The Living Lab as a Practical Approach for ICT Design: Setup and Maintenance Work in Domestic Environments

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Abstract

Living labs have garnered a significant amount of attention in human computer interaction (HCI) research. They have been established as practical approaches to the design of information and communication technology (ICT) mainly in the domestic domain and in private sectors. Research fields such as domestic domains and private sectors are characterized by both complex contexts and even more complex technical solutions, which are exposed to high competitive pressure from the consumer market. These circumstances create the need for a profound understanding of users and an iterative design process in the field of application to provide additional benefits to users or to uncover unexpected needs related to the designed solutions. Living labs address this need by focusing on an intensive and continuous co-creation process involving users and relevant stakeholders, including researchers, practitioners, and public institutions, in the design of new ICT solutions and services. The design process through living labs, which distinguishes them from other approaches, is characterized by long-term studies with sustained access to the field of application. The access to the field of application is not only used to elicit requirements but also to investigate appropriation and usage in real use contexts.

Long-term co-creation studies in practice are characterized by intensive stakeholder and user interactions, users' and stakeholders' exchange of experiences and knowledge, and the management of living lab projects with respect to a variety of unpredictable factors in users' everyday lives. However, few studies have addressed how co-creation and collaboration processes in living labs are actually managed and what kind of challenges have to be surmounted on social, technical, and managerial levels across the contributing groups in order to successfully establish and coordinate living lab research in a long-term and sustained way. This thesis addresses these issues via two overarching research questions: (1) What does it mean to establish living labs as practical approaches for ICT design in domestic environments? and (2) What are the challenges one faces in maintaining related infrastructural and social settings in longitudinal design processes, and how can they be addressed successfully?

In order to answer these research questions, two living lab projects conducted in the domestic field are presented and analyzed from a meta-perspective. Both projects concerned the design and appropriation of ICT applications that support households' everyday activities and were established as longitudinal studies in real-life settings, the participants' homes. They followed a co-creation approach where users held a central role and were actively involved throughout the entire design process. Based on these two case studies, this thesis examines the organizational setup of research projects, the applied living lab environments, the selection of user samples, and the evolving work practices of stakeholders and users. The analysis focuses not only on the design processes but also on long term-related effects, evolving roles, and related social and ethical issues that living lab operators, stakeholders, and users had to address over a long period of time.

This thesis contributes to four essential managerial principles addressing methodological, structural, and social issues of long-term collaborations in living labs. They are framed as the practical management of maintenance work, aims for cost

reduction and process optimization, and intend to strengthen collaboration between the actors involved in living labs and foster their participation.

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List of Abbreviations

ACM	Association for Computing Machinery
BIT	Journal on Behaviour & Information Technology
CHI	ACM SIGCHI Conference on Human Factors in Computing Systems
CoI	Community of Interest
CoP	Community of Practice
CRM	Customer Relationship Management
CSCW	Computer-Supported Cooperative Work
DCS	Design Case Study
ENoLL	European Network of Living Labs
EPG	Electronic Program Guide
GD	Grounded Design
HCI	Human Computer Interaction
HDMI	High-Definition Multimedia Interface
HDTV	High-Definition television
ICT	Information and Communication Technology
IJHCS	International Journal of Human-Computer Studies
IT	Information Technology
iTV	Interactive Television
IwC	Interacting with Computer - The Interdisciplinary Journal of Human-Computer Interaction
KBS	Knowledge-Based System
MIT	Massachusetts Institute of Technology
OS	Operating System
PD	Participatory Design
PPA	Physiological Profile Assessment
QoL	Quality of Life
RCT	Randomized Control Trial
ResearchOps	Research Operations
SMEDL	SocialMedia Experience and Design Lab

SMM	Senior Mobility Monitor
SWOT analysis	Strengths, Weaknesses, Opportunities, Threats (strategic planning method)
TOCHI	ACM Transactions on Computer-Human Interactions
TV	Television
TVX	ACM International Conference on Television and Online Video
UX	User Experience
WiFi	Wireless Fidelity

Part I
Fundamentals

The first part of this thesis outlines its structural and conceptual fundamentals. Chapter 1 (Introduction) addresses the research field and presents the overarching research questions. Chapter 2 (Related Work) lays out the theoretical essentials and situates the goals and objectives of this thesis within its research discourse. Chapter 3 (Study Outline) describes the overall research approach and methodology used for this thesis.

1 Introduction

This section will first outline the field of research in which this thesis and its related research activities can be located. Then, the research goals and central research questions will be derived, and an overview of the thesis's structure will be given.

1.1 Motivation

When we view ourselves as consumers, we feel we are becoming increasingly sensitive to the tremendous variety of new information and communication technology (ICT) products and services in the market that promise to make our everyday life at home easier and more comfortable. From a design-oriented perspective, this diverse range leads to increased interest in research and development processes that coincide with ICT innovations. Already during the 1980s, domestic contexts became relevant in human computer interaction (HCI) research. Lull (1990), for instance, investigated the usage behavior and social practices of television (TV) consumption. Following the introduction of PC technologies and broadband Internet in the late 1990s, a number of new devices, such as interactive televisions (iTV), smartphones, tablet PCs, and further wearables – to name just a few – were created. With these devices, various applications and services, such as instant messaging, social networks, health tracking, and smart home monitoring evolved over time and shaped individual communication and the consumption behavior of users. How these technologies have been used and managed within the home has been investigated by a variety of researchers in the field of HCI and computer-supported cooperative work (CSCW) (O'Brien et al. 1999; Crabtree and Rodden 2004; Grinter et al. 2009; Hess et al. 2012a; Poole 2012).

Now more than ever, academia and companies in the field of HCI strive for solutions to support consumers' everyday life with technology. The number of competitors is growing, which has resulted in high market pressure and has made innovative product design risky. Many products that have entered the market have been unable to reach the critical mass and have consequently failed. Dijksterhuis (2016) estimates a failure rate of 50% to 75% for consumer goods. One of the reasons for this level of failure seems to be many products and services' lack of innovative character and their lack of focus on current user needs (Slater and Mohr 2006). Frissen and Lieshout (2006) remark that the social practices and rhythms of users as well as cultural contexts are not adequately considered in product design. Consequently, this lacking consideration of usage contexts has an impact on technical obsolescence, which decreases as a result. The technical obsolescence describes how long ICT artifacts are attractive to users and how long they are used in the everyday life. With the current societal transition toward sustainability and the conscious use of resources, technical obsolescence seems contradictory and further reveals the importance of understanding users, their residential circumstances, and social contexts in the design of ICT for domestic environments. New solutions must therefore provide additional benefits and an enjoyable user experience (UX) or even raise non-expected needs to attract users regarding the new solutions.

Given the abovementioned societal and market-based circumstances, user-centered design approaches are now inevitable. Moreover, this kind of design approaches are

not new, as Scandinavian researchers initiated the first movements of participatory design (PD) in the late 1980s (Bødker et al. 1987; Ehn and Kyng 1987; Floyd et al. 1989). This approach was characterized by a democratic mindset in workplaces and linked to possibilities for employees to influence processes and outcomes. Over the years, PD has been extended beyond workplaces to involve people and their contexts in generic design processes (Ehn 2008). In this regard, PD informs design through the early and active involvement of users and additionally reveals psychological values by affecting users' commitment and their usage motivations. However, when HCI research started to extend their field of research to private spaces, they had to deal with new challenges. Getting access to field was not as easy as in work contexts, but it is essential to get a contextual understanding (O'Brien et al. 1999; Grinter et al. 2009).

To gain contextual understanding and, moreover, a deeper understanding of people's mindsets, ethnography is important in HCI. Ethnographic methods, such as interviews and observations, provide access to people and their individual experiences and help uncover their motivations for certain actions. Ethnography has to face similar challenges in practice as mentioned before for PD. Ethnographic studies can go far beyond interviewing or observing people. Ethnography must also address contextual challenges. It is often unclear how to adapt ethnographic methods to domestic environments and how to know which methods are adequate for work contexts. This debate is still ongoing (Brown and Bell 2004; Crabtree et al. 2009; Schmidt 2011; Bonacin et al. 2019). Methods that require researchers' presence from the beginning are not suitable in every situation. Self-documentation methods, such as diary studies (Bolger et al. 2003; Carter and Mankoff 2005; Sohn et al. 2008) and probes, have proven suitable for accessing sensitive environments such as the home (Gaver et al. 1999; Crabtree et al. 2003; Hutchinson et al. 2003; Boehner et al. 2007). These methods furthermore incentivize people to reflect on actions that were often done unconsciously. Ethnography enriches the design process through describing people's patterns of thinking and acting and builds a valuable basis for user-centered approaches.

One step ahead, the more complex technology development proves to be, the more important it is to proceed iteratively and evolutionarily and to consider technology appropriation (Rohde et al. 2009; Stevens et al. 2009; Wulf et al. 2011; Wulf et al. 2015b; Wulf et al. 2015a). Often non-predictable reactions or new needs can be exposed because certain reactions and needs only emerge when a technology is used (Orlikowski and Hofman 1997; Swiderski 2008). Technology appropriation "in the wild" should be understood as an integral part of the design process. Nevertheless, researchers and practitioners must still produce a higher level of contextual understanding and user involvement in the design process.

To address these needs, in the past two decades, living labs have evolved as a novel approach to advancing the design process for complex ICT solutions. When living labs are used to their full extent, they represent an approach that combines ethnography and PD with relevant methods and infrastructures and extend its practical accents through long-term appropriation studies in the field, which thus far have not strongly focused on ICT development. Based on in these kind of field activities, living labs can be described as a practical approach to ICT design. The term "approach", as applied in

this thesis, adheres to a definition that describes a way of doing or addressing something. Following this definition, the living lab should be understood as a specific way of approaching ICT design in practice with respect to infrastructural and methodological settings, and the associated managerial tasks. Living labs thus provide guidance and ways how to access the field of application and how to involve users in co-design processes in the long run. Moreover, they aim to unite different stakeholders from academia, industry, public sectors, and users in long-term collaborations, especially for domestic contexts (Eriksson et al. 2005; Eriksson et al. 2006; Følstad 2008) but also for professional contexts (Frößler et al. 2007; Holtzblatt et al. 2019). Thereby, a common understanding of design goals among the involved actors can be achieved, and this common understanding can be the basis for practice-based design. Practice-based design starts with an investigation of users in the field. It begins by understanding users and their social rhythms, continues with design processes in an iterative and co-creative manner with early user tests mainly in "quasi-natural" lab settings, and ends with investigations on the appropriation of the designed ICT artifacts in their actual context of use and, if possible, over a long period of time (Ogonowski et al. 2018). A variety of living lab research projects can be found in domestic and private sectors (for example, Anastasiou et al. 2012; Müller et al. 2012; Müller et al. 2015; Castelli et al. 2017; Jakobi et al. 2017).

In practice, there are different manifestations of the living lab approach. The approach particularly refers to the differences that exist regarding study duration, when and how users are integrated into living lab projects, and how the notion of "real-world" environment is materially understood. Schuurman et al. (2009) described the living lab approach, for instance, as two varying approaches for offering new technologies to users. Living labs as environments can entail either "making the technology or product available in the user's home" or making "a home where the technology or product is available and where users come to stay for a certain period". Timeframes for how long users can interact with designed artifacts can vary from hours (Kanstrup 2008), to days (de Ruyter and Aarts 2004; Intille et al. 2005), to several months (Bergvall-Kåreborn and Larsson 2008; Schuurman et al. 2009; Schwartz et al. 2013).

In examining the overall design process of ICT solutions for domestic environments, research discourses in general exist on ethnography and empirical methods for investigating users, their social situations, and their usage behavior in the field before technical interventions such as newly designed prototypes are implemented (Crabtree and Rodden 2004; Randall et al. 2007; Grinter et al. 2009). The portfolio of methods for conducting user-centered ideation and co-creation processes is continuously growing as well (Crabtree et al. 2003; Hutchinson et al. 2003; Lindquist et al. 2007; Lucero Vera 2009), and moreover, a recent living lab study, focusing on infrastructural settings revealed a general trend away from lab tests to field studies, where the integration of new ICT artifacts can be investigated in the actual context in which they are used (Alavi et al. 2020). All these approaches together have produced an understanding of the dynamics in innovative product design processes, but they have not encompassed organizational aspects of iterative product development and relationship building to their full extent. In particular, when examining long-term collaborations in living labs for domestic environments, few research is found that reflects the entire process of user involvement. Consequently, we know only little

about the challenges involved. In particular, we know little about how these processes are organized and managed, which roles are import, and to what extent maintenance work plays an important role in keeping living labs as a practical approach and especially long-term field studies running. This thesis and its associated research intend to close this research gap.

1.2 Research Goals and Central Research Questions

The discourse around early context studies informed by ethnography, user-centered design processes based on PD, and appropriation studies, which make use of ethnographic methods, shows how the living lab approach can be framed for ICT design. As described above, many case studies exist where the living lab was used as methodological approach for reaching defined research aims but were not used to their full extent of understanding users and usage contexts, designing in a co-creative manner, and investigating appropriation processes in a long run. Moreover, little research exists that analyzes living lab processes to, for instance, illuminate users' motivations and expectations (Schuurman et al. 2010b; Leonardi et al. 2014). However, there are a few exceptions, including the work of Frößler et al. (2007) and Johansson et al. (2011).

In principle, living labs hold promise for complex ICT design, but researchers must still conduct fundamental investigations on an organizational level and investigations particularly concerning longitudinal stakeholder and user interactions. This thesis will contribute to resolving these issues by taking a meta-perspective and analyzing two practice-based ICT research projects concerning the domestic environment. The analysis will not only focus on the design process but also on established long-term-related structures, evolving roles, and related social and ethical issues living lab operators, stakeholders, and users confront. This analysis will be made through describing the organizational setup of research projects, the applied living lab environments, the selection of the user sample, and work practices of stakeholders and users. This thesis will also contribute to aspects of maintenance work from technical and managerial perspectives with respect to how long-term collaboration in ICT development can be established to create innovative technical solutions.

This leads to two overarching research questions. The first is, what does it mean to establish living labs as practical approaches for ICT design in domestic environments? The second is, what are the challenges one faces in maintaining related infrastructural and social settings in longitudinal design processes?

Consequently, two perspectives will be addressed that allow for further, more detailed questions. The first perspective is characterized by infrastructural aspects and raises the following questions:

Which kind of infrastructural settings are applicable for long-term collaborations?

What is needed to make the best use of infrastructures?

The second perspective takes a managerial point of view and addresses the following questions:

What values and challenges arise from stakeholders and users collaborating over a long period of time?

What are the roles of stakeholders and users in living lab settings?

What are the stakeholders' and users' expectations?

How do living lab operators address these expectations and maintain relationships?

These questions will be addressed in the further course of this thesis and verified by examples from the field.

1.3 Structure of Thesis

To answer the research questions, the thesis is structured into three main sections: (I) fundamentals, (II) research outcomes, and (III) analysis.

Part I: Fundamentals

The first part presents the fundamentals of the thesis. Chapter 1 includes my motivation for why the living lab approach is a promising candidate for complex ICT design and why it is necessary to investigate managerial aspects of the design process, overall project progression, and stakeholder and user interactions. Chapter 2 therefore introduces theoretical essentials on ethnography and PD processes as they concern the home. Chapter 2 concludes with an overview on living lab research from a theoretical and practical perspective to define the research gap. Chapter 3 presents an outline of the thesis and provides an overview of the applied methodology. Both case studies on which this thesis is based are introduced via a brief overview of the project's aims, living lab setups and environments, and the designed ICT systems.

Part II: Research Outcomes

The second part comprises the research outcomes on the setup of living labs and maintenance work from a methodological, praxeological, and managerial perspective when designing ICT for domestic environments. One of the arguments is that living lab studies are valuable for designing socio-technical innovations with a user-centered focus. The approach, however, must be investigated from a meta-perspective to extend the guidelines on how to best maintain living lab environments, their technical settings, and relationships between stakeholders and users. The chapters comprising this second part have all been published in peer-reviewed journals or conferences and have been adapted to the format of this thesis with only minor modifications including spelling corrections and the uniform use of abbreviations.

