary, R. (2011) Understanding interaction design practices. In Proc. SIGCHI Conf. Human Factors in Computing Systems, Vancouver, BC, Canada, pp. 1061–1070. ACM, New York, NY.

Gould, J.D., Boies, S.J. and Ukelson, J. (1988) How to design usable systems. Handbook Human–Computer Interact., 2, 231–254.

Gould, J.D. and Lewis, C. (1985) Designing for usability: Key principles and what designers think. Commun. ACM, 28, 300–311.

Greenberg, S. (2001) Context as a dynamic construct. Hum.–Comput. Interact. 16, 257–268.

Gulliksen, J., Boivie, I., Persson, J., Hektor, A. and Herulf, L. (2004) Making a difference—a survey of the usability profession in Sweden, pp. 207–215. ACM Press.

Gunther, R., Janis, J. and Butler, S. (2001) The UCD Decision Matrix: How, When, and Where to Sell User-Centered Design into the Development Cycle. http://www.ovostudios.com/upa2001/

Hagen, P., Robertson, T., Kan, M. and Sadler, K. (2005) Emerging Research Methods for Understanding Mobile Technology Use. In Proc. 17th Australia Conf. Computer-Human Interaction: Citizens Online: Considerations for Today and the Future, Canberra, Australia, pp. 1–10. Computer-Human Interaction Special Interest Group (CHISIG) of Australia, Narrabundah, Australia.

Hassenzahl, M. and Tractinsky, N., (2006) User experience—a research agenda. Behav. Inform. Technol. 25, 91–97.

Hinman, R. (2012) The Mobile Frontier. Rosenfeld Media.

Hudson, W. (2000), May 3. User-Centered Survey Results. Message posted to CHI-WEB@ACM.ORG, archived at http://listserv.acm.org/scripts/wa-ACMLPX.exe?A2=ind0005A&L=CHI-WEB&F=&S=&P=9056

Hulkko, S., Mattelmäki, T., Virtanen, K. and Keinonen, T. (2004) Mobile Probes. In Proc. Third Nordic Conf. Human–Computer Interaction (NordiCHI), Tampere, Finland, pp. 43–51. ACM, New York, NY.

ISO. (1998) ISO 9241-11:1998 Ergonomic Requirements for Office Work with Visual Display Terminals (VDTs)—Part 11: Guidance on Usability. International Organization for Standardization, Geneva.

ISO. (2010) ISO 9241-210:2010 Ergonomics of Human–system Interaction—Part 210: Human-centred Design for Interactive Systems. International Organization for Standardization, Geneva.

Johnson, P. (1998) Usability and Mobility; Interactions on the move. In Proc. First Workshop on Human–Computer Interaction with Mobile Devices.[location of the conf.]

Jumisko-Pyykkö, S. and Vainio, T. (2010) Framing the Context of Use for Mobile HCI. Int. J. Mobile Human Comput. Interact., 2, 1–28.

Kanstrup, A.M., Bjerge, K. and Kristensen, J.E. (2010) A living laboratory exploring mobile support for everyday life with diabetes. Wireless Personal Commun., 53, 395–408.

Karat, J. and Karat, C.-M. (2003) The evolution of user-centered focus in the human–computer interaction field. IBM Syst., J. 42, 532–541.

Kjeldskov, J. and Graham, C. (2003) A Review of Mobile HCI Research Methods. In Chittaro, L. (Ed.), Human-Computer Interaction with Mobile Devices and Services, pp. 317–335. Springer Berlin Heidelberg.

Kjeldskov, J., Graham, C., Pedell, S., Vetere, F., Howard, S., Balbo, S. and Davies, J. (2005) Evaluating the usability of a mobile guide: the influence of location, participants and resources. Behav. Inform. Technol., 24, 51–65.

Kjeldskov, J. and Paay, J. (2010) Indexicality: understanding mobile human–computer interaction in context. ACM Trans. Computer–Human Interact. 17, 14:1–14:28.

Kjeldskov, J. and Stage, J. (2004) New techniques for usability evaluation of mobile systems. Int. J. Human–Computer Stud., 60, 599–620.

Lazar, J., Feng, J. H. and Hochheiser, H. (2010) Research Methods in Human–Computer Interaction. Wiley.

Lu, J., Yu, C.-S., Liu, C. and Yao, J. E. (2003) Technology acceptance model for wireless Internet. Internet Res., 13, 206–222.

Macleod, M. and Bevan, N. (1993) MUSiC Video Analysis and Context Tools for Usability Measurement. In Proc. INTERACT '93 and CHI '93 Conf. Human Factors in Computing Systems, p. 55. ACM, New York, NY.

Maguire, M. (2001) Context of use within usability activities. Int. J. Human–Computer Stud., 55, 453–483.

Millen, D. R. (2000) Rapid Ethnography: Time Deepening Strategies for HCI Field Research. In Proc. 3rd Conf. Designing Interactive Systems: Processes, Practices, Methods, and Techniques, Brooklyn, New York, USA, pp. 280–286. ACM, New York, NY.

Monahan, K., Lahteenmaki, M., McDonald, S., and Cockton, G. (2008) An Investigation into the Use of Field Methods in the Design and Evaluation of Interactive Systems. In Proc. 22nd British HCI Group Annual Conf. People and Computers: Culture, Creativity, Interaction—Volume 1, Liverpool, UK, pp. 99–108. British Computer Society, Swinton, UK.

Nardi, B. A. (1996) Context and Consciousness: Activity Theory and Human–Computer Interaction. The MIT Press.

Nielsen, J. (1993) Usability Engineering. Academic Press, Boston.

Paternó, F. (2005) Model-based tools for pervasive usability. Interact. Comput., 17, 291–315.

Paternó, F., Santoro, C. and Spano, L.D. (2009) MARIA: a universal, declarative, multiple abstraction-level language for service-oriented applications in ubiquitous environments. ACM Trans. Comput.–Hum. Interact., 16, 19:1–19:30.

Po, S., Howard, S., Vetere, F. and Skov, M.B. (2004) Heuristic Evaluation and Mobile Usability: Bridging the Realism Gap. In Brewster, S. and Dunlop, M. (Eds.), Mobile Human–Computer Interaction, pp. 49–60. Springer, Berlin.

Rogers, Y., Sharp, H. and Preece, J. (2007) Interaction Design: Beyond Human–Computer Interaction (2nd edn.). Wiley.

Rosenbaum, S., Rohn, J. A. and Humburg, J. (2000) A Toolkit for Strategic Usability, pp. 337–344. ACM Press.

Rosson, M. B. and Carroll, J. M. (2001) Usability Engineering: Scenario-based Development of Human–Computer Interaction. Morgan Kaufmann.

Roto, V., Popescu, A., Koivisto, A. and Vartiainen, E. (2006) Minimap: A Web Page Visualization Method for Mobile Phones. In Proc. SIGCHI Conf. Human Factors in Computing Systems, Montréal, Québec, Canada, pp. 35–44. ACM, New York, NY, USA.

Schuler, D. and Namioka, A. (1993) Participatory Design: Principles and Practices. CRC Press.

Shin, D.-H. (2007) User acceptance of mobile Internet: implication for convergence technologies. Interact. Comput., 19, 472–483.

Stolterman, E. (2008) The nature of design practice and implications for interaction design research. Int. J. Design, 2, 55–65.

Strömberg, H., Pirttilä, V. and Ikonen, V. (2004) Interactive scenarios—building ubiquitous computing concepts in the spirit of participatory design. Personal Ubiquitous Comput., 8, 200–207.

Suchman, L. (2006) Human–Machine Reconfigurations: Plans and Situated Actions. Cambridge University Press.

Svanæs, D. (2001) Context-aware technology: a phenomenological perspective. Hum.–Comput. Interact., 16, 379–400.

Tamminen, S., Oulasvirta, A., Toiskallio, K., Kankainen, A. (2004) Understanding mobile contexts. Personal Ubiquitous Comput., 8, 135–143.

Venturi, G., Troost, J. and Jokela, T. (2006) People, organizations, and processes: an inquiry into the adoption of user-centered design in industry. Int. J. Hum.–Comput. Interact. 21, 219–238.

Vermeeren, A.P.O.S., Law, E.L.-C., Roto, V., Obrist, M., Hoonhout, J. and Väänänen-Vainio-Mattila, K. (2010) User Experience Evaluation Methods: Current State and Development Needs. In Proc. 6th Nordic Conf. Human–Computer Interaction: Extending Boundaries, Reykjavik, Iceland, pp. 521–530. ACM, New York, NY.

Vredenburg, K., Mao, J.-Y., Smith, P.W. and Carey, T. (2002) A Survey of User-centered Design Practice. In Proc. SIGCHI Conf. Human Factors in Comput. Syst., Minneapolis, Minnesota, USA, pp. 471–478. ACM, New York, NY.

Wigelius, H. and Väätäjä, H. (2009) Dimensions of Context Affecting User Experience in Mobile Work. In Gross, T., Gulliksen, J., Oestreicher, L., Palanque, P., Prates, R. O. and Winckler, M. (Eds.), Human–Computer Interaction–INTERACT 2009, pp. 604–617. Springer, Berlin, Heidelberg.

Paper 3

Eshet, E., de Reuver, M. and Bouwman, H. (2016). The role of organizational strategy in the design of mobile systems: A study of mobile practitioners.

Under revision in: Communications of the Association for Information Systems (CAIS)

Communications of the Association for Information Systems

Research Paper ISSN: 1529-3181

The role of organizational strategy in the design of mobile systems: A study of mobile practitioners

Eyal Eshet
Turku Centre for Computer Science (TUCS)
Faculty of Social Sciences, Business and Economics, Åbo Akademi University, Finland
eeshet@abo.fi

Mark de Reuver
Faculty of Technology, Policy and Management, Delft University of Technology, The Netherlands

Harry Bouwman
Faculty of Technology, Policy and Management, Delft University of Technology, The Netherlands

Abstract:

The efficient and effective usage of insights on users and their usage context is strategically important to organizations. With the proliferation of mobile systems, gaining timely and relevant insights is increasingly challenging due to the heterogeneous and dynamic contexts of use, the abundant availability of information on usage behaviour as well as the intense time constraints imposed by the highly competitive mobile market. This paper develops a conceptual model that considers strategy foci as motivators affecting the efficient and effective usage of insights on users and context, as a specific issue in design practices. Mediating effects of design resources, like time and financial constraints, organizational practices, as well as design competences are examined. To test the conceptual model a survey was conducted with 100 mobile practitioners and PLS was used to estimate the model. The model shows that focus on an innovation strategy greatly affects data usage on user and their context, directly and indirectly, i.e. mediated by organizational practices and design competences. Strategies with a focus on cost have no direct effect on the usage of user insights, but lead to negative impacts on design competences and practices.

Keywords: IS development; Organizational strategy; Mobile systems; Interaction design; Survey

1 Introduction

The new mobile era, labeled the 'mobile apps era' (Eshet and Bouwman, 2014), introduces challenges to the design practice of mobile systems, specifically with regard to our main focus, i.e. how designers gain insights on users and context of use. First, in contrast to the typically single context of use in stationary computing (e.g. desktop and web-applications), the use of mobile computing devices (e.g. mobile phone) is characterized by multi-context of use due to the mobility of people and the devices they carry with them (Henfridsson and Lindgren, 2005). In addition, due to the affordability of mobile devices, there is an increased diversification of users, and new classes for situated activities that are made possible with mobile computing (Johnson, 1998). Consequently, the diversity of users and variety of use contexts put a strain on the effective collection and analysis of relevant user data. Secondly, rapid technological developments in recent years, for instance in embedded sensors and wireless technology, allow the real-time collection and analysis of actual usage behaviour data. The so-called 'Big Data' leads to a continuous flow of data about user behaviour, which is further fuelled by insights from a growing amount of market research companies. With the excess availability of usage data, the efficient use of such insights, i.e. understanding the relevant from the ordinary, becomes more difficult. Lastly, application stores like those provided by Apple and Google have democratized the development and distribution of mobile systems, which resulted in an increasingly competitive and dynamic mobile market (Bergvall-Kåreborn and Howcroft, 2011). Moreover, Agile approaches are increasingly adopted for the design and development of mobile systems (Eshet and Bouwman, 2014), though the Agile principle on short system delivery cycles limits the time to understand users (Seffah et al. 2005). Given the competitive pressures and resource constraints for design, the effective and efficient usage of user and context data becomes more strategically important.

Organizational strategy and its relation to a specific aspect in the design of mobile systems, i.e. the efficient and effective usage of data on users and context of use, has not been a topic of research, to our knowledge. The new mobile era introduces challenges beyond BYOD (bringing your own devices) or channel strategies, affecting a company into its capillaries. Understanding how an outside-in perspective on organization strategies (De Wit and Meyer, 2010) is combined with an inside-out strategies focused on providing resources and building competences in order to support design practices is utmost important. From an outside-in perspective views on cost focused strategies vis-à-vis strategies focused on innovation

are relevant to consider (Christensen, 1997; Porter, 1985; Tidd et al. 2005). From an inside-out perspective the availability of design resources and capabilities, as extensively discussed in strategic management and IS literature needs attention (Barney, 1991; Mata et al. 1995; Wernerfelt, 1984). Research on the relation between IS and resources and capabilities are rather high level and focus in a generic way on IT assets, processes or IS Capabilities (Wade and Hulland, 2004) rather than on specific practices. IS research has paid extensive attention to 'Design Science" (Cross, 2001; Hevner et al. 2004; Peffers et al. 2007; Sein et al. 2011), though research on the effect of organizational strategy on design practices has yet to be developed within IS research. Research in Human-Computer Interaction (HCI) emphasizes the relation between design practices and resources and competences as well as management level support (e.g. Rosenbaum et al. 2000; Venturi et al. 2006), though a relation between the organizational strategy and design practice has not been established. Particularly with the increasing dominance of mobile-based information systems, attention to design practices is utmost important, let alone with the emergence of Big Data.

In this paper we focus on how organizations' strategies affect the usage of data in design practices as mediated by usage of design resource and capabilities. We contribute to strategic management literature by connecting a strategy focus with mobile design practices, specifically with regard to data usage about users and context. As far as we are aware, a quantitative research focusing on this relation has not been introduced yet. This paper is also unique because we contribute to how time and financial constraints, design capabilities as well as organizational practices mediate between strategy and the usage of data on users and context, following HCI-based views on design practices. By connecting strategic management insights with design practices the study also contributes to "Design Science" approaches in IS. Seen the identified gaps in literature, this paper examines:

RQ: How innovation and cost focused strategies affect the efficiency and effectiveness of data usage on users and context in the design of mobile systems, as mediated by design resources and competences, as well as organizational practices.

We conducted a survey among user experience (UX) designers and interaction designers, software developers, project managers and owners who are active in the design and development of mobile systems (i.e. applications, services) to collect their perceptions and views. The study was carried out when the use of mobile systems became a common practice in work and non-work activities of people in

many western countries. Relating organizational strategic aspects to the design practice is important for managers. By doing so we relate IS research with a focus on strategy to research in HCI practices.

The remainder of this paper is organized as follows. In the next section an overview of extant literature, the hypotheses and conceptual model are provided. Section three explains the overall research methodology. Section four presents the study results, followed by a discussion of the results in section five. The final section concludes the paper, points out limitations and suggests follow up research.

2 Theory and Hypotheses

In this paper we focus on specific activities within the design practice of mobile systems. Design is essentially a problem-solving activity intended to find a better fit of a form, the solution, to its context, anything that places demands on the form and defines the problem (Alexander, 1964). The process of design broadly involves a set of activities that practitioners perform to analyze the problem, synthesize a solution and evaluate the fit of the solution (Alexander, 1964). These activities are commonly defined, loosely, as the design practice. In this paper, we are particularly interested in user-centered design practices, i.e. actions that aim at gaining insights on users, such as interview, observation, and usability testing during the design of mobile systems.

A mobile system is considered here from a sociotechnical perspective. First, mobility is an attribute of the human rather than the system, and is roughly defined as people's ability to move between locations that vary in their spatial, temporal, and social settings (Henfridsson and Lindgren, 2005). People carry their computing devices with them while moving, and use the devices in varied multi-contextual settings. Accordingly, mobile devices are considered here as carried-on devices (Dix et al. 2000), in particular mobile phones and tablet computers. The software program that runs on these mobile devices is defined here as 'mobile system'. Examples of mobile systems include native platform application (i.e. mobile app), web-based solution (i.e. HTML5) or a hybrid solution.

Gaining insights on users and their context of use is essential to the development of usable and useful software systems, as emphasized by research in various disciplines, e.g. Management of Information Systems (MIS) (Robey and Markus, 1984), Strategic Management (Boland, 1978), Software Engineering (Schmidt et al. 2001), Human-Computer Interaction (Gould and Lewis, 1985), the emerging fields of User Experience (UX) design (Hassenzahl and Tractinsky, 2006) and Interaction Design (Sharp et al. 2007) as

well as international standards (ISO 9241-210, 2010). Commonly, organizations use an idiosyncratic approach to collect and analyze user data. Regardless of the approach, an efficient and effective use of this data, the dependent variable in our research, is important to the success of the project, and therefore relevant to the implementation of the organizational strategy.

Practitioners who are involved in the design practice of systems do not work in a vacuum, but within organizations with their specific strategies and organizational routines. Hence, understanding the influence of different strategies and work procedures on the design practice is relevant to IS design management. Organizational strategy can be conceptualized from two perspectives, i.e. outside-in and inside-out (De Wit and Meyer, 2010). One approach that is typical for outside-in views in Strategic Management literature is Porter's (1985) approach on strategic positioning. Porter emphasizes two core types of competitive advantage i.e. cost and differentiation. In combination with the scope of activities, this leads to three strategies: cost leadership, differentiation or focus. Porter's ideas have been refined by Treacy and Wiersema (1993) by focusing on operational excellence, product leadership, and customer intimacy. In practice, a focus on cost and operational excellence leads to cost awareness and optimization to reduce costs. This implies that also with regard to design practices, cost awareness is key and collecting data on user behaviour and user context has to be very efficient and effective. Usage of existing secondary data and low cost alternatives, like using freely available Internet reports on mobile usage, for gaining insight on user behaviour and usage context would be favoured in a cost leadership strategy. Therefore we propose the next hypothesis:

Hypothesis 1: If a strategy of a company focuses on cost leadership then usage of data on user behaviour and user context in mobile system design practices will be more efficient and effective.

Similarly to Porter's differentiation strategy and Treacy and Wiersema's product leadership view, emerging and transformational strategies (Mintzberg et al. 2009) with a focus on the impact of disruptive or incremental innovation (Christensen 1997; Tidd et al. 2005), adopt an outside-in approach. What these approaches have in common is how companies and organizations respond to changes in their external environment, like technology innovation, changes in consumer demand or competitor behaviour. These changes in consumer demand and behaviour, as is in the case with mobile systems, may affect an organization and require a response from top-management, such as by offering new products and

services. In innovation focused strategies, making use of user-centered design approaches and activities requires in depth engagement with users, such as by conducting contextual interviews, participatory observation, focus groups and analyses of data collected via sensors. In principal these are time and resource consuming activities and therefore less effective and efficient. Therefore we suggest the next hypothesis:

Hypothesis 2: If a strategy of a company focuses on continuous innovation, usage of data on user behaviour and user context in mobile system design practices will be less efficient and effective.

In response to outside-in models, Barney (1991) developed the resource-based view on strategy, focusing on how rare resources and capabilities give firms a competitive advantage. If resources and capabilities are rare, hard to imitate, and there are limited alternatives this will contribute to reinforcing a company's strategy. So resources and capabilities play an important role in dealing with the critical contingencies that firms are facing. Design-related resources, such as the competences and experience of design practitioners, may be part of these critical resources and capabilities.

In IS literature, research into resources and capabilities is quite extensive, though on a high-level. In this study, we focus on resource and capabilities that are specifically relevant for design practices. Insights on the work of practitioners, who are involved with user-centered design activities, show that their work is affected by resource constraints, in terms of time and budget (Monahan et al. 2008; Rosenbaum et al. 2000; Vredenburg et al. 2002), the integration of design practice techniques within an organization (Bygstad et al. 2008; Gulliksen et al. 2006), organizational culture (Iivari, 2006), organizational work practices in terms of internal communication (Rosenbaum et al. 2000; Venturi et al. 2006), and management support (Gulliksen et al. 2006; Rosenbaum et al. 2000; Venturi et al. 2006). In addition, the competences of designers, i.e. skill acquisition and the degree of expertise, is an important element to consider (Hertzum and Jacobsen, 2001; Gulliksen et al. 2006; Suwa and Tversky, 2001).

In this research we consider organizational work practices in terms of actions that contribute to creativity, open collaboration and sharing of ideas; design resources are considered in terms of budget and time made available to designers; and design competences are considered in terms of capabilities in dealing with user centric design methods. These concepts are mediating the relation between organizational

strategies and the effective usage of data in design practices. Stimulating creative and collaboration focused work practices require stimulation of competences as well as significant time and budgets. Existing HCI studies and literature mainly highlight the challenges in promoting and implementing user-centered design practices within an organization (Gulliksen et al. 2004; Rosenbaum et al. 2000; Venturi et al. 2006) and provide guidelines for dealing with the institutionalization of user-centered design practices (Mayhew, 1999; Schaffer, 2004). Since there is no existing literature in this area, hypothesis formulation is based on generic insights from innovation literature relating to business strategy.

We first specify the original hypotheses one and two for the relation between the strategy concept and the three concepts of work practices, resources, and competences. Before we discuss the hypotheses, we introduce the relation between these three concepts and effective usage of data in design practices.

For strategies with a focus on cost leadership, the hypotheses are:

Hypothesis 1a: If a strategy of a company focuses on cost leadership then organizational practices will be more regulated leaving less room for creativity, open collaboration and sharing of ideas.

Hypothesis 1b: If a strategy of a company focuses on cost leadership then design resources will be limited.

Hypothesis 1c: If a strategy of a company focuses on cost leadership then organizational competences will be focused on re-use of methods and data.

For strategies with a focus on innovation we expect different patterns.

Hypothesis 2a: If a strategy of a company focuses on innovation then organizational practices will be leaving more room for creativity, open collaboration and sharing of ideas.

Hypothesis 2b: If a strategy of a company focuses on innovation then design resources will be abundant.

Hypothesis 2c: If a strategy of a company focuses on innovation then organizational competences will be stimulated.

Applying the techniques and tools to understand users and the context of use is much dependent on the availability of financial and time resources. Several studies observed that budget and time constraints

have a significant influence on the user-centered design practice (e.g. Monahan et al. 2008; Rosenbaum et al. 2000; Vredenburg et al. 2002). These resources may have a determinant role on the approach that practitioners take during the design practice, for instance how much effort, if any, is put into user and context studies and how evaluation is carried out. Thus, financial and time resources are directly in a positive way linked to the competences and experience of practitioners who are involved in the design practice.

Hypothesis 3: If financial and time resources are abundant then these will have a strong positive impact on usage of data on user behaviour and user context in mobile design practices.

On a more general level it can be assumed that financial and time resources also impact design competences and organizational practices in general. More budget and time also implies that there will be more opportunities to develop design capabilities and more attention to new ideas and to feedback, as well as joint teamwork. Therefore, we propose the following hypotheses on the mediating roles of organizational practices and design competences.

Hypothesis 3a: Financial and time resources have a strong positive impact on organizational practices.

Hypothesis 3b: Financial and time resources have a strong positive impact on design competences.

Prior studies observed that internal communications within the organization (Rosenbaum et al. 2000; Venturi et al. 2006), management support (Gulliksen et al. 2004; Rosenbaum et al. 2000; Venturi et al. 2006), and involvement of cross-functional teams (Rosenbaum et al. 2000) are key success factors for user-centered design practice in organizations. Iivari (2006), examining the role of organizations in facilitating user involvement, observed that organizational practices have influence on usability work. Hence, we may hypothesize on the relation between organizational practices and the efficiency and effectiveness of the design practice with regard to usage of data.

Hypothesis 4: Organizational practices will have a positive impact on the effective usage of data on user and use context.

Last, the competences of practitioners who are involved in design are relevant. A competence can be understood as a qualification that makes someone fit to perform a particular activity (Ritter and Gemünden, 2004). Competences such as the knowledge and experience of individual workers in an organization are core organization resource. Competences related to the design practice, such as proficiency with user-centered techniques and tools to understand users and the context of use are no exception; they might be a critical resource that allows an organization to have a competitive advantage. Prior studies have observed that the knowledge and experience of design practitioners largely affect the outcome of usability evaluation (Hertzum and Jacobsen, 2001), and the approach and implementation of the design practice (Gulliksen et al. 2006). Suwa and Tversky (2001) observed the superiority of experienced designers over novices in generating new ideas from external representations, such as sketches. However, merely having a competence is not enough; the competence should be put into an efficient and effective use that generate value to the organization (Ritter and Gemünden, 2004). Highly competent and experienced practitioners, besides being more aware to the importance of design practice-related qualifications in bringing value to the organization, are better equipped to create such value. Experienced practitioners are more informed about the overall importance of and the different possibilities to understand users and the context of use. Hence, experienced practitioners are also more aware of the need for financial and time resources to the design practice. Hence, we may hypothesize that the more competent and experienced practitioners are with design practice-related activities, the more efficient and effective the design practice is in general and more specifically on the use of data.