Chapters 4 and 5 both emphasize the empirical value of contextual long-term living lab studies for designing domestic ICT solutions and reveal changes within different target groups, families, and older adults by appropriating and using ICT systems over time.

Chapter 4 presents findings from a qualitative empirical long-term study focusing on the appropriation and use of new marketable multimedia devices (media center systems and smartphones) in the domestic settings of 16 households in Germany.

Changes in TV consumption and smartphone usage were observed over time. The research focus was not only on media usage during the day but also on social phenomena that change or even occur by introducing new devices into household settings. This study informed later ICT design. The empirical results were published in the following conference paper: *Hess, J., Ley, B., Ogonowski, C., Reichling, T., Wan, L., and Wulf, V., 2012. New Technology @ Home: Impacts on Usage Behavior and Social Structures. In: Proceedings of the European Conference on Interactive TV and Video - EuroITV '12. New York, New York, USA: ACM Press, 185–194.*

Chapter 5 focuses on a six-month qualitative empirical study on the integration of an ICT-based fall prevention system (exercising in front of the TV and activity tracking based on a wearable) into older adults' daily life activities. The investigation comprised 12 participants and emphasized sustainable physical effects on participants' fall risk and positive impacts on their health literacy, self-management of health, and individual wellbeing, which also function as motivational factors for users. The study has been published as the following journal article: *Ogonowski, C., Aal, K., von Rekowski, T., Vaziri, D., Randall, D., Schreiber, D., Wieching, R., and Wulf, V., 2016. ICT-based Fall Prevention System for Older Adults: Qualitative Results from a Long-Term Field Study. In: ACM Transactions on Computer-Human Interaction, 23 (5).*

Chapter 6 presents first reflections on a living lab process from a meta-perspective based on the research presented in Chapter 4. Lessons learned from 2.5 years of research in the field of home entertainment were derived. The focus of this research lies on the users' role and their longitudinal involvement. Insights about and challenges in user management as they concern the selection process, trust building, and managing motivation over time were highlighted. The results were published in the following conference paper: *Ogonowski, C., Ley, B., Hess, J., Wan, L., and Wulf, V., 2013. Designing for the Living Room: Long-Term User Involvement in a Living Lab. In: Proceedings of the International Conference on Human Factors in Computing Systems - CHI'13. New York, New York, USA: ACM Press, 1539–1548.*

Chapter 7 builds on the previous chapter and reflects on the entire project duration, with a specific focus on the users' role and their dynamics, the impact of user characteristics and expectations, and related ethical issues. Insights were compared with those from a similar living lab study from the UK, which was also conducted on the topic of social TV, to validate common findings. This comparative study was published as the following journal article: *Ley, B., Ogonowski, C., Mu, M., Hess, J., Race, N., Randall, D., Rouncefield, M., and Wulf, V., 2015. At Home with Users: A Comparative View of Living Labs. In: Interacting with Computers, 27 (1), 21–35.*

While Chapter 7 focuses on user-researcher relationships (among other topics) and reflects on them from a meta-perspective over the whole project period of four years, Chapter 8 presents an ethnographic method for narrative mapping to gain self-reflections from participating households and academic researchers. The chapter also provides an understanding of how stakeholders felt during collaboration, what they saw as catalysts and barriers, and how their expectations and feelings changed over time. These insights were published in the following conference workshop paper: *Ogonowski, C. and Ley, B., 2014. Sketching a Narrative Map: Reflections on User-Researcher Relationships and Project Progression. In: CSCW '14 Workshop:*

Designing with Users for Domestic Environments: Methods, Challenges, Lessons Learned. 1–5.

Chapter 9 concludes the research with an analysis on the perspectives of all involved stakeholders (academia, industry, and participating households). It focuses on different stakeholders' viewpoints and the existing asymmetries and difficulties of living lab collaborations. A new definition of the user's role and the call for the general role of a living lab facilitator are stated and discussed with respect to the living lab as practical approach. Findings were published in the following journal article: *Ogonowski, C., Stevens, G., Hess, J., Randall, D., and Wulf, V., 2018. Managing Viewpoints: Maintenance Work in Sustainable Living Lab Research. In: International Reports on Socio-Informatics, 15 (1), 3–37.*

Part III: Conclusion

The third part closes the thesis by comparing the described living lab projects on ICT design for domestic environments in order to derive methodological, managerial, and structural lessons to be used in long-term collaborations with stakeholders and users in living lab settings. Chapter 10 (Summary of Findings) summarizes the empirical insights regarding the methodological challenges that arose during the acquisition of participating users, investigations of social phenomena, and changes in usage behavior over time. This chapter also summarizes challenges concerning the environmental settings and the stakeholders' roles and their interactions. Chapter 11 (Implications) presents findings derived from field research and stakeholder management. Chapter 11 further discusses strengthening collaborations and developing collaborative thinking and central roles, which keep living lab projects running, as well as the role of users as stakeholders. Chapter 12 (Closing Remarks and Outlook) summarizes the thesis by highlighting its main contributions to the setup and maintenance work of living labs and concludes with an outlook on aspects that could be interesting to address in future meta-research on living labs.

2 Related Work

This section will first introduce related work from the most important academic streams regarding understanding users in domestic contexts and fostering user-centered design approaches. This introduction will lead an introduction to living labs and their characteristics as practical approach, and based on this, the research gap on managerial processes and roles in living labs will be identified.

2.1 Researching the Home

With the increasing digitalization of the home and its variety of digital devices, the need for a better contextual understanding of this environment is growing, and adequate ICT design is more relevant than ever. In HCI, the home became popular with respect to, for example, family interactions with new media, new forms of communication and entertainment, smart home technologies, energy management, sustainability, and aging at home and home care (Crabtree and Rodden 2004; Palen and Aaløkke 2006). Thus, the domestic domain is manifold in its use cases and scenarios, complex in its social structures and is characterized by context-sensitive behavior. Social and physical factors both impact how individuals interact with technical artifacts in the home (Blomberg et al. 1993). Over time, usage behavior and even habits change following the introduction of new ICT devices and services, and most of these lead to more flexible usage behavior. Investigations on the design space and thus the context help uncover social practices that evolve and change over time due to technical and social influences and help provide a better understanding of users, their usage behavior, and related emotions (Blomberg et al. 1993).

Accessing the private space of the home – which provides inhabitants with safety, a feeling of security, and a place for social cohesion – is challenging for researchers, as they are “strangers”. Consequently, home access requires a cautious and sympathetic approach. Ethnography and what Randall et al. (2007) denominate as fieldwork have been established for investigations of domestic lives. They use preliminary qualitative methods such as interviews, observations, and video analysis. In addition, self-documentation methods such as diary studies are also often applied in this context (Bolger et al. 2003; Sohn et al. 2008). Diaries in particular are used as ice breakers for establishing initial trust relationships between researchers and users when it seems inappropriate for researchers to be present in the field. These methods help uncover habituated usage behavior and facilitate users to reflect own usage behavior, which build a good basis for further investigations (Gaver et al. 1999; Carter and Mankoff 2005). Obrist et al. (2008) and Hess et al. (2011a), for instance, conducted physical diary studies and combined them with interviews in order to identify user requirements for interactive television usage. By contrast, Graham et al. (2007) and Kubey and Csikszentmihalyi (1990) used digital devices for self-documentation. Graham et al. (2007) thus investigated user behavior with regard to digital content sharing in everyday life. Kubey and Csikszentmihalyi (1990) gathered data on consumed TV content using a reminder from a pager that repeated every 10 minutes. Participants were asked to not only document what content they watched but also the social situations in which they watched in order to investigate their reciprocal influence.

Quantitative methods were also used, including large-scale surveys and data tracking on, for instance, device-use time and consumed content.

Many studies provided insights on content-related consumption behavior and how devices are typically used in the home (Lull 1990; Obrist et al. 2008). Smith and Krugman (2010) showed how digitalization has changed watching behavior to be more controlled and flexible in TV and video consumption. O'Hara et al. (2007) analyzed video consumption on mobile devices. Tsekleves et al. (2009) investigated the role of the TV in the living room and stated that TVs are important for both video content and information-based content from the Internet. Bernhaupt et al. (2011) showed what kinds of challenges have arisen from the convergence of the TV and the Internet. A specific focus on social practices and their related changes have also been investigated. From a sociological point of view, Turkle (2011) analyzed how smartphones influenced established communication habits towards more digital social exchange and less physical interaction. Barkhuus (2009) explored how TV consumption on computers changed people's viewing habits and daily routines with respect to fixed program schedules. One of Barkhuus's findings is that content consumption has become time independent and more individualized through on-demand access.

Ethnographic and empirical studies within the domestic domain have led to insights into users' mindsets, related social structures, and ICT usage. They are necessary in contexts where technological innovations evolve rapidly, where user behavior could change radically, and where users have, at best, a rudimentary understanding of what is possible for future design. According to these characteristics of the domestic domain, ethnographically oriented studies have generated a profound understanding of users' needs and have helped validate early design ideas and define requirements of future design.

2.2 Designing with Users

Matching users' needs or even creating unimagined needs through the design of ICT artifacts for domestic use requires not only a profound understanding of context but also strong interactions with users during the design process. In general, PD aims to involve various stakeholders and users in the design process to generate solutions that will be accepted by users and will improve their everyday life in the long run. With the characteristics of the Scandinavian approach (Bødker et al. 1987; Ehn and Kyng 1987; Bjerknes and Brattetig 1995), which stands out because it democratized processes, transferring organizational knowledge and improving work practices by transforming existing "symmetries of ignorance" into symmetries of learning and participation (Fowles 2000), has been developed as an appropriate understanding of user participation, also for the private sector (Ehn 2008). Bødker et al. (2004) emphasized the long-term character of PD processes. Genuine participation, in their words, requires continuous user involvement to create a shared understanding of problems and needs. This kind of participation, however, is accompanied by topics regarding the heterogeneity of tasks, organizational complexity, and issues on balancing different actors' rights and responsibilities.

Although moving research practices from their original work contexts to domestic and leisure contexts has not been done without challenges. It raised an ongoing debate on the adequacy of this transition and ways to overcome such challenges (Kensing and Blomberg 1998; Bødker et al. 2004; Bannon et al. 2011; Schmidt 2011; Bonacin et al. 2019). A general understanding about why users should be integrated into ICT design has been established, and a variety of methods have evolved over time (Greenbaum and Kyng 1991; Muller and Kuhn 1993; Bødker et al. 2004; Ehn 2008). With PD research context-sensitive methods to carefully stimulate the involvement of users in the design process have evolved. One of these methods are the cultural probes. Gaver et al. (1999) introduced this method to allow users to express their thoughts in an open and creative manner. The method has been modified over the years. Hutchinson et al. (2003), for instance, applied it as a technology probe, which inspired the design for and with families. Crabtree and Rodden (2004) evaluated different techniques for exploring the home and compared standard full-time recording against self-documentation methods, to which they attributed greater value. Obrist et al. (2008) modified the method to be a creative and playful probe for gaining insight on TV consumption, the TV's ongoing digitalization, and its interactive applications for the living room. Lindquist et al. (2007) described the use of co-design methods and reflected on their aptitude for the home.

However, few studies have addressed long-term user involvement in participative or co-creative design processes. Castelli et al. (2017) described different co-design stages in their 18-month study with a stronger output-driven focus on data visualization for smart home control and monitoring . Sleeswijk Visser and Visser (2006) undertook a study where they periodically involved the same user group in an iterative design process. In contrast to Castelli et al. (2017), Sleeswijk Visser and Visser reflect more on the strengths and values of continuous user involvement. They argue that reusing users is valuable for future design iterations because users do not have to be acquired and onboarded again. Such users are familiar with the context and can provide feedback on a deeper, more detailed level than they could if they were not involved in earlier design stages. However, these users' expectations for a new iteration could be higher than previous iterations, and user feedback could be negative if, for example, feedback from a previous round was not addressed. Wulf et al. (2015a) agree with Sleeswijk Visser and Visser's general idea about reusing users in an iterative design process and emphasize the relevance of investigating the appropriation and usage of designed artifacts in their real-life context. They recommend a practice-based approach that allows an iterative design process, continuous user engagement, and context-relevant insights from the appropriation and use of a device in the field, especially for complex ICT designs such as those fostering sociability, inclusion, and social awareness, those that aim at efficiency, and for sensitive contexts (Wulf et al. 2011). Research from Schwartz et al. (2013), Wan et al. (2014), Jakobi et al. (2018), and Müller et al. (2015) followed Wulf et al.'s advice in the domestic context, and they also applied it with respect to ICT design for public spaces (Meurer et al. 2014; Stein et al. 2017). Tolmie and Crabtree (2008) also investigated research technology in the home and questioned how it influences or even disrupts existing usage behavior and established usage patterns and what effect it has on research results.

Having said this, there is a wide range of work describing and reflecting on applied PD methods and related fieldwork, but there are fewer works reflecting on methods and processes at a meta-level (Dick et al. 2012; Taylor et al. 2013). One of the requirements described above regarding implementation of PD is that a mutual understanding among stakeholders must be built as early as possible. Establishing a mutual language and a common ground of understanding is one of the main challenges in interacting with various stakeholders such as designers, developers, and users. Different design practices and organizational goals can strongly influence the mutual understanding. Dachtera et al. (2014) confirmed this challenge in their investigations on publicly funded research projects; they found that academic partners often dominated the user-centered design processes. Mediating skills that have a strong impact on success-oriented collaborations were identified as essential for developing a mutual understanding among stakeholders. Dachtera et al. (2014) have shown that the involvement of users in the design process is a challenge on the one hand, and on the other hand, the involvement of practitioners is also challenging and requires skills beyond user-researcher interactions. Interactions with both groups of actors, users and practitioners, demand for sensibility. The relationship with practitioners also requires a stronger economic thinking. Soini and Pirinen (2005) more explicitly examined different workshop formats as constructs for a common setting of various actors that collaborate and share knowledge by generating ideas and conceptions in early design stages. They derived three distinct ways for fostering collaboration in output-driven workshops: sharing insights, clustering competencies, and identifying common denominators.

Viewing the actors' roles shows the influence that different types and their related accentuations have regarding the quality of relationships between researchers, designers, and users. In this context, Soini (2006) investigated the facilitator's role as an industrial designer and stated that facilitation requires specific skills for exploiting the role's full potential, for instance, visualization skills, social skills, and basic research skills. In a slightly different way how actors' roles can be understood, von Hippel (1976) first argued that users' needs should be the foundation of the design process. However, he spent little effort in discussing the effects the user's role have on the process. Vines et al. (2013) scrutinized the user's role in PD methods, including their influence on different forms of participation, the benefits that users and organizers receive in the design process, and the degree of shared control with users. Vines et al. (2013) argued not just to reflect on conceptual challenges but also on pragmatic and ethical issues when collaborating with users. With a specific focus on ICT designs for older adults, Newell et al. (2006) stated that active and iterative user involvement in the design process requires methodological adaptations for the field of research and lasting changes in the mindsets of participating stakeholders. However, these changes in stakeholders' mindsets can be assumed to be a general requirement for participative approaches in the field of HCI.

2.3 Living Labs

With CSCW and HCI research turning to the social and thus to public spaces and the domestic domain, there is no longer a concomitant interest in only the design of technical systems but rather in the design of products in a holistic perspective. The need for new methods of product design inevitably leads to the need for new approaches to complex ICT design. Living labs have been posed as a possible answer and are still discussed by researchers and practitioners today. The following section will first introduce living labs as practical approaches and detail the discourse about various characteristics and how they are conceived in practice. Subsequently, different interpretations and accentuations how the term is applied in a real-life environment will be presented. The third subsection will focus on the importance of co-creation in living labs.

2.3.1 Living Lab Approach

In the past two decades, the term “living lab” and its methodological varieties have attracted increasing attention mainly in the domestic and public fields of ICT research and development. Early movements of living labs have been reported in HCI literature by Eriksson et al. (2005), Ballon et al. (2005), and Bergvall-Kåreborn et al. (2009). These early movements can be seen as responses to designers’ need for contextual understanding in order to define requirements and evaluate interactions with new social and ubiquitous technologies (Dourish 2001). The term living lab was first defined by William Mitchell and his colleagues at the Massachusetts Institute of Technology (MIT) Media Lab (Galli). During this time, in 2010, the living lab was considered an instrument for understanding complex phenomena through the careful study of users and their interactions with new IT artifacts in real-life environments (Eriksson et al. 2005). The “real-life environment” was initially equated with stationary labs in early living lab research, such as labs at university campuses. These labs had the character of a private home and provided opportunities to observe participants and to measure their behavior. Living labs drew on early insights from product design, as shown by von Hippel (1978; 1986), for instance, where product testing was mainly conducted in quasi-naturalistic but nevertheless controlled environments.

Over time and depending on the research context, the goals of living labs and the stakeholders involved in living labs experienced further evolutionary developments and have been applied with varying accentuations of user involvement and environments. However, there is no mutual consent regarding the definition of the living lab as an approach in the current literature (Carroll and Rosson 2013; Alavi et al. 2020). Living labs can thus be described as practical approaches where several stakeholders such as, for example, academics, practitioners, and public institutions collaborate with users by following user-centered research methods for “sensing, prototyping, validating, and refining complex solutions” (Eriksson et al. 2005) in multiple real-life environments (Niitamo et al. 2006; Almirall 2008). The users thereby can maintain an active and longer-term role in co-creation processes and become involved in ideation, iterative design phases, and the appropriation of designed artifacts in their actual use context by providing context-sensitive feedback (Schaffers

et al. 2007). These characteristics can generally be seen as the strengths of living labs relative to the academic streams in ICT design previously described in this chapter.

Hence, it can be argued that this approach is broadly based on PD philosophies and practices, with a focus on user involvement in the design process. The approach aims to achieve shared understandings and mutual learning among several stakeholders (Greenbaum and Kyng 1991; Kensing and Blomberg 1998; Bødker et al. 2004). It further contains characteristics related to user-centered design approaches (Dell'Era and Landoni 2014) and co-creation (Sanders and Stappers 2008; Pallot et al. 2011) that are informed by early user involvements in ideation and evaluations of ICT design. Living labs also gained acceptance beyond the scope of ICT design, and some researchers have described them as innovation spaces or even as innovation approaches (Bergvall-Kåreborn and Ståhlbröst 2009). This notion mainly comes from business and management literature that bridges the gap between research and innovation (Schuurman et al. 2012; Schuurman et al. 2015). Further fields where living labs have proved to be popular are architecture and building in the context of sustainability (Liedtke et al. 2012) and living comfort (Hasan et al. 2018).

The general establishment of living labs in Europe was influenced by research and development funding from the EU Commission, who piloted the European Network of Living Labs (ENoLL). In 2006, ENoLL was founded to build a sustainable strategy for innovation processes in Europe. They have established four main characteristics that qualify a living lab:

- Exploring user behavior within usage contexts and of market conditions;
- Bringing together designers and users in co-creation processes;
- Conducting experiments within usage scenarios; and
- Evaluating products and services in real-life environments (OpenLivingLabs).

Følstad (2008) emphasized similar characteristics but did not mention the economic perspective stressed by ENoLL. He conducted a comprehensive literature review and identified nine characteristics, of which four were valid for all investigated living labs. Based on Følstad's literature review, living labs' strengths are as follows:

- Gaining insights into unexpected ICT uses and new service opportunities;
- Evaluating or validating new ICT artifacts with users;
- Experiencing and experimenting with ICT artifacts in contexts familiar to users; and
- Enabling mid- or long-term evaluations with users (Følstad 2008).

Schaffers et al. (2007) emphasized early and continuous user involvement in the design process that captures both ideas and experiences users make in real-usage contexts as a value of the approach. However, literature reviews have shown from a methodological point of view that user-centric aspects have not been fully realized over long periods of time or with respect to continuous user participation. The user-centric aspect was mainly applied in single or several successive design phases focused on understanding users, designing with users, or learning through practice-based appropriation, but it was not used throughout the entire design process starting with

understanding the context, co-creation, and appropriation. Few studies have made use of the potential of all design phases (Følstad 2008). Moreover, the latest research has focused on the evolution of the general definition of living labs and how the approach has been applied. However, practice still reveals heterogeneity in implementation, even after two decades of living lab research. Alavi et al. (2020) identified two aspects that described whether living labs are suitable for research projects or should even be promoted by it. The aspects refer to the goal to be achieved and result from methodological and infrastructural requirements:

- If research requires specific methodological requirements such as longitudinal studies, stakeholder collaboration, or naturalistic living environments to prove the validity of ecological data; and
- If diverse physical infrastructures are needed (for instance, lab settings for controlled measurements, everyday environments for appropriation studies with associated social effects, and innovation spaces for early ideation phases in neutral environments).

However, requirements on both suitable methods and infrastructure vary in practice. Alavi et al. (2020) stressed that methodological descriptions of living labs have not used the same wordings and physical infrastructures highly scale by affordances for research with respect to the chosen approach (qualitative, quantitative, or mixed). Alavi et al. (2020) identified interdependencies between methodological requirements and applied infrastructures in living lab settings in HCI research.

Again, the current state of research regarding the overall understanding of living labs emphasizes different notions and should more closely examine how such an approach to ICT design is applied in practice.

2.3.2 Environments in Living Labs

When referring to the uniqueness and strengths of living labs, two main aspects that distinguish the concept from others in design research should be kept in mind. One concerns the mechanisms for providing long-term interactions with close user participation. The other aspect concerns the possibility to deploy research technology to the field and gain an understanding on how users appropriate and integrate IT artifacts into daily routines and how habits can change after some time. This section will examine the latter aspect and elicit how living lab environments are used in practice.

As mentioned, living labs focusing on public and domestic sectors create real-life environments in different ways. The living lab landscape was pioneered by the MIT PlaceLab (Intille et al. 2005), Georgia Tech's Aware Home (Kidd et al. 1999), Philips HomeLab (de Ruyter and Aarts 2004), and Fraunhofer Inhouse (Budweg et al. 2012), to mention just a few. These pioneers simulated home environments in test centers and equipped these environments with sensors to gather data from ambient assistant systems and context-aware services. In these environments, mainly evaluation studies were conducted under controlled conditions, where users could stay for very short or long periods of time, to test designed artifacts once, over several hours, or over a few days, depending on the study (Abowd et al. 2000; Abowd et al. 2002; Panek et al. 2007; Jago et al. 2011). The advantage of these environments is that early and

imperfect prototypes can be tested, for instance, as concerns usability and user acceptance without requiring major organizational efforts and expenses associated with a technical rollout. However, disadvantages of these environments are that they are artificially built and thus do not resemble users' own homes, which influences users' actions. Thus, data resulting from these environments is not as meaningful as data from field studies. Short-term visits often cannot uncover profound added values of tested artifacts in detail and their associated cross-functional interdependencies with other artifacts in the everyday life of users. Living lab research has also been conducted with users in actual use contexts (i.e. participants' homes). Bergvall-Kåreborn and Larsson (2008) and Schuurman et al. (2009), for instance, investigated appropriation processes and collected contextual feedback on users' experiences, their technology acceptance and on the usability of ICT artefacts. Obrist et al. (2008) accessed participants' homes and investigated their usage behavior for several weeks to gain an in-depth understanding of the context and users' needs in order to substantiate the design process. Müller et al. (2015) and Wan et al. (2014) described ICT design case studies to foster older adults in their everyday lives. For the design process, they applied the living lab approach in its fullest understanding. They continuously involved users in different design stages and used participants' homes as research environments. They started with context studies in participants' homes, conducted co-creation workshops, and evaluated designed solutions in participants' everyday lives. These qualitative empirical living lab studies usually involved smaller user samples, as these studies have often been more contextually driven with a focus on the depth rather than the breadth of data. By contrast, studies within artificial living lab settings allow greater scalability for qualitative or quantitative research because of controlled lab conditions, which allow more comparability between study results, especially when significance in gathered data is to be achieved. Further aspects are reduced costs with respect to both time and money for visiting participants and less technical support for the new systems in the field.

As mentioned, over the first decade of living lab research, relatively few studies exploited the potential for long-term and "naturalistic" studies by involving participants continuously over the whole research period and in the entire design process. These studies also investigated technology appropriation, technology acceptance, and usage in daily routines to uncover in-depth values of the design and even to identify unexpected technical requirements on designed solutions (Ståhlbröst 2004; Lievens et al. 2010; Mulvenna et al. 2011). Tolmie and Crabtree (2008) described the methodological dilemma that arises when users' usage behavior was interrupted by the introduction of a new technology. Lab tests, for instance, only provide user feedback at one point in time that is produced in an artificial environment. Long-term living lab studies in their actual use context instead offer the chance for ICT artifacts to become an integral part of the home and the users' everyday life, which helps produce more realistic feedback. The turn from one-point evaluations to established user routines helps overcome this "anthropological strangeness". This argument was pushed through marketable ICT design, especially against the backdrop of research fields such as the Internet of Things, smart cities, and big data and their growing technical infrastructures. In line with this argument, Alavi et al. (2020) noted an emerging trend toward long-term studies with a stronger focus on context in living

lab research. They stated that short-term studies in artificial built-up environments such as labs at test centers are still used to conduct evaluations when necessary and where prototypes are not stable enough for feasible rollouts. However, such studies are no longer the majority as of late 2010. Alavi et al. (2020) identified five strands that distinguish living labs infrastructurally and how this correlate with methodological decisions (see Figure 1). These five strands are as follows:

- *Visited places*: Simulated artificial environments such as living rooms, kitchens, bathrooms, etc. that are equipped with sensors where participants are invited to measure their usage behavior under controlled conditions; these environments are mainly used for short-term evaluations.
- *Instrumented places*: Suitable for in-the-wild studies; living environments are used and equipped with technical artifacts; these naturalistic settings are used for longitudinal contextual studies and for quantitatively demonstrating the validity of assumptions; they are limited to a specific place.
- *Instrumented people*: Users are equipped with wearables, mobile devices, and applications for data collection; these offer opportunities for large-scale investigations with significant flexibility regarding place and duration; there is no limitations regarding physical location or timespan.
- *Lived-in places*: Newly built environments (for instance, flats, schools, offices, or other semi-public spaces) equipped with sensors; in comparison with instrumented places, lived-in places did not exist before and thus cannot be upgraded technically; in comparison with visited places, they are designed for long-term studies, allow for fairly high control of data collection and quality, and are mostly used for interdisciplinary purposes by professionals such as architects, designer, and developers.
- *Innovation spaces*: Seen as platforms but with a focus on a social environment that brings several stakeholders together; they are used for strong user engagement in innovation processes, as workshops require, and are mostly physical.

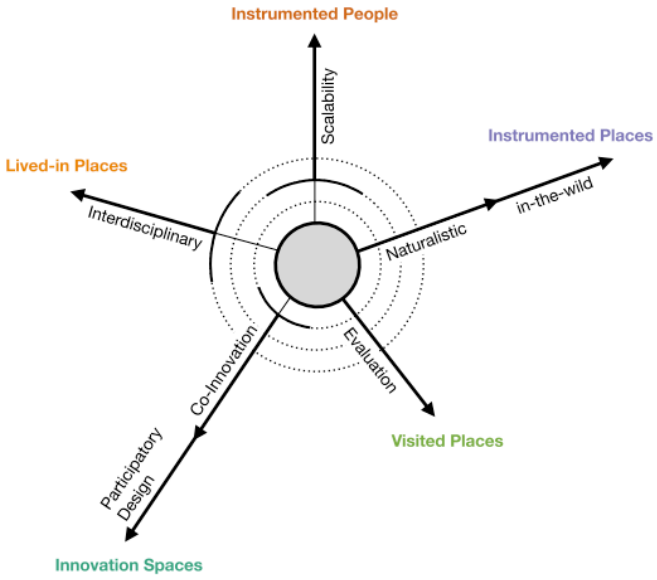

Figure 1: Environmental trends and corresponding research approaches in living labs based on Figure 4 of Alavi et al. (2020).

However, the identified strands cannot be seen as solely infrastructure. They often are combined in living lab projects in order to make best use of the different environmental settings. For instance, regarding smart homes and energy consumption, Schwartz et al. (2013) investigated individuals' energy consumption awareness in a longitudinal field study in participants' homes. The researchers supplemented their field data with mobile device data gathered from outside the home. Castelli et al. (2017) also conducted a long-term field study for visualizing smart home data. They supplemented their empirical investigations with a co-creation workshop and usability studies evaluating prototypes in an artificial home. Kanstrup (2008) conducted studies in the Skagen living lab and involved participants in the early design stage of idea creation. She organized multi-day workshops with first prototypes and discussed them with respect to lab and real-world conditions.

Nevertheless, little research exists on the long-term involvement of users for domestic ICT design in living labs on a conceptual level. Some extant studies note certain limitations. For example, Bergvall-Kåreborn and Larsson (2008) and Lievens et al. (2010) mention that prototypes have to compete for acceptance and usage with other devices and services. External factors affect users' behavior as well and must be considered when interpreting data. Lievens et al. (2010) emphasized the importance of prototypes' added value to users. As mentioned above regarding participative approaches, Sleeswijk Visser and Visser (2006) argued for the value of returning participants in iterative design processes. How to achieve this value of returning users and their actual usage contexts in living labs is not well specified, nor are the contingencies associated with environmental challenges and maintenance work related to the technical setup.

2.3.3 Co-Creation in Living Labs

Multi-stakeholder interactions and close user collaboration over long periods of time are mentioned as other unique values of the living lab approach. These aspects have often been neglected in the description of living lab studies (Mulvenna et al. 2011). Only few studies have analyzed co-creation processes and derived high-level implications. Bergvall-Kåreborn et al. (2009) named five key principles for the success of collaboration: continuity, openness, realism, empowerment of users, and spontaneity. Supportive values such as trust, user acceptance, and transparency have been emphasized, but no one has described in detail how they can be achieved in practice. Few studies have discussed processes of co-creation that occur or fail to occur in living lab settings.

Two exceptions reflecting on living labs from a conceptual level are the studies of Schuurman et al. (2009; 2010b). They applied a SWOT analysis (a strategic planning method that focuses on strengths, weakness, opportunities, and threats of business ventures and projects) to research mobile TV. They identified advantages and disadvantages related to the quality of participating users, in sense of recruitment criteria for longer term participation, and their roles at different stages in the design process. Based on their analysis, they argue that living lab studies are time and cost intensive for iterative design and have a high risk of dropouts, especially in longer studies, and that users can be reluctant to use prototypes in everyday life (Schuurman

et al. 2009). The authors also analyzed users' roles. Schuurman et al. (2010b) investigated different typologies, roles, and the aptitude of different roles for living lab research. The lead user approach by von Hippel (1976; 1986) was thereby supplemented by "Pro-Ams," "Power Users," and "bystanders," which are meant to help better understand how users can be involved in different design stages. Pro-Ams are users who have a high interest in the product being developed and are therefore well suited for co-creation due to their additional programming skills. Power Users are quite similar, but they do not have any programming skills, which is why Schuurman et al. (2010b) described them as less suitable for co-creation. Their value lies in their intense usage behavior and how they uncover unexpected use cases and user requirements. The third user type Schuurman et al. described is the bystander. Bystanders are individuals who are not directly using and interacting with a given product or its design process but expose, for instance, concomitant social changes. Schuurman et al. (2010b) mentioned that the importance of bystanders is related to actual use contexts. They also mentioned how participants' can become bystanders following contextual and habit changes. Leonardi et al. (2014) investigated factors influencing users' satisfaction, expectations, and motivational drivers in longitudinal living lab studies. Aside from the aspects of learning something new, social exchange, and incentives, they did not provide descriptions of less obvious aspects such as technical problems and how to address them to increase user motivation.