Hypothesis 5: There is a positive relation between practitioners' design competences and effective usage of data on user and use context.

The hypotheses formulated above are combined in the model presented in Figure 1. Next, we explain how the data was collected and the model was tested.

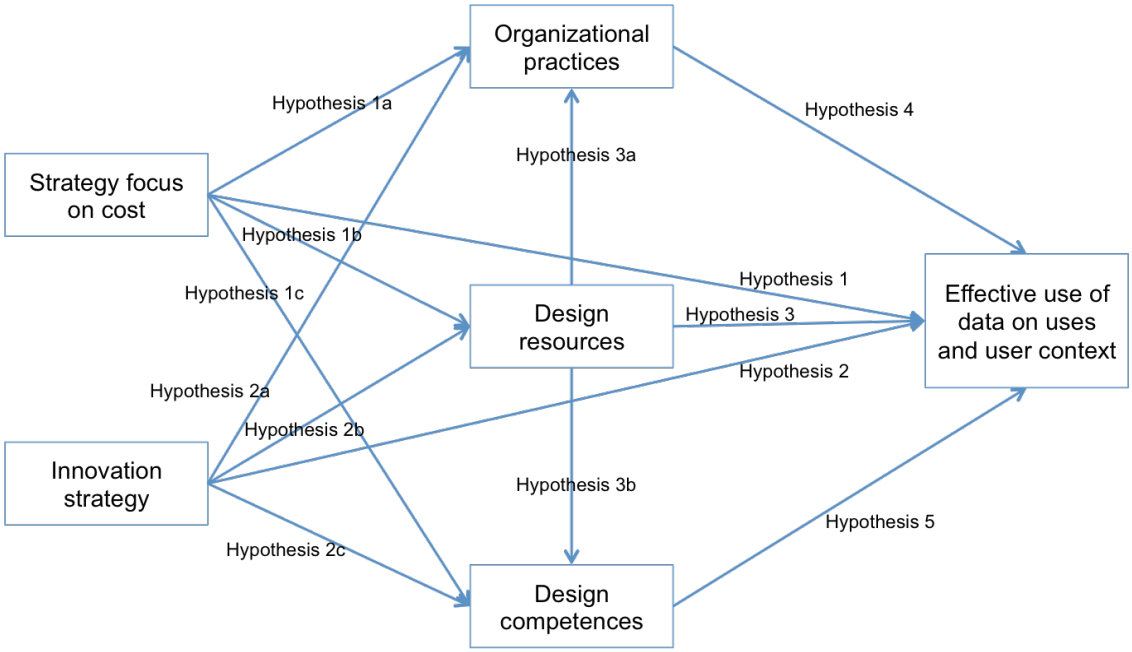

Figure 1. The Conceptual Model

3 Methodology

To test our conceptual model, a survey method with the PLS-SEM technique was selected. SEM is especially useful to test models that include mediation, and makes it possible to test the structural and measurement parts of a model at the same time.

3.1 Sample

Data was collected by means of an online questionnaire among practitioners who are involved in the design and development of mobile apps. This was emphasized both in the survey invitation and in the introduction to the questionnaire. To ensure a broad perspective on the design practice, we were interested in responses from practitioners in the following three project roles: (a) usability and design specialists (e.g. UX designers, interaction designers); (b) project managers; and (c) software developers. The parametric size of such populations is difficult to estimate, as there are no relevant databases. In particular those involved in usability and design work have numerous job titles and educational backgrounds. Thus, data was collected based on non-probabilistic sampling, a valid and common practice (Lazar et al. 2010), as it is often not possible to apply a strict random sampling.

Potential respondents were contacted through multiple channels, particularly individual e-mail invitations and the mailing lists of professional communities (HCI, UXPA, IXDA). In addition, a link to the

questionnaire was posted on relevant and active discussion forums (e.g. LinkedIn groups, Google+ communities), and on Twitter, using relevant hash (#) tags. The survey was available online for 4 weeks during February– March 2013.

We received a total of 100 responses from 20 countries, mainly from practitioners based in Finland (46%), US (12%), Sweden (9%), Netherlands (5%) and Israel (5%) with other countries representing a smaller percentage. Most of the respondents work as UX designers (33%), project managers (19%), software developers (8%) and project owners (7%).

Respondents work primarily in companies (as opposed to freelancers) of different sizes. About 28% of the companies have 10 or fewer employees, 24% have 11-50 employees, 7% have 51-100 employees, 18% have 101-1000 employees, and the remaining 23% have more than 1000 employees. The median size of companies is 46 and the mode is 5. In terms of business sectors, software (36%) and usability/UX consulting (18%) were the two largest categories, with other sectors, including education, telecommunications, design, technology research and gaming representing a single-digit percentage. At face value, the respondents work in environments in which we would expect them to be active – small, medium-sized and large enterprises mainly in the software business and usability/UX consulting. Although we cannot claim representativeness, we assume that the respondents represent a common sample for our population.

While other studies (e.g. Clemmensen et al. 2013; Ji and Yun, 2006) found differences between usability specialists and software developers, we extensively tested difference between the three groups (usability and design specialists, project managers and software developers) for the core constructs based on ANOVA, but were unable to find any significant differences. Therefore, we conclude that the sample is homogeneous enough to conduct SEM.

3.2 Measures

The survey was pilot-tested following Dillman's (2000) three-stage recommendations. Questions were grouped into four sections: (1) Addressing the context of use in mobile computing – the perceived importance of contextual aspects and the use, purpose, and perceived effectiveness of methods to gather data on users and the context of use; (2) Utilizing the collected data – usage and evaluation of methods for data analysis and informing the design; (3) Organizational settings – business sector, size,

organizational practices, strategy and competitive environment, and (4) Demographic data – geographical location, experience with design practice, and main role in mobile application projects. The items used from the questionnaire are presented in Table 1.

Confirmatory factor analysis, using Warp PLS, showed acceptable levels of convergent and discriminant validity. Convergent validity was acceptable for all constructs. Factor loadings exceeded -70 and all average variance extracted (AVE) were above .60 (Fornell and Lacker, 1981). Construct reliability was acceptable as Composite Reliability is above .80, exceeding the .60 benchmark. Multi-collinearity was not significant since the average of full collinearity VIF equals 1.099, and full collinearity VIF equals 1.445, were way below the 3.3 benchmark.

Table 1: Confirmatory Factor Analysis

Construct	Question heading	Item	Std factor loading	AVE	VIF	Composite reliability
Innovation strategy (Rönkkö and Peltonen 2012) Reflective scale STRAT_INN	How important are the following aspects to your company's strategy? (5-point, not at all important, extremely important)	Producing a continuous stream of innovative products/services	.89	.78	1.544	.88
		Being unique in our industry (e.g. with regard to product/service)	.89			
Cost-focus strategy (Treacy and Wiersema 1993) Reflective scale STRAT_COST	How important are the following aspects to your company's strategy? (5-point, not at all important, extremely important)	Being cost leader with our products/services	.83	.61	1.113	.82
		Optimizing our operations to minimize development costs	.71			
		Emphasizing economies of scale and scope with our products/services	.79			
Organizational practices/culture (Seyal et al. 2004) Reflective scale ORG_PRACT	How well do the following statements describe the work practices at your company? (7-point, strongly disagree, strongly agree)	Employees are encouraged to contribute to the team	.88	.75	1.895	.90
		Employees are given regular feedback on their performance	.81			
		Employees are encouraged to bring new ideas to work practice	.91			
Design practice: Competences (Monahan et al. 2008) DP_COMPET	How do the following factors influence the expected result from the data gathering methods you have used? (5-point, not at all influential, extremely influential)	Experience with methods from previous projects	.84	.70	1.238	.83
		Competences of available staff	.84			
Design practice: Resources (Monahan et al. 2008) DP_RESOU	How do the following factors influence the expected result from the data gathering methods you have used? (7-point, not at all influential, extremely influential)	Project budget	.89	.79	1.198	.88
		Project time constraints	.89			

Formative scale EVAL_DATA	To what level do you agree or disagree with the following statements. The data we gather … (7-point, strongly disagree, strongly agree)	Is efficiently used in my company (Efficiency = achieving the maximum productivity with minimum wasted effort)	.77	.61	1.684	.86
		Is effectively used in my company (Effectiveness = being successful in producing the desired result)	.86			
		Significantly improve our understanding of contexts of use	.79			
		Is crucial to the success of our mobile app	.70			

Discriminant validity is acceptable, as the average squared correlation of any pair of constructs does not exceed the average of the respective average variance extracted (see Table 2).

Table 2: Interconstruct correlations and Square Root of AVE

	STRAT_INN	STRAT_COST	ORG_PRACT	DP_COMPET	DP_RESOU	EVAL_DATA
STRAT_INN	(0.886)					
STRAT_COST	-0.023	(0.780)				
ORG_PRACT	0.549	-0.239	(0.869)			
DP_COMPET	0.125	0.042	0.006	(0.839)		
DP_RESOU	-0.023	0.190	-0.134	0.337	(0.890)	
EVAL_DATA	0.455	-0.135	0.546	0.281	0.100	(0.782)

4 Results

We trimmed the original conceptual model in Figure 1 by omitting insignificant paths. The final structural regression model as shown in **Error! Reference source not found.**Figure 2, presented a good fit (Tenenhaus GOF equals .432). Overall, the explained variance of evaluation of data usage is moderate (R2= .42).

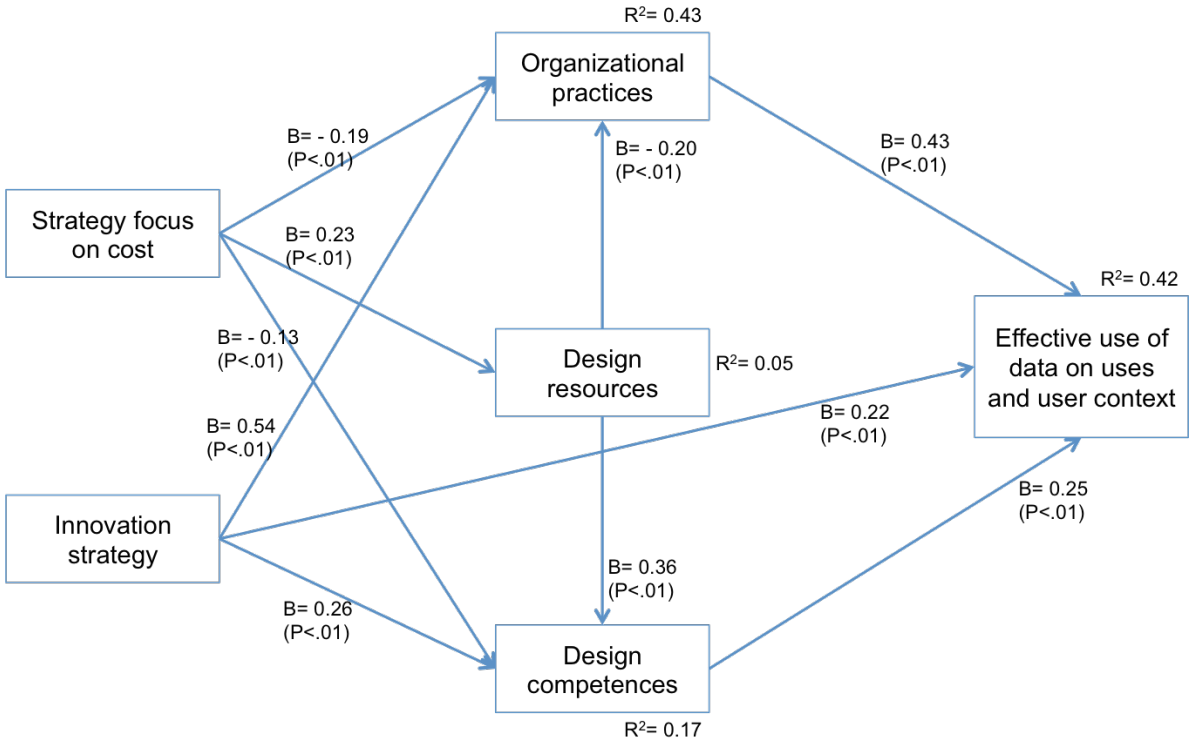

Figure 2. Structural Regression Model

With regard to our hypotheses, we address the implications in the discussion section. Table 3**Error! Reference source not found.** gives an overview of the hypotheses: seven are accepted, four rejected, and two hypotheses show an opposite direction. We will discuss the results in more detail in the next section.

Table 3: Overview of Accepted and Rejected Hypotheses

Hypothesis 1	If a strategy of a company focuses on cost leadership then usage of data on user behaviour and user context in mobile design practices will be more efficient and effective	Rejected
Hypothesis 1a	If a strategy of a company focuses on cost leadership then organizational practices will be more regulated leaving less room for creativity, open collaboration and sharing of ideas	Accepted
Hypothesis 1b	If a strategy of a company focuses on cost leadership then design resources will be limited	Opposite direction, but weak relation
Hypothesis 1c	If a strategy of a company focuses on cost leadership then organizational competences will be focused on re-use of methods and data	Accepted, weak relation
Hypothesis 2	If a strategy of a company focuses on continuous innovation, usage of data on user behaviour and user context in mobile design practices will be less efficient and effective	Reject
Hypothesis 2a	If a strategy of a company focuses on innovation then organizational practices will be more less leaving more room for creativity, open collaboration and sharing of ideas	Accepted
Hypothesis 2b	If a strategy of a company focuses on innovation then design resources will be abundant	Rejected
Hypothesis 2c	If a strategy of a company focuses on innovation then organizational competences will be stimulated.	Accepted
Hypothesis 3	If financial and time resources are abundant then these will have	Rejected

	a strong positive impact on usage of data on user behaviour and user context in mobile design practices.	
Hypothesis 3a	Financial and time resources have a strong positive impact on organizational practices	Opposite direction
Hypothesis 3b	Financial and time resources have a strong positive impact on design competences	Accepted
Hypothesis 4	Organizational practices will have a positive impact on the effective usage of data on user and use context	Accepted
Hypothesis 5	There is a positive relation between practitioners' design competences and effective usage of data on user and use context	Accepted

5 Discussion

In this section, we discuss the results and the hypotheses in greater detail. First of all, it is interesting to see that the model itself, which relates the organizational context and innovation strategies to the design practice, particularly with regard to mobile systems and how design and usability specialists, project managers and software engineers use data on users and the dynamic context of mobile use, has a high predictive value and explains the effectiveness of the design practice to a significant extent. To our knowledge, this is one of the first attempts to connect the broader stream of research on strategy and innovation to design practices, and also one of the first approaches that go beyond qualitative or descriptive models with regard to design practices, to develop an explanatory model. However, the model remains limited in the sense that it is focused on the design practice, while the proof of the pudding will be in the connection of the model with evaluation of the actual usage of applications. This means that we can only claim to contribute to how design practice leads to better user informed designs, while taking strategy orientation and how design teams operate within constraints of an organizational setting into account.

There is no main effect between a cost-focused strategy and the effectiveness in which data on users and use context is used in the design practice of mobile systems (hypothesis 1). The effect is mediated by the availability of resources, practices and design competences (hypotheses 1 a-c). It is striking that only the relation with resources is positive contrary to our expectations (hypothesis 1b), while the other two relations are negative (hypotheses 1a and 1c). This implies that cost focused companies are prepared to invest but don't positively contribute to favorable organizational practice and design competences. This finding confirms traditional insights from strategic management literature regarding the cost focused strategies in which optimization is core.

In contrast to cost leadership strategy, there is a relation between an innovation-focus strategy and efficiency in which data on users and usage context are used in the design practice of mobile systems

(hypothesis 2). Strikingly, there is no relation between a focus on innovation and the availability of resources (hypotheses 2b). Apparently it is more important to develop positive organizational practices and design competences than providing budgets and time (hypotheses 2a and 2c). This finding confirms insights from innovation management, in which specifically the discussion on open innovation and knowledge management illustrates the importance of having an open exchange of information, insights and knowledge. Facilitating internal communication within an organization was previously emphasized as a key to user-centered design practice (Rosenbaum et al. 2000; Venturi et al, 2006). The connection between an outside-in strategy focus with an inside-out perspective with a focus on resources and competences and practice proves to be fruitful. We will discuss the relation between the latter in more detail.

Although earlier studies emphasize the significant influence of budget and time-related constraints on the design practice (e.g. Monahan et al. 2008; Rosenbaum et al. 2000; Vredenburg et al. 2002), this does not affect practice with regard to effective data usage (hypothesis 3). Organizations rely mainly on the practitioners' design competences and organizational practices. However it is striking that there is a negative relation between design resources (time and budget) and organizational practices. This implies that due to temporal and financial constraints designers rely on open communication and collaboration (hypothesis 3a, but then with a reversed direction). The impact of design resources on competences shows a moderate positive contribution (hypothesis 3b).

Creation and sharing of ideas and knowledge within the organization, in order to streamline the design practice proves to be highly relevant (hypothesis 4). This relation is the strongest. Design teams that are open and sharing are more likely to make use of all kind of data sources that are relevant to them in a more effective way.

Our results show that the competences and experiences of practitioners are essentially the key determinant of an effective data usage (hypothesis 5), at least in the context of mobile systems design. The hypothesis supports the idea that competent practitioners are more likely to make efficient and effective use of the resources, by finding alternative solutions to a design problem and capitalizing on earlier experiences. However, the actual qualifications and experience of practitioners with regard to the design and development of mobile systems were not studied. In future research, a more extensive

operationalization of these two concepts, in relation to a practitioner's specific competences may better explain their role in the design practice.

On a practical level, our findings imply that practitioners, especially those in managerial positions, in organizations that design and develop mobile systems, should take steps to stimulate organizations and ensure they have practitioners with relevant skills and experience to produce better user-informed designs in a timely manner. As we explained before, understanding users and their context of use during the design practice in the mobile apps era requires new competences. In the highly competitive mobile business market, obtaining such competences may be part of the rare capabilities that give an organization a competitive advantage.

6 Conclusion, Limitations and Future Research

In this paper, we have shown that there are links between the organizational strategy and the way practitioners, particularly UX and interaction designers, deal with data on user and context when designing mobile systems. The innovation focused strategies have a direct impact on the way designers work, i.e. their practices, and individual competences, but also with regard to how effective they use data sources on users and the context of use. However, when dealing with the dynamic user context and needs, practitioners rely on their competences and experience from earlier projects, mainly due to project resource limitations.

This is the first study that relates organizational context and innovation strategies with design practices, particularly with regard to the way in which practitioners make use of data on user needs and the context of use. To our knowledge, this is also the first study that tries to develop more explanatory models with regard to design practice in the HCI discipline. The connection between an outside-in strategy focus with an inside-out perspective that focuses on resources, competences, and practice, proves to be fruitful. It is clear that the latter play an important mediating role.

Due to this rather innovative character, we have tried to establish a theoretical basis in strategic and innovation management literature, as well as a focus on resource-based views. In doing so, we think that an important under-researched domain is addressed. Developing explanatory models, instead of descriptive and more qualitative models, that take a strategy perspective as a starting point, and pays attention to moderating resources and capabilities in explaining a specific design practice, may extend our

knowledge on design practices. Research focusing on outcome expectations from the design practice, both with regard to constraints and competences, needs to be extended. The same goes for the way information on users and their context exactly plays a role in design practices. An efficient usage of the data may be hindered by the quality of the data, a lack of precision or even by information overload. With regard to further research we see two distinct avenues. On the one hand, we want to advocate the development of more sound conceptual models and a more detailed and precise operationalization of core concepts to be tested in large-scale surveys. On the other hand, we want to propose more detailed qualitative research into everyday design practices. More extensive research will provide deeper insights, which again are open to testing by more quantitative research.

On a practical level, this research highlights the importance of having an open innovative strategy, i.e. encouraging the contribution of ideas and facilitating the communication of information within an organization, to achieve a better informed design. Moreover, practitioners with relevant skills and experience in terms of understanding user needs and context of use can be critical assets, giving organizations a competitive advantage.

The limitations of this study are related to the data we collected, as well as the model we tested. One of the main issues with regard to research into designers is that data is collected based on a convenience sample and that is highly dependent on the willingness on the part of practitioners to participate. We put a lot of effort in collecting data by addressing respondents in several ways. To further research in this domain, it is necessary to involve more UX and interaction designers, project managers and software engineers, not only in the interest of science, but also because research that is based on more representative samples can help improve their working practices.

With regard to the limitations of the model, we did not consider the socio-spatial context in which the designed system is being used. For instance, whether the system is used for specific work-related activities in relatively stable and predictable context of use or for non-work activities in more diverse and dynamic context of use. Including a factor on the context of use would allow a more thorough analysis on the tendency of designers to collect user and context data, as well as analyzing the interactions between organizational factors and context of use factors and their influence on designers. Moreover, developing and testing alternative models is necessary and expedient. With this paper, we wanted to connect

strategic and innovation management research to research into design practices, and in this way open new research venues.

Acknowledgments

The authors wish to thank Balsamiq Studios and Rally Software for giving away a few licenses of their software to motivate participation in the study. The research work for this study was funded by TUCS - Turku Centre for Computer Science and by a grant from the Foundation for Economic Education in Finland (Liikesivistysrahasto).

References

Alexander, C. (1964). *Notes on the Synthesis of Form*. Harvard University Press.

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, *17*(1), 99–120.

Bergvall-Kåreborn, B., & Howcroft, D. (2011). Mobile Applications Development on Apple and Google Platforms. *Communications of the Association for Information Systems*, *29*, 565–580.

Boland, R. J., Jr. (1978). The Process and Product of System Design. *Management Science*, *24*(9), 887–898.

Bygstad, B., Ghinea, G., & Brevik, E. (2008). Software development methods and usability: Perspectives from a survey in the software industry in Norway. *Interacting with Computers*, *20*(3), 375–385.

Christensen, C. M. (1997). *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Harvard Business Press.

Clemmensen, T., Hertzum, M., Yang, J., & Chen, Y. (2013). Do Usability Professionals Think about User Experience in the Same Way as Users and Developers Do? In P. Kotzé, G. Marsden, G. Lindgaard, J. Wesson, & M. Winckler (Eds.), *Human-Computer Interaction – INTERACT 2013* (pp. 461–478). Springer Berlin Heidelberg.

Cross, N. (2001). Designerly Ways of Knowing: Design Discipline Versus Design Science. *Design Issues*, *17*(3), 49–55.

De Wit, B., & Meyer, R. (2010). *Strategy Synthesis: Resolving Strategy Paradoxes to Create Competitive Advantage* (3 edition). Australia: Cengage Learning.

Dillman, D. A. (2006). *Mail and Internet Surveys: The Tailored Design Method -- 2007 Update with New Internet, Visual, and Mixed-Mode Guide* (2nd ed.). Wiley.

Dix, A., Rodden, T., Davies, N., Trevor, J., Friday, A., & Palfreyman, K. (2000). Exploiting space and location as a design framework for interactive mobile systems. ACM Trans. Comput.-Hum. Interact., 7(3), 285–321.

Fornell, C., & Larcker, D. F. (1981). Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. *Journal of Marketing Research*, *18*(1), 39–50.

Gould, J. D., & Lewis, C. (1985). Designing for usability: key principles and what designers think. *Commun. ACM*, *28*(3), 300–311.

Gulliksen, J., Boivie, I., & Göransson, B. (2006). Usability professionals—current practices and future development. *Interacting with Computers*, *18*(4), 568–600.

Gulliksen, J., Boivie, I., Persson, J., Hektor, A., & Herulf, L. (2004). Making a difference - a survey of the usability profession in Sweden. In *Proceedings of the third Nordic conference on Human-computer interaction (NordiCHI'04)* (pp. 207–215). ACM Press.

Hassenzahl, M., & Tractinsky, N. (2006). User experience - a research agenda. *Behaviour & Information Technology*, *25*(2), 91–97.

Henfridsson, O., & Lindgren, R. (2005). Multi-contextuality in ubiquitous computing: Investigating the car case through action research. Information and Organization, 15(2), 95–124.

Hertzum, M., & Jacobsen, N. E. (2001). The Evaluator Effect: A Chilling Fact About Usability Evaluation Methods. *International Journal of Human-Computer Interaction*, *13*(4), 421–443.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly*, *28*(1), 75–105.

Iivari, N. (2006). "Representing the User" in software development—a cultural analysis of usability work in the product development context. *Interacting with Computers*, *18*(4), 635–664.