By taking a stronger analytical lens on collaboration practices, Almirall and Wareham (2009) analyzed living lab research methodologies to explore how users could be involved in user-centered design processes to make use of the full potential of co-creation. Følstad (2008) and Alavi et al. (2020) also focused on the perspectives of multiple stakeholders and identified that user participation is emphasized in living lab design processes. However, they did not analyze or discuss contingencies that may influence or even fundamentally affect long-term collaboration.

Few studies address cross-organizational collaboration in living labs. One of them was a part of the project on "IT for Adoption and Intelligent Design for E-Government" (ITAIDE) (Baida et al. 2007; Frößler et al. 2007; Tan et al. 2010; Klein et al. 2011). Frößler et al. (2007) used a practice-theoretical approach to investigate network relationships. They described living labs as dynamic, open-ended, environments lacking clearly defined goals that require a willingness among stakeholders for continuous sense making and negotiation. How collaboration will occur can only be partially specified by project contracts; consequently, social capital is crucial for the involved stakeholders to address the inherent uncertainties of innovation development (Klein et al. 2011). In another longitudinal living lab project, which was four years long, Hakkarainen and Hyysalo (2013) rated mutual learning as one of the key values of the living lab approach. They examined power issues between different stakeholders and participants' reluctance in the co-design process. Based on mentioned differences in responsibility and decision-making, mutual learning is contingent upon so-called "innovation intermediaries." Such persons can help rank priorities and dissolve conflicts by finding compromises. Carroll and Rosson (2013) conducted a comparative study based on several in-the-wild studies from community informatics projects and derived several advantages of collaboration within communities, such as making the

skills and knowledge of community members more visible and thus usable for the entire community.

Johansson et al. (2011) described the activities within living labs as interactions between different "communities of practice" (CoP) and analyzed the facilitation of different support mechanisms. They derived a process model that distinguishes between "product/service brokering" and "process brokering". Product/process brokering focuses on processes of perspective making and perspective taking between CoPs with respect to innovation and design processes (idea creation, concept development, and evaluation). Process brokering instead focuses on maintaining basic communication and interaction processes (Johansson et al. 2011). Similarly, Mulvenna et al. (2011) revealed a general challenge to living lab approaches, which concerns how to transform knowledge on usage patterns, social habits, and further user feedback into design ideas. Moreover, they indicated uncertainties regarding the collaboration and engagement of users. To address these issues, they built a toolkit with practical advice for researchers and designers (Beamish et al. 2012).

2.4 Research Gap

Over the years, living labs have evolved as practical approaches in HCI, particularly for ICT design in the domestic domain. Simultaneously, however, a common definition of their key values does not exist. The latest trends regarding the research design of living labs show a promising movement toward long-term investigations using real usage contexts and a movement toward stronger user involvement in co-creation processes. This movement towards long-term studies is in line with the understanding of how this thesis has been conducted living lab research.

Knowledge exists on appropriate research methods and the appropriateness of different research environments for different research aims, as demonstrated in the section above. Nevertheless, little has been written about how co-creation and collaboration processes of disparate groups are actually managed – successfully or otherwise – and what kind of challenges have to be surmounted on social, technical, and managerial levels in order to successfully establish and coordinate living lab research in a continuous and sustained way. There is a need to deconstruct the living lab approach in a way that enables a practical and nuanced understanding of the relationship between users and other stakeholders and reveals what additional work is necessary for successful and effective long-term collaborations, regardless of whether this work is directly related to project tasks.

3 Study Outline

The following section will first outline the applied methodology and then provide a brief overview of the two case studies that serve as the basis for this thesis.

3.1 Methodology

This research uses an inductive approach, where the research questions have been elaborated and refined while both studies were conducted. Each study has its own research questions that contributed toward the final overarching questions addressed in the thesis. On the one hand, overarching research questions explore what it means to make living labs for ICT design in domestic environments, and on the other hand, they uncover challenges and how to address them through living lab maintenance. The two projects have broadly similar elements in terms of domain, local context, applied methods, and partnerships. For each project, a regional user sample was selected and equipped as local living lab environment. Further living lab environments were used in both projects, including a stationary lab at the university, which was used to conduct early user tests, and meeting rooms, which were used for co-creation workshops. There are many similarities but also differences between the two studies. In particular, participants were recruited in different ways, and the collaborations evolved in different ways over time. Both research projects were planned as longitudinal studies with the aim of designing ICT solutions for domestic environments in a co-creative manner. The two studies have different target groups. In one, the target group is families, and in the other, the target group is older adults. The project targeting families addressed social-media-related TV and video consumption. For the project with older adults, use cases concerned an interactive training system for physical and cognitive exercise that intends to prevent falls.

Both research projects used a practice-based perspective regarding the design of ICT solutions. Research activities were oriented around Grounded Design (GD), a praxeological research paradigm for designing research with roots in pragmatism (Rohde et al. 2017). To structure the projects' design processes, both projects applied design case studies (DCS). Wulf et al. (2015a; 2018) introduced DCS to build a framework for GD. As represented in Figure 2, a DCS can be described as a three-phased design process. The first phase comprises an empirical study in the domain of real-world significance. In principle, this phase aims for a deep understanding of the target context with respect to its organizational, technical, and social practices. Identified problems, user needs, and new needs that arise are transferred to ICT design and technically implemented in the second phase. The design phase is followed by the third phase of the evaluation of ICT artifacts in practice and suggests long-term appropriation to uncover possible complex effects on the usage behavior or social interactions of users (Wulf et al. 2015a). Each phase requires the strong collaboration of academics, industry experts, domain experts, and users. With this need of multiple stakeholders' collaboration in mind, a DCS framework does not claim to specify specific empirical and design methods or how to access the field of application. It rather should be seen as a process model for designing practice-oriented ICT solutions. Living labs in context of co-creation in design in practice constitute an approach for

developing DCS. In doing so, living labs not only provide access to users and the field of application in order to gain insights for ICT design, but they also foster long-term collaboration with users and other stakeholders by using different environments at different design stages. Consequently, living labs can be used to accomplish the three phases of DCS together, but the approach can also be used to accomplish any of the three phases on its own.

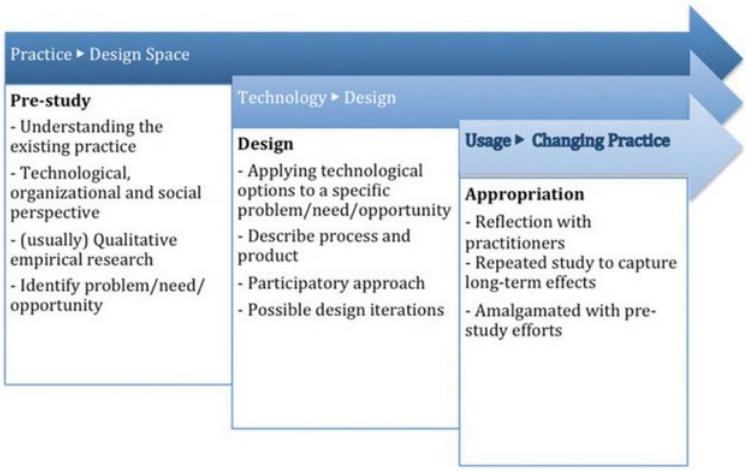

Figure 2: Schematic representation of the design case study framework (Wulf et al. 2015a).

For this thesis, the selected research projects were framed as DCS, where each project consists of several such studies depending on which further sub-aspects in addition to the main project aim are to be addressed from a socio-technical perspective. The projects had a dual purpose. On the one hand, they aimed to reach the project goals with the help of the living lab approach. The living lab approach provided ways to continuously involve participants throughout research and design processes and appropriation studies in the field that lead to positive changes in user behavior as a result of new ICT solutions. On the other hand, the research projects themselves served as objects of research for this thesis. They are used to analyze, compare, and reflect on living lab processes on a meta-perspective with regards to organizational, technical, and social aspects. To close the mentioned research gap, several qualitative empirical methods were applied to collect data on experiences with the living labs approach in practice. Over the project's duration, data was continuously gathered and analyzed. Data sources included interview transcripts and observation notes from participants' home visits, participants' self-documentation from diary studies and a feedback tool, workshop notes, video material from user tests, sketches from narrative mapping sessions, and interview transcripts of participating stakeholders (researchers and practitioners).

For the analysis of the qualitative material, a grounded-theory-oriented approach was applied to the extent that "theoretical sampling" and "constant comparison" were used (Glaser and Strauss 1967). Theoretical sampling in this work means that the collected data was analyzed in an iterative manner. Based on gained insights on a given research question, it was decided how the data set could be deepened with the help of further questions, which aim to refine the understanding on living labs as approaches for ICT design. In addition, decisions were made regarding what additional data was needed

and how it could be gathered from the field. Empirical data was first structured by its content (Mayring 2000) and was then analyzed by following an open coding process that mainly used inductively derived categories based on gathered data (Corbin and Strauss 2008). Coded material was then compared between the case studies themselves and between the projects. Depending on the derived research questions, the focus was on, on the one hand, participants' usage behavior, individual perceptions of change, and social phenomena. On the other hand, the focus was on stakeholders' and users' interactions in living lab settings and related dynamics; similarities and differences; strengths, challenges, and weaknesses; and contingencies that arose from the context and from prevailing circumstances.

All qualitative research conducted for this thesis has been confronted with dilemmas known from ethnographic practices and action research. Reflections on collaborative practices were also made from researchers, which were involved in the projects as active part. Nevertheless, researchers should be a part of the investigated setting to gain an in-depth understanding and to provide context-related insights. Concurrently, researchers must take a neutral and critical stance, which is much easier for outsiders (Mathiassen 2002). To address the circumstances of the researchers' role, we took the view of a participating observer and followed Clifford and Marcus's (2010) recommendation of applying a reflexive process, where researchers consider their role in an ethnographic narrative. In addition, for each analysis, we involved co-authors of the publications who were not part of the projects. They took the role of a "neutral" third party. In doing so, they ensured a critical external view and scrutinized insider knowledge as kind of "reality test." For this kind of meta-research, we considered this role necessary for strengthening the reliability of interpretations and results and for producing intersubjective comprehensibility.

3.2 Case Studies

The research conducted in the domestic field mainly derives from two research projects where several DCS were realized and touchpoints between the participating stakeholders and users were investigated. This section will provide a brief overview of both projects.

3.2.1 SocialMedia: Cross-Platform Social TV Application for Families

The SocialMedia project was a four-year research project (2009–2013) that focused on the research and design of multimedia content-related companion services for different stationary and mobile devices to allow cross-media consumption behavior and related social interactions. This project was publicly funded by the Ministry of Innovation, Science, Research, and Technology of the federal state of North Rhine-Westphalia, Germany, with resources from the European Union for regional development (Ziel 2) (No. 280411902).

When the project started in 2009, TV sets mainly offered TV content. Interactive services, such as instant messaging or other media activities, were available on web-enabled devices, such as PCs and laptops, tablet PCs, and smartphones. A flexible cross-media platform with community functionalities is seeing as highly attractive for

addressing future user and market needs. The project consortium consisted of two academic and two industrial partners who all had a strong interest in designing new social media technologies with either a technical or empirical focus. They were complemented by a mixed sample of 16 households with 27 participants (14 males and 13 females) who were involved from the beginning of the project. Participants were acquired via a call for participation in local newspapers and radio stations. They could apply to the project via an online form and were selected based on initial telephone interviews. The minimum requirements for participation were a broadband connection, television reception, an interest in the project, a willingness to participate actively in co-creation processes (including testing prototypes at home), and for organizational reasons, a residence close to the university.

The SocialMedia project was established as a local living lab where researcher, designer, and user collaborated together. Users contributed to different project stages of co-design during the four-year project. They contributed via creative workshops, mockup discussions, usability tests, long-term appropriation of prototypes, and redesign activities.

Figure 3: SocialMedia framework connects video content with social media functions.

For these research and design phases, the project used various living lab environments, and the main focus was on private households and their natural domestic setting. To investigate the appropriation of ICT, long-term usage, and daily routines, households were equipped with marketable technology from the beginning, namely a media center system connected to the TV set, an HD TV if they did not own one already, and a smartphone with Android OS (see Figure 3 and, for more details, see Hess et al. 2011a). Later on, different maturity levels of the prototypes were introduced in households. On-site visits were conducted to implement technical rollouts and to make regular interviews and observations to gain a contextual understanding of media usage

behavior within households and how it changed over time. Self-documentation methods were also used to complement interviews and observations.

The same technical setup was also installed in a more artificial setting at the university. A user experience lab was rebuilt into a living room and complemented by an observation room. Both rooms were connected via a mirrored windowpane and allowed for more than one or two project members to watch test sessions. This environment was used as a place for joint discussion with living lab stakeholders and users. In early project phases, for instance, PowerPoint mockups were displayed on the TV screen or paper prototypes for the mobile application were discussed, and early user tests were conducted under controlled conditions. Other meeting rooms at the university were used for co-creation sessions during the design and redesign phases.

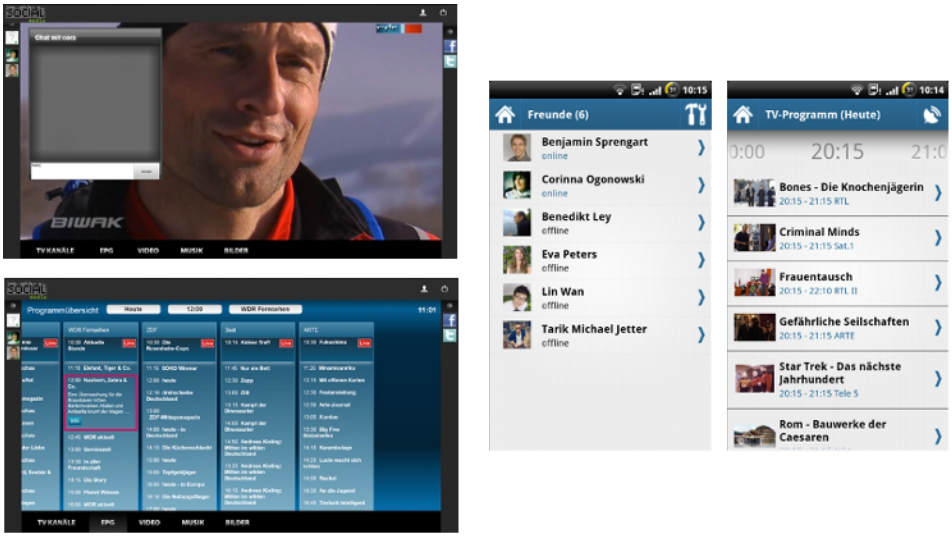

Figure 4: Left-hand side: TV interface with fade-in navigation and opened chat window, below with electronic program guide (EPG). Right-hand side: Smartphone interface with listed chat contacts and EPG.

Several social-TV-related services and features were designed within the living lab as single case studies. These included a chat messenger that could switch flexibly between the TV and a smartphone (see Figure 4); gesture control that could be used as an extension of or replacement for the TV remote control; event-based media rules that hide, for instance, the messenger when more than one household member watched TV via the TV set; in-situ feedback that allowed participants to send system-related feedback immediately when something occurred, for instance a technical problem or feedback on improvements, and the feedback can be enriched with various data such as a text description, audio messages, or photographs; photograph sharing with location-based references and ad-hoc group building; and a concept for an interactive coffee table (Ley and Stein 2010; Wan and Tweer 2010; Herbrechter et al. 2011; Hess et al. 2011b; Hess et al. 2012c; Wan et al. 2013; Ley et al. 2015). In addition to the developed features, changes in participants' usage behavior and daily routines were observed. One of the main findings was that users established non-linear consumption behavior with respect to TV and video content. Users no longer aligned their daily routines to TV programming and the laptop obtained a new role of a working device.