ISO. (2010). *ISO 9241-210:2010 Ergonomics of human-system interaction-Part 210: Human-centred design for interactive systems*. Geneva: International Organization for Standardization.

Ji Yong Gu, & Yun Myung Hwan. (2006). Enhancing the Minority Discipline in the IT Industry: A Survey of Usability and User-Centered Design Practice. *International Journal of Human-Computer Interaction*, *20*(2), 117–134.

Johnson, P. (1998). Usability and Mobility; Interactions on the move. In *Proceedings of the First Workshop on Human-Computer Interaction with Mobile Devices*.

Lazar, J., Feng, J. H., & Hochheiser, H. (2010). *Research Methods in Human-Computer Interaction*. John Wiley & Sons.

Mata, F. J., Fuerst, W. L., & Barney, J. B. (1995). Information Technology and Sustained Competitive Advantage: A Resource-Based Analysis. *MIS Quarterly*, *19*(4), 487–505.

Mayhew, D. J. (1999). *The Usability Engineering Lifecycle: A Practitioner's Handbook for User Interface Design*. Morgan Kaufmann.

Mintzberg, H., Ahlstrand, B., & Lampel, J. (2009). *Strategy Safari: The Complete Guide Through the Wilds of Strategic Management*. Pearson Prentice Hall.

Monahan, K., Lahteenmaki, M., McDonald, S., & Cockton, G. (2008). An investigation into the use of field methods in the design and evaluation of interactive systems. In *Proceedings of the 22nd British HCI Group Annual Conference on People and Computers: Culture, Creativity, Interaction - Volume 1* (pp. 99–108). Swinton, UK: British Computer Society.

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, *24*(3), 45–77.

Porter, M. E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance*. Simon and Schuster.

Ritter, T., & Gemünden, H. G. (2004). The impact of a company's business strategy on its technological competence, network competence and innovation success. *Journal of Business Research*, *57*(5), 548–556.

Robey, D., & Markus, M. L. (1984). Rituals in Information System Design. *MIS Quarterly*, *8*(1), 5–15.

Rönkkö, M., & Peltonen, J. (2012). Software Industry Survey. Aalto University, Software Business Lab. Retrieved from http://www.softwareindustrysurvey.org/

Rosenbaum, S., Rohn, J. A., & Humburg, J. (2000). A toolkit for strategic usability. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems (CHI'00)* (pp. 337–344). ACM Press.

Schaffer, E. (2004). *Institutionalization of usability: a step-by-step guide*. Addison-Wesley Professional.

Schmidt, R., Lyytinen, K., & Mark Keil, P. C. (2001). Identifying software project risks: An international Delphi study. Journal of Management Information Systems, 17(4), 5–36.

Seffah, A., Desmarais, M. C., & Metzker, E. (2005). HCI, Usability and Software Engineering Integration: Present and Future. In A. Seffah, J. Gulliksen, & M. C. Desmarais (Eds.), Human-Centered Software Engineering — Integrating Usability in the Software Development Lifecycle (pp. 37–57). Springer Netherlands.

Sein, M., Henfridsson, O., Purao, S., Rossi, M., & Lindgren, R. (2011). Action design research. *MIS Quarterly*, *35*(1), 37–56.

Seyal, A. H., Awais, M. M., Shamail, S., & Abbas, A. (2004). Determinants of Electronic Commerce in Pakistan: Preliminary Evidence from Small and Medium Enterprises. *Electronic Markets*, *14*(4), 372–387.

Sharp, H., Rogers, Y., & Preece, J. (2007). *Interaction design: beyond human-computer interaction* (2nd edition). Wiley.

Suwa, M., & Tversky, B. (2001). Constructive perception in design. In J. Gero & M. L. Maher (Eds.), *Computational and cognitive models of creative design V* (pp. 227–239). University of Sydney, Australia: Key Centre of Design Computing and Cognition.

Tidd, J., Bessant, J., & Pavitt, K. (2005). *Managing Innovation: Integrating Technological, Market and Organizational Change*. John Wiley & Sons.

Treacy, M., & Wiersema, F. (1993). Customer intimacy and other value disciplines. *Harvard Business Review*, *71*(1), 84–93.

Venturi, G., Troost, J., & Jokela, T. (2006). People, Organizations, and Processes: An Inquiry into the Adoption of User-Centered Design in Industry. *International Journal of Human-Computer Interaction*, *21*(2), 219–238.

Vredenburg, K., Mao, J.-Y., Smith, P. W., & Carey, T. (2002). A survey of user-centered design practice. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 471–478). New York, NY, USA: ACM.

Wade, M., & Hulland, J. (2004). Review: The Resource-Based View and Information Systems Research: Review, Extension, and Suggestions for Future Research. *MIS Quarterly*, *28*(1), 107–142.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, *5*(2), 171–180.

Paper 4

Eshet, E., & Bouwman, H. (2015). Approaching Users and Context of Use in the Design and Development of Mobile Systems. In Design, User Experience, and Usability: Users and Interactions. Lecture Notes in Computer Science, 9187, pp. 508-519. Springer International Publishing.

Approaching Users and Context of Use in the Design and Development of Mobile Systems

Eyal Eshet[1(✉)] and Harry Bouwman[2]

[1] Åbo Akademi University Turku, Turku, Finland
eeshet@abo.fi
[2] Delft University of Technology, Delft, The Netherlands
W.A.G.A.Bouwman@tudelft.nl

Abstract. Mobile systems are used by a large variety of users in heterogeneous and dynamic everyday life situations. Approaching users in these contexts poses a challenge for practitioners. To examine practitioners' effort in understanding users and contexts of use, we conducted 15 in-depth interviews with those involved in the design and development of mobile systems for media and finance. We observed that the efforts of design practitioners in subcontracting companies are commonly hindered by strict resource constraints from the client, which result in opportunistic and more obscured data on users. The findings draw attention to the role of the business environment on approaching users and context of use.

Keywords: Interaction design · Mobile computing · User studies · Context of use

1 Introduction

Understanding users and their context of use is a core principle of the User-Centered Design (UCD) philosophy, which has long been considered fundamental to the design of interactive systems [1]. More recently, the fields of User Experience (UX) [2] and Interaction Design [3] re-emphasize this principle. Until recent, computing devices were mainly stationary, resulting in usage in fairly homogeneous and stable contexts of use. In stationary settings, contextual considerations are limited and their influence on the system design fairly predictable [4].

In contrast, the context of use in mobile computing (hereafter, mobile context) is inherently dynamic and heterogeneous in nature with increased variability of systems, users and tasks [5]. Moreover, the context of use is subject to rapid and unpredictable changes [6] as the use of mobile computing is increasingly entwined with the continuous changing of context in people's everyday lives [7]. Consequently, understanding users in mobile contexts call for field-oriented user studies that span both spatial and temporal dimensions. Existing studies (e.g. [8]) observed that conducting user studies, particularly in naturalistic contexts of use, poses a major challenge for practitioners.

A. Marcus (Ed.): DUXU 2015, Part II, LNCS 9187, pp. 508–519, 2015.
DOI: 10.1007/978-3-319-20898-5_49

In order to support practitioners in this endeavor, a deep understanding of existing design practice and rationality is necessary [9]. However, empirical data on the professional practice in the industry, particularly with regard to field-oriented user studies, is limited. Hence, this paper aims to shed light on how users are approached in the design of mobile systems (e.g. the methods used, the types of users that inform the design), as well as the rationality for practitioners' course of action.

To answer these questions, we conducted in-depth interviews with 15 practitioners, mainly those in design roles, complemented by the views of software developers and project managers. All the practitioners are involved in the design and development of consumer mobile systems related to traditional media and finance. Overall, we examined six projects in media and seven in finance.

We contribute to the literature on design practice by emphasizing the business environment complexity and its influence on understanding users in context. Researchers with ambitions to support practice should consider the limitations caused by the business environment. Organizations, especially those that subcontract design services, should better support design practitioners in reaching the actual users.

2 Background and Related Work

Context is an important construct in design. According to Alexander [10], design is a problem-solving activity aimed at finding a fit between form, i.e. the solution to be created, and context, i.e. anything that places demands on the form and defines the problem. In Human-Computer Interaction (HCI), form is an interactive system, while context is anything that may affect system use. Hence, context is mostly referred as the context of use. The International Standardization Organization (ISO) in their standards for system usability (e.g. [11]), indicates that context of use is determined by characteristics of the users, their tasks, and the technical, physical, social and organizational environments in which a system is used. Successful implementation of interactive systems is believed to be dependent on practitioners' understanding of such contextual aspects [11].

Achieving this understanding requires the involvement of target users in their context of use throughout the project lifecycle. Gould, Boies and Ukelson [12] stress the 'early and continual focus on users' as a key principle for designing usable systems. Bevan and Macleod [13] argue that reliable evaluations should be conducted with "representative users performing representative work tasks in appropriate circumstances" [p. 55]. Last, follow-up evaluations should be conducted on actual system usage [11] to address the evolving nature of context [14].

Understanding of relevant contextual aspects becomes a more prominent challenge in mobile computing as the context of use is subject to rapid and unpredictable changes [6] with new classes of users and tasks [5]. Dix et al. [7] argue that the use of mobile devices is entwined in the contexts of everyday life. Indeed, the recent proliferation of touch-based carry-on devices (e.g. smartphone, tablet) highlights this embedded-ness of technology in all daily activities. Essentially, approaching such heterogeneous and dynamic contexts of use emphasizes ethnographic-oriented user studies [15] with active participation of target users [14]. The importance of longitudinal studies was

emphasized in understanding the actual use of technologies [16] and to capture experiential outcomes (e.g. expectations and motivations) in relation to the situated context [2]. Bentley and Barrett [17] argue that integrating mobile experiences "into the contexts of daily life is often the hardest part to get right" [p. 34]. From a design and development perspective, conducting user studies in situ requires resources that are often in short supply.

Existing surveys on the UCD practice (e.g. [18, 19]) have not focused on the development of software for mobile computing, let alone from a mobile context lens. Nevertheless, the studies indicate on the commonly used methods, such as interview and usability testing. Time and budget constraints along with the lack of experienced personnel and lack of management support are underlined as the major factors that affect the UCD practice.

Monahan et al. [20] emphasized mobile computing by focusing on the utilization of contextual field methods, although respondents were not limited to those involved in mobile computing. Practitioners mostly used interview and user observation, while resource constraints was a major factor affecting the execution of user studies.

Aiming at understanding the design practice of mobile systems from a context of use perspective, Eshet and Bouwman [8] conducted a survey with practitioners in design, management, and development roles. The authors observed that the methods often used by practitioners are more suitable for addressing a stationary context rather than the mobile context. They argue that time and budget constraints as well as practitioners' experience and competence mainly affect the selection of UCD methods.

Dow et al. [21] conducted a qualitative study with 11 designers in various fields, aiming at improving the design of ubiquitous computing systems. While storytelling is highlighted as a key design activity to communicate the intended context of use, it is unclear how designers gain insights to create the stories. In another qualitative study with 11 designers, who work on context-aware systems, Bauer et al. [22] aimed at understanding designers' view and use of context. While the authors discuss the use of artifacts and other representations in conveying contextual information, the means of obtaining insights about users and their context of use is not mentioned. The authors emphasize designers' "difficulty in finding ways to explore the user's interaction with the system in context" [ibid, p. 434] and the role of designers' experience in alleviating such challenge.

The challenge to approach users in situations that are beyond a fixed space and limited time led to efforts by researchers to devise new approaches. For instance, to uncover relevant contextual aspects, self-reporting diary studies have been suggested (e.g. [23, 24]); and to make evaluations more lifelike, a usability lab augmented with situational elements is advocated [25] (for reviews of methods, see e.g. [16, 26, 27]).

However, Stolterman [9] points to the underutilization of scientifically devised methods by professional practitioners. The discrepancy between the design practice in academic and in industry settings results from the fundamentally different objectives and work circumstance. Consequently, Stolterman [9] calls for a deeper understanding of the existing practice and rationality of practitioners.

3 Methodology

3.1 Study Approach

To complement the largely 'snapshot' view provided by existing surveys, we used open-ended interviews that allows to 'go deep' on a specific topic [28], in this case approaching users and context in the design and development of mobile systems.

Acknowledging the distinct backgrounds and views of the internal and external stakeholders that are involved in projects [29], we approached practitioners in various roles: design-oriented, business/management and software development. The triangulation of perspectives by different informants increases the accuracy of findings [30]. Taking the substantial differences between scientific methods and the design practice in industry into account [9], we focused on practitioners in commercial companies.

Regarding mobile, we focused on carry-on devices [7], i.e. touch-based smartphone and tablet, given practitioners' engagement with both form factors. We define mobile system as a software program that runs on these devices, whether native platform application (i.e. mobile app), browser-based web application (e.g. HTML5) or a hybrid solution. As such systems abounds, we limit the scope to media (e.g. news, magazines, TV), and finance (e.g. banking, payment, investment). These categories represent everyday use of mobile, while differ in user base, e.g. anyone in media vs. customers in finance, and perceived contexts of use, e.g. heterogeneous and generic vs. more specifically defined. Last, we mainly considered consumer systems (B2C), as they demonstrate a greater spread of contexts of use in everyday life.

3.2 Sample

We conducted interviews with 15 practitioners (N_p) in Finland during October 2013 – March 2014. The participants were approached through an online search and by using a snowball sampling. Most participants (N_p = 11) work in design-related roles, while other participants have business/management roles (N_p = 2) and software development roles (N_p = 2). Participants' professional experience ranges between 1-15 years (avg. 10.5; med. 10; std. dev. 3.72), while professional experience with mobile computing varies between 1-15 years (avg. 8.7; med. 9; std. dev. 3.45). Six participants were involved with six different media system projects and nine participants with seven different finance system projects. A total of 14 interviews were conducted: 13 individual and an interview with two practitioners. Except for one remote interview online, all interviews took place in situ.

Participants work in 11 companies of different sizes: two companies are small with up to 50 employees, four are medium-sized with as far as 1000 employees, and five companies are large with over 1000 employees. Medium and large companies include big players in the market. Seven companies are subcontractors that provide IT solutions, while four companies design and develop in-house or use external services.

3.3 Interview Procedure

Following the open-ended type of interviews [31], we used the following high-level topics to guide the discussion: perception of mobile users and means of defining users; perception of the usage environment; methods, techniques and tools to gain user insights; means to interpret the data and generate design ideas; means to evaluate the design practice and project; organizational project settings; professional background and work responsibilities.

Interviews lasted between 36–94 min. (avg. 59 min.) and audio-recorded for transcription and further analysis. The main part of the interview focused on walking through a particular, preferably recent or current, project that fit the study scope.

3.4 Data Analysis

The analysis was largely organized in three phases. First, the interviews were transcribed following a rather denaturalized approach [32]. After that, transcripts were sent to participants for validation. Next, we read through the transcripts. Secondly, following a grounded theory approach [33], we coded the transcripts using Atlas.ti ([34], http://www.atlasti.com/). Last, we explored the findings by using a cross-case synthesis table [31], along with an experimental framework.

Following Miles and Huberman [35] recommendation for having initial list of codes, we coded instances in which practitioners employed relevant UCD methods and techniques, including less-formal ones. For eliciting the factors that affect practitioners in their efforts to understand users in context, we started by open coding followed by axial and selective coding. With axial coding, we aimed at finding dimensions and relationships between the initial factor categories, while the selective coding aimed at identifying the core factors. The coding scheme was complemented with code definitions.

The cross-case synthesis table was used to explore patterns in practitioners work. The synthesis matrix incorporates an array of attributes, including project meta-data (e.g. media/finance category, subcontractor/in-house position, target user definition), UCD methods and the phase in which they were used (requirements, evaluation, usage), type of users involved (e.g. project-internal, social peer groups, actual/representative), type of contexts studied (e.g. artificial, partly representational, naturalistic), length of studying users (ad hoc vs. longitudinal), the factors that affect practitioners' work and other indicators that can help to explain their work motives. Examining certain attributes can indicate on a specific pattern in practitioners' work.

The experimental tabular framework examines the core principles required in order to address the mobile context and the project phases in which the principles should be applied. Grounded in the UCD philosophy (as explained in the background section), the principles include the involvement of **target users**, who are studied in their **real-life contexts** over **time**. The phases include the **requirements** phase to understand user needs and inform the design; the **evaluation**, to test design proposals; and actual **usage**, to continually adapt systems to the evolving and changing nature of context and user

needs. The framework emphasizes the method in which practitioners approached target users in actual context over time, to varied extent.

4 Findings

4.1 Approaching Target Users

Table 1 presents the methods that practitioners used in understanding target users and actual context. Out of the 13 examined projects, practitioners approached the intended user group, during one or more phases, in eight projects. Of these projects, studies that involve real-life contexts of use were conducted in six projects, in which five of them were also carried out to some temporal length. The number in brackets denotes the number of projects in which the method was employed.

To understand users, practitioners mainly relied on interviews in early requirements phase, while pilot and lab testing were used for evaluating solutions. Real-life context was studied in early phase by using contextual interview and ethnography. Evaluations in context were conducted with a pilot test. Fairly the same applies to conducting studies over time. Evidently, studying ordinary situations is a great challenge, resulting in only three projects in which practitioners made early efforts to approach users in their daily life. Diary study was not used, considered to be less cost-efficient, i.e. more time consuming and uncertain in producing valuable insights. Interestingly, an augmented usability lab to resemble in-shop payment experience was used in early phase rather than in evaluation, to uncover issues with various payment methods.

Also noticeable is the lack of user studies during the usage of systems. While practitioners often gain insights on the actual usage through various user feedback channels and usage analytics, we included in the framework only studies in which users are intentionally approached.

We observed that practitioners approached target users in four out of four in-house design projects against four out of nine projects in which the design service was subcontracted. Particularly, projects in the usage phase are all in-house. In addition, in six out of the eight projects in the framework practitioners highlighted that approaching users was managed by their own, or by the client, organization.

Table 1. Methods used in projects that approached target users

Requirements	Evaluation	Usage
Contextual interview (2)[a] [b]	Pilot test (4)[a] [b]	Phone interview (1)[b]
Interview (2)	Lab usability test (2)	Survey (1)
Survey (2)	Interviews (1)	
Ethnography (1)[a] [b]		
Augmented lab (1)		

[a] Study conducted in real-life context
[b] Study conducted over time

4.2 Approaching Other Types of Users

In the other five projects, practitioners did not approach actual or representative users. Table 2 presents the type of users and how they were involved throughout the project. Noticeably, practitioners gained user insights from those who are easily available, e.g. colleagues and client personnel (some are involved in the project) and their close social peers like friends and relatives.

Given the lack of target user insights, practitioners mainly use workshop settings to brainstorm and generate ideas, both internally and with the client. User needs are therefore based on the assumptions of those participating in the workshops. Evaluations are commonly informal by giving the system to colleagues and client personnel to use for some time. By this, practitioners gain some insights into relevant contextual aspects, although the usage by tech-savvy people and those familiar with the system may mislead design practitioners. The visible lack of efforts to understand the actual usage is likely the result of these five projects being in a subcontractor position, in which the work is often characterized by a short-term contract.

Besides that, clients play a more significant role on discouraging practitioners in their effort to approach users. First of all, given that users are often the client's customers, clients may be reluctant to share this asset. Secondly, clients strictly limit the project resources to the essential design and development, which leaves no room for conducting user studies. Consequently, practitioners often ground their understanding of users on external data sources that are provided by the client as well as by social peers. While time and budget constraints were mentioned by most practitioners in this study, Table 2 shows that practitioners in subcontracting firms are less likely to approach users in actual contexts of use than their counterparts who work in-house.

Table 2. Approaching users other than the target group

Phase / Type of users	Requirements	Evaluation	Usage
Social peers	Concept ideation and validation with relatives (1)	Testing with friends, neighbors (1)	
Project internal	Workshop with client (4) Concept ideation and validation with colleagues (1)	Testing by colleagues (4) Testing by client (3) Pilot with client personnel (1)	
Random		Testing with random people on the street (1)	

5 Discussion

Mobile systems are nowadays an integral part of people's everyday life. Understanding users needs in these dynamic and heterogeneous contexts is a challenge faced by practitioners. We conducted in-depth interviews with various mobile practitioners in different companies, aiming at shedding light on their efforts to approach users in actual contexts. In this section we discuss our main finding, namely the reliance on traditional UCD methods and the influence of the business environment on practitioners efforts to understand users. Last, we discuss the limitations of the study.

Overall, approaching users is difficult, while conducting user study in naturalistic contexts occurs in very few exceptional cases. Prior studies (e.g. [8, 18, 20]) already observed the low utilization of field-oriented studies, urging scholars to explore alternative ways to study users in context. As discussed before in this paper, numerous methods have been conceived and practiced by researchers.

In contrast, practitioners mainly rely on traditional methods to understand users and context. The use of interviews (incl. contextual), surveys, usability lab and pilot test indicate on practitioners' inclination to use established methods. Most likely, practitioners are familiar with these methods from their formal education, training and/or professional work, since practitioners' experience is a major factor affecting the choice of methods [8]. Considering resource constraints, which are well known determinants of the design practice (e.g. [8, 18, 20]), practitioners incline to use methods that are perceived to produce relevant insights within time and budget limitations. Hence, practitioners may perceive other methods as less cost-effective or may not have experience using them.

Gaining experience with a new method, like diary study and rapid ethnography, requires first awareness of it and demonstration of its cost-justification. Such knowledge is acquired largely through formal education and training. Hence, cost-efficient user study approaches should be promoted in the education of professional designers, while new approaches should be distributed beyond the academia. In addition, researchers, who work on new approaches to solve the problems of practitioners, should be more thoughtful of the complexity, uncertainty and value conflicts in the problems faced by professional practitioners [36]. One such complexity is the business environment.

Users and context are more likely to be approached in in-house, rather than in subcontracted, projects. According to Barney [37], organizations can achieve a competitive advantage by investing in valuable, rare and hard to imitate resources and capabilities. Design competences, e.g. trained professionals and their work activities (incl. UCD methods), can be considered a part of the organizational resources and capabilities. Apparently, organizations that invest in in-house design competences understand its strategic value, which makes it more likely that practitioners would be supported in their efforts to understand users and context. Organizations that subcontract design competences from a third party may be more interested in the cost-efficient delivery of the outcome and less knowledgeable in the operational activities required in achieving a usable and useful outcome. Moreover, our findings suggest that users are

more likely to be approached when the organization alleviates the burden of recruiting users, such as in providing access to its customer base.

The business relationship has a more significant effect on understanding users and context. With few resources available for conducting user studies, practitioners in a subcontracting type of relationship mainly rely on user data that is provided by the client. Such understanding of users adds another level of obscurity to the common second-order understanding as discussed by Krippendorf [38]. That is, practitioners understanding of users is embedded in the understanding of client's understanding of users' understanding of something. This recursive course of action significantly affects the understanding of user needs, especially in light of the business perspective of the client. Looking for workarounds to achieve a second-order understanding of users, practitioners default to gain insights from close social peers that may or may not represent their target users.

This practice is assumed to be common, since design practitioners are mostly employed by professional usability/UX consultants or software houses [8, 20]. Schön [36] warns on the negative effect from a practice that becomes repetitive, essentially "the practitioner may miss important opportunities to think about what he is doing … he is drawn into patterns of errors which he cannot correct" [p. 61]. Since practitioners are not experimenting with actual users, becoming accustomed to a third-order understanding of users may affect practitioners' knowledge about users as well as the development of competences to gain new knowledge, especially considering the shift to mobile computing with its notable impact on understanding people.

The business environment complexity in the work of design practitioners is often overlooked in HCI research. Obviously, simulating the business environment in research is difficult. One suggestion is to foster more collaboration between research and practice by means of action research type of studies that are conducted within actual settings of professional practice.

The limitations of the study include our sample, which is based on practitioners in a specific country. Based on the practitioners' professional experience and distribution in terms of company sizes and type (in-house, subcontractor), we assume that the sample reflects the business practice in Finland. Additionally, we conducted interviews in the Netherlands to further develop and validate our findings. Regarding systems, we acknowledge the fact that other categories may have more specific use cases (e.g. business, games) and encourage the examination of possible differences.

Second, we relied merely on practitioners' recollections of their activities. As such, the responses can be biased or may simply suffer from an inaccurate articulation of the events due to poor recall. We alleviated this shortcoming by focusing on experiences from a particular and recent project. An ethnographic-oriented study of the topic would be obviously valuable.

Third, the analysis of verbal text is inherently selective and interpretive [35]. The selection of data is based on the questions that guided the study and by looking for commonalities instead of unique statements. To address possible misinterpretations on words and statements, we asked participants to review their transcripts, read through the transcripts several times, and focused on the meaning in the context of statements rather than specific words.

Last, the findings are limited in the sense that they merely focus on the design practice, while the evaluation of the actual use of systems and the relations between this evaluation and the design practice was not tested. That is, does a better-informed design lead to better performing systems from a user perspective?