Most participants no longer used their laptops for TV or video-related leisure activities in the living room (Hess et al. 2012a).

3.2.2 iStoppFalls: ICT-based Fall Prevention System for Older Adults

The iStoppFalls project was a three-year research project (2011–2014) that focused on designing an in-home ICT-based exergaming system intended to predict and prevent falls by older adults. The project was publicly funded by the European Commission under the 7th Framework Programme (grant agreement 287361) and the Australian Government.

Based on ongoing demographic changes, 22% of the European population is expected to be aged 65 years or older by the year 2025 (European Commission 2013). Falls are prevalent among this target group and often lead to decreased autonomy and diminished individual wellbeing. Preventing falls is key, and an ICT-based fall prevention system with a specific focus on continuous fall risk assessment and self-monitoring was developed to address this issue. In order to design such a system, a project consortium consisting of five academic partners from Germany, Austria, Spain, and Australia and two industrial partners from the Netherlands and Germany was established. These parties had an interest in improving older adults' everyday lives through exergaming at home, which was meant to significantly reduce fall risk. This research and development had a technical, empirical, and health focus.

The iStoppFalls project was also established as a local living lab where researcher, designer, and user collaborated together, but in this case, the user sample was a varying two-staged sample due to health requirements of participants and the required comparability of the international randomized control trial (RCT). The first user sample consisted of 12 participants (four males and eight females) aged between 60 and 85 years old from Germany. These individuals were involved in a context study and in several early co-design stages for the system design itself. They were engaged in identifying important functions, the interaction design of the app, and the design of the exergame, for which virtual game worlds and scenarios were created (Meurer and Wieching 2012; Wieching 2012). A second user sample consisted of another 12 participants (five males and seven females) aged between 65 and 80 years old. These individuals were acquired for a six-month evaluation study conducted at a later stage of the project, which this thesis mainly refers to.

In order to acquire participants, older adults with an interest in taking part in the project were actively addressed. Existing collaborations with local and national senior organizations were used to contact individuals in this target group. As minimum requirements, participants could not have any major or chronic diseases and could not have fallen during the previous year. Participants also needed a broadband connection, a TV set with an HDMI port, at least three meters of space in front of their TV, an interest in regular exercise at home, and a residence close to the university for organizational reasons.

To conduct the six-month study, the project also used various infrastructural settings. Although the study's main focus was on private households and their natural domestic setting, this study further collected data on experiences outside the home using a

mobility tracker (see Figure 5 No. 4). To examine the appropriation and long-term usage of the ICT-based training system and its integration into daily routines, participants were equipped with an interactive TV system that was connected to and used via the TV. This system was comprised of a set-top box with a controller, a Mini-PC with exergames (strength training, balance games, and a fall risk assessment), a Microsoft Kinect for movement detection, voice control, and a tablet PC (see Figure 5 and, for more details, see Marston et al. 2015).

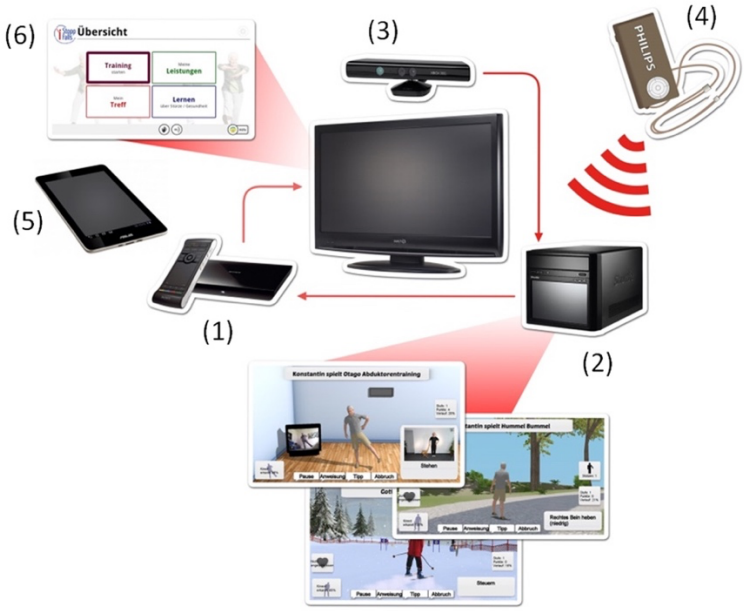

Figure 5: iStoppFalls system with single components: (1) set-top box with controller, (2) Mini-PC with three different exergame components, (3) Microsoft Kinect, (4) Senior Mobility Monitor, (5) tablet PC as alternative input device, (6) interactive TV program.

A mixed-methods approach was used to collect data. Regular on-site visits were conducted to collect qualitative data by conducting interviews and observations. Quantitative data on training duration, exercise level, and daily walked steps was gathered through the system's usage. In addition, the same technical setup was installed in the user experience lab at the university. This environment and other meeting rooms at the university were used for physical meetings and for the regular exchange of experiences with older adults and stakeholders from the university during the study, which was also the case in the SocialMedia project.

Two of the results of the six-month study included the successful integration of exercises into the everyday lives of older adults and improvements in participants' self-perceptions and quality of life. An international multicenter RCT with a total of 153 community-dwelling people in Germany, Spain, and Australia and a control group was conducted in parallel over a duration of 16 weeks. Study results proved that the designed exergame reduced the physiological risk of falling within the study sample (Gschwind et al. 2015; Vaziri et al. 2016).

Part II
Research Outcomes

The second part of this thesis presents a collection of outcomes derived from the conducted studies. It follows the overall objective on how living labs can be set up and maintained for ICT design in domestic environments. It gives insights into existing ICT usage practices and daily habits, applied living lab infrastructures, participants' involvement in design processes, and long-term collaborations between several living lab stakeholders. The outcomes address both methodological aspects of the research and associated management and infrastructural questions. The presented studies (the two introduced case studies) were conducted in collaboration with colleagues.

4 New Technology@Home: Impacts on Usage Behavior and Social Structures*

Abstract. Studying domestic usage contexts has become an important field in research. Recent technological improvements have made media available on different devices, in different contexts and from different places. The adoption and appropriation of new devices and technologies has led to a more flexible usage behavior. However, even if we know about such a behavior, many questions, regarding how new technology changes the user's media usage and how these changes affect the social structure in a household, are still unanswered. We will address this topic in our work and want to provide an insight on how recent media consumption patterns have changed due to the appropriation of new technologies in the home. Based on a qualitative long-term living lab study we will present various patterns based on changes in media usage routines and their influences on households as social systems. The results provide a detailed understanding of how the new technology is embedded within domestic life by considering potentials and conflicts that also address further design oriented work.

Keywords: living lab; diary study; television; living room; media usage

4.1 Introduction

Television is the one mainstream mass media that can be found in every living room. It is not only a source of information, but also an established medium for relaxation and entertainment that is consumed alone, together with friends, or with other household members. While the reasons for TV consumption have remained the same, manifold technological developments have changed the way it is typically used (Bernhaupt et al. 2008; Obrist et al. 2008). From a technological point of view, television has been transformed into a medium that is uncoupled from the traditional television screen and is complemented by on-demand services on the Internet that can be consumed on a PC or mobile device (O'Hara et al. 2007; Barkhuus 2009). Instead of watching television purely along the traditional TV schedule, users today can decide on their own, what they want to watch and when (Barkhuus and Brown 2009; Irani et al. 2010). Beyond these changed consumption options, a variety of other web-enabled devices, e.g. smartphones, game consoles, Media Center systems or tablet PCs, are available at home and offer a large number of new possibilities to handle and consume media. Therefore, research on television, as a changing phenomenon, has become an increasing focus in Human-Computer Interaction (HCI) in the sense of developing new devices and interaction concepts for domestic environments.

Mobile technologies, such as smartphones and tablet computers, additionally enrich the TV experience (Cesar et al. 2009). The personal device as a secondary screen enables many options to access additional content, e.g. tagging and sharing content or

* *Hess, J., Ley, B., Ogonowski, C., Reichling, T., Wan, L., and Wulf, V., 2012. New Technology @ Home: Impacts on Usage Behavior and Social Structures. In: Proceedings of the European Conference on Interactive TV and Video - EuroITV '12. New York, New York, USA: ACM Press, 185–194.*

complementary chat functionalities. But at the same time, these new options also correlate with the basic single use of devices versus the shared use of devices, which then brings up questions concerning ownership and privacy. Aspects of personalization, security and privacy in interactive television (iTV) environments are related to each other and need to be handled carefully (Bernhaupt et al. 2010).

Understanding how users appropriate new technologies and how they integrate them into their daily routine or how routines can change due to new technologies, are important aspects when developing new designs that are closer to the user's needs. Several user studies have provided insights into how new technologies are applied in practice. Earlier studies have explored patterns of technique usage (O'Brien et al. 1999) and the nature of communication among household members (Crabtree and Rodden 2004). Other studies, e.g. (Brown and Barkhuus 2006), have focused on the users' practices of how new video-on-demand technologies have influenced the way media is consumed.

In our research we will focus on technologies and concepts which make value of current home infrastructures that include different devices, media and TV access from different sources and access to social services via the Internet. Together with partners from the industry and users, we co-develop new prototypes for the home. In order to understand the design context and to evaluate the concepts, we set up a living lab were households participate in a long-term manner. A phenomenon called 'cross media jumps' already was identified in previous work (Hess et al. 2011a). However, many questions regarding how new technology changes the user's media usage and how these changes affect the social structures within a household, were still unanswered. The empirical data presented in that paper summarizes results of the media usage behavior before and after equipping households with state of the art technologies. We provide insights on how users adapt new functionalities and how these technologies influence media usage behavior within households.

We have conducted a two-stage qualitative empirical study with 16 households from our living lab. Under real world conditions, we explored each household's media usage behavior before and after introducing new devices (a smartphone and a Media Center system). We compared the results from both studies with regards to changes in media usage and identified several phenomena related to the devices and media usage itself, as well as social influences in the households. We also received interesting insights into the users' individual perception of the changes that occurred to their media usage behavior. The relevant findings are discussed and presented in the form of usage patterns that may be of relevance to consider for further design.

4.2 Technology Studies at Home

Searching through the literature we found a large number of television related studies. One of the early studies about traditional television viewing was done by Lull (1990) in the 1980s, in which he was already exploring established social practices of behavior in families when watching television in the living room. As shown in the study, television can nurture interpersonal relationships, e.g. by having a common topic to talk about. Nowadays, new technologies have changed the once simple act of watching

broadcast television in several respects. Television is embedded in a process that Barkhuus & Brown (2009) described as the video media lifecycle. Watching television today means much more than the simple consumption of planned programs; it facilitates a number of possible functionalities related to searching, obtaining, sharing, collecting, and discussing the content. New technologies such as personal hard-disk video recorders and download/streaming portals on the Internet support these processes and have changed the way in which users watch television (Brown and Barkhuus 2006). Smith and Krugman (2010) investigated these practices with regards to established consumption patterns and how users perceive changes in their media usage. They found that personal hard-disk video recorders lead to a more flexible and controllable TV consumption, which makes the user's viewing behavior more convenient. In this context, Irani et al. (2010) dealt with the concept of rhythms and plasticity in order to analyze new temporalities of media consumption. Both rhythm and plasticity co-exist and effect watching experiences. The plasticity of time describes the way users interrupt or reduce the time they spend watching content by using, for instance, time-shifting or skipping functions, rhythm refers to the organization of when and with whom content should be watched, which is related to daily routines. Hence, they were able to analyze more flexible and open uses regarding TV consumption in the home (Irani et al. 2010). In this regard, Wonneberger et al. (2009) developed a process model of sequential-viewing patterns that allows investigating the dynamics of the entire viewing process, namely from the beginning, when users start watching TV, until they turn off the device. Therefore, a typology of influential factors has been deduced from the existing models of watching television. The factors that influence and change viewing habits fall into four categories: individual characteristics, program structure, social environment and context. Applying these factors when investigating existing phenomena would help clarify television watching behavior (Wonneberger et al. 2009).

In recent years a lot of research on audience behavior and design-related issues has inspired new insights into the domestic space. In their work, Bernhaupt et al. (2011) presented new trends in the living room. Based on two ethnographical studies, they analyzed 7 aspects that became important in the context of iTV. Apart from the importance of privacy, security, personalization and communication, watching television is still characterized as a communal activity that is relevant to the user's social life. Obrist et al. (2008) also identified similar user requirements, based on their findings, they derived recommendations for an iTV concept that should offer, for instance, content related information, recommendations and communication services. In relation to this, Tsekleves et al. (2009) have investigated the role of television in the living room. In their findings, they emphasized the importance of the television set as a shared device - not only for watching television together but also to make sharing information on the Internet possible or to share data stored on the computer via the TV screen. Bernhaupt et. al. (2011) then specifically investigated the changes an interactive TV system will bring to the living room behaviors in terms of security and privacy. The results indicated that new forms of user interaction were required, which should enable personalized access to the content on the television and the new forms of connectivity for all devices used in the living room.

From a sociological point of view, Turkle (2011) investigated how the phenomenon of mobile devices, as an additional source of media content, changes our social life with respect to our communication behavior. The fact that users get the feeling of being together but also being alone was one of the findings that was emphasized. Turkle deducted that users prefer text messages instead of physical appointments or if they meet, everyone is busy on their mobile device and face-to-face conversations will be reduced. In addition, Barkhuus (2009) explored in her study the phenomenon of watching television on a computer and how the Internet influences user behavior. She showed that especially tech-savvy users combine original characteristics of the computer as a working instrument with leisure activities and entertainment aspects of television. The Internet as an additional channel for video content offers users the chance to break away from well elaborated program schedules of broadcasters and enables a more specific and time-independent access to content. Even if such new technologies and services enable a personalized and individual media consumption, the well elaborated program schedules still have a huge influence onto the users' viewing habits. Embedded in social practices, television series for instance are shared among friends or recorded content is watched the same day it is broadcasted live (Barkhuus and Brown 2009). Knowing about this social importance, research often focused on concepts that allowed shared experiences on TV remotely via exchange and communication functionalities (Harboe et al. 2008; Nathan et al. 2008; Huang et al. 2009).

Besides computers, portable web-enabled devices such as smartphones or tablet PCs have also become increasingly important for accessing video content, and also content is normally customizable and can be shared on the go (Cesar et al. 2009). In their study O'Hara et al. (2007) also focused on video consumption on mobile devices. They noted that mobile video consumption is more than just a personal pastime. Mobile video is seen as an important feature in bringing video content into social situations and places, which is not possible with a fixed TV set. Basapur et. al. (2011) developed a secondary device concept that enhances watching TV by providing auxiliary information and media. The additional content is semantically related and synchronized to the ongoing TV content. A three-week field test with 11 households confirmed that the experience with a second device for additional information is quite positive. O'Hara et al. (2007) also stated that people have an additional opportunity to effectively coordinate their various viewing interests without losing their proximity to the family. In the context of simultaneous use of mobile devices, those multi-media devices are often referred to as 'second devices' or as a 'second screen' (Tsekleves et al. 2007; Cesar et al. 2009; Tsekleves et al. 2009) used to retrieve additional information or to use it for associated social activities. The work of Steimle et. al. (2010) tried to identify the usage pattern of tabletop systems involving both physical and digital media, and concluded with design implications for hybrid tabletop systems.

In our present study, we want to contribute to the altered consumption process of audiovisual content by using new technologies and devices in the living room. Moreover, we will fill the gap of how media usage behavior is influenced by new technologies over a long period of time. While changing habits are mostly investigated in the use of single devices, as for instance the aspect of computer or mobile use to watch broadcast or video content, it is reasonable to consider the whole usage setting

with all its influencing factors in order to understand the interplay of different multi-media devices in the living room. Therefore, our aim is to explore established media usage behavior and accumulated social interactions before technical interventions have happened and after they were appropriated as new functions. These two steps allow an immediate comparison of established media usage behavior and its changes regarding social experiences and individual TV and video consumption in households.

4.3 Method

Our study aims to explore the daily media usage behavior in domestic environments on a long-term basis, which will influence the design of new entertainment concepts. As an empirical frame for these investigations we used the living lab concept (Almirall 2008; Følstad 2008). The concept offers a setting where several players, e.g. academia, industry, public facilities, and users, come together in an innovative and open development process that takes real usage contexts into account (Niitamo et al. 2006). As users have become an important factor for research and development, they were involved actively, from the early research stages to the entire design cycle. The synergy of both, utilizing real world settings and conducting long-term inquiries, workshops and interviews, contributed to a co-creation process with a potential output in acceptable and usable applications and services. These characteristics lead up to the unique value of the concept. Our living lab (Hess and Ogonowski 2010; Hess et al. 2011a) consists of players from academia, media companies and of participants of a local user sample. We applied this research setting to the strength of co-creation opportunities and long-term investigations in real usage contexts such as peoples' homes. Within the understandings of usage contexts, established media usage and appropriation of new media constitute one of the core aspects of our design paradigm. Thus, research and design cycles proceed strongly circumstanced and affects positively on bridging identified gaps and users' needs.

In the context of our two-stage empirical study, we at first wanted to gain an in-depth understanding of current media usage and device usage of households in relation to the consumption of audiovisual content and social aspects in their daily routines. After the first study we undertook a technical intervention while providing living lab households with current marketable technologies at this point. Each household was equipped with a Media Center system with Windows Media Center which was connected to the TV set and an Android OS smartphone. Households with a tube television were additionally equipped with a high definition television. We chose this system based on the fact that the Windows Media Center offers a stable performance software solution for TV consumption. In addition, it basically helps reach a common experience within households regarding the Media Center's technical functionalities. Again, Android OS was chosen because of its openness for application development, as well as because of its strong acceptance within the user market. Due to a limited budget, we were only able to equip each household with one smartphone, so that only one person at a time was able to use the device, unless they shared it with other household members, which was rarely the case. By implementing the marketable technologies in the peoples' home, we gave a brief introduction to the systems and their functionalities, but didn't demonstrate to do specific tasks or had them use the

systems if they felt uncomfortable with it. In most households' marketable technologies are replacing existing TV systems. One of the two households, who already had a Media Center system, even replaced the existing solution with the new one. The reason for that was the easier handling of the new system itself. The other household used their Media Center system until our framework was running, because their own system was perfectly integrated into their own network. The participants spent a couple of months using and learning the new functionalities on their own and integrating the technologies into their daily routines. Then, in the second stage we investigated how the new technologies were appropriated and how the media usage behavior had changed over time.

In an interval of 9 months, we conducted two self-documenting diary studies (February and December 2010) with our living lab households. The first study consisted of a three-week documentation period, while the second study was designed for a two week period. Therefore, we designed a cultural probe (Gaver et al. 1999; Bernhaupt et al. 2008) that helped participants with self-reflection and stimulated them in an open and creative manner, to give researchers an insight into their private space. Our probe contained one media diary for each participant in the household, a digital camera, a privacy policy, a stand-up display to remind participants of the documentation and some sweets for motivation. The diary study is also a common approach in exploring the context in question through the participants themselves (Carter and Mankoff 2005). Therefore, the method helped gain structured and in-situ feedback. The diary study is also a favorable way to establish a trusting relationship between participants and researchers, which is necessary for long-term investigations.

The diary represents the most important part of the study. It contains semi-structured pages, on which the participants are asked to document every single audiovisual media usage with the following information:

- Date and time of usage
- Number of persons involved
- Kind of media (TV, video, Internet, cinema, or other) and synchronous usage with other media
- Content of media
- Motivation for media usage
- Communication with others about the content

Apart from the camera, which was used to get more visual insights into the consumption settings, the diary of the first study also included special creative pages with different tasks, which helped us to understand the households better, in regards of their social structure, lifestyle, experiences and individual opinions without invading the household's privacy. One task, for example, involved asking participants to sketch the layout of their homes and their technical equipment within each room. Beyond that, they were asked to mark their favorite spot, helping us gain some understanding of where household members feel most comfortable and relaxed, and to understand the relationship between their comfort and the organization of technical equipment in the household. These tasks were also used to make the documentation period less monotonous and to keep the participants motivated.

After each study, we collected the probes from the households and conducted additional semi-structured feedback interviews with each participant of the household to reflect on their own media usage behavior, the relevance of devices, changes in consumption behavior, and the diary study itself. In our study, we had 27 participants (14 m, 13 f) from 16 households (5 couples with children, 5 couples without children, 2 single households with children and 4 single households without children), which also made up the user group of our living lab (see Table 1: Characteristics of living lab participants). They all resided in the urban region of Siegen-Wittgenstein, Germany, and were between 13 to 51 years old. The sample was divided into two groups to reproduce a heterogeneous sample with various types of users. Upon doing so, we did not aim at creating a representative profile, but with regards to our design focus, we wanted to address mainstream media users. One group (11 participants) consisted of users with existing experiences in using smartphones and/or Media Center systems. The other group (16 participants) only possessed minor technical experience within these fields and applications, but they all had a high daily TV and Internet usage in common. The participants were recruited via a call for participation in local newspapers and radio stations. The following selection process was based on semi-structured telephone interviews and predefined characteristics (e.g. sociodemographic factors, broadband connection, technical skills, communicative competence) and is also described in detail (Hess and Ogonowski 2010).

Table 1: Characteristics of living lab participants.

Households	**Characteristics of participants (sex, age, tech. experience [high +, low –])**
Couples with children	F1_1 *(m 51 –)*, F1_2 *(f 41 –)*, F1_3 *(f 13 –)* F2_1 *(m 38 +)*, F2_2 *(f 34 +)* F3_1 *(m 43 –)*, F3_2 *(f 44 –)*, F3_3 *(f 18 –)* F4_1 *(m 38 +)* F5_1 *(m 37 +)*
Couples without children	C1_1 *(m 32 +)*, C1_2 *(f 36 –)* C2_1 *(m 29 –)*, C2_2 *(f 24 –)* C3_1 *(m 37 +)* C4_1 *(m 38 +)*, C4_2 *(f 34 +)* C5_1 *(m 34 +)*, C5_2 *(f 24 –)*
Single households with children	E1_1 *(f 43 –)*, E1_2 *(f 15 –)*, E1_3 *(m 16 –)* E2 *(f 38 –)*
Single households without children	S1 *(m 44 –)* S2 *(f 46 –)* S3 *(m 35 +)* S4 *(m 28 +)*

Out of the first diary study, we received an overall of 26 duly completed diaries (14 m, 12 f), with a number of 669 entries in total (average 25 entries per person). One female participant was absent during the study and was not able take part. From the second study, we received 20 diaries (11 m, 9 f) with a number of 296 entries in total (average 15 entries per person). Seven participants did not complete the diary due to their limited time during the stressful pre-Christmas period. Two participants explained in the additional interview that they did not see any sense in documenting their media usage again, because they believed it had remained the same.

The collected data, the entries in the media diaries and interviews, were digitalized and transcribed. By using inductively and deductively derived categories, the data was coded, analyzed and triangulated afterwards, with regard to media usage patterns, changes in media usage behavior due to the intervention of the described technologies, social phenomena, and individual perception of change.

4.4 Results

Our results give an insight into how people use current multi-media devices in their domestic environment, how they appropriate recent technologies into their daily routines and how technologies affect and change those routines. We have looked at the changing role of devices within consumption processes and their flexible usage opportunities, the corresponding social phenomena and at the user's individual perception of change through the intervention of new technologies.

4.4.1 Device and Media Usage Behaviors

From a technological perspective, current media usage behavior is permanently influenced by both new functions and possibilities on existing platforms and on new devices. Thereby, the usage of a single device changes individually and will be supplemented by the functionality of other devices or even substituted by others. One of the interesting phenomena identified in our long-term study, was the changing media usage behavior assigned to available devices and the special kind of expedient device usage.

4.4.1.1 Integration of new Devices

The Media Center system became an important role in daily routines and changed the role of PC/laptop usage. A good example is given by F2_2, who was using a laptop intensively for email, social networks and news before the introduction of the marketable technology happened. Her laptop had a fixed place in the kitchen, so that the usage of the television and the Internet happened spatially divided. As the results of our second study revealed, her usage behavior changed by using the Media Center system now, which offered additional opportunities for accessing online content. TV and Internet usage became flexible and more integrated in the living room as F2_2 explained in the interview: *"I turn the computer [Media Center system] on and then watch breakfast television to relax [...] switch to the Internet, check Facebook for new messages, check web.de, surf a bit on bild.de, switch to the TV program again, [...] it is much faster than using my laptop in the kitchen, until it is booted [...] that is much*

easier with the computer [Media Center system]. Due to the introduction of the Media Center system, additional opportunities for accessing online content emerged out of its functionalities. However, this device did not substitute the laptop usage at all but offered a situational flexible media usage within the households.

Other participants, who already used the laptop simultaneously to the television in the living room, as we knew from our first study, also switched to the Media Center system instead: F5_1 described a simultaneous usage of the laptop in order to check e-mails, Facebook, Amazon or eBay. In the second study he reflected that the Media Center system partly substituted these functions previously done on the laptop. But F5_1 also explained that more active tasks, such as printing or writing mails, were still done on the PC. *"Actually, it [the laptop] is replaced [by the Media Center system]. We own a laptop, it is also here [under the coffee table], but it is being used very rarely. From this point of view things will be done mostly with the Media Center system. With the exception of checking email and printing, which is done on the stationary PC."* For a more spontaneous usage of the Internet, such as searching or retrieving situationally relevant information while sitting on the couch, one participant (C3_1) enhanced this usage directly via the TV. In the meantime, in such situations he did not use the smartphone or netbook anymore.

In addition to that, we could also identify another interesting usage behavior with regards to the Media Center system: it's full list of features makes it a perfect media hub for parties., C5_1 reflected on his party experience and pointed out that because of the all-round features, he really appreciated the Media Center system as a party media hub: *"When my friends were here, we used mainly the Media Center system to listen to music and watch YouTube videos. That's also what I valued especially. With the Media Center system, one is able to do everything: to surf the net, to watch a film, or listen to music."* (C5_1)

We could also identify shifts from PC/laptop towards the smartphone. Several participants used the smartphone instead of the laptop to regularly check email. In case of S1, this change became visible very well. Before technologies were introduced, he was not using any media in the morning (with the exception of the radio from time to time), because the morning was a busy time for him. In the second study he already used the smartphone in the morning to check his email. A similar behavior could be identified by S2. She described it with the reason of prioritizing follow-up activities based on her business email: *"After I get up in the morning, I check my email. [...] Maybe that is just curiosity, is there something important, is it necessary to react immediately? Or will I have time to handle other things?"*

The introduction of the smartphone established practices of flexible media usage. S4 described this practice with a 'just-in-time' behavior. Through the permanent availability of the smartphone and the option to go online, media usage is flexibly distributed throughout the day and is not limited to the evening anymore. S4 explained this kind of improved flexibility as follows: *"Information and exchange have turned into a 'just-in-time' behavior. If you want to look up something, or because you're bored, you can directly check what's new, scroll down a bit and then exit again. I'd say that's rather flexible."*

4.4.1.2 Flexible Device Usage

Besides the above-described integration of new devices in users' daily routines, an interesting behavior regarding the choice of devices for simple and short-term online activities, e.g. looking for brief information or checking email, could be identified when watching television. As almost all of the present devices (laptop, Media Center system or smartphone) were appropriate for these activities, participants described choosing a device based on a "least-effort" consideration. C4_1 for example stated: *"in case the laptop is not in my grasp, I'll use the iPad as it is ready immediately. And if the iPad is not in my grasp […] I would use the smartphone. However, if the laptop is next to me, I will of course use the laptop"*.

For more complex online activities that involve entering large amounts of text or complex graphical output, participants chose their device more carefully. For this purpose, S1 described situations where TV content made him gather brief information using his smartphone. However, *"in case I wanted more in-depth information, I would boot up the laptop, as it has a larger screen"*.

Moreover, the presence of other household members is taken into consideration when choosing a device: *"The PC must run parallel to watching TV together with other family members and then it's difficult to watch TV and check email simultaneously on the TV"* (F3_1). He also stated that it was no problem, if no other family member was sitting next to him in front of the TV. *"Then I use this function during commercials"* (F3_1). In addition to this, when watching TV alone, the simultaneous usage of a smartphone can be beneficial, as watched content will not be interrupted or covered. For this purpose, E1_2 explains, that *"when I sit in front of the PC or TV [watching video content in both cases], I normally use the smartphone for surfing and texting with other people or checking if someone emailed me. The advantage is that you don't need to interrupt the video to do something else"*.

Besides those short-term role assignments, we also recognized long-term assignments, where devices were given fixed roles for significant periods of time. This was especially obvious by the fact that participants separated leisure activities from working activities in the living room, if they worked at home (for their business, studying for school or university).

Concerning this phenomenon S2 realized that after appropriating new technologies, she now uses the smartphone and the Media Center system to surf the Internet on weekends. She did not turn on her PC anymore when she wasn't working, despite the fact that TV/Media Center system and computer were not spatially divided in the living room. In a similar way C5_1 said that for him the laptop *"has a well-defined scope. Of course, I'm working on it. Furthermore, I use it for surfing, occasionally for gambling, while the Media Center system is primarily used for movies and music"*. Also, a clear task specific and physical separation could be found in other households. C2_2 explained that after the introduction of the marketable technologies, her laptop *"now remains in the room where she studies or works. In the past, it was also used in the living room since it was the only device with internet-capability […]. I have established a total separation between university [work] […] and private affairs – for the fun of it"*. Another participant (E1_3) used her computer to do homework in the afternoon. After she had finished her tasks, she went to the living room to chat online

with friends and play online games on the Media Center system. Particularly, in both of the latter cases, the introduction of the Media Center system clarified the assignment of fixed roles for the devices and their physical configuration within the households.

4.4.2 Social Phenomena

The introduction of the Media Center system and the smartphone changed the landscape of electronic appliances in the households. As a result, a new usage pattern for each individual user has been observed, which was presented in the previous chapter. Nevertheless, social structures within the households also adapted to the change. We identified some subtle yet interesting changes that happened during our entire study.

4.4.2.1 Conflicts in Device Sharing

Sharing devices in households is sometimes tricky, as some household members may dominate and monopolize some devices for a certain period of time. Almost every household has an established hierarchy of access for each device, e.g. children occupy the TV during animation time. Device domination used to be a problem before the new hardware was introduced. After the hardware introduction - although this domination continues to exist - this problem has become less severe by the decoupling of content and device. There is now a wider range of possible devices from which to access the same content. Thus, the device no longer plays a decisive role in this situation.

In one household the mother (F1_2) had very little chance to use the computer before our hardware introduction, because her husband and her daughter were always occupying it. *"I've noticed that I seldom use our computer. Looks like I don't need it and my husband spends quite a lot of time sitting in front of it, playing, my child also. To be honest, I think I have neither the time nor the chance to use it."* After we introduce the hardware, she started to use the Media Center system to surf the Internet when the computer was not available. Interestingly she claimed her Internet usage in the second study to be 'relatively high', given that she didn't even realize that she needed the Internet during the first study.