6 Conclusion

In this paper we examined the design practice of mobile systems, particularly regarding the approaching of users and contexts of use. We used interviews to collect data from mobile practitioners, mainly in design roles. Our main finding emphasizes the business environment complexity and offers a valuable contribution to interaction design theory, education and practice, particularly with the current transition to mobile systems and the significant effect of mobility on context.

Our findings show that practitioners mostly use traditional methods to understand users and context, such as interviews, surveys and lab testing. These methods are very limited with regard to gaining insights on users in context. As practitioners tend to use methods they are familiar with, this has implications on the education and training of design practitioners in approaches that are more suitable to understand users in dynamic and heterogeneous contexts.

Moreover, we emphasize the business environment complexity that practitioners face in their effort to understand users and context and that is often overlooked in HCI research. Essentially, we observed that in-house design practitioners are more likely to approach users and context of use than their counterparts in subcontracting organizations. In addition, design practitioners in subcontracting firms are often dependent on a third-order understanding of users through the client organization, which obscure their necessary understanding of target users in context. Hence, organizations that obtain external design competences and wish to address user needs should make more effort to support design practitioners in actualizing their expertise. We highlight the facilitation of access to users as an example of such support.

Researchers that aim at solving the problems of professional designers in their efforts to understand users and context should show careful consideration to the business environment complexity. This can be achieved by acting as a researcher-practitioner and gaining a first-order understanding of the rich and complex problems that professional practitioners face.

Acknowledgments. We are grateful to the participants for sharing their experiences with us. The study was supported by grants from Turku Centre for Computer Science, Åbo Akademi Foundation and the Foundation for Economic Education in Finland.

References

1. Gould, J.D., Lewis, C.: Designing for usability: key principles and what designers think. Commun. ACM **28**, 300–311 (1985)

2. Hassenzahl, M., Tractinsky, N.: User experience - a research agenda. Behav. Inf. Technol. **25**, 91–97 (2006)
3. Rogers, Y., Sharp, H., Preece, J.: Interaction design: beyond human-computer interaction. Wiley, New York (2007)
4. Hinman, R.: The Mobile Frontier. Rosenfeld Media, Brooklyn (2012)
5. Johnson, P.: Usability and mobility; interactions on the move. In: Proceedings of the First Workshop on Human-Computer Interaction with Mobile Devices (1998)
6. Forman, G.H., Zahorjan, J.: The challenges of mobile computing. Computer **27**, 38–47 (1994)
7. Dix, A., Rodden, T., Davies, N., Trevor, J., Friday, A., Palfreyman, K.: Exploiting space and location as a design framework for interactive mobile systems. ACM Trans. Comput.-Hum. Interact. **7**, 285–321 (2000)
8. Eshet, E., Bouwman, H.: Addressing the Context of Use in Mobile Computing: a Survey on the State of the Practice. Interact. Comput. iwu002 (2014)
9. Stolterman, E.: The nature of design practice and implications for interaction design research. Int. J. Des. **2**, 55–65 (2008)
10. Alexander, C.: Notes on the Synthesis of Form. Harvard University Press, Cambridge (1964)
11. ISO: ISO 9241-210:2010 Ergonomics of human-system interaction-Part 210: Human-centred design for interactive systems. International Organization for Standardization, Geneva (2010)
12. Gould, J.D., Boies, S.J., Ukelson, J.: How to design usable systems. Handbook of human-computer interaction. **2**, 231–254 (1988)
13. Bevan, N., Macleod, M.: Usability measurement in context. Behav. Inf. Technol. **13**, 132–145 (1994)
14. Dourish, P.: What we talk about when we talk about context. Pers. Ubiquitous Comput. **8**, 19–30 (2004)
15. Greenberg, S.: Context as a dynamic construct. Hum.-Comput. Interact. **16**, 257–268 (2001)
16. Hagen, P., Robertson, T., Kan, M., Sadler, K.: Emerging research methods for understanding mobile technology use. In: Proceedings of the 17th Australia conference on Computer-Human Interaction: Citizens Online: Considerations for Today and the Future, pp. 1–10 (2005)
17. Bentley, F., Barrett, E.: Building Mobile Experiences. MIT Press, Cambridge (2012)
18. Rosenbaum, S., Rohn, J.A., Humburg, J.: A toolkit for strategic usability. In: Proceedings of the SIGCHI conference on Human Factors in Computing Systems (CHI 2000), pp. 337–344. ACM Press (2000)
19. Bygstad, B., Ghinea, G., Brevik, E.: Software development methods and usability: Perspectives from a survey in the software industry in Norway. Interact. Comput. **20**, 375–385 (2008)
20. Monahan, K., Lahteenmaki, M., McDonald, S., Cockton, G.: An investigation into the use of field methods in the design and evaluation of interactive systems. In: Proceedings of the 22nd British HCI Group Annual Conference on People and Computers: Culture, Creativity, Interaction, vol. 1, pp. 99–108. British Computer Society, Swinton (2008)
21. Dow, S., Saponas, T.S., Li, Y., Landay, J.A.: External representations in ubiquitous computing design and the implications for design tools. In: Proceedings of the 6th Conference on Designing Interactive Systems, pp. 241–250. ACM, New York (2006)
22. Bauer, J.S., Newman, M.W., Kientz, J.A.: What designers talk about when they talk about context. Hum.-Comput. Interac. **29**, 420–450 (2014)
23. Consolvo, S., Walker, M.: Using the experience sampling method to evaluate ubicomp applications. IEEE Pervasive Comput. **2**, 24–31 (2003)

24. Brandt, J., Weiss, N., Klemmer, S.R.: txt 4 l8r: lowering the burden for diary studies under mobile conditions. In: CHI 2007 extended abstracts on Human Factors in Computing Systems, pp. 2303–2308. ACM, New York (2007)
25. Kjeldskov, J., Stage, J.: New techniques for usability evaluation of mobile systems. Int. J. Hum Comput Stud. **60**, 599–620 (2004)
26. Coursaris, C.K., Kim, D.J.: A Meta-Analytical Review of Empirical Mobile Usability Studies. J. Usability Stud. **6**, 11:117 (2011)
27. Eshet, E.: Human-centered design in mobile application development: emerging methods. IJMHCI **4**, 1–21 (2012)
28. Lazar, J., Feng, J.H., Hochheiser, H.: Research Methods in Human-computer Interaction. Wiley, New York (2010)
29. Suchman, L.: Located accountabilities in technology production. Scand. J. Inf. Syst. **14**, 91–105 (2002)
30. Patton, M.Q.: How to Use Qualitative Methods in Evaluation. SAGE Publications, Thousand Oaks (1987)
31. Yin, R.K.: Case study research: design and methods, 3rd edn. Sage Publications Inc., CA (2003)
32. Oliver, D.G., Serovich, J.M., Mason, T.L.: Constraints and opportunities with interview transcription: towards reflection in qualitative research. Soc. Forces **84**, 1273–1289 (2005)
33. Strauss, A., Corbin, J.M.: Basics of Qualitative Research: Grounded Theory Procedures and Techniques. Sage Publications Inc., Thousand Oaks (1990)
34. Muhr, T.: ATLAS/ti — A prototype for the support of text interpretation. Qual Sociol. **14**, 349–371 (1991)
35. Miles, M.B., Huberman, A.M.: Qualitative Data Analysis: An Expanded Sourcebook. SAGE Publications, Thousand Oaks (1994)
36. Schön, D.A.: The Reflective Practitioner: How Professionals Think In Action. Basic Books, New York (1984)
37. Barney, J.: Firm Resources and Sustained Competitive Advantage. J. Manag. **17**, 99–120 (1991)
38. Krippendorff, K.: The Semantic Turn: A New Foundation for Design. CRC Press, Boca Raton (2005)

Paper 5

Eshet, E. and Bouwman, H. (2016). Context: the final frontier in the practice of user-centered design?

Under revision in: Interacting with Computers.

Context: the final frontier in the practice of user-centered design?

User-Centered Design (UCD) practitioners in industrial context are often faced with multilevel factors that hinder their effort to *involve users in a naturalistic context*, and so meet one of the core UCD principles. Seen the heterogeneous and dynamic context of mobile system use, applying this principle becomes more challenging. Based on in-depth interviews with various mobile practitioners in Finland and the Netherlands, we explore the core factors that affect UCD practitioners in meeting this challenge. Our findings confirm the impact of the professional-client relationship as a key factor that inhibits the involvement of users. Novelty aspects, e.g. practitioners' unfamiliarity with the users and the perceived innovativeness of the designed system, largely explain the involvement of users *in situ*. Interestingly, these conditions are not idiosyncratic to mobile computing. We discuss the contextual factors' implications on UCD and emphasize alternative strategies that support practitioners in their effort to involve users.

Eyal Eshet
Åbo Akademi University,
Gezeliusgatan 2 A,
20500 Turku,
Finland

eeshet@abo.fi

Harry Bouwman
Delft University of Technology,
Jaffalaan 5,
Delft, 2628 BX,
Netherlands

W.A.G.A.Bouwman@tudelft.nl

Keywords: User centered design; ubiquitous and mobile computing; empirical studies in interaction design; empirical studies in HCI

Research highlights:

- The involvement of users is particularly challenging in contract-based projects
- Client organizations restrict resources and access to users, often their customers
- Consequently, UCD practitioners in subcontracting firms default to a third-order understanding of users
- Novelty aspects, especially unfamiliarity with users and system innovativeness, encourage field studies
- We report on alternative strategies that encourage the involvement of target users

1. INTRODUCTION

User-Centered Design (UCD, also HCD to exchange 'user' with 'human') has long been established as the major approach to designing useful and usable interactive software systems (Norman and Draper, 1986; ISO 9241-210, 2010). Its fundamental principle emphasizes the need to *explicit understand users and context of use by involving users throughout the design and development process*. Extensive research, particularly within the Human-Computer Interaction (HCI) community, has contributed a wide range of methods and approaches aimed to support UCD practitioners in this effort (e.g. Nielsen, 1993; Beyer and Holtzblatt, 1998; Rosson and Carroll, 2001; Laurel, 2003). However, involving users, especially in field studies, has proven to be difficult (Rosenbaum et al. 2000; Monahan et al. 2008; NN, 2014), particularly in the context of industrial projects.

Projects are complex social systems that are embedded in a dynamic, often inter-organizational context. First, different project types, e.g. contract-, project-, and in-house- development, affect the timing and ability to involve users (Grudin, 1991a). Moreover, projects involve stakeholders at various levels within the organization as well as external clients. Stakeholders have distinct backgrounds and views (Suchman, 2002), different expectations that have to be satisfied (Krippendorf, 2006) as well as criteria for project success (Baxter and Sommerville, 2011). Organizations also have their own history (El Emam and Madhavji, 1995), strategy (Grudin 1991a), culture and established work practices (Iivari, 2005). This influences the inclination of decision-makers to support user involvement, particularly with providing resources (time, budget) and capabilities (Damodaran, 1996). Last, projects revolve around

specific interactive software systems with different nature and different diversity of users, which affect the effort to identify and access relevant users (Axtell et al. 1997). The emergence of mobile computing in recent years has an impact on UCD practitioners, as the context of interactive systems use greatly expand.

Mobile computing devices (e.g. mobile phone) are used in multi-contextual settings that are significantly more dynamic, heterogeneous, and unpredictable than the typical single-context of use with stationary computing devices (e.g. desktop) (Forman and Zahorjan, 1994; Hinman, 2012). In addition, because they are highly affordable, mobile devices significantly increase the diversity of users, tasks and access devices (Johnson, 1998). The emergence of the mobile apps era (NN, 2014), the rise of wearable computing (Meeker, 2013), sensing technologies, and more broadly a cross-channel computing experience further interweave our lives with technology. Making sense of such rich contextual settings is an essential skill for the success of interactive systems that run on mobile devices (i.e. mobile systems), although it is a major challenge for practitioners (Hinman, 2012; Bentley and Barrett, 2012). In essence, the explicit understanding of users and their context of use during the design and development of mobile systems require an ethnographic and longitudinal approach that puts more emphasis on the involvement of users in their actual context of use (Tamminen et al. 2004). Given the aforementioned resource constraints that inhibit the practice of UCD activities, such an approach requires more investment in these resources. Thus, the design of mobile systems creates a greater challenge to the involvement of users, let alone in the context of use.

Empirical insights into the factors that affect the involvement of users *in-situ* during the design and development of mobile systems, particularly in the mobile apps era and in industrial context, are scant. A recent literature study (Eshet, 2012) on the UCD practice of mobile systems in scientific projects during the mobile apps era indicates on a significant increase in the use of context-oriented (i.e. field) methods, especially for evaluations. However, comparable insights from a survey on the UCD practice in an industrial context (NN, 2014) show that the frequency of applying field methods reflects the practice observed in prior studies (Venturi et al. 2006; Monahan et al. 2008), which did not focus on mobile computing. More empirical insights into the situated circumstances that affect UCD practitioners to explicitly understand users and contexts of use are needed. Such insights into practitioners' existing work and rationality are considered a fundamental step in theorizing the design practice and supporting UCD practitioners' work (Stolterman, 2008; Goodman et al. 2011). Accordingly, this study aims at contributing to design practice theory by shedding light on the *core factors that affect UCD practitioners in industrial context to (1) involve users, and (2) involve users in the context of use, in the design, development, and post-deployment of particular mobile systems during the mobile apps era*.

We conducted in-depth qualitative interviews in Finland and the Netherlands, engaging practitioners, mainly in UCD roles (e.g. UX designer, interaction designer, usability specialist, user researcher), with complemented views from those in software development and project management. All the practitioners we interviewed are involved in mobile system design and/or development in industrial context. We focused on generic systems that are related to traditional media (e.g. news, magazines, video) and more specific systems for finance (e.g. banking, payment), representing nice-to-know and need-to-know type of user activities, respectively. These system categories are widespread, demonstrating the usage in heterogeneous and dynamic social, physical, and technological context. And although many of the use cases may be similar to the use of these systems on stationary computing, they

also present opportunities for use cases that are distinct to mobile computing, such as live report of news events and in-store mobile payment.

This paper contributes to a timely examination on the factors that influence UCD practitioners' work. We reconfirm the professional-client relationship as a barrier to the involvement of users, particularly the financial constraints that UCD practitioners in contract-based projects are faced with. However, the involvement of users in context of use is encouraged by conditions that are related to novelty in the project case, particularly the mental and cognitive distance between users and practitioners and the perceived innovativeness of the designed system play a crucial role. The findings emphasize the need for a more ecological research into the design practice, and have implications on the UCD approach and its education.

The paper is organized as follows: in Section 2, we examine the theoretical background on the core UCD principle of user involvement, delineate the concepts of user involvement and context of use, and review related studies; in Section 3, we explain our research approach and describe the research methodology; in Section 4, we present the results; in Section 5, we discuss the findings and limitations, and suggest avenues for further research; finally, in Section 6, we present our conclusions.

2. THEORETICAL BACKGROUND

2.1. User involvement as core UCD principle

The involvement of users is a fundamental principle of UCD approaches for the design of usable and useful interactive systems. Norman and Draper (1986) were arguably the first to use the term 'User-Centered System Design', arguing in favor of the importance of understanding intended users during system design. Gould (1988) anchored this understanding in an early and continual active involvement of users throughout the system design and development process. Later on, the work by Macleod and Bevan (1993) was instrumental in standardizing the UCD approach (ISO, 1999, replaced by ISO 9241-210, 2010). The ISO standard describes a high-level complementary development approach that reinforces Gould's early principle for usable system design: *explicit understanding of users and context of use* by *active involvement of users throughout design and development*. This principle is considered the *sine qua non* of UCD (Gulliksen et al. 2003), as indicated by seminal design approaches that advocate the principle, among them are participatory design (Schuler and Namioka, 1993), usability engineering (Nielsen, 1993; Mayhew, 1999), contextual design (Beyer and Holtzblatt, 1997), goal-directed design (Cooper, 1999), scenario-based design (Rosson and Carroll, 2001), User Experience (UX) design (Hassenzahl and Tractinsky, 2006) and Interaction Design (Sharp et al. 2007). Moreover, the *lack* of adequate user involvement is considered as a major software-project risk (Schmidt et al. 2001). Despite the consensus on the principle, the interpretation of the user involvement concept and the operationalization of the principle greatly vary (Kujala, 2003).

To start with, Krippendorf (2006) emphasizes that users are not merely those who use the system, but all stakeholders that the system may directly or indirectly affect. Accordingly, there are different types of user groups. Identifying all the stakeholders in a project is a prerequisite to the involvement of users.

As a concept, user involvement, or participation, have multiple interpretations that loosely describe a direct contact with users during the system development process (Kujala, 2003). The terms 'involvement' and 'participation' are commonly used synonymously (Iivari and Iivari, 2011), although Barki and Hartwick (1989)

attempted to conceptually distinguish them based on the users' psychological level of attachment with the system (involvement), and the users' functional level of performing different activities during the design (participation). Damodaran (1996) suggests a more practical classification of user involvement based on the level of involvement, from (1) informative - users provide and/or receive information; (2) consultative – users comment on a predefined service or range of facilities; and (3) participative – users influence decisions relating to the whole system. Each level can be characterized by *direct* or *indirect* involvement (Grudin, 1991b; Iivari and Iivari, 2011); *direct* refers to the involvement of *actual* users; in case the real users are not known during design or when the user population is too large to be accommodated in the design, the involvement is *indirect* using *representative* users or *surrogate.* Surrogate denotes intermediaries that stand for the actual users, such as UCD/usability specialists (Iivari and Iivari, 2011). Another type of user involvement is End-User Development (EUD) (Sutcliffe, 2004), which suggests that users are the sole designers and implementers of their systems. However, EUD is not commonly discussed in the UCD literature (Iivari and Iivari, 2011) and hence, beyond the scope of this paper. Last, Grudin (1991b) emphasizes that user involvement is considered as involvement when it has an impact on the design.

On the practical level, Damodaran's (1996) levels of user involvement are implemented in various forms that can be described on different continuums, e.g. from ethnographically observing users (Blomberg et al. 1993) to self-reporting diaries by users (Consolvo and Walker, 2003); from remote involvement through a questionnaire to face-to-face user interviews (Sharp et al. 2007); from ad-hoc user evaluation of solutions (Gothelf and Seiden, 2013) to participatory design with users during the entire project lifecycle (Schuler and Namioka, 1993); and from artificial context such as a usability test in laboratory (Nielsen, 1993) to naturalistic context as with contextual inquiry (Beyer and Holtzblatt, 1997). The HCI literature contains scores of other methods and techniques for involving users in design (e.g. Laurel, 2003; Randall et al. 2007).

Formally, the principle on user involvement emphasizes: (1) active involvement by at least informative and consultative levels; (2) users must be the direct users or indirect representative of the prospective user groups; (3) the involvement should occur during an early project phase, to collect fundamental information for specifying user requirements and to inform the design (informative), in evaluations, to test design proposals (consultative), and in follow-up evaluations of actual system usage (consultative); (4) user involvement should take place in the intended context of use, especially for design evaluations (Gould, 1988; Gulliksen et al. 2003; ISO 9241-210, 2010).

The usability of interactive systems is dependent on the context of use, an umbrella term that broadly refers to the users and the situational environment in which users use a system. 'Context' is an everyday label with many connotations. In HCI, 'context' is often explained in terms of the internal processes, e.g. human goals, motives, and background; and external resources, e.g. the people, objects, and real-world settings of the situated environment (Nardi, 1996; Bradley and Dunlop, 2005). Essentially, any course of action is always situated within specific context, and hence dependent on, and dynamically defined within, internal and external contextual aspects (Nardi, 1996; Dourish, 2004; Suchman, 2006). With HCI, courses of action are related to the *use* of interactive system, and thus termed 'context of use'. Descriptions of 'context of use' commonly encompass high-level dimensions that can be classified into internal processes, i.e. user profiles and user tasks, and external

resources, i.e. the technical, physical, cultural, social and organizational environment in which the system is, or intended to be, used (Maguire, 2001; ISO 9241-210, 2010). Each dimension holds various low-level aspects that are likely to be relevant for design. Maguire (2001) summarizes many of these contextual aspects, such as user's task knowledge, task frequency, network settings, workplace space and furniture, group working and organizational policy on computer use. With the use of mobile computing devices in nearly unlimited range of situations, the variety of contextual aspects significantly expands.

2.2. User involvement in the design of mobile systems

To start with, we clarify the concept of mobile systems in this paper. Dix et al. (2000) distinguish between three categories of mobile computing: (1) carried-on devices, such as PDA and wearable computers; (2) autonomous devices, such as robots; and (3) devices embedded in another moving object, such as in-car computing. In this research, mobility is considered an attribute of human, not the system. Mobility is roughly defined as people's ability to move between locations that vary in their spatiality, temporality, and social settings (Henfridsson and Lindgren, 2005). During this movement, people carry their computing devices with them and use them in varied multi-contextual settings. Accordingly, this paper is focused on the first category of carried-on devices, particularly mobile phones and tablet computers. For brevity, the interactive software systems that run on these devices are labeled here as 'mobile systems' (elsewhere also termed applications, programs, and services).

In fact, portable computers, i.e. laptops, are also carried-on devices. However, in this paper we do not regard them as mobile for two interrelated reasons: firstly, mobile phones are ubiquitously carried-on and used even during motion whereas laptops are carried-on merely for specific uses or specific places and are used during still time. For instance, the shoppers in retail store, audience in a game, and tourists on the beach are all likely to carry a mobile phone. In contrast, laptops are likely to be carried by those on duties, e.g. official scorers and timekeepers in a game, or carried by tourists merely during flight and accommodation. Secondly, modern mobile phones (i.e. smartphones) and tablet computers are coupled with sensors that allow the adjustment of systems based on the situated context of use.

The varied contexts of mobile system use expand the typically single-context in which traditional stationary systems are used, both in the internal context and external context. The removal of time and place constraints in the use of mobile devices creates a heterogeneous external context of use that is characterized by rapid and unpredictable changes (Forman and Zahorjan, 1994; Tamminen et al. 2004). Schilit et al. (1994) describe the mobile context of use in terms of the spatial settings (i.e. location of use), social surroundings (i.e. people nearby), and physical resources (e.g. light, noise, network connectivity), emphasizing the dynamic changes in these dimensions overtime. Chen and Kotz (2000) also emphasize the temporal dimension, i.e. the time and day of use, while Johnson (1998) adds new aspects to the technical dimension, e.g. the increased diversity and integration of devices and services. Being carried on, mobile devices also increase the internal context; Johnson (1998) highlights the increased diversification of users due to the affordability of mobile devices; additionally, there are new classes for situated courses of actions, or tasks, that are made possible with mobile computing, e.g. health and insurance report in emergency situations such as a road accident.

Jumisko-Pyykkö and Vainio (2010) synthesized and summarized the contextual aspects that are more specific to the context of mobile system use, including aspects such as the sensed environment (e.g. light and sound), user's motion (e.g. sitting, walking) and mobility (e.g. wondering, traveling), dependency on network connectivity (e.g. WiFi hotspots, telecom network base stations), user's attention switches due to interrupting events caused by the environment, and dynamics of the socio-spatial environment (e.g. other people who are physically or virtually present, using the device in-shop, on street, at work during same usage session). Jumisko-Pyykkö and Vainio's (2010) study indicates that the design of mobile systems requires significantly more contextual considerations than the design of stationary systems. For instance, although an insurance report can be done on a stationary- or on mobile- systems, the internal psychological state and the external spatial, temporal, social, physical, and technical environments are much richer when the report is made on the scene using a mobile system. Fundamentally, understanding the context of mobile use requires field studies that include both spatial and temporal dimensions, e.g. longitudinal ethnographic studies (Tamminen et al. 2004). These studies can capture aspects of the internal processes, their relation to the situated external resources (Hassenzahl and Tractinsky, 2006), and the dynamic changes over time.

In recent years, the proliferation of mobile devices, mainly in the form of touch-based smartphone and tablet computers, and the ubiquitous use of mobile systems (known as mobile apps), marked the emergence of the 'mobile apps era'. This era demonstrates the increasing embeddedness of technology in people's everyday professional and private lives, and affects user involvement in at least two ways: firstly, the expansion in the diversity of users and contextual considerations requires new *competences* to explicitly understand users and context of use. Application stores (i.e. app stores) democratized mobile software design and development, a domain that was historically controlled by telecommunication network operators and handset manufacturers. Consequently, the focus in system design and development has quickly shifted from stationary systems to mobile systems with scores of UCD practitioners jumping on the mobile bandwagon. Hinman (2012) argues that practitioners are often not equipped with methods and tools for making sense of the diversity of users and variety of context of mobile device use, although these competences are essential in designing great mobile experiences. Bentley and Barrett (2012) assert that understanding the rich context of mobile use, beyond simple classifications as 'abroad', 'home', 'work/school', 'significant other place', and 'elsewhere' (Soikkeli et al. 2013), is a major challenge for practitioners.