In another household, the situation was similar. C1_2 had very little access to the computer, regardless of the first or the second study. But through the introduction of the new devices, she then had the possibility to fall back on to the smartphone or the Media Center system to surf the Internet: "*I could barely use it [PC] earlier (laugh). But now, I don't actually need it. Because now most of the time I use the smartphone to surf the Internet, or the TV [Media Center system]*". The PC is not always the first device for browsing the web. In another case the participant (F2_2) first tried to use the Media Center system to surf the Internet, if not possible, she then turned to the laptop: *"When the children don't let me use the TV, for example. They want to keep watching their program, but I want to check something on the Internet…They don't let me. Then I'll turn to the laptop, it's in standby mode all day long."*

4.4.2.2 Family Obligation

As a family, the members have an intrinsic tendency for physical proximity, even when this sometimes seems obligatory. From our study we realized that this phenomenon

commonly exists in multi-person households. The representative pattern of "co-watching but with different interests" happened in the living room when some household members were bored by the TV program being watched. Instead of leaving the living room, they choose to stay but to use another device to do something else parallel to watching television.

For example, in one household, one participant (C2_2) is interested in a TV series but her boyfriend (C2_1) is not. C2_1 then used the smartphone to browse the Internet in the meantime. In another household the introduced smartphone also turned out to be used when co-watching. C1_2 described her usage as follows: *"I use the smartphone when C1_1 is watching something on TV, but I'm not interested. I'll still sit beside him and just watch with 'one eye open', most of the time though I'll be playing or surfing the Internet on the smartphone."* We could identify the same phenomenon in households with children. In one case the child (F1_3) now has the opportunity to do more things while sitting next to its parents. *"When my parents are watching the television and I'm bored with what they're watching, I use the smartphone [to play and text with friends]"* (F1_3).

4.4.2.3 Plasticity of Time

8.15 p.m. used to be considered as 'prime time' for watching television. One has to align his social life to the planned TV program, if he doesn't want to miss it. But now, with the help of recording and time-shift, users are able to uncouple their personal timeline from the elaborated program schedule of broadcasters.

One household reported that with the function of recording and time-shift provided by the Media Center system, they felt quite relaxed at dinner. As they normally cooked around 8 p.m., they used to hurry so that they could catch up to the TV program by 8.30 p.m. But after the hardware introduction, they let the Media Center system record the program. In this way they could have dinner without being under pressure and enjoy the show later, and were then also able to manually skip the commercials: *"Now we often start watching TV at 8.30 or 8.45 p.m.. We let it record first, then we watch and then we can skip the commercials. We actually do this quite often."* (C2_2)

Another quite surprising way of use we identified, was that the electronic program guide was used for baby-sitting. One participant (E2) reflected that she was arranging the children's day according to the TV schedule. E2 stated that: *"EPG helps me a lot when I have to be away and leave the children alone. Then I'll say: 'now this program is broadcasted, then this, then this and I'll be back by this program'. In this sense I often structure the children's day according to the TV program."*

4.4.3 Perception of Change

As shown before, the implementation of technologies in households has led to changes in the daily routine of media consumption and social behaviors within a household. Even if the severity of these changes differs between various participants, they were always obvious. However, the participants' reflection and the degree of awareness of individual changes were distinguishable from the empirically ascertained behavior.

Some of the participants described their altered usage behavior in a detailed and well aware manner. C2_2 for example mentioned that the TV consumption remained constant or even decreased, because of the opportunity to surf the Internet on the television set as an alternative to watch low-quality TV content. Furthermore, the boot time of the Media Center system often led to the decision to leave the device off and thus to a more conscious television consumption. In contrast, the same participant described that the cell phone usage increased strongly and was kind of like an addiction. In the past she often left her phone at home but now she thinks to herself: *"Oh my god, you left your smartphone at home!"*. F2_2 said that there are no changes concerning her consumption behavior or time, but that the usage itself became more convenient due to the new integrated internet-capability of the television. *"You just remain seated on the couch and you have your keyboard. Otherwise, during commercials I would go to [the laptop in] the kitchen and log on to Facebook or elsewhere. [Now] I can just remain under my blanket and do it on the TV. That's great!"*. Another good example for a distinct awareness of individual changes in media usage behavior is found in a statement of C5_1. For him the opportunity to now be able to watch high-definition content already poses a fundamental improvement.

In contrast to that conscious perception of individual changes in media usage behavior, other participants did not recognize any changes. Also, participants that before had described changes for several usage situations, did not discern existing changes in other situations. C2_2 for example, who described variances in her TV consumption and cell phone usage behavior, said that a simultaneous usage of various media did not take place in her household. Her boyfriend (C2_1) however said that when watching TV together, he sometimes used the smartphone to surf the Internet when he was bored of the TV content his girlfriend was watching. The missing awareness regarding the changes becomes even clearer in the following statement of E1_1: *"I always do the same. Because until now the Media Center system doesn't offer much new."* Although she is aware of the new devices, for her, there is no change happening when using same functions (e.g. browser games, Internet, instant messaging) on different devices (PC at the desk or TV screen). Her daughter (E1_2) even confirms that her mother's usage behavior has changed insofar that she now uses the Media Center system excessively: *"When I come home from school, I use the Media Center system to watch animes on the Internet until 8 p.m, when my mother chucks me out."*.

Another good example is the following excerpt from the feedback interview after the second diary study with F3_2:

Interviewer (I): *"What changes did you recognize that are associated with the new devices?"*

F3_2: *"[…] regarding the box [Media Center system]?"*

I: *"Exactly!"*

F3_2: *"Ehm… No. Well, I record more now. I like recording, yes. But actually no changes."*

I: *"Did your daily routine change?"*

F3_2: *"No, not at all!"*

I: *"Everything remained the same?"*

F3_2: *"Yes!"*

I: *"Did the TV's role change?*

F3_2: *"No, no!"*

I: *"You use it the same way as before?"*

F3_2: *"Yes!"*

I: *"The same intensity, the same content?"*

F3_2: *"Yes, right. Nothing's changed."*

I: *"How do you organize your TV consumption? How do you plan watching TV? Has something changed?"*

F3_2: *"I don't plan watching TV. I always watch the same things, I don't have to plan."*

I: *"Regarding the Media Center system: Which functions do you use exactly?"*

F3_2: *"The recording function."*

This example illustrates clearly that the participant, despite the fact that she is using the new recording function of the Media Center system now, is not aware of any changes in her TV usage behavior. The statement also shows that when she says, she does not plan her TV consumption, this statement is contradicted by the fact that recording in principle requires planning (e.g. programming the timer). In the interview with F1_2 we had a similar experience. She also mentioned that the usage of the TV set did not change, but in her answer to the question about what functions she used on the Media Center system, she mentioned several services she could not use before (e.g. watching shared movies from the PC via Wi-Fi, recordings, Internet).

An additional interesting result concerns the fact that the participants' reflection upon changes in individual media usage was often induced by the applied diary study. Some participants assumed that they were aware of their usage behavior and the accompanied changes. Only by keeping the diary did they come to see significant differences between their assumed and real usage behavior. S1 describes this experience as follows: *"This is interesting. After the first diary I had no idea what could happen and I never thought that I would change. But this already started with the second diary, realizing that a lot has changed."*. S3 stated something similar and challenged his self-perception. *"I am appalled at how much media I consume and also by how standardized it actually is. Once I regarded myself as an individualist, but in actually I am a normal person. Through the project I became more aware of my media usage."*

4.5 Discussion

The introduction of the new devices in our living lab households caused several expected changes within the participants media usage behavior. Many of our general findings about the meaning of television and the flexibility of TV consumption

underline earlier research: Obrist et al. (2008) investigated the TV usage and the television's role in daily life, Barkhuus (2009) explored convergent media usage but only focused on the computer. Brown & Barkhuus (2006) showed how the introduction of a PVR influenced the TV watching behavior. Moreover, we identified interesting phenomena in regard to how changes were induced by new devices and how they affected daily routines and social structures within the households.

Device-Shift: The trend of converging functions on various devices offers users the freedom of choice with regard to the used device. We identified that both the Media Center system and the smartphone take over various tasks of the PC or laptop regardless of whether if they are used in a single or multi-person household. However, this substitution occurs only in specific situations, an entire replacement could not be observed. In case of the Media Center system, the usage primarily takes place simultaneously to watching broadcast television (e.g. using the Internet during commercials or retrieving additional content) or as a new alternative to habitual TV consumption (e.g. watching on demand content from the Internet or hard disk). Here it is an interesting result that the new functions the Media Center system brings to the TV, are frequently used but did not result in an increasing usage of the TV set as a whole. The situation is different with the smartphone. Its permanent presence led to a more frequent usage and an altered usage behavior of the service itself. Email or social networks for instance were no longer used at specific times, but it was at hand all day long. This characteristic also led to changes in the synchronous device usage while watching TV. While the laptop was previously the device mainly used for this purpose, after the introduction of the new devices, it was in many cases substituted by the smartphone. This could be observed with participants with lower technical experience. Participants who already had experience with smartphones, had already shown this usage behavior before.

This raises an interesting question concerning the 'second devices' or 'second screens' and its integration into the situations, when media were consumed (Tsekleves et al. 2007; Cesar et al. 2009; Tsekleves et al. 2009; Basapur et al. 2011). However, our study did not confirm an implicit order, where the television came first, and computer / laptop / smartphone / tablet PC were second, instead the order changed according to the users' attention and his main activity.

Expedient choice of devices: We found out that despite the fact that many services and functions (e.g., Internet, email) can now be accessed and used platform independently, the choice of the device is, however, not arbitrary. The users made unconscious decisions based on (a) *what effort* they would be willing to put into satisfying their information or communication needs and (b) *which device* to use. This obviously (a) depends on the urge and importance while (b) depends on a set of different influences. The following list of encountered factors from our study is derived from the classification of influencing factors for TV viewing of Wonneberger et al. (2009):

- **Individual influences:** tiredness, comfort, joy of use, individual role assignment of devices, etc.
- **Physical influences:** location of the device, mobility of the device, boot time, usability aspects, interdependency with synchronous activities, etc.

- **Social influences:** device is occupied, consideration for others, privacy concerns, ownership situations, etc.

Particularly in multi-person households, we could identify a stronger influence of social factors. In these cases, users sometimes had to choose an alternative device, because the preferred one was occupied by another family member. Otherwise, the more devices exist in households, the more opportunities emerge, which allow diverse access to media content. The phenomenon of expedient choice of devices hence confirmed the assumption that the convergence of media does not lead to a substitution of existing devices, but to a more flexible and complementary device usage. While this on the one hand enhanced the user experience, on the other hand, it also created a challenge for the right design. The same function is now used on different devices, which requires function sets to be defined to adapt to the characteristics and capabilities of each device. The user now has access to a wider range of devices, and "jumping" between devices becomes more frequent. Therefore, an awareness function is needed, to accurately locate the user so that corresponding services could be provided. The increased number of devices has also increased the difficulty of personal configurations. In this sense a cloud setting capability to centrally and dynamically arrange the configurations on all devices should be promising.

Role assignment: A surprising result is that after the introduction of the new devices, some of the participants assigned specific roles to their devices. The laptop or PC was previously the sole web-enabled device in most of the living lab households and used for any internet-based activities. Now, with the new devices, it was assigned the role of a work computer, while the Media Center system and the smartphone were used for leisure time activities. Another example is that the Media Center system was only used for multimedia (TV, YouTube, music, etc.) while communication applications were used on the laptop or smartphone. Both phenomena could be found in all household structures, as well as in both types of experienced users. This raises the questions of whether this behavior is based on traditional device roles (PC/laptop as a working tool), which are still embedded in the users' way of thinking, and what this means for the future design of new devices and interfaces. To answer these questions more investigation into this behavior is necessary.

Restricted device access: Because the devices were previously limited in numbers (mainly the PC), the members of many multi-person households had to share. This led to the situation that some household members gave others the advantage to use the devices more often, or that hierarchical structures were a handicap for household members when it came to device access. This was often the case in households with a mixed technical experience. Participants with less experience dedicated devices to other household members with more experience. However, the first diary study showed that the missing or restricted access to devices, respectively the Internet, did not affect the users' needs being satisfied or unsatisfied. Instead, they mentioned that there was no need for an intensified usage. The introduction of the Media Center system and the smartphone made two new devices available, which solved the problem of restricted access. Interestingly though, this led to a heavily increased use by those participants with primarily less technical experience, who previously had to deal with restricted access to the then existing devices, even if they had mentioned before that they were satisfied with their amount of device usage. This phenomenon shows on the

one hand that the need for device usage depends on the access possibilities, and that easier access causes more intensive usage. On the other hand, we can see that a larger number of devices within a household does not dissolve hierarchies of device sharing. but leads to an easier device access for any household member.

The living rooms' social situation: Our study still confirms earlier findings e.g. from Bernhaupt et al. (Bernhaupt et al. 2008), that watching TV in multi-person households is an important social activity and an unspoken family obligation, where family members come together in the living room, to spend the evening together. However, it is not invariably the case that the program choice is to everyone's liking, so that compromises have to be found and that some are bored with the program. The smartphone as a new ultra-mobile device offers the possibility to follow individual interests without breaking up the physical coming-together, but also does not result in enhanced conversations. This behavior, which was critically discussed by Turkle (2011), helps on the one hand to ease conflicts regarding the program choice, but on the other hand it breaks up the existing social cohesion within households. Family members are present in the room but no longer interested in common activities, so that they focus on other online activities on their mobile devices and were limited in following conversations. Therefore, the design of new concepts for tabletop systems should be seen as a challenge in order to recreate social cohesion in the living room.

Loose binding to elaborated program schedules: One of the frequently used functions of the Media Center system was the recording feature. The study showed that many households, regardless of their household structure and technical experience, used the EPG to plan recordings for the entire week and watched the content on the weekend. However, contrary to the findings from Brown & Barkhuus (2006), the given program schedules are often established by daily routines and TV content is watched when broadcasted. As a consequence, other activities have to be shortened or aborted in order to not miss the beginning of a television show. In our study we identified an interesting behavior that deals with this circumstance and extends earlier findings from Irani et al. (Irani et al. 2010). The participants were still guided by the given schedule but in order to finish previous activities (e.g. cooking and dining), they used the time shift feature to record the TV show and then watch after they had finished dinner. This allowed for a more relaxed evening schedule on behalf of social activities within the household.

Methodological challenges: The results of our study show that the participants' perception of their changed usage behavior strongly differs from each other. While some of the participants did not notice any changes, others reflected on their changed usage in a very detailed manner. One point we found, was that especially the smartphone was identified as a new device that fundamentally changed mobile usage, while changes based on the Media Center system were noticed less strongly. This brings up the question, if new devices or functionalities that are embedded in existing usage scenarios (TV set in the living room) are less perceived than devices that evolve new habits of usage (smartphone). In addition to that a more general question is how pronounced the changes have to be, so that users notice them as such. Hence, the participants' reflective faculties pose a major challenge for such a long-term field study. Because of this, the selected methods have to aim at continuously stimulating

the users' reflection. A good example is the interview excerpt in chapter 4.4.3, where the interviewee helped the participant by asking specific and precise questions to reflect and describe her unconscious usage behavior.

Furthermore, we consciously used self-documenting methods in order to keep the living room a private space and to build trust for further interviews and long-term investigations within the field. Even if our data base is not completed, for our explorative procedure it was important to get an insight into the real life, understanding usage behavior and changes that occur over time. It could be seen as a limitation of the qualitative study that we did not use a tracking system which gathers more quantified data about the devices, used functionalities, timeframes and consumed content. Otherwise, it has to be considered carefully, if to use a tracking system without destroying natural TV consumption behavior as well as the trusted relationships. For further investigations it could be helpful to track timespans and used functionalities, but not the detailed content information.

Another study limitation is related to the limited budget, due to which we could fit each household with only one smartphone. For more extensive results especially within multi-person households it would be helpful to equip households with more than one device, because of their characteristic as personal device. Within our study only two households shared the smartphone with the other household members, most of them used it as a personal device. As a positive feedback from the field, we noticed that three of the households purchased another device, so that we could get a better understanding of the smartphones' integration into daily routines.

4.6 Conclusion

In this work we explored current practices of adopting and using new marketable devices in domestic environments. For this purpose, we conducted a qualitative long-term study with 27 participants in 16 households of our living lab. In the first step of the two-stage empirical study, we wanted to gain an in-depth understanding of the current media and device usage. After the first stage we introduced the marketable devices – each household got an Android OS-equipped smartphone and a Microsoft Media Center system. In the second step, nine months later, we wanted to figure out how the new devices had changed the media usage behavior and how these changes impact on social structures within the households.