Secondly, the expansion in the diversity of users and contextual considerations requires more *resources* to explicitly understand users and context of use. The app store model and its financial incentives quickly resulted in an increasingly competitive and dynamic market (Bergvall-Kåreborn and Howcroft, 2011). Moreover, the design and development of systems is increasingly grounded in Agile approaches (NN, 2014) with its principle on short system delivery cycles. Considering the diversity of mobile users and the need for longer sessions of involvement, especially in the context of use, the competitive pressure as well as the integration of UCD within Agile's short cycles increases the challenge to effectively and efficiently identify and involve relevant users during the design of mobile systems.

To sum up the theoretical discourse, a core UCD principle emphasizes the *involvement of users* during the design and development of interactive systems, including the involvement of users in the *context of use*, especially for design

evaluations. Furthermore, we draw attention to the application of the UCD principle not only during design and development, but also during actual system usage, that is, in *post-deployment*. Applying the principle to the varied context of mobile system use puts more emphasis on the study of users *over time and across spaces*. Naturally, the extent of 'over time' and 'across spaces' depends on the task in hand and the likely consequences of its outcome. The mobile apps era puts more prominent challenges to the involvement of users and to the understanding of the context of use.

Existing studies on the UCD practice (Rosenbaum et al. 2000; Vredenburg et al. 2002; Venturi et al. 2006; Monahan et al. 2008; NN, 2014) continuously observed a gap between the UCD principle and the actual practice in industrial context, particularly regarding field studies in the actual context of use. Next, we review related work to explain the forces that affect the implementation of the UCD principle in an industrial context.

2.3. Factors that affect the involvement of users

The involvement of users commonly takes place in the course of a project with multiple stakeholders, both within an organization and with stakeholders from other organizations. To address this complexity, we use the layered model of software development process, developed by Curtis et al. (1988), to analyze and organize the factors. The model focuses on the actors that affect the involvement of users and includes five layers: business environment, company, project, team, and individual practitioner.

We looked at the literature on the broader scope of UCD (also usability) work, practice, and activities and more narrowly on user involvement. UCD studies commonly highlight factors that affect UCD in general and may be relevant, though we focus on the factors that are reported specifically in relation to the task of involving users. We consider involvement on all of Damodaran's (1996) levels, both direct and indirect. Last, we examined reports on the practice in the industry, as opposed to the practice in academic-oriented projects.

Figure 1 presents the layered model on the factors that affect user involvement in industrial context, and Table 1 elaborates on the core issues, examples, and references. The model is by no means exhaustive. However, the insights cover different types of business environments, such as software industry (Grudin, 1991a), telecom industry (Balaji et al. 2005), and the public sector (Hamilton et al. 2011); large companies (Axtell et al. 1997) and SME's (Wilson et al. 1997); different project types, such as contract (Jokela and Buie, 2012), product development (Kangas and Kinnunen, 2005), and in-house development (Symon, 1998); different system type and extent of user diversity, such as a system for internal administration by a very specific group of users (Axtell et al. 1997) and a social media system for a cross-cultural and global audience (Chilana et al. 2012); and various roles, cultural-, educational-, and professional- background of practitioners. Moreover, the insights were elicited using multiple research methods, such as direct report of practitioners' own experience, action research, case study, interview, and survey. Hence, we believe that the model reflects the main forces that encourage and inhibit the involvement of users.

Naturally, there is a lot of interplay between the layers of the model and the specific factors, as noted by Axtell et al. (1997). In the model, we simplified the representation of this interplay by encompassing all the layers within an outer frame, suggesting that the involvement of users (or lack of involvement) is commonly a result of multiple factors on multiple layers. This also affects the allocation of factors

to the most appropriate layer, which is based on our interpretation of the reported case. Obviously, certain factors can be associated with more than one layer.

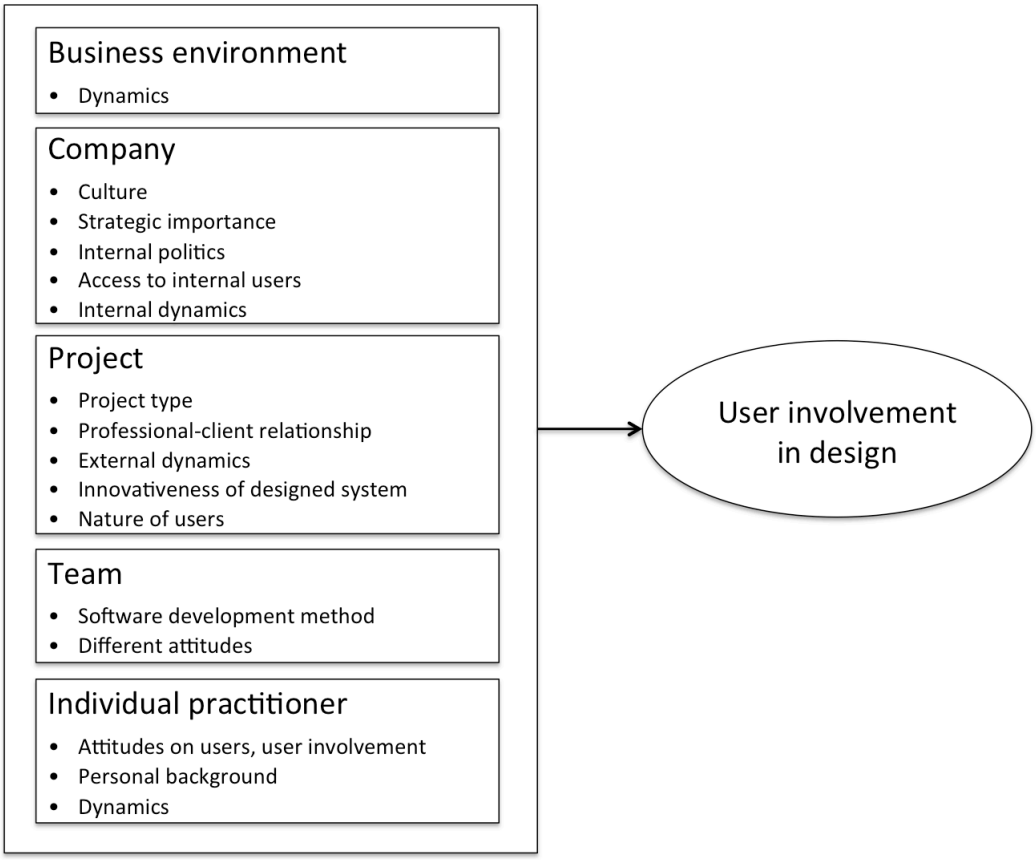

Figure 1: Factors that affect user involvement in industrial context

The model demonstrates the complex reality that UCD practitioners face in their effort to involve users. Different types of projects, e.g. contract-, product-, and in-house- development, influence the timing of user involvement (Grudin, 1991a). Practitioners particularly face challenges to access users in contract- and product-development projects (Iivari, 2005). The various forces on all layers include multiple stakeholders with divergent views, roles, and interest in the design; moreover, environmental and project-specific factors, such as the nature of the system and its users, can limit or encourage user involvement; also, unpredictable changes in most, if not all, layers, add uncertainty to the complex reality of projects.

The factors of organizational strategic importance (especially related to resources and capabilities), nature of users in a project, and practitioners' attitudes are most commonly observed, though the complexity of projects and interplay between factors signifies that other factors may play a key role in a specific case, for instance, a power struggle between UCD practitioners and technical developers that erupt during a project (Gasson, 1999). Moreover, factors can both encourage and inhibit user involvement even within one specific case; for instance, in a governmental system for the public, Hamilton et al. (2011) noticed a governmental policy that regard user involvement as an impediment to project success, though practitioners managed to get management support for user involvement after a non-UCD approach for the project brought it to a halt.

Table 1: Factors that affect user involvement and examples from industry cases

Layer	Factor	Examples	References
Business environment	Dynamics	Constant technological and cultural changes requires ongoing user research	Balaji et al. (2005); Blom et al. (2005); Page (2005); Henfridsson and Lindgren (2010)
Company	Culture	Historical focus on engineering and rational design; practitioners' freedom to take own action regarding user involvement	Poltrock and Grudin (1994); El Emam and Madhavji (1995); Symon (1998); Iivari (2004); Iivari (2005); Hamilton et al. (2011)
	Strategic importance	Established user involvement practices; resource (time, budget) and capabilities (personnel, positions); management support; advocate in influential position	Grudin (1991a; 1991b); Poltrock and Grudin (1994); Damodaran (1996); Axtell et al. (1997); Wilson et al. (1997); Symon (1998); Iivari (2004); Balaji et al. (2005); Blom et al. (2005); Iivari (2005); Kangas and Kinnunen (2005); Kujala et al. (2005); Ahtinen et al. (2007); Bruno and Dick (2007); Sy (2007); Baxter and Sommerville (2011); Hamilton et al. (2011); Iivari and Iivari (2011); Chilana et al. (2012)
	Internal politics	Power struggle between and within departments	Grudin (1991b); Symon (1998); Gasson (1999)
	Limited access to internal users	Restrained access by management, sales; users not motivated to participate	Grudin (1991b); Poltrock and Grudin (1994); El Emam and Madhavji (1995); Heinbokel et al. (1996); Wilson et al. (1997); Wale-Kolade (2015)
	Internal dynamics	Societal conditions and change during project time	Grudin (1991a)
Project	Project type	User involvement is more challenging in contract and product development type of project than in-house	Grudin (1991a); Kangas and Kinnunen (2005); Iivari (2006); Bruno and Dick (2007); Iivari and Iivari (2011); Wale-Kolade (2015)
	Professional-client relationship	Formal agreements; project's internal politics; commercial and political pressure from sponsoring partner	Grudin (1991a); Gasson (1999); Bruno and Dick (2007); Baxter and Sommerville (2011); Jokela and Buie (2012); Pagano and Brügge (2013); Wale-Kolade (2015)
	External dynamics	Withdrawal of partner	Gasson (1999); Hamilton et al. (2011)
	Innovativeness of designed system	No previous insights; study leading-edge market for latest trends	Grudin (1991a); Gasson (1999); Balaji et al. (2005); Page (2005); Ahtinen et al. (2007); Henfridsson and Lindgren (2010); Chilana et al. (2012)
	Nature of users	Identify relevant types and roles of users with diverse population; single vs. multi user; limited access to users due to cultural-, geographical- barriers, sensitivity of user's work; short-time vs. long-time involvement sessions	Grudin (1991a, 1991b); El Emam and Madhavji (1995); Damodaran (1996); Axtell et al. (1997); Kaderbhai; 1998; Kujala and Kauppinen (2004); Balaji et al. (2005); Blom et al. (2005); Page (2005); Winschiers (2006); Bruno and Dick (2007); Hertzum (2008); Henfridsson and Lindgren (2010); Baxter and Sommerville (2011); Iivari and Iivari (2011); Rasmussen et al. (2011); Chilana et al. (2012)
Team	Software development method	Integration into short agile cycles within inter-organizational context	Axtell et al. (1997); Sy (2007); Chilana et al. (2012); Wale-Kolade (2015)
	Attitudes	Divergent views within team	Iivari (2004); Iivari (2005);
Individual practitioner	Attitudes on users and user involvement	Under- and over-estimate user diversity; trust own experience and reason; field studies are time consuming and unwieldy; fear of delegating too much control to users	Gould and Lewis (1985); Poltrock and Grudin (1994); Wilson et al. (1997); Symon (1998); Iivari (2004); Iivari (2005); Kujala and Kauppinen (2004); Kujala et al. (2005); Hertzum (2008); Baxter and Sommerville (2011); Rasmussen et al. (2011); Pagano and Brügge (2013)
	Personal background	Experience; various educational backgrounds	Grudin (1991b); Iivari (2004); Iivari (2005); Hertzum (2008)
	Dynamics	Practitioner move on to new project or leave company	Grudin (1991b)

Insights on user involvement in field studies during the design of mobile systems mainly highlight the need for resources, the nature of the designed system, its users and context of use as affecting user involvement. Kujala and Kauppinen (2004) report on the difficulty to identify relevant users for field studies due to the diversity of users. Balaji et al. (2005) and Blom et al. (2005) report on the dynamic of the mobile use environment, and the security and privacy of users as a challenge to contextual ethnographic studies, while the lack of available products or prototypes in case of a truly innovative system affects the ability to conduct customer studies. Kangas and Kinnunen (2005) report on a mobile system that had to be tested in a lab environment due to limited budget, which found to be not useful because the system's use cases are strongly context dependent. Page (2005), working at a large and global software development company, reports on the need for ongoing field studies due to the rapidly changing technological environment in mobile and the aim to elicit requirements for innovative systems. Consequently, the company's management created new anthropologist positions. Due to the global distribution of their products, the company also outsourced user studies to local vendors. Ahtinen et al. (2007) highlight the luxury of having a professional user research at the company as instrumental on their field study of road maintenance workers. Resource constraints are most commonly mentioned as a factor that affects the conduct of field studies (Monahan et al. 2008; Baxter and Sommerville, 2011).

Henfridsson and Lindgren (2010) emphasize the problem of 'unknown users' in a universal product development project that hinders the identification of relevant users. In addition, the authors highlight challenges to user involvement in context of use with interconnected systems, in their case a project for in-car infotainment system that connects with mobile devices. Specifically, the context of the system use constantly switches from in-car context to varied out-of-car contexts, even during a usage session. That extends and complicates the context of the designed infotainment system; it requires attention to local contexts of the mobile device usage, beyond the typical in-car habitat that the automotive industry is familiar with. Moreover, the interconnectedness requires the involvement of stakeholders from different industries (e.g. consumer electronics) that have different perceptions on users.

Insights on user involvement in design particularly during the mobile apps era are scant. Bauer et al. (2014) observed that designers commonly face "difficulty in finding ways to explore the user's interaction with the system in context" (ibid, p.434), while the professional work experience of designers (with context-aware systems) plays a role in overcoming such a challenge. NN (2014) indicate that practitioners who are involved in mobile system design perceive field methods (e.g. contextual inquiry, participatory design, field evaluation) as being highly effective, although practitioners use these methods rather marginally due to time and budget constraints, followed by the practitioners' experience and competence with such approaches and methods.

Understanding the existing work activities, experiences and work contexts of UCD practitioners is essential to scholars who aim at theorizing and improving the design practice (Stolterman, 2008; Goodman et al. 2011). Our aim in this paper is to build on the existing insights by examining user involvement in design, especially by making use of field studies, during the mobile apps era. More specifically, the study aims at explaining *the core factors that affect UCD practitioners in industrial context to (1) involve users, and (2) involve users in the context of use, in the design, development, and post-deployment of particular mobile systems during the mobile apps era*.

3. METHODOLOGY

3.1. Study approach

Multiple research approaches are essential in order to generate a deep understanding of professional practice (Kemmis, 2009). Earlier, we conducted a survey that provided a 'snapshot' overview of the phenomenon (NN, 2014). For the inquiry in this study, we selected the in-depth interview method because it helps us to understand the world of others (Patton, 2002) and allows us to 'go deep' into contextual aspects of the specific inquired topic (Lazar et al. 2010).

To examine various project contexts and possible patterns, we conducted multiple interviews in different organizations and projects. This also addresses the replication logic for validation purposes (Yin, 2003). A second level of replication logic was implemented by conducting interviews in two countries, The Netherlands and Finland. We selected these countries due to our knowledge of the local industries and due to the geographical proximity to relevant practitioners.

We approached practitioners in various roles in industrial projects. We mainly focused on UCD practitioners, those who are involved in UCD work; commonly, practitioners in UCD roles use a plethora of job titles (Gulliksen et al. 2006), such as interaction designer, UX designer, and usability engineer/specialist (Gulliksen et al. 2006; Sharp et al. 2007). Acknowledging the complex organizational environment in which user involvement takes place, we complemented the views of UCD practitioners with the views of those in decision-making roles on a management level, and roles related to software development. Given the substantial differences between the design practice in scientific projects and in industrial context (Stolterman, 2008), we specifically approached practitioners in industrial and commercial context.

We also set boundaries on the socio-technical scope of mobile systems. We approached practitioners who are involved in the design and development of mobile systems, including native platform applications (i.e. mobile apps), browser-based mobile web applications (e.g. HTML5) and any hybrid solution, which run on carried-on devices such as touch-based smartphones, tablet devices, and their crossbreeds, taking into consideration practitioners' engagement with multiple form factors. Due to the broad variety of categories for mobile systems (e.g. for entertainment, well-being, education and productivity), we focused on two categories that increasingly represent everyday mobile use: *media* (e.g. news, magazines, streaming video) and *finance* (e.g. banking, payment, investment). These categories differ in their user base and perceived contexts of use: media is more generic, often consumed by anyone with a suitable device in relatively heterogeneous and generic contexts, while finance systems are commonly restricted to customers of the organization in question and used in more specifically defined contexts. Moreover, both media and finance provide opportunities for use cases that are specific to carried-on devices, such as citizen reporting of events from the scene and in-store mobile payment. On the social level, we looked at consumer systems (B2C), rather than systems for internal use by organizations (B2E) and between organizations (B2B), since consumer systems demonstrate a greater variety of contexts of use in everyday life.

3.2. Sampling

Our subject of observation is the practitioner in the context of a mobile system project. We conducted interviews with 41 practitioners (N_p). Some participants were recruited from our network of contacts, while others were approached by direct e-

mail based on an online search and by using a 'snowball' sampling. The study in the Netherlands took place in September-October 2013. Apart from a subcontracting company that has its headquarters in the Netherlands and took part in a project for a Dutch client, all participants are based in the Netherlands. The study in Finland took place in October 2013 – March 2014.

Table 2 presents the distribution of the participants among the scoped roles. Most participants (N_p=24, 58%) work in UCD roles, while other participants have business/management roles with decision-making power (N_p=11, 27%) and software development roles (N_p=6, 15%). Five of the participants in design roles are females (three in the Netherlands, two in Finland). Participants have a broad professional experience, ranging between 1-18 years (avg. 8.4; med. 9). Particular experience with mobile computing ranges between 1-15 years (avg. 5.8; med. 5). Table 3 further specifies the practitioners' experience in each study. Participants from Finland have notably twice as much mobile experience as their counterparts in the Netherlands, which is likely attributed to the role of Nokia, a Finnish company, in the history of mobile technology.

Table 2: Participants' roles

Main role category	Examples of role titles	Netherlands (N_p)	Finland (N_p)	Total
UCD	Interaction designer, UX designer, UX consultant, UX specialist, user researcher, usability specialist, head of design, creative director	13	11	24
Business / management	Business developer, business analyst, business owner, head of operations, project manager, commercial director, development manager, top management	9	2	11
SW development	IT/software architect, software developer	4	2	6

Table 3: Participants' professional experience (years)

Professional experience	Netherlands	Finland
Overall experience (avg./med.)	7.2 / 6.5	10.5 / 10
With mobile computing (avg./med.)	4.1 / 3	8.7 / 9

With regard to mobile system projects, the participants discussed their experience from 16 different projects in media and 16 projects in finance (see Table 4). The number of projects we examined is lower than the number of participants, because participants from the same company often shared their views on the same project. Note that few participants had experience with both categories and their allocation in the table is based on the main project being discussed.

Table 4: Business categories and examples of projects

Business category	Examples	No. of projects
Media	Newspaper/magazine application, content publishing on mobile, video-on-demand/live broadcasting service	16
Finance	Private/business banking service, investment service, finance management service	16

The participants work in 25 companies of different sizes and business categories. In the Netherlands, we approached participants from 14 companies, while in Finland, we examined the practices in 11 companies. Based on the EU definition of small and medium-sized enterprises (SME) (European Commission, 2014), three of the

companies are micro–sized, with up to ten employees, five companies are small, with up to 50 employees, three companies are medium-sized, with up to 250 employees, and the remaining 14 companies are large, with more than 250 employees. Medium-sized and large companies include big players in both the Dutch and the Finnish markets.

With regard to design and more specifically the UCD work of involving users, it is mostly provided as an external service within a scope of a project or a longer-term business relationship. Most of the companies we examined are subcontractors that to a greater or lesser extent provide IT solutions, e.g. design or development (see Table 5). Subcontractors closely resemble contract- and product- development projects in Grudin's (1991a) classification of project types. Eight other companies design and develop mostly in-house. Here, 'in-house' denotes the location of design and UCD practitioners within the organization that sponsors and owns the system. It resembles Grudin's (1991a) 'in-house' project type in terms that UCD practitioners have knowledge about the target users, often the organization's customers, at the outset of the project. Companies with in-house design and UCD capabilities may occasionally use external design vendors due to lack of specific competences, personnel, or for outsider opinions. The company in the 'subcontract' category does not possess design and UCD competences and hence, uses external design services in their projects. Notably, companies that develop and support in-house design competences are all large companies in their industries.

Table 5: Location of design services and companies' core business

Design service	Core business	No. of companies
Subcontractor	IT solutions, digital / UX / service design agency	16
In-house	Telecom operator, mobile device manufacturer, financial services, media publishing / broadcasting	8
Subcontract	Financial services	1

3.3. Interview procedure

The interviews were conducted in English following the interview guide approach (Patton, 2002), that is, including a range of high-level topics for discussion, while allowing for in-depth probing and questioning on a specific subject (also labeled as semi-structured interviews). The list of discussion topics was distributed to participants in advance and included the following subjects:

- Perception of mobile users and means of defining users
- Perception of the environment in which mobile services are used
- Methods and techniques used to elicit data about users, incl. motivation to use them
- Means to interpret the data and generate design ideas
- Means to evaluate the design practice and project
- Organizational project settings
- Professional background and work responsibilities

In all, the first author conducted 37 interviews, in which 33 were individual interviews. Another four interviews were with two practitioners who work for the same company and know each other well, for instance practitioners who have different roles (e.g. UX designer and IT architect) in a similar project. Most interviews (N=29) were face-to-face in situ, while eight interviews were conducted remotely via using Skype (http://www.skype.com/) with Ecamm Network's Call

Recorder (http://www.ecamm.com/mac/callrecorder/). The interviews lasted between 35-115 min. (avg. 61 min.) and were audio-recorded for transcription and further analysis. The variance in interview length is attributed to the role of the interviewee, especially with regard to the interviewee's insights on the UCD work.

Each interview started with a brief introduction on the study and its topic, followed by the participant's education, professional experience and current responsibilities. The main part of the interview focused on a particular, preferably recent or current, project that matched the criteria (see Table 4 for examples of these projects). The recorded material included all the discussions except for the initial introduction. Finally, transcriptions were sent to participants for proofreading and possible corrections (18 responded), prior to analysis.

3.4. Data analysis

The analysis was conducted by the two authors and organized in three phases. Firstly, we transcribed and read the interviews. In the second part, using a grounded theory approach (Strauss and Corbin, 1990), we conducted a data analysis of the transcripts using Atlas.ti (Muhr, 1991, http://www.atlasti.com/). Finally, we explored and examined the findings using a cross-case, in this paper cross-project, synthesis technique (Yin, 2003). Note that, while the narrative of the analysis suggests a linear series of connected events, the actual process is highly recursive with constant reflection on ideas and theories that come into awareness.

First, transcription was conducted by the first author, following a relatively denaturalized approach (Oliver et al. 2005) that focused on the meanings and perceptions in the conversation, while striving to keep the original wording. To increase the validity of transcripts, they were sent to the interviewees for validation. Next, we read the transcripts and discussed the main themes that were observed, which helped to limit the scope of the data analysis to the most significant concerns.
Conforming to a grounded theory approach, the data analysis process started with open coding of the data from Finland. As advocated by Miles and Huberman (1994), the explorative open coding was based on an initial list of codes that is largely informed by theoretical knowledge, in this case on the UCD practice. Accordingly, the codes included the various UCD methods; the continuums of user involvement, types of use context, and the temporal dimension; factors that directly encourage and inhibit the involvement of users, their involvement in field studies, and factors that determined the length of user studies; and instances that can further explain the practitioners' motives (see Table 6 for the main code attributes). With the term 'users', we mean the end-users of the system, i.e. those who directly operate the system (Rasmussen et al. 2011). While the discussion focused on a specific project, practitioners occasionally explained their approach by using examples from other projects and from their work in general. These insights were also examined, as they provided a deeper understanding of the motivation for practice. The coding scheme was complemented with code definitions.

With the open coding, twelve categories emerge to characterize 'encouraging' factors, while seventeen categories characterize 'inhibiting' factors. Some factors did not directly affect any principle, but were included due to their significant influence on the project outcome, for instance the synergy between the design and development teams. Next, we moved to axial and selective coding.

The process of axial coding aims at finding dimensions and relationships between the initial categories, while in selective coding, the focus is on reduction by identifying the core concepts that explain the phenomenon under study. In our

analysis, these activities were intermingled, since connecting and creating a higher-level concept for the categories in question is intuitively an interrelated practice. The axial-selective coding process started by reviewing the categories for possible relationships. This resulted in a reduction by three 'encouraging' categories and seven 'inhibiting' categories. Next, we removed categories that do not directly affect the core principle (one category for each end). Finally, to examine the significance of factors, we set an arbitrary relevance threshold for categories that requires at least 33% of the participants mentioning a specific factor. This was applied after an assessment of the relevance of some unique codes, in order to prevent some peculiar insights from being lost. The relevance threshold step did lead to a further reduction of four 'encouraging' categories and five 'inhibiting' categories. As may be expected, most 'encouraging' categories ended up mirroring fairly similar themes in the 'inhibiting' categories. We classified the categories based on the model presented in Figure 1. Having the core factor categories from the Finnish study in place, we proceeded to validate the findings.

With the transcripts from the Dutch study, we conducted in-depth analysis based on the categories identified earlier, which resulted in indicating examples that were classified under the existing factor categories.

Last, we examined the findings using a cross-project synthesis matrix that provides an overview of the studied phenomenon on a project basis. The synthesis (Table 6 in Appendix 1) allowed us to examine patterns for certain attributes. This extensive analysis process helped reveal some deeper insights.

4. FINDINGS

Our analysis resulted in the identification of seven core factors (Figure 2) to explain what inhibit and encourage UCD practitioners in their effort to involve users and to conduct field studies over time during the design, development and post-deployment of mobile systems. The identified factors reconfirm previously observed factors and emphasize their influence in the mobile apps era. In this section, we pay special attention to the project-level factors: (1) the professional-client relationship in a specific project type; and (2) the perceived novelty in the project, particularly regarding the mental distance between prospective users and practitioners. The former found to be a common barrier to user involvement for UCD practitioners in certain project type; the latter provides a deeper explanation on the inclination to conduct field studies. As noted before, the involvement of users often results from a combination of the factors due to their interrelatedness.

Throughout this section, we include selected quotes from the discussion with practitioners as typical examples. The square brackets in the quotes denote inserted words by the authors to protect the confidentiality of participants and their companies/clients, or in order to clarify the context of their wording. Similar to Schön (1983), we use the term 'client' to denote the recipient of the professional design (or UCD) service in a subcontracting type of business relationship. Participants occasionally use the word 'customer' for the same purpose.

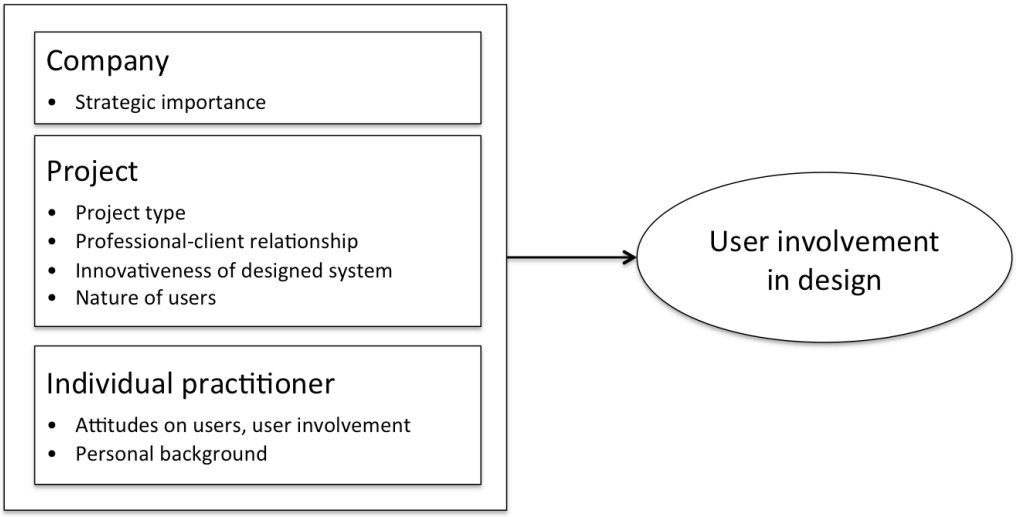

Figure 2: Identified core factors

4.1. Professional-client relationship

The professional-client relationship mostly refers to companies that provide professional design service to clients, i.e. subcontracting or consultancy firms in a contract- or product- development projects. Our participants who work in such firms often indicated on aspects that are related to the business relationship as affecting the involvement of target users. In particular, we emphasize economic constraint, the degree of openness in the relationship, and the term-wise length of the relationship.

4.1.1. Economic constraint

Professional UCD practitioners, especially in consultancy firms, often face a conflict between the decision criteria as defined by the profession, i.e. the principle on user involvement, and the need to sustain their source of income. Essentially, UCD practitioners are aware of the professional criteria and make an effort to formally approach users, e.g. by including user study components in the project plan; though, they face great difficulties in convincing their clients that an explicit understanding of target users is an integral part of the design work. In order to secure the contract, UCD practitioners agree to work within strict financial and temporal constraints that are imposed by the client and significantly limit the ability to involve users.

Without direct involvement of actual users or indirect involvement of representative users, UCD practitioners often default to indirect involvement of those who are easily available, e.g. project-internal practitioners and social peer groups. More often than not, the design proposals are solely informed by surrogate data sources provided by the client. In some cases, practitioners motivate such approach by arguing for the client knowledge of their users. Ultimately, consultancies aim at having a successful and long-lasting business relationship, and thus, satisfying the client is a key objective that affects the rationality of UCD practitioners.

An interaction designer with more than 15 years of experience, who works in a UX design team for a company providing IT solutions, tells us about the effort to comply with professional criteria in light of the business reality:

> "Time and budget are the main things. If we don't get paid for that then we don't do it ... Nowadays, the process starts with our plan for a project based on what would be good for our customer. Of course, there is a price

> for that (e.g. 100K). Then the customer reviews the plan and says that they have 75K, but still wants to have the same product. The first things to go out are all kinds of user research and planning. Development is always required, so you cannot cut on that. Design work is also needed. So in almost every project nowadays, all the things the customer thinks are not absolutely necessary are removed. That is the business nowadays."

A lead UX designer with 15 years of experience at a large software house reinforce the business reality:

> "We rarely go to the actual end-users to ask these questions, because that's the way it goes. It costs money and our customers most often don't want to pay for that."

An experienced UX designer who works at a large company that provides IT solutions explains the rationality for relying on user data provided by the client:

> "Mostly we rely on workshops with our customers, because we cannot be experts in all business fields, so we must trust that our customers know their customers. We question them on the kind of customers they have, what are they trying to do with your product, since we are a sub-contractor."

A creative director with 14 years of experience, who works in a design service agency, bluntly explain the ultimate goal of sustaining the business:

> "Maybe it sounds a bit impolite, but we are in a prostitution business; the client is using our expertise on a daily basis. They want us to achieve a goal within that time period. In that sense, we are really rental, and we want to achieve that goal the best way that we can on the way. So one of the big parameters of evaluating a project is customer satisfaction. … at the end of the day what decides whether it's good or not is still the customer."

Last, the difference between design as a consultant and in-house regarding user involvement, is neatly explained by a UX designer, who has prior experience from working in-house and currently works as a subcontractor:

> "In my previous company, when we did in-house design, whenever we had new features up and running, we did a semi-formal usability test by inviting people in and give them things to do. It was easy there because you pay them and you've got time to do things like that. But as a consultancy, it is harder to sell this idea."

Obviously, the economic issues are a type of resource constraints that may be classified in the company's strategic importance factor (Figure 1). However, we believe its emphasis in the professional-client relationship is important in drawing attention to the business complexity in the practice of UCD, since design and UCD services are increasingly provided in contract type of projects by professional consultancies (Sharp et al. 2007; Monahan et al. 2008; NN, 2014). Furthermore, with the aim to support UCD practitioners, such deeper understanding of the source of their work challenges is required.

Notwithstanding the economic constraint, there are great variations in the type of relationships between professionals and clients that affect, among other things, UCD practitioners' ability to involve users.

4.1.2. Openness in relationship

In most of the observed projects, the target users are the customers of the client, a crucial asset of the client's organization. Hence, the client is in a key position to facilitate or impede the access to this asset. Our study participants provided evidence

that gaining access to target users is related to the degree of openness in the professional-client relationship. That is, open type of relationship fosters a direct channel to indirect representative users and sharing of crucial user data. For instance, the client may facilitate the burden of recruiting users for pilot testing. In a more integrated type of relationship, UCD practitioners may work as part of the internal client's project team. To start with, this integration allows the practitioners to more easily practice UCD instead of convincing the client on the importance of UCD. In contrast, a more strict relationship that merely focuses on the outcome of design may hinder access to target users.

A UX designer in a subcontractor firm commented on the access to usage data:

> "That depends on what kind of relationship we have with the client … With one big media client, we have good and open relationship, so whenever we build a new version, we first look at the market data."

Another UX designer in a subcontractor firm describes how a client commonly facilitates the access to users in evaluations:

> "A very much-used approach is pilot testing. Our customer has a certain group of people that they know and are confident working with, so we run a pilot with about 40 people"

An external UX designer that works in the client's facilities as part of the internal client's project team explains the privileges:

> "[The financial institution] has a UX team, I've never seen a complete design team like that (only UX, not UI or other design) and five of them are focused full-time on mobile. So, in this case, I don't have to explain my role and practices. I can start straight away. With the previous organization, I had to explain every time to my team what I can do and how I can do that."

In contrast, an experienced business developer, working at a large international company that provides IT solutions, explains the logic in the access to target users:

> "We provide the service to our clients and they provide it to their end customer. The end customer is not our customer in the end. The data is part of our customer's asset."

A UX designer at another large IT solutions company explains that the lack of direct access to users' data affects not only the design and development efforts, but also the redesign during the post-deployment phase:

> "We design it, but Communication and Marketing department takes the credit afterwards. They are watching and collecting all the insights from the call center and other sources. It is actually out of our hands. We get it back in our evaluation, on the hallway or at a coffee table. Formally, the business is more involved. We are not really involved at that point any more. But when you look at optimization, you should be involved to see the new opportunities for redesign or new app or new functionality."

4.1.3. Length of relationship

Finally, formal contracts that define the scope of service the professional is providing to the client often include a temporal condition. Ad-hoc and short-term contracts that end with the delivery of the design artifact, or a working system, inhibit UCD practitioners from engaging in future commitments to the system during its post-deployment phase. An experienced interaction designer explains:

> "Typically, we don't collect any [actual usage data], because (it may sounds harsh, but) we get paid to do the application and then it is their [client] business."

To summarize, the business complexity, particularly the economic constraint that UCD practitioners in subcontracting firms face, is a significant barrier to user involvement in design and practitioners' ability to explicitly understand users. Clients often impose strict resource constraints that require UCD practitioners to rely on surrogate and more obscured user insights. More importantly, the difficulty in 'selling' user research as part of design suggests that clients may have a different perception of 'design' as a service. Nevertheless, working toward a more open, integrated, and long-term type of relationship can alleviate such inhibiting factors.

4.2. Novelty in project case

The Oxford Dictionary defines 'novelty' as a thing that is unfamiliar, new or unusual (http://www.oxforddictionaries.com). Accordingly, our study participants underline the unfamiliarity with users' mentality, the perceived newness or innovativeness of the system and an unusual project size as aspects that encourage the involvement of users, particularly in field studies.

4.2.1. Mental distance to users

The mental and cognitive distance between users and practitioners was indicated as a factor that affect the involvement of users in real-life contexts, especially in projects in which UCD practitioners study users in the early requirements phase. In these projects, the defined target users were, for instance, users of mobile devices in Asia and people without a bank account in a developing country.

Moreover, during the interviews, participants often provided examples from other projects, beyond the media and finance domains that we examined. These examples further emphasize the unfamiliarity with target users' way of life, habits and tasks as a determining factor for the early and continuous involvement of users within their context of use. Examples of such projects include a wristband system for elderly people and a mobile learning system for school pupils.

The specific mobile system categories we examined, especially media, as well as the focus on consumer systems suggest a great diversity of users that create difficulties to explicitly define the users. Without well-defined user population, anyone can be considered a user. Consequently, practitioners often 'represent' the users, since they 'know' what the users need and act as surrogates to actual or representative users. Especially given the lack of resources to involve users, practitioners learn to rely on their own knowledge of users for the design of the first release of the system, and modify the design based on actual usage data (e.g. log analytics, various feedback channels), taking advantage of the quick updates that became intrinsic to the lifecycle nature of mobile systems. Given the difficulty to identify the user population, the focus of discussions turns to the system's content or functionality. Moreover, a shorter mental and cognitive distance to users suggest that practitioners are more familiar with users' daily habits and tasks, and hence, less likely to justify a resource-consuming field study of users.

In a project for a newspaper app for a big media publisher, a lead UX designer at a subcontractor company that provides design and development services, explains the difficulty in designing for everybody:

> "Honestly, often we mostly consider one main group, or we are thinking on different media users; some people who want to get the information right away, some people who are still used to the newspaper format. And so we try to come up with solutions that fit everybody… regarding media apps, it is so much themed by the content."

In a project for mobile video-on-demand for a large broadcasting company, the head of design with close to 20 years of experience explains the familiarity with users:

> "We didn't formally collect any data. Just went about and designed it. It sounds very arrogant and actually it is – we think we know what the people want so we are going to make it in the way that we think is best … we have a pretty good idea of who the viewers and users are, so we think we know what they want."

A lead UX designer, who works as consultant especially for the media industry, questions the cost-efficiency from a user research in light of the quick gains from actual usage data:

> "I have to say that sometimes, when the budget is scarce, the design process is a bit like hero-based without real user interaction – kind of that we believe we know what's best and we get it pretty close and then we iterate and publish it. This often seems much more efficient than spending time on a user research, when you can actually have data from the market after two month and you already learn better."

Last, a UX consultant at a financial institution explains their reasoning for testing systems in lab rather than in the field, indicating on their familiarity with users' habits and usage patterns in light of the resource constraints:

> "Mobile is not mobile. You use it most of the time when you are in bed, kitchen table, on the couch. 90% of usage is not mobile, the other 10% is really when you are on the move … even if we would like going to field, it would take a lot of time and resources to be able to get the same results [as in the lab] with that many people"

4.2.2. Perceived innovativeness

This novelty aspect, commonly perceived by practitioners in terms of innovativeness, is closely related to the previous factor, since systems that are designed for unfamiliar users inevitably present new aspects for practitioners. As such, these aspects positively affect the allocation of resources to studying users. However, we also observed that innovativeness is a factor when practitioners are rather familiar with the users, such as bank customers. But innovativeness as such does not guarantee the involvement of users in context of use in case, for instance, of practical barriers such as the unavailability of a system to test. By contrast to the perceived innovativeness, practitioners' mindset with regard to a routine type of system was identified as a factor inhibiting the involvement of target users. Particularly in the business domains of this research (media and finance), most of the projects we examined can be considered as 'copy-cats', e.g. mobile applications for reading news, watching videos and conducting private banking. These types of systems already exist in electronic format for stationary computing and provide practitioners with a starting list of functionalities. Otherwise, in routine type of projects, the routine element itself may inhibit the inclination to involve users.

A lead UX designer at a design agency explains the link between newness and a participatory type of user involvement:

> "Occasionally, when we design something completely new and need to understand how people behave, we conduct a contextual brainstorm session, like moving with a magic thing method or carry on a pen, and we walk around with the users telling them the magic thing can do anything you can think of."

In a project of designing a mobile wallet for bank customers at a financial institution, the business owner explains the logic for involving rather familiar users:

> "We went against the standards of a mobile wallet … we knew that mobile wallets with payments have come and died for the past ten years, so they did something wrong. So what can we do differently? It came from the consumer interviews, but was still difficult for some people to accept."

His colleague at the project, a UX designer, explains why they created a lab simulation for an in-store payment environment rather than testing in real retail store:

> "The product is not mature enough for that [testing in real store], as we only have demos and try to understand the basics of the mobile payment thing."

By contrast, a development manager with over 15 years of experience, currently working at a financial institution, does not see a need for user involvement in a 'copycat' private banking app:

> "We didn't see our service as a breakthrough, because we were not the first in the industry with a mobile solution. There was nothing really new in that, so we did not see any reason to do a big research."

A UX designer and IT architect working at a financial institution, both with more than 10 years of experience, explain how they elicit user needs for a mobile banking app:

> "[UX designer] we don't really collect user data up front … we don't do a market research up front to uncover the hidden needs of users … [IT architect] because they are not hidden. We have a tremendous backlog of what we want to offer our customers. It is based on what we have available on the web, but also what we ourselves see that customers want, what competitors do, what the market does"

Last, an interaction designer who worked on more than 40 mobile apps, mainly for news and magazines, over a period of three years, for a media publishing company, describes the logic in testing routine type of applications:

> "Common apps, like news application that we have already made, we don't test so much as we tested the first news applications. But if it's a truly new one, for instance with [vendor name], we definitely want to test it before release."

4.2.3. Project size

Naturally, sizeable projects are more significant to the organizational strategy; they require a bigger investment and certain requirements are observed more closely to alleviate the risks of failure. In our study, sizeable projects were mostly the ones that also involved unfamiliar users, for instance a project on a media entertainment platform for mobile users in Asia and a project on private banking in developing countries. However, large projects also can involve familiar users, as commented by a UX specialist in a redesign project of the organization's cross-platform web presence:

> "Now with the web concept, because it is such a huge investment, there are more resources for user understanding as well."

5. DISCUSSION

The use of mobile devices, e.g. touch-based smartphones and tablet computers, is integrated into people's everyday life. Understanding the needs of users in such dynamic and varied context of use is a growing challenge for UCD practitioners.

Essentially, it requires user studies in real-life context over time throughout the project life cycle. Using in-depth interviews with practitioners in different companies, we outlined the core factors that encourage and inhibit practitioners to involve users in context of use. In particular, we emphasize project-level factors, i.e. the business complexity in a professional-client relationship, as a barrier to user involvement in the first place, and the mental distance between users and practitioners as a key factor that affect the inclination to conduct field studies.

Our study contributes a deeper understanding on what influences UCD practitioners' efforts and rationality to involve users, especially to involve them in field studies. Regarding the specific challenges to involve users in a contract type of software development projects, we reconfirm the findings observed by prior studies (e.g. Grudin, 1991a; Iivari 2004; Bruno and Dick, 2007; Iivari and Iivari, 2011) and emphasize the importance of addressing them in the mobile apps era. More interestingly, we provide a new perspective on the rationality to involve users in their context of use, namely the mental and cognitive distance between users and practitioners and novelty in the system being designed. These factors likely provide a more in-depth explanation to the marginal use of field studies in an industry context as observed by prior studies (Rosenbaum et al. 2000; Vredenburg et al. 2002; ; Venturi et al. 2006; Monahan et al. 2008; NN, 2014).

Interestingly, although the research was focused on mobile computing, these factors are not idiosyncratic to the design of mobile systems; they may hold true for stationary systems as well. But the factors are indeed specific to the industrial context. In academic projects, these factors are easily overlooked; firstly, simulating the business environment in academic research is difficult; and secondly, involving users, regardless of their mental distance from practitioners or the perceived innovativeness of the system, is a fundamental part of any reported design endeavor.

In this section, we discuss the business environment complexity and the mental distance between practitioners and target users as well as their implications in order to draw attention to their importance. We close by discussing the limitations of our study.

5.1. The business complexity

This research draws attention to the changing business environment in which UCD is practiced. As we observed, the business complexity has a direct influence on UCD practitioners' rationality for involving users. It suggests that the main challenge facing UCD practitioners with regard to the explicit understanding of users is dealing with clients who inhibit their access to users. Dealing with clients is becoming a common practice with regard to professional design service, as such services are increasingly provided by consultant companies acting as subcontractors in a project (Monahan et al. 2008; NN, 2014). However, the business environment complexity may not be restricted to consultancies; in-house UCD practitioners in departments that operate as a profit center within organizations may be faced with the same economic constraint as design consultants.

Previous studies continuously highlighted the influence of project type and professional-client relationship on user involvement in design. Grudin (1991a) demonstrated the gaps in the timing of user involvement for contract- and product-software development projects, as opposed to in-house projects. Iivari (2004; 2005; 2006) and Iivari and Iivari (2011) observed that the involvement of users is more challenging in software companies and product development projects than in-house development, indicating that the literature on user involvement is much focused on

the development of workplace systems. The difficulty to 'sell' user involvement to clients as well as the contract-based short-term relationships between professionals and clients was observed by Bruno and Dick (2007).

From a broader perspective of usability work, Trenner and Bawa's (1998) book on the politics of usability, although compiled nearly two decades ago, is highly relevant to the discussion on user involvement today. It contains practical accounts on many of the factors discussed in this paper, including the professional-client relationship. For instance, Thomas (1998) and Simpson (1998) elaborate on the politics of working as consultant and the need for an approach that balance between user-centeredness and client-centeredness. Their views are also reflected in a more recent book (Sharon, 2012), which provides a practitioner view and guidelines on excelling UX research and design in the industry, both in-house and in a professional-client type of projects. Our findings regarding the professional-client relationship merely reconfirm prior findings and emphasize the economic constraint as the main inhibiting factor on user involvement. Moreover, the project-level challenges to user involvement suggest that measuring the strength and weaknesses of the UCD in organizations by using different usability capability maturity (UCM) models (Jokela et al. 2006) may not be sufficient. UCM models should have a broader project focus to account for all project stakeholders in various project types.

As a result of the business complexity, the design practice in subcontracting companies is often characterized by a third-order understanding of target users. In Krippendorf's (2006) view, designers' understanding of stakeholders, including users, is always ground in a second-order understanding, that is to say, the understanding of users' understanding of something. Second-order understanding is qualitatively different from the direct understanding of that something by someone else. For instance, the position and worldview of each stakeholder affect their second-order understanding. Working under strict resource constraints, combined with an objective to satisfy their clients, UCD practitioners, especially in subcontracting firms, establish a second-order understanding merely of the client, while the understanding of users is dependent on external data sources, particularly the client, but also the UCD practitioners themselves by 'representing' the users. In other words, designers default to a mediated *third-order understanding* of users - the understanding of the client's understanding of the users' understanding of something. With the client commonly focusing on the business objectives, such recursive understanding adds a critical level of obscurity to the explicit understanding of users in context of use.

Does the ambiguity of 'design' take a toll on user involvement? Organizations that provide design and UCD services commonly market it using the word 'design', such as UX design, interaction design, and digital design. However, 'design' is a daily used label that invokes multiple connotations (Blevis et al. 2006). The findings suggest that client organizations conceive the design service mainly in terms of the expected outcome (either a design proposition or the actual system). Within this view, the explicit understanding of users and context of use by conducting recursive studies is an entirely different professional service or otherwise a technical knowledge that professional designers and/or the client ought to possess. Thus, outcome-oriented design views may inhibit the involvement of users. This calls for a further study to understand the perception of, and expectations from, 'design' by the stakeholders who hire professional design services, both in-house and external, as well as its effect on the UCD practice.

Furthermore, in a client-subcontractor type of relationship, outcome-based project contracts are considered an efficient tool to co-align the interests of the agent, in this case the 'supplier' of the design service, with those of the principal, the client organization (Eisenhardt, 1989). Apart from the outcome, contracts commonly outline the type and extent of work to be done. Browne (1998) discusses the key role of the first meeting with clients on establishing the fundamentals for UCD work. Bruno and Dick (2007) observed that the formal contract and its term affect the type of business relationship and ability to involve users. In the context of governmental projects, Jokela and Buie (2012) highlighted the role of the formal contract on the ability to involve users. With regard to contracts, we touched upon the type of professional-client relationship and emphasized a few strategies that can help practitioners involve users in context, e.g. strive for a more open, integrated, and long term relationship with clients. Obviously, more ecological insight is needed on the narratives between designers and clients as well as more broadly on all types of projects, e.g. using case studies, in order to provide UCD practitioners with established strategies.

The business complexity also highlights an educational aspect. It requires students in design schools to be made aware of and acquire competencies and/or tools to be able to deal with the complexity discussed above. In addition, by participating in real industrial projects with multiple stakeholders, students may come up with creative solutions.

Essentially, research efforts to develop our understanding of the UCD approach require sensitivity to the context of its practice. Clearly, simulating the business environment in academic research is difficult. Hence, scholars, especially those aiming at supporting UCD practitioners, must engage in a type of action research that entails a close collaboration with practitioners, similar to the case described by Poltrock and Grudin (1994). Such collaboration between research and practice helps us to gain insights on the actual challenges to UCD in different contextual project settings, and practical techniques that practitioners devise to deal with the challenges.

5.2. Context: the final frontier in the practice of UCD?

Novelty aspects in the nature of the project, particularly the mental distance between users and practitioners, suggest that for UCD practitioners who design mobile systems for consumers, context may be the final frontier. In Captain Kirk's Oath, the starship Enterprise is on a mission "to explore strange new worlds, to seek out new life and new civilizations, to boldly go where no man has gone before" (Wikipedia, 2014). UCD practitioners are engaged in crafting new forms. As such, they explore new worlds; 'world' as in aspects of human life; 'explore' as in examining how their forms fit the context of human life. During the design, context is their final frontier. While the Enterprise had a five-year mission to explore space, UCD practitioners do not have this luxury. Consequently, they study users in real-life contexts over time in very exceptional cases when they seek out and try to understand new life and new civilizations. That is, life that is considerably unfamiliar to them and distant from their mental representations. The available insights about these civilizations are most likely not enough to inform the design, because apparently they go where no UCD practitioner has gone before.

The exceptional attentiveness to real-life context is relatively in accordance with Suchman's (2002) local improvisations. Suchman refers to *local improvisation* as the "means by which anything – technological systems, organizational forms, everyday projects – are made to work" (ibid. p.139) by designers, who are 'unlocatable' and

use ‘generative practices’ to “deliver technological solutions to equally decontextualized and consequently unlocatable ‘users’” (ibid. p.140). With regard to the ‘unlocatability’ concept, Suchman emphasizes that a greater distance, e.g. geographical, cultural, and experiential, requires a greater effort in appropriating technologies into local circumstances. Suchman’s observation is largely based on her work at a research and development department of a large US-based enterprise that produces new technologies. Our findings reconfirm Suchman’s ‘unlocatability’ concept in the design of consumer mobile systems, emphasizing that a greater mental and cognitive distance between users and ‘unlocatable’ practitioners encourage greater attentiveness to users and context of use.

Accordingly, this observation suggests that neither the variety and constant changes in the context of mobile system use nor the development of new methods and tools lead UCD practitioners in industrial context to conduct studies with users in *real-life contexts of use*. Rather, the familiarity with the user group and the perceived innovativeness of the system, is a more accurate predictor for the extensiveness of applying the core UCD principle. However, these factors do not guarantee user involvement in context. Like Arnold’s (2003) observation on the Janus-faces of mobile phones, the innovativeness of the design system also has a Janus-faced nature as observed in our study and in prior studies. For instance, innovativeness can encourage UCD practitioners to go overseas and closely study users in a leading-edge market (Page, 2005), but it can also be a barrier to user research in case no prototypes or relevant systems are available (Balaji et al. 2005).

The findings also entice questions into the UCD approach. We may ask whether the involvement of users in their contexts of use over time is a universal requirement for the design of all system types or merely for specific custom-made systems? If user involvement is considered as involvement only when it has an impact on the design as Grudin (1991b) asserts, can we measure the effect of user involvement on the design? Inevitably, any measurement has to also consider the outcome, i.e. the actual system usage and the experience by users. We advocate a more comprehensive research that connects observations on the work of UCD practitioners with studies on the actual usage of the designed system (e.g. log data, survey, diary) as well as insights on the system performance (e.g. analytics, app store rankings and reviews) to shed more light on the raised questions.

5.3. Limitations

Firstly, our findings are preliminary, mainly based on qualitative interviews with practitioners in a specific region and regarding systems in specific categories. Based on the practitioners’ professional experience and distribution in terms of company sizes and type (in-house, subcontractor), we assume that the sample is fairly representative of the business practice in this region. Studies in other countries and regions can further validate the findings. While our focus on consumer systems for finance and media aimed to highlight the use of systems in everyday life, we are aware that other categories (e.g. health, education, games) and other social settings (e.g. systems for work activities) may have more specific user groups and use cases that affect the practitioners’ inclination to involve users in context. A study on mobile systems in other particular categories can further develop our preliminary findings.

Secondly, we relied merely on the practitioners’ recollections of their activities. Recalling past events and experiences is, by its very nature, “one step removed from reality” (Lazar et al. 2010, p.179). The responses can be biased or may simply suffer from an inaccurate articulation of the events due to poor recall. We alleviated this

shortcoming by focusing on experiences from a particular and recent project. Nevertheless, projects were at different phase of their life cycle and we only captured part of their history to date. An ethnographic study of the topic would be obviously valuable.

Thirdly, analyzing verbal text is inherently selective and interpretive (Miles and Huberman, 1994). Data collected from interviews in the form of transcripts is rich and complex, requiring the researcher to separate the relevant from the irrelevant, and only includes those statements that most strikingly support our argumentation. We selected the data based on the questions that guided the study and by looking for commonalities instead of unique statements. Since words, and statements, can have multiple meanings, the analysis is always interpretive. To address possible misinterpretations, we first asked participants to review their transcripts, after which we read through the transcripts several times, focusing on understanding the meaning in the context of statements.

Finally, the findings mainly provide information regarding the factors that affect UCD practitioners to involve users in their real-life context of use. To begin with, further research is needed into the design practices being carried out, their extent and how the observed data actually affect the design. Moreover, this study merely assessed the potential to which mobile systems are user- and context-informed during the design, while the evaluation of the actual use of systems and the relationship between this evaluation and the design practice has yet to be established. In other words, does a better-informed design lead to better performing systems, from a user perspective?

6. CONCLUSION

In this paper, we examined the design practice of mobile systems, particularly regarding the encouraging and inhibiting factors that affect UCD practitioners in their effort to attend to a core UCD principle: the involvement of users, particularly in real-life context of use. We used qualitative interviews to collect insights from industrial practitioners who are involved in the design and development of consumer mobile systems in various roles: mainly in UCD roles (e.g. interaction/UX design, usability specialist, user research) complemented with the views of those in project management roles and software development roles. The findings offer a valuable contribution to interaction design theory and practice, particularly with the current transition toward mobile systems and the significant effect of mobility on context.

Our findings emphasize the business environment complexity practitioners face in their effort to explicitly understand users during the design of media and finance mobile systems. Particularly, practitioners in subcontracting firms in contract-based projects are often faced with an economic constraint and no direct access to users, which leads them to a third-order understanding of users, through the client organization and to self 'represent' the users. Regarding field studies in a real-life context of use, we observed that conditions of novelty in the project, specifically the unfamiliarity of practitioners with the users' mentality and tasks, the perceived innovativeness of the designed system, and unusual project size are key motivators to explore target users in their real-life context of use over time, especially in early requirements phase. Hence, we suggest that context, i.e. a field study, may be the final frontier in the design of specific consumer systems.

The findings of this paper contribute to interaction design theory by helping to explain the rationality of UCD practitioners' way-of-doing. We underline the need for further research on the UCD approach and the professional-client relationship, in particular, to better understand the consequences of involving users in context over time on the actual system usage, and to examine strategies that counter the negative impacts of the business complexity on UCD practitioners. Essentially, such research efforts require a multi-method approach that is sensitive to the context of design practice.

REFERENCES

Ahtinen, A., Nurminen, J.K., Häkkilä, J., 2007. Developing a Mobile Reporting System for Road Maintenance: User Research Perspective, in: Proceedings of the 4th International Conference on Mobile Technology, Applications, and Systems and the 1st International Symposium on Computer Human Interaction in Mobile Technology, Mobility '07. ACM, New York, NY, USA, pp. 1–7. doi:10.1145/1378063.1378065

Arnold, M., 2003. On the phenomenology of technology: the "Janus-faces" of mobile phones. Information and Organization 13, 231–256. doi:10.1016/S1471-7727(03)00013-7

Axtell, C.M., WATERSON, P.E., CLEGG, C.W., 1997. Problems integrating user participation into software development. International Journal of Human-Computer Studies 47, 323–345. doi:10.1006/ijhc.1997.0143

Balaji, T.S., Landers, B., Kates, J., Moritz, B., 2005. A Carrier's Perspective on Creating a Mobile Multimedia Service. Commun. ACM 48, 49–53. doi:10.1145/1070838.1070865

Barki, H., Hartwick, J., 1989. Rethinking the Concept of User Involvement. MIS Quarterly 13, 53–63. doi:10.2307/248700

Bauer, J.S., Newman, M.W., Kientz, J.A., 2014. What Designers Talk About When They Talk About Context. Human–Computer Interaction 29, 420–450. doi:10.1080/07370024.2014.896709

Baxter, G., Sommerville, I., 2011. Socio-technical systems: From design methods to systems engineering. Interacting with Computers 23, 4–17. doi:10.1016/j.intcom.2010.07.003

Bentley, F., Barrett, E., 2012. Building Mobile Experiences. MIT Press.

Bergvall-Kåreborn, B., Howcroft, D., 2011. Mobile Applications Development on Apple and Google Platforms. Communications of the Association for Information Systems 29, 565–580.

Bevan, N., Macleod, M., 1994. Usability measurement in context. Behaviour & Information Technology 13, 132–145.

Beyer, H., Holtzblatt, K., 1997. Contextual design: defining customer-centered systems. Morgan Kaufmann.

Blevis, E., Lim, Y.-K., Stolterman, E., 2006. Regarding Software as a Material of Design. Presented at the Wonderground, Design Research Society, Lisbon, pp. 1–18.

Blomberg, J., Giacomi, J., Mosher, A., Swenton-Wall, P., 1993. Ethnographic field methods and their relation to design, in: Schuler, D., Namioka, A. (Eds.), Participatory Design: Principles and Practices. pp. 123–155.

Blom, J., Chipchase, J., Lehikoinen, J., 2005. Contextual and Cultural Challenges for User Mobility Research. Commun. ACM 48, 37–41. doi:10.1145/1070838.1070863

Bradley, N.A., Dunlop, M.D., 2005. Toward a multidisciplinary model of context to support context-aware computing. Hum.-Comput. Interact. 20, 403–446. doi:10.1207/s15327051hci2004_2

Browne, D., 1998. Selling Usability Services, in: Trenner, L., Bawa, J. (Eds.), The Politics of Usability, Practitioner Series. Springer London, pp. 21–31.

Bruno, V., Dick, M., 2007. Making Usability Work in Industry: An Australian Practitioner Perspective, in: Proceedings of the 19th Australasian Conference on Computer-Human Interaction: Entertaining User Interfaces, OZCHI '07. ACM, New York, NY, USA, pp. 261–264. doi:10.1145/1324892.1324948

Chen, G., Kotz, D., 2000. A survey of context-aware mobile computing research. Technical Report TR2000-381, Dept. of Computer Science, Dartmouth College.

Chilana, P., Holsberry, C., Oliveira, F., Ko, A., 2012. Designing for a Billion Users: A Case Study of Facebook, in: CHI '12 Extended Abstracts on Human Factors in Computing Systems, CHI EA '12. ACM, New York, NY, USA, pp. 419–432. doi:10.1145/2212776.2212819

Consolvo, S., Walker, M., 2003. Using the experience sampling method to evaluate ubicomp applications. Pervasive Computing, IEEE 2, 24–31.

Cooper, A., 1999. The Inmates are Running the Asylum–Why High-Tech Products Drive Us Crazy and How 2 to Restore the Sanity. Indianapolis: Sams.

Curtis, B., Krasner, H., Iscoe, N., 1988. A Field Study of the Software Design Process for Large Systems. Commun. ACM 31, 1268–1287. doi:10.1145/50087.50089

Damodaran, L., 1996. User involvement in the systems design process-a practical guide for users. Behaviour & Information Technology 15, 363–377. doi:10.1080/014492996120049

Dix, A., Rodden, T., Davies, N., Trevor, J., Friday, A., Palfreyman, K., 2000. Exploiting space and location as a design framework for interactive mobile systems. ACM Trans. Comput.-Hum. Interact. 7, 285–321. doi:10.1145/355324.355325

Dourish, P., 2004. What we talk about when we talk about context. Personal Ubiquitous Comput. 8, 19–30. doi:10.1007/s00779-003-0253-8

Eisenhardt, K.M., 1989. Agency Theory: An Assessment and Review. ACAD MANAGE REV 14, 57–74. doi:10.5465/AMR.1989.4279003

Emam, K.E., Madhavji, N.H., 1995. A field study of requirements engineering practices in information systems development, in: , Proceedings of the Second IEEE International Symposium on Requirements Engineering, 1995. Presented at the , Proceedings of the Second IEEE International Symposium on Requirements Engineering, 1995, pp. 68–80. doi:10.1109/ISRE.1995.512547

Eshet, E., 2012. Human-Centered Design in Mobile Application Development: Emerging Methods. IJMHCI 4. doi:10.4018/IJMHCI

European Commission, 2014. What is an SME?

Forman, G.H., Zahorjan, J., 1994. The challenges of mobile computing. Computer 27, 38–47. doi:10.1109/2.274999

Gasson, S., 1999. The reality of user-centered design. Journal of Organizational and End User Computing (JOEUC) 11, 5–15.

Goodman, E., Stolterman, E., Wakkary, R., 2011. Understanding interaction design practices, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '11. ACM, New York, NY, USA, pp. 1061–1070. doi:10.1145/1978942.1979100

Gothelf, J., Seiden, J., 2013. Lean UX: Applying Lean Principles to Improve User Experience. O'Reilly Media, Inc.

Gould, J.D., 1988. How to design usable systems, in: Helander, M. (Ed.), Handbook of Human-Computer Interaction. Elsevier, Amsterdam, The Netherlands, pp. 757–785.
Gould, J.D., Lewis, C., 1985. Designing for usability: key principles and what designers think. Commun. ACM 28, 300–311. doi:10.1145/3166.3170
Grudin, J., 1991a. Interactive Systems: Bridging the Gaps Between Developers and Users. Computer 24, 59–69.
Grudin, J., 1991b. Systematic Sources of Suboptimal Interface Design in Large Product Development Organizations. Human–Computer Interaction 6, 147–196. doi:10.1207/s15327051hci0602_3
Gulliksen, J., Boivie, I., Göransson, B., 2006. Usability professionals—current practices and future development. Interacting with Computers 18, 568–600. doi:10.1016/j.intcom.2005.10.005
Gulliksen, J., Göransson, B., Boivie, I., Blomkvist, S., Persson, J., Cajander, Å., 2003. Key principles for user-centred systems design. Behaviour & Information Technology 22, 397–409. doi:10.1080/01449290310001624329
Hassenzahl, M., Tractinsky, N., 2006. User experience - a research agenda. Behaviour & Information Technology 25, 91–97. doi:10.1080/01449290500330331
Heinbokel, T., Sonnentag, S., Frese, M., Stolte, W., Brodbeck, F.C., 1996. Don't underestimate the problems of user centredness in software development projectsthere are many! Behaviour & Information Technology 15, 226–236. doi:10.1080/014492996120157
Henfridsson, O., Lindgren, R., 2005. Multi-contextuality in ubiquitous computing: Investigating the car case through action research. Information and Organization 15, 95–124. doi:10.1016/j.infoandorg.2005.02.009
Henfridsson, O., Lindgren, R., 2010. User involvement in developing mobile and temporarily interconnected systems. Information Systems Journal 20, 119–135. doi:10.1111/j.1365-2575.2009.00337.x
Hertzum, M., 2008. On the Process of Software Design: Sources of Complexity and Reasons for Muddling through, in: Gulliksen, J., Harning, M.B., Palanque, P., Veer, G.C. van der, Wesson, J. (Eds.), Engineering Interactive Systems, Lecture Notes in Computer Science. Springer Berlin Heidelberg, pp. 483–500.
Hertzum, M., Jacobsen, N.E., 2001. The Evaluator Effect: A Chilling Fact About Usability Evaluation Methods. International Journal of Human-Computer Interaction 13, 421–443. doi:10.1207/S15327590IJHC1304_05
Hinman, R., 2012. The Mobile Frontier, 1st ed. Rosenfeld Media.
Iivari, J., Iivari, N., 2011. Varieties of user-centredness: an analysis of four systems development methods. Information Systems Journal 21, 125–153. doi:10.1111/j.1365-2575.2010.00351.x
Iivari, N., 2006. "Representing the User" in software development—a cultural analysis of usability work in the product development context. Interacting with Computers 18, 635–664. doi:10.1016/j.intcom.2005.10.002
Iivari, N., 2005. Usability Specialists – "A Mommy Mob", "Realistic Humanists" or "Staid Researchers"? An Analysis of Usability Work in the Software Product Development, in: Costabile, M.F., Paternò, F. (Eds.), Human-Computer Interaction - INTERACT 2005, Lecture Notes in Computer Science. Springer Berlin Heidelberg, pp. 418–430.
Iivari, N., 2004. Enculturation of User Involvement in Software Development Organizations - an Interpretive Case Study in the Product Development Context, in: Proceedings of the Third Nordic Conference on Human-Computer Interaction, NordiCHI '04. ACM, New York, NY, USA, pp. 287–296. doi:10.1145/1028014.1028059
ISO, 2010. ISO 9241-210:2010 Ergonomics of human-system interaction-Part 210: Human-centred design for interactive systems. International Organization for Standardization, Geneva.
ISO, 1999. ISO 13407:1999 Human-centred design processes for interactive systems. International Organization for Standardization, Geneva.
Johnson, P., 1998. Usability and Mobility; Interactions on the move, in: Proceedings of the First Workshop on Human-Computer Interaction with Mobile Devices.
Jokela, T., Buie, E., 2012. Getting UX into the contract, in: Usability in Government Systems: User Experience Design for Citizens and Public Servants. Elsevier, pp. 251–266.
Jokela, T., Siponen, M., Hirasawa, N., Earthy, J., 2006. A survey of usability capability maturity models: implications for practice and research. Behaviour & Information Technology 25, 263–282. doi:10.1080/01449290500168079
Jumisko-Pyykkö, S., Vainio, T., 2010. Framing the Context of Use for Mobile HCI. International Journal of Mobile Human Computer Interaction 2, 1–28. doi:10.4018/jmhci.2010100101
Kaderbhai, T., 1998. Overcoming Inertia within a Large Organization, in: The Politics of Usability, Practitioner Series. Springer London, pp. 35–48.
Kangas, E., Kinnunen, T., 2005. Applying user-centered design to mobile application development. Commun. ACM 48, 55–59. doi:10.1145/1070838.1070866
Kemmis, S., 2009. Understanding professional practice: A synoptic framework. Understanding and researching professional practice 19–38.
Krippendorff, K., 2006. The Semantic Turn: A New Foundation for Design. CRC Press.
Kujala, S., 2003. User involvement: A review of the benefits and challenges. Behaviour & Information Technology 22, 1–16. doi:10.1080/01449290301782
Kujala, S., Kauppinen, M., 2004. Identifying and Selecting Users for User-centered Design, in: Proceedings of the Third Nordic Conference on Human-Computer Interaction, NordiCHI '04. ACM, New York, NY, USA, pp. 297–303. doi:10.1145/1028014.1028060
Kujala, S., Kauppinen, M., Lehtola, L., Kojo, T., 2005. The role of user involvement in requirements quality and project success, in: 13th IEEE International Conference on Requirements Engineering, 2005. Proceedings. Presented at the 13th IEEE International Conference on Requirements Engineering, 2005. Proceedings, pp. 75–84. doi:10.1109/RE.2005.72
Laurel, B., 2003. Design research: Methods and perspectives. MIT press.
Lazar, J., Feng, J.H., Hochheiser, H., 2010. Research Methods in Human-Computer Interaction. John Wiley & Sons.

Macleod, M., Bevan, N., 1993. MUSiC video analysis and context tools for usability measurement, in: Proceedings of the INTERACT '93 and CHI '93 Conference on Human Factors in Computing Systems, CHI '93. ACM, New York, NY, USA, p. 55. doi:10.1145/169059.169072

Maguire, M., 2001. Context of Use within usability activities. International Journal of Human-Computer Studies 55, 453–483. doi:10.1006/ijhc.2001.0486

Meeker, M., 2013. KPCB Internet Trends 2013.

Miles, M.B., Huberman, A.M., 1994. Qualitative Data Analysis: An Expanded Sourcebook. SAGE Publications.

Monahan, K., Lahteenmaki, M., McDonald, S., Cockton, G., 2008. An investigation into the use of field methods in the design and evaluation of interactive systems, in: Proceedings of the 22nd British HCI Group Annual Conference on People and Computers: Culture, Creativity, Interaction - Volume 1, BCS-HCI '08. British Computer Society, Swinton, UK, pp. 99–108.

Muhr, T., 1991. ATLAS/ti — A prototype for the support of text interpretation. Qual Sociol 14, 349–371. doi:10.1007/BF00989645

Nardi, B.A., 1996. Context and consciousness: activity theory and human-computer interaction. The MIT Press.

Nielsen, J., 1993. Usability engineering. Academic Press, Boston.

NN. 2014

Norman, D.A., Draper, S.W., 1986. User centered system design. Hillsdale, NJ.

Oliver, D.G., Serovich, J.M., Mason, T.L., 2005. Constraints and Opportunities with Interview Transcription: Towards Reflection in Qualitative Research. Soc Forces 84, 1273–1289.

Pagano, D., Brügge, B., 2013. User Involvement in Software Evolution Practice: A Case Study, in: Proceedings of the 2013 International Conference on Software Engineering, ICSE '13. IEEE Press, Piscataway, NJ, USA, pp. 953–962.

Page, C., 2005. Mobile Research Strategies for a Global Market. Commun. ACM 48, 42–48. doi:10.1145/1070838.1070864

Patton, M.Q., 2002. Qualitative research and evaluation methods. Sage. Thousand Oaks, CA.

Poltrock, S.E., Grudin, J., 1994. Organizational Obstacles to Interface Design and Development: Two Participant-observer Studies. ACM Trans. Comput.-Hum. Interact. 1, 52–80. doi:10.1145/174630.174633

Randall, D., Harper, R., Rouncefield, M., 2007. Fieldwork for Design, Computer Supported Cooperative Work. Springer London, London.

Rasmussen, R., Christensen, A.S., Fjeldsted, T., Hertzum, M., 2011. Selecting users for participation in IT projects: Trading a representative sample for advocates and champions? Interacting with Computers 23, 176–187. doi:10.1016/j.intcom.2011.02.006

Rosenbaum, S., Rohn, J.A., Humburg, J., 2000. A toolkit for strategic usability, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'00). ACM Press, pp. 337–344. doi:10.1145/332040.332454

Rosson, M.B., Carroll, J.M., 2001. Usability engineering: scenario-based development of human-computer interaction. Morgan Kaufmann.

Schilit, B., Adams, N., Want, R., 1994. Context-Aware Computing Applications, in: First Workshop on Mobile Computing Systems and Applications, 1994. WMCSA 1994. Presented at the First Workshop on Mobile Computing Systems and Applications, 1994. WMCSA 1994, pp. 85 –90. doi:10.1109/WMCSA.1994.16

Schmidt, R., Lyytinen, K., Mark Keil, P.C., 2001. Identifying software project risks: An international Delphi study. Journal of management information systems 17, 5–36.

Schön, D.A., 1983. The Reflective Practitioner: How Professionals Think In Action, 1 edition. ed. Basic Books, New York.

Schuler, D., Namioka, A., 1993. Participatory design: Principles and practices. CRC PressI Llc.

Sharon, T., 2012. It's our research: getting stakeholder buy-in for user experience research projects, 1st ed. ed. Morgan Kaufmann, Waltham, MA.

Sharp, H., Rogers, Y., Preece, J., 2007. Interaction design: beyond human-computer interaction, 2nd edition. ed. Wiley.

Simpson, N., Trenner, L., Bawa, J., 1998. Cultivating an Effective Client Relationship to Promote a User-Centred Culture, in: The Politics of Usability, Practitioner Series. Springer London, pp. 111–124.

Soikkeli, T., Karikoski, J., Hämmäinen, H., 2013. Characterizing Smartphone Usage: Diversity and End User Context. International Journal of Handheld Computing Research 4, 15–36. doi:10.4018/jhcr.2013010102

Stolterman, E., 2008. The nature of design practice and implications for interaction design research. International Journal of Design 2, 55–65.

Strauss, A., Corbin, J.M., 1990. Basics of qualitative research: Grounded theory procedures and techniques. Sage Publications, Inc, Thousand Oaks, CA, US.

Suchman, L., 2006. Human-machine reconfigurations: Plans and situated actions. Cambridge University Press.

Suchman, L.A., 2002. Practice-Based Design of Information Systems: Notes from the Hyperdeveloped World. The Information Society 18, 139–144. doi:10.1080/01972240290075066

Sutcliffe, A., 2004. End-user development. Communications of the ACM 47, 31–32.

Sy, D., 2007. Adapting Usability Investigations for Agile User-centered Design. J. Usability Studies 2, 112–132.

Symon, G., 1998. The Work of IT System Developers in Context: An Organizational Case Study. Hum.-Comput. Interact. 13, 37–71. doi:10.1207/s15327051hci1301_2

Tamminen, S., Oulasvirta, A., Toiskallio, K., Kankainen, A., 2004. Understanding mobile contexts. Personal Ubiquitous Comput. 8, 135–143. doi:10.1007/s00779-004-0263-1

Thomas, C., Trenner, L., Bawa, J., 1998. Consultants with Clout, in: The Politics of Usability, Practitioner Series. Springer London, pp. 99–110.

Trenner, L., Bawa, J., 1998. The Politics of Usability: A Practical Guide to Designing Usable Systems in Industry. Springer Science & Business Media.

Venturi, G., Troost, J., Jokela, T., 2006. People, Organizations, and Processes: An Inquiry into the Adoption of User-Centered Design in Industry. International Journal of Human-Computer Interaction 21, 219–238.

doi:10.1207/s15327590ijhc2102_6
Vredenburg, K., Mao, J.-Y., Smith, P.W., Carey, T., 2002. A survey of user-centered design practice, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '02. ACM, New York, NY, USA, pp. 471–478. doi:10.1145/503376.503460
Wale-Kolade, A.Y., 2015. Integrating usability work into a large inter-organisational agile development project: Tactics developed by usability designers. Journal of Systems and Software 100, 54–66. doi:10.1016/j.jss.2014.10.036
Wikipedia, 2014. Where no man has gone before. Wikipedia, the free encyclopedia.
Wilson, S., Bekker, M., Johnson, P., Johnson, H., 1997. Helping and Hindering User Involvement — a Tale of Everyday Design, in: Proceedings of the ACM SIGCHI Conference on Human Factors in Computing Systems, CHI '97. ACM, New York, NY, USA, pp. 178–185. doi:10.1145/258549.258699
Winschiers, H., 2006. The Challenges of Participatory Design in a Intercultural Context: Designing for Usability in Namibia. PDC 73–76.
Yin, R.K., 2003. Case Study Research: Design and Methods, 3rd Edition, 3rd ed. Sage Publications, Inc, CA, USA.

Appendix 1: Cross-project synthesis matrix

Table 6: Cross-project synthesis attributes and values

Section	Attribute	Description	Value
1. Project meta-data	Participant ID		ID
	Category	Category of the developed system	Media/finance
	Description	Brief description of project	
	Form factor	Multiple values are possible	Phone, tablet, mobile web, cross-platform
	Org. position	Position of the practitioner's organization in the project	Subcontractor (with type of client)/in-house
	Target users	Definition of target users by the practitioner	
2. How users are involved?	User involvement	What types of users are involved, in what practice and in which phase	User categories as emerged from analysis: • Undefined/unknown • Indirect: project-internal groups (developers, designers, client) • Indirect: social peer groups (friends, colleagues, family) • Indirect: random people (street, bar) • Indirect: representative users • Direct: actual users Practice: As stated by participants Phase: • Requirements • Evaluation • Usage
	Contexts	What types of contexts, in what practice and in which phase	Context categories as emerged from analysis: • Artificial (lab, office) • Artificial augmented (lab) • Representative (home, street) • Naturalistic (real life or closely imitating) Practice: As stated by participants Phase: as in user involvement
	Over time	In which phase and for how long was the practice carried out (only for practices that were not ad hoc)	Phase: as in user involvement Length: • Limited time (as stated) • Continual
3. What affect the involvement of users?	Encourage	Factors that *encourage* the involvement of target users in real-life contexts of use over time	• Strategic importance • Practitioner's experience, education • Nature of users, system
	Inhibit	Factors that *inhibit* the involvement of target users in real-life contexts of use over time	• Limited resources, capabilities • Project type, professional-client relationship • Nature of users, system
4. Indicators that can further explain practitioners' motives	Concerns	Concerns that practitioners sought to understand	Core categories as emerged from analysis: • Users 'meaningful' context (needs, goals, habits, behavior) • 'Incidental' context (spatial-temporal, social, culture, legal, domain)

			• System (functionality, technical challenges, input/output, gestures) • Business environment (business goals, client/other stakeholders, marketing, competition)
	Project objectives	Regarding system state and final outcome	System state: • New • Redesign • Incremental improvement Outcome objective categories as emerged from analysis: • Increase usage • Generate revenues • Add functionality • Add customers • Intangible benefits (long-term, reputation, help users) • Unclear
	Project evaluation	Project evaluation criteria	Criteria categories as emerged from analysis: • Client satisfaction • User/customer satisfaction • Stay on budget • Revenues • Usage figures • None
	Notes	Other relevant contextual data about the practitioner and/or project	

Turku Centre for Computer Science
TUCS Dissertations

1. **Marjo Lipponen**, On Primitive Solutions of the Post Correspondence Problem
2. **Timo Käkölä**, Dual Information Systems in Hyperknowledge Organizations
3. **Ville Leppänen**, Studies on the Realization of PRAM
4. **Cunsheng Ding**, Cryptographic Counter Generators
5. **Sami Viitanen**, Some New Global Optimization Algorithms
6. **Tapio Salakoski**, Representative Classification of Protein Structures
7. **Thomas Långbacka**, An Interactive Environment Supporting the Development of Formally Correct Programs
8. **Thomas Finne**, A Decision Support System for Improving Information Security
9. **Valeria Mihalache**, Cooperation, Communication, Control. Investigations on Grammar Systems.
10. **Marina Waldén**, Formal Reasoning About Distributed Algorithms
11. **Tero Laihonen**, Estimates on the Covering Radius When the Dual Distance is Known
12. **Lucian Ilie**, Decision Problems on Orders of Words
13. **Jukkapekka Hekanaho**, An Evolutionary Approach to Concept Learning
14. **Jouni Järvinen**, Knowledge Representation and Rough Sets
15. **Tomi Pasanen**, In-Place Algorithms for Sorting Problems
16. **Mika Johnsson**, Operational and Tactical Level Optimization in Printed Circuit Board Assembly
17. **Mats Aspnäs**, Multiprocessor Architecture and Programming: The Hathi-2 System
18. **Anna Mikhajlova**, Ensuring Correctness of Object and Component Systems
19. **Vesa Torvinen**, Construction and Evaluation of the Labour Game Method
20. **Jorma Boberg**, Cluster Analysis. A Mathematical Approach with Applications to Protein Structures
21. **Leonid Mikhajlov**, Software Reuse Mechanisms and Techniques: Safety Versus Flexibility
22. **Timo Kaukoranta**, Iterative and Hierarchical Methods for Codebook Generation in Vector Quantization
23. **Gábor Magyar**, On Solution Approaches for Some Industrially Motivated Combinatorial Optimization Problems
24. **Linas Laibinis**, Mechanised Formal Reasoning About Modular Programs
25. **Shuhua Liu**, Improving Executive Support in Strategic Scanning with Software Agent Systems
26. **Jaakko Järvi**, New Techniques in Generic Programming – C++ is more Intentional than Intended
27. **Jan-Christian Lehtinen**, Reproducing Kernel Splines in the Analysis of Medical Data
28. **Martin Büchi**, Safe Language Mechanisms for Modularization and Concurrency
29. **Elena Troubitsyna**, Stepwise Development of Dependable Systems
30. **Janne Näppi**, Computer-Assisted Diagnosis of Breast Calcifications
31. **Jianming Liang**, Dynamic Chest Images Analysis
32. **Tiberiu Seceleanu**, Systematic Design of Synchronous Digital Circuits
33. **Tero Aittokallio**, Characterization and Modelling of the Cardiorespiratory System in Sleep-Disordered Breathing
34. **Ivan Porres**, Modeling and Analyzing Software Behavior in UML
35. **Mauno Rönkkö**, Stepwise Development of Hybrid Systems
36. **Jouni Smed**, Production Planning in Printed Circuit Board Assembly
37. **Vesa Halava**, The Post Correspondence Problem for Market Morphisms
38. **Ion Petre**, Commutation Problems on Sets of Words and Formal Power Series
39. **Vladimir Kvassov**, Information Technology and the Productivity of Managerial Work
40. **Frank Tétard**, Managers, Fragmentation of Working Time, and Information Systems

41. **Jan Manuch**, Defect Theorems and Infinite Words
42. **Kalle Ranto**, Z_4-Goethals Codes, Decoding and Designs
43. **Arto Lepistö**, On Relations Between Local and Global Periodicity
44. **Mika Hirvensalo**, Studies on Boolean Functions Related to Quantum Computing
45. **Pentti Virtanen**, Measuring and Improving Component-Based Software Development
46. **Adekunle Okunoye**, Knowledge Management and Global Diversity – A Framework to Support Organisations in Developing Countries
47. **Antonina Kloptchenko**, Text Mining Based on the Prototype Matching Method
48. **Juha Kivijärvi**, Optimization Methods for Clustering
49. **Rimvydas Rukšėnas**, Formal Development of Concurrent Components
50. **Dirk Nowotka**, Periodicity and Unbordered Factors of Words
51. **Attila Gyenesei**, Discovering Frequent Fuzzy Patterns in Relations of Quantitative Attributes
52. **Petteri Kaitovaara**, Packaging of IT Services – Conceptual and Empirical Studies
53. **Petri Rosendahl**, Niho Type Cross-Correlation Functions and Related Equations
54. **Péter Majlender**, A Normative Approach to Possibility Theory and Soft Decision Support
55. **Seppo Virtanen**, A Framework for Rapid Design and Evaluation of Protocol Processors
56. **Tomas Eklund**, The Self-Organizing Map in Financial Benchmarking
57. **Mikael Collan**, Giga-Investments: Modelling the Valuation of Very Large Industrial Real Investments
58. **Dag Björklund**, A Kernel Language for Unified Code Synthesis
59. **Shengnan Han**, Understanding User Adoption of Mobile Technology: Focusing on Physicians in Finland
60. **Irina Georgescu**, Rational Choice and Revealed Preference: A Fuzzy Approach
61. **Ping Yan**, Limit Cycles for Generalized Liénard-Type and Lotka-Volterra Systems
62. **Joonas Lehtinen**, Coding of Wavelet-Transformed Images
63. **Tommi Meskanen,** On the NTRU Cryptosystem
64. **Saeed Salehi**, Varieties of Tree Languages
65. **Jukka Arvo**, Efficient Algorithms for Hardware-Accelerated Shadow Computation
66. **Mika Hirvikorpi**, On the Tactical Level Production Planning in Flexible Manufacturing Systems
67. **Adrian Costea**, Computational Intelligence Methods for Quantitative Data Mining
68. **Cristina Seceleanu**, A Methodology for Constructing Correct Reactive Systems
69. **Luigia Petre**, Modeling with Action Systems
70. **Lu Yan**, Systematic Design of Ubiquitous Systems
71. **Mehran Gomari**, On the Generalization Ability of Bayesian Neural Networks
72. **Ville Harkke**, Knowledge Freedom for Medical Professionals – An Evaluation Study of a Mobile Information System for Physicians in Finland
73. **Marius Cosmin Codrea**, Pattern Analysis of Chlorophyll Fluorescence Signals
74. **Aiying Rong**, Cogeneration Planning Under the Deregulated Power Market and Emissions Trading Scheme
75. **Chihab BenMoussa**, Supporting the Sales Force through Mobile Information and Communication Technologies: Focusing on the Pharmaceutical Sales Force
76. **Jussi Salmi**, Improving Data Analysis in Proteomics
77. **Orieta Celiku**, Mechanized Reasoning for Dually-Nondeterministic and Probabilistic Programs
78. **Kaj-Mikael Björk**, Supply Chain Efficiency with Some Forest Industry Improvements
79. **Viorel Preoteasa**, Program Variables – The Core of Mechanical Reasoning about Imperative Programs
80. **Jonne Poikonen**, Absolute Value Extraction and Order Statistic Filtering for a Mixed-Mode Array Image Processor
81. **Luka Milovanov**, Agile Software Development in an Academic Environment
82. **Francisco Augusto Alcaraz Garcia**, Real Options, Default Risk and Soft Applications
83. **Kai K. Kimppa**, Problems with the Justification of Intellectual Property Rights in Relation to Software and Other Digitally Distributable Media
84. **Dragoş Truşcan**, Model Driven Development of Programmable Architectures
85. **Eugen Czeizler**, The Inverse Neighborhood Problem and Applications of Welch Sets in Automata Theory

86. **Sanna Ranto**, Identifying and Locating-Dominating Codes in Binary Hamming Spaces
87. **Tuomas Hakkarainen**, On the Computation of the Class Numbers of Real Abelian Fields
88. **Elena Czeizler**, Intricacies of Word Equations
89. **Marcus Alanen**, A Metamodeling Framework for Software Engineering
90. **Filip Ginter**, Towards Information Extraction in the Biomedical Domain: Methods and Resources
91. **Jarkko Paavola**, Signature Ensembles and Receiver Structures for Oversaturated Synchronous DS-CDMA Systems
92. **Arho Virkki**, The Human Respiratory System: Modelling, Analysis and Control
93. **Olli Luoma**, Efficient Methods for Storing and Querying XML Data with Relational Databases
94. **Dubravka Ilić**, Formal Reasoning about Dependability in Model-Driven Development
95. **Kim Solin**, Abstract Algebra of Program Refinement
96. **Tomi Westerlund**, Time Aware Modelling and Analysis of Systems-on-Chip
97. **Kalle Saari**, On the Frequency and Periodicity of Infinite Words
98. **Tomi Kärki**, Similarity Relations on Words: Relational Codes and Periods
99. **Markus M. Mäkelä**, Essays on Software Product Development: A Strategic Management Viewpoint
100. **Roope Vehkalahti**, Class Field Theoretic Methods in the Design of Lattice Signal Constellations
101. **Anne-Maria Ernvall-Hytönen**, On Short Exponential Sums Involving Fourier Coefficients of Holomorphic Cusp Forms
102. **Chang Li**, Parallelism and Complexity in Gene Assembly
103. **Tapio Pahikkala**, New Kernel Functions and Learning Methods for Text and Data Mining
104. **Denis Shestakov**, Search Interfaces on the Web: Querying and Characterizing
105. **Sampo Pyysalo**, A Dependency Parsing Approach to Biomedical Text Mining
106. **Anna Sell**, Mobile Digital Calendars in Knowledge Work
107. **Dorina Marghescu**, Evaluating Multidimensional Visualization Techniques in Data Mining Tasks
108. **Tero Säntti**, A Co-Processor Approach for Efficient Java Execution in Embedded Systems
109. **Kari Salonen**, Setup Optimization in High-Mix Surface Mount PCB Assembly
110. **Pontus Boström**, Formal Design and Verification of Systems Using Domain-Specific Languages
111. **Camilla J. Hollanti**, Order-Theoretic Mehtods for Space-Time Coding: Symmetric and Asymmetric Designs
112. **Heidi Himmanen**, On Transmission System Design for Wireless Broadcasting
113. **Sébastien Lafond**, Simulation of Embedded Systems for Energy Consumption Estimation
114. **Evgeni Tsivtsivadze**, Learning Preferences with Kernel-Based Methods
115. **Petri Salmela**, On Commutation and Conjugacy of Rational Languages and the Fixed Point Method
116. **Siamak Taati**, Conservation Laws in Cellular Automata
117. **Vladimir Rogojin**, Gene Assembly in Stichotrichous Ciliates: Elementary Operations, Parallelism and Computation
118. **Alexey Dudkov**, Chip and Signature Interleaving in DS CDMA Systems
119. **Janne Savela**, Role of Selected Spectral Attributes in the Perception of Synthetic Vowels
120. **Kristian Nybom**, Low-Density Parity-Check Codes for Wireless Datacast Networks
121. **Johanna Tuominen**, Formal Power Analysis of Systems-on-Chip
122. **Teijo Lehtonen**, On Fault Tolerance Methods for Networks-on-Chip
123. **Eeva Suvitie**, On Inner Products Involving Holomorphic Cusp Forms and Maass Forms
124. **Linda Mannila**, Teaching Mathematics and Programming – New Approaches with Empirical Evaluation
125. **Hanna Suominen**, Machine Learning and Clinical Text: Supporting Health Information Flow
126. **Tuomo Saarni**, Segmental Durations of Speech
127. **Johannes Eriksson**, Tool-Supported Invariant-Based Programming

128. **Tero Jokela**, Design and Analysis of Forward Error Control Coding and Signaling for Guaranteeing QoS in Wireless Broadcast Systems
129. **Ville Lukkarila**, On Undecidable Dynamical Properties of Reversible One-Dimensional Cellular Automata
130. **Qaisar Ahmad Malik**, Combining Model-Based Testing and Stepwise Formal Development
131. **Mikko-Jussi Laakso**, Promoting Programming Learning: Engagement, Automatic Assessment with Immediate Feedback in Visualizations
132. **Riikka Vuokko**, A Practice Perspective on Organizational Implementation of Information Technology
133. **Jeanette Heidenberg**, Towards Increased Productivity and Quality in Software Development Using Agile, Lean and Collaborative Approaches
134. **Yong Liu**, Solving the Puzzle of Mobile Learning Adoption
135. **Stina Ojala**, Towards an Integrative Information Society: Studies on Individuality in Speech and Sign
136. **Matteo Brunelli**, Some Advances in Mathematical Models for Preference Relations
137. **Ville Junnila**, On Identifying and Locating-Dominating Codes
138. **Andrzej Mizera**, Methods for Construction and Analysis of Computational Models in Systems Biology. Applications to the Modelling of the Heat Shock Response and the Self-Assembly of Intermediate Filaments.
139. **Csaba Ráduly-Baka**, Algorithmic Solutions for Combinatorial Problems in Resource Management of Manufacturing Environments
140. **Jari Kyngäs**, Solving Challenging Real-World Scheduling Problems
141. **Arho Suominen**, Notes on Emerging Technologies
142. **József Mezei**, A Quantitative View on Fuzzy Numbers
143. **Marta Olszewska**, On the Impact of Rigorous Approaches on the Quality of Development
144. **Antti Airola**, Kernel-Based Ranking: Methods for Learning and Performace Estimation
145. **Aleksi Saarela**, Word Equations and Related Topics: Independence, Decidability and Characterizations
146. **Lasse Bergroth**, Kahden merkkijonon pisimmän yhteisen alijonon ongelma ja sen ratkaiseminen
147. **Thomas Canhao Xu**, Hardware/Software Co-Design for Multicore Architectures
148. **Tuomas Mäkilä**, Software Development Process Modeling – Developers Perspective to Contemporary Modeling Techniques
149. **Shahrokh Nikou**, Opening the Black-Box of IT Artifacts: Looking into Mobile Service Characteristics and Individual Perception
150. **Alessandro Buoni**, Fraud Detection in the Banking Sector: A Multi-Agent Approach
151. **Mats Neovius**, Trustworthy Context Dependency in Ubiquitous Systems
152. **Fredrik Degerlund**, Scheduling of Guarded Command Based Models
153. **Amir-Mohammad Rahmani-Sane**, Exploration and Design of Power-Efficient Networked Many-Core Systems
154. **Ville Rantala**, On Dynamic Monitoring Methods for Networks-on-Chip
155. **Mikko Pelto**, On Identifying and Locating-Dominating Codes in the Infinite King Grid
156. **Anton Tarasyuk**, Formal Development and Quantitative Verification of Dependable Systems
157. **Muhammad Mohsin Saleemi**, Towards Combining Interactive Mobile TV and Smart Spaces: Architectures, Tools and Application Development
158. **Tommi J. M. Lehtinen**, Numbers and Languages
159. **Peter Sarlin**, Mapping Financial Stability
160. **Alexander Wei Yin**, On Energy Efficient Computing Platforms
161. **Mikołaj Olszewski**, Scaling Up Stepwise Feature Introduction to Construction of Large Software Systems
162. **Maryam Kamali**, Reusable Formal Architectures for Networked Systems
163. **Zhiyuan Yao**, Visual Customer Segmentation and Behavior Analysis – A SOM-Based Approach
164. **Timo Jolivet**, Combinatorics of Pisot Substitutions
165. **Rajeev Kumar Kanth**, Analysis and Life Cycle Assessment of Printed Antennas for Sustainable Wireless Systems
166. **Khalid Latif**, Design Space Exploration for MPSoC Architectures

167. **Bo Yang**, Towards Optimal Application Mapping for Energy-Efficient Many-Core Platforms
168. **Ali Hanzala Khan**, Consistency of UML Based Designs Using Ontology Reasoners
169. **Sonja Leskinen**, m-Equine: IS Support for the Horse Industry
170. **Fareed Ahmed Jokhio**, Video Transcoding in a Distributed Cloud Computing Environment
171. **Moazzam Fareed Niazi**, A Model-Based Development and Verification Framework for Distributed System-on-Chip Architecture
172. **Mari Huova**, Combinatorics on Words: New Aspects on Avoidability, Defect Effect, Equations and Palindromes
173. **Ville Timonen**, Scalable Algorithms for Height Field Illumination
174. **Henri Korvela**, Virtual Communities – A Virtual Treasure Trove for End-User Developers
175. **Kameswar Rao Vaddina**, Thermal-Aware Networked Many-Core Systems
176. **Janne Lahtiranta**, New and Emerging Challenges of the ICT-Mediated Health and Well-Being Services
177. **Irum Rauf**, Design and Validation of Stateful Composite RESTful Web Services
178. **Jari Björne**, Biomedical Event Extraction with Machine Learning
179. **Katri Haverinen**, Natural Language Processing Resources for Finnish: Corpus Development in the General and Clinical Domains
180. **Ville Salo**, Subshifts with Simple Cellular Automata
181. **Johan Ersfolk**, Scheduling Dynamic Dataflow Graphs
182. **Hongyan Liu**, On Advancing Business Intelligence in the Electricity Retail Market
183. **Adnan Ashraf**, Cost-Efficient Virtual Machine Management: Provisioning, Admission Control, and Consolidation
184. **Muhammad Nazrul Islam**, Design and Evaluation of Web Interface Signs to Improve Web Usability: A Semiotic Framework
185. **Johannes Tuikkala**, Algorithmic Techniques in Gene Expression Processing: From Imputation to Visualization
186. **Natalia Díaz Rodríguez**, Semantic and Fuzzy Modelling for Human Behaviour Recognition in Smart Spaces. A Case Study on Ambient Assisted Living
187. **Mikko Pänkäälä**, Potential and Challenges of Analog Reconfigurable Computation in Modern and Future CMOS
188. **Sami Hyrynsalmi**, Letters from the War of Ecosystems – An Analysis of Independent Software Vendors in Mobile Application Marketplaces
189. **Seppo Pulkkinen**, Efficient Optimization Algorithms for Nonlinear Data Analysis
190. **Sami Pyöttiälä**, Optimization and Measuring Techniques for Collect-and-Place Machines in Printed Circuit Board Industry
191. **Syed Mohammad Asad Hassan Jafri**, Virtual Runtime Application Partitions for Resource Management in Massively Parallel Architectures
192. **Toni Ernvall**, On Distributed Storage Codes
193. **Yuliya Prokhorova**, Rigorous Development of Safety-Critical Systems
194. **Olli Lahdenoja**, Local Binary Patterns in Focal-Plane Processing – Analysis and Applications
195. **Annika H. Holmbom**, Visual Analytics for Behavioral and Niche Market Segmentation
196. **Sergey Ostroumov**, Agent-Based Management System for Many-Core Platforms: Rigorous Design and Efficient Implementation
197. **Espen Suenson**, How Computer Programmers Work – Understanding Software Development in Practise
198. **Tuomas Poikela**, Readout Architectures for Hybrid Pixel Detector Readout Chips
199. **Bogdan Iancu**, Quantitative Refinement of Reaction-Based Biomodels
200. **Ilkka Törmä**, Structural and Computational Existence Results for Multidimensional Subshifts
201. **Sebastian Okser**, Scalable Feature Selection Applications for Genome-Wide Association Studies of Complex Diseases
202. **Fredrik Abbors**, Model-Based Testing of Software Systems: Functionality and Performance
203. **Inna Pereverzeva**, Formal Development of Resilient Distributed Systems
204. **Mikhail Barash**, Defining Contexts in Context-Free Grammars
205. **Sepinoud Azimi**, Computational Models for and from Biology: Simple Gene Assembly and Reaction Systems
206. **Petter Sandvik**, Formal Modelling for Digital Media Distribution

207. **Jongyun Moon**, Hydrogen Sensor Application of Anodic Titanium Oxide Nanostructures
208. **Simon Holmbacka**, Energy Aware Software for Many-Core Systems
209. **Charalampos Zinoviadis**, Hierarchy and Expansiveness in Two-Dimensional Subshifts of Finite Type
210. **Mika Murtojärvi**, Efficient Algorithms for Coastal Geographic Problems
211. **Sami Mäkelä**, Cohesion Metrics for Improving Software Quality
212. **Eyal Eshet**, Examining Human-Centered Design Practice in the Mobile Apps Era

Turku
Centre *for*
Computer
Science

http://www. tucs.fi

tucs@abo.fi

University of Turku
Faculty of Mathematics and Natural Sciences
- Department of Information Technology
- Department of Mathematics and Statistics

Turku School of Economics
- Institute of Information Systems Science

Åbo Akademi University
Faculty of Science and Engineering
- Computer Engineering
- Computer Science

Faculty of Social Sciences, Business and Economics
- Information Systems

ISBN 978-952-12-3392-0
ISSN 1239-1883

Eyal Eshet

Examining Human-Centered Design Practice in the Mobile Apps Era