We identified several social and usage phenomena concerning device-shifting, expediency of devices, roles of devices, restricted access to devices within families, campfire effect in the living room, and the binding to program schedules. Furthermore, we identified a strongly diverging reflective faculty regarding the individual perception of changes among the participants. Our results show that new devices and services are adapted rapidly within a household and result in a better, more flexible and more comfortable media usage. But our results also indicate that current concepts bring forth several issues that need to be investigated further in future research. On the one hand, even if proposed as 'convergence' of current solutions, it is not supported at an optimal level, e.g., when switching between television and Internet on the Media Center system. On the other hand, further solutions need to better address the

expediency, e.g., using related services on a secondary device that is in a reachable distance or the separation of shared and personal use, e.g. by additional personalized content on mobile devices.

The results of our study provide insights that may affect design of new cross-platform concepts in current home IT infrastructures. Such environments are characterized by a diversification of devices, services and content offers. Content is accessible on different devices and can be enriched with functionalities that support personalization and social exchange as well. However, as an important issue we should address the social cohesion also within households. We observed different patterns including conflicts in device sharing, role assignment and expedient choice related to personal interests. But these observations also raise a more critical aspect, that everyone is consuming media only for himself, even if sitting together in the living room. Further work may address this issue by approaches that support activities also within households, e.g., by using an interactive secondary public display. Also, privacy aspects need to be considered carefully. New and flexible options to access content and services also are related to management, e.g., roles and rights, and profile, e.g. household vs. personal profiles.

5 ICT-based Fall Prevention System for Older Adults: Qualitative Results from a Long-Term Field Study*

Abstract. Falls and their consequences are arguably most important events for transition from independent living to institutional care for older adults. Information and communication technology (ICT)-based support of fall prevention and fall risk assessment under the control of the user has a tremendous potential to, over time, prevent falls and reduce associated harm and costs. Our research uses participative design and a persuasive health approach to allow for seamless integration of an ICT-based fall prevention system into older adults' everyday life. Based on a 6-month field study with 12 participants, we present qualitative results regarding the system use and provide insights into attitudes and practices of older adults concerning fall prevention and ICT-supported self-management of health. Our study demonstrates how it can lead to positive aspects of embodiment and health literacy through continuous monitoring of personal results, improved technical confidence, and quality of life. Implications are provided for designing similar systems.

Keywords: exergame, fall prevention, fall risk, older adults, qualitative research, long-term study, living lab

5.1 Introduction

There has been a significant demographic shift in almost all first world societies, such that age structures are rapidly changing. It is expected by 2025 that 22% of the European population will be aged 65 and over, rising to 30% by 2050 (European Commission 2013). Unsurprisingly, there has been a considerable amount of research effort geared towards understanding the physical, cognitive and social challenges that this group of 'older adults' may face. How to support these challenges, however, remains an obdurate problem. In relation to this, a growing body of research papers and articles has been published during the last decade, which targets "the relationship between technologies and growing old" (page 2, Vines et al. 2015). Our particular concern, the challenge of reducing health risks of older adults by the use of information and communication technology (ICT), has become a recognized and important issue (Sørensen et al. 2012). A significant health impairment that is often experienced by older adults is the risk and experience of falls and fall related injuries. This is a problem not only for older adults themselves but is also a challenge for public health systems (Kannus et al. 2005).

Falls are very prevalent in this segment of society. More than 30% of people older than 65 suffer at least one fall a year, of which half experience multiple falls (Gillespie et al. 2012). Prevention is key, and there is a large body of work that points to the fact that to increase people's health and quality of life (QoL) we need to encourage them

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* *Ogonowski, C., Aal, K., von Rekowski, T., Vaziri, D., Randall, D., Schreiber, D., Wieching, R., and Wulf, V., 2016. ICT-based Fall Prevention System for Older Adults: Qualitative Results from a Long-Term Field Study. In: ACM Transactions on Computer-Human Interaction, 23 (5).*

to become more physically active as a preventative measure (Ferrucci et al. 2000; Obi et al. 2013). There is now strong evidence to support the view that early intervention reduces the risk of falls, and that exercise is the single most effective intervention strategy, at least in community dwelling populations (Gillespie et al. 2012). Early detection of older adults who are likely to be at risk from falling, researchers agree, is a fundamental element in controlling or reducing this kind of incident (Yardley and Smith 2002). There is less evidence about how best to effect such measures in the context of the individual or communal home. Home interventions based on different forms of assistive technology devices clearly have the potential to overcome some of the barriers to sustainable preventive training and physical independence. They may also go some way, as we will argue below, towards supporting cognitive and social wellbeing.

In recent years, the evidence base for ICT-based health behavior change interventions has been growing. The number of computer-tailored interventions has increased, particularly in physical activity studies (Broekhuizen et al. 2012). Several systematic reviews have already documented the effect of these interventions on physical activity (Sherrington et al. 2008; Gillespie et al. 2012). Programs that combine ICT-tools with face-to-face interaction seem to be most effective (Campbell et al. 1997). Nevertheless, how best to effect long-term sustainable change of practices with ICT artifacts in relation to health and exercise among older adults is as yet unresolved.

Given that chronic diseases and falls are – to a large extent – preventable (Nolte and McKee 2008; James et al. 2012; Siefken et al. 2012), the significance of health literacy (Sørensen et al. 2012) and prevention activities is beyond dispute. A complicating factor lies in relationship between physical health, psychological wellbeing and sociality. Merleau-Ponty (2002) referred to this some years ago as 'embodiment'. The term has its origins in European phenomenology and refers to the way in which our experiences are grounded in our physical being. The body is thus the precondition of everything that follows in social life, including social interaction. It follows, then, that when the body is somehow problematized, there are social and psychological consequences. Self-efficacy and self-esteem in relation to bodily function are crucial elements for older adults when defining and attempting to achieve sustainable preventive health targets by themselves (Timmer et al. 2003). Thus, self-monitoring and persuasive control by means of ICT may be key to motivating behavioral change over a longer period of time. Although much research and design work has been done with regard to this purpose (Lai et al. 2013; Schoene et al. 2013; Uzor et al. 2014; Gerling et al. 2015), no ICT-based solutions for both continuous fall preventive training and fall risk assessment which offer seamless incorporation into the daily life activities of community-dwelling older adults – and at the same time provide them with the opportunity to track their fall risk continuously on their own – are yet available.

To address these issues, in this work, we present qualitative results from a long-term living lab study over a period of six months, where 12 older adults in a community-dwelling setting used a fall preventive training system for reducing their risk of falling, based on the principle of 'exergames' – a combination of different strength training, balance games and fall risk assessment supported through ICT. To triangulate with

qualitative findings, some descriptive (entirely non-parametric) quantitative data is also used. In doing so, we will present insights from real life ICT use in the wild and into strategies which evolve when integrating ICT-supported exercise training activities in older adults' daily routines. In addition, we analyze the additional effects of continuous fall risk monitoring in this group. Findings contribute to a better understanding of the appropriation of ICT-based fall prevention systems and how to design such ICT artifacts with and for older adults.

5.2 Related Work

In order to design ICT-based exergames for fall prevention and fall risk prediction in older adults, insights drawn from persuasive design, concepts of self-efficacy and embodiment to create systems that match with user needs and stimulate a transformation in behavior. In this section, we reflect on previous work on the factors that influence behavior, exergames and fall-risk assessment tools as well as previous research about designing with older adults.

5.2.1 Persuasive Design

Research around persuasive technology design has evolved in recent years and explicitly attempts to engender cognitive or emotional changes through technology-mediated transformation (Fogg 2002; Torning and Oinas-Kukkonen 2009). Existing behavior, usage patterns and attitudes, it is argued, can either be reinforced or cushioned through the use of ICT (Oinas-Kukkonen and Harjumaa 2008). In particular, in the field of health and wellbeing, the growing number of commercial ICT solutions for tracking physical activities (e.g. Nike+, Apple's health app, wearables like smart watches or wristbands and exergames like Nintendo Wii Sports) attests to this fact. Interactions with this technology and the immediate feedback on people's performance encourage their motivation to become more physically active and aims to increase their quality of life (QoL) in the long term (Ferrucci et al. 2000; Obi et al. 2013).

Torning and Oinas-Kukkonen's (2009) literature review argues that personalization, self-monitoring, social comparison and rewards are the most used design principles in persuasive design research. These principles are, we argue, just as essential for the design of ICT-based preventive exergames with and for older adults. Eckert et al. (2004) highlighted the desire expressed by older adults for training support at home, largely because of trouble reaching specialized facilities (e.g. those sometimes found in community centers for the aged) where physical training programs are offered (Schutzer and Graves 2004). On the other hand, training programs are difficult to apply alone (American Geriatrics Society 2001). Moreover, older adults are often unaware of the level of risk and thus are less motivated to do exercises (Gerberding et al. 2008). Further, due to a lack of health literacy, they sometimes do not know how to apply appropriate prevention strategies in their everyday life (Bouwhuis 2003; Mattke et al. 2010).

Overcoming these barriers is imperative for designers who wish to work alongside older adults to design, develop and test fall prevention exergames (Wulf et al. 2011).

Relevant factors include identifying preferences, attitudes and capabilities as well as technology acceptance in order to influence or 'nudge' changes in behavior and motivation for autonomous training. In particular, for fall prevention, feedback mechanisms and continuous self-monitoring are significant aspects of persuasive design.

5.2.2 Embodiment and Self-Efficacy

Users' motivation for engaging in (training) activities can be directly linked to individual perception of self-efficacy (Bandura 1997). Self-efficacy is defined as "one's belief in one's ability to succeed in specific situations" (ibid). This confidence or self-efficacy was identified in prior research to be a consistent predictor of short and long term success (Strecher et al. 1986), also for engaging in exergame-related activities (Song et al. 2011). Hence, as the domain of exergaming often constitutes a new experience for older adults, their attitudes and self-efficacy may diverge from their experiences in other contexts. In practice, a gap between the self-perception of older adults and their actual bodily abilities or practices is often noticeable (Macvean and Robertson 2013).

While many researchers in affective or persuasive computing already address a linkage between mind and body (Damasio 1994) or motivation and physical abilities (Fogg 2002). Berkovsky et al. (2012) created a game which "leverages the playfulness and addictive nature of computer games to motivate players to engage in mild physical activities". This game evaluation was conducted with 135 young players. Relatively little is known, however, about the quality of this relationship in older adults and how we might design IT artifacts for them (Hummels et al. 2007). One perspective to deal with these issues, as we have suggested, is offered by Merleau-Ponty's concept of 'embodiment'. This means that our corporeal experiences are interactively constructed and embedded in our everyday practices. Thus, subjective perception of external stimuli is determined by their significance for the body (Merleau-Ponty 2002). Focusing on the body perception of older adults, it becomes apparent that an ICT design is needed which enables older adults to attain a body perception that is in accordance with their current fitness and sportive abilities. Various design principles have been espoused, including that users should have support for social influences, should be able to monitor activity levels, that practical constraints should be taken into consideration, etc. (see Consolvo et al. 2006) and Sinclair et al. (2007) for an overview of research).

5.2.3 Fall Preventive Exergames

In recent years a considerable amount of research has been done in the area of exergames to combine serious gaming and health-protective exercising. Early attempts have shown results which suggest the positive acceptance of interactive videogames for rehabilitation of older adults (Betker et al. 2006; Studenski et al. 2010). Fall preventative games and exercises, it is suggested, should cover a wide range of physical tasks (balance and strength) delivered in numerous formats, some of which are likely to result in greater reductions in falls than others.

Sherrington et al. (2008), for instance, conclude that greater relative effects are seen in studies evaluating programs that include balance training and entail a higher level of exercise. It has been suggested that the minimal effective exercise dose for fall prevention would equate to a two to three times weekly program running over 24 weeks with a weekly total exercise dose of 120 minutes. Strategies for achieving sustainable long-term exercise participation are therefore crucial. Effective fall prevention programs could, it is suggested, either be conducted in a group setting and/or as an individualized program at home (Sherrington et al. 2008).

In a controlled study by Lai et al. (2013) 30 older adults above the age of 65 years trained over six weeks with an interactive video-game based exercise (30 minutes of exercise, three times a week). After the intervention, a significant improvement in different measurements could be shown (Lai et al. 2013). Schoene et al. (2013) explored the use of an exergame where older adults had to perform steps on a step pad. The exergame itself consisted of different stepping games which were displayed on the TV; participants had to follow instructions and step as accurately as possible in terms of direction and timing. At the end of the eight-week study, older adults have improved with respect to several outcomes related to falls (Schoene et al. 2013).

Even exercise sessions limited to ten minutes per session, it seems, can help to improve concentration, at least temporarily (Gao and Mandryk 2012). Uzor et al. (2014) attempted over the course of a three-year project to make fall rehabilitation less boring and more enjoyable. At the end of a twelve-week study with the prototype in eight households, it was established that adherence to the exercise regime was higher by those participants who used the system, as opposed to those who did not.

Positive results regarding motor functions, walking and balance, were also found in a study conducted in Japan by Sato et al. (2015), where participants completed 24-game sessions while playing once or twice a week. Gerling et al. (2015) carried out a study over the period of three months with 16 participants in two long-term facilities. Their results suggest that “playing video games in the context of a weekly activity is enjoyable and empowering [but the game design should consider] the range of skills and abilities among older adults” (Gerling et al. 2015). Ijsselsteijn et al. (2007) also discuss principles of digital game design for older adults, which impinge on the “senior’s experience of interacting with digital games”. These include changes in motor abilities, response speed as well as cognitive processing (Ijsselsteijn et al. 2007).

Zaczynski and Whitehead (2014) elaborated design guidelines for exercise gaming. They examined different approaches on feedback, learning and orientation and lack of visibility. Another set of guidelines for movement-based games was developed by Mueller and Isbister (2014). This set was evaluated by experts and is based on currently published research papers and game design venues. However, we argue that further exploration in this field is still needed to establish how best to engage older adult users in this respect (Zaczynski and Whitehead 2014).

5.2.4 Fall Risk Assessment Tools

The individual fall risk of older adults is typically measured by a physician or physiotherapist using (subjective) questionnaires and (objective) physical (clinical)

tests. These screening instruments are widely used both in research and in clinical practice, e.g., for physicians or physiotherapists. Even though the usefulness of these instruments is acknowledged for hospital or care facility patients, certain limitations need to be assessed when applying such an ICT-based approach into a community-dwelling setting (Scott et al. 2007).

The fall risk of frail or acutely ill older people often varies over time as they develop and recover from illness, or experience postural instability, delirium, hypotension etc. (Oliver 2008). Yet, fall risk-assessment tools have tended to be applied as 'one-off' measurements that do not reflect this reality. Merely to say that a fall risk assessment has been completed does not mean that anything concrete has been done to prevent falls. The provision of a home-based continuous and unobtrusive fall risk monitoring system will thus make access to far richer data possible, data that can be used to understand the physical, cognitive and possibly social decline of older adults rather better than 'one shot' clinical assessment tools can. Monitoring fall risk over time may enable the older adults themselves, or their carers, to realistically identify risks and thus implement more tailored preventive measures.

5.2.5 Designing with Older Adults

Previous research has identified a need for better sources of information concerning technological requirements for the design of appropriate systems and services for older adults (Whitney and Keith 2009; Lindsay et al. 2012). The accompaniment of traditional technology design approaches with an investigation into users' needs and their everyday lives and practices has been recognized as a necessity in the development of technology for this target group (Ebert and Heimermann 2004). This often implies an active involvement in the design process and collaboration between older adults, researchers and industry that require methodological adaptations and changes in stakeholders' mindset (Newell et al. 2006). In this context, the term 'living lab' and its methodological opportunities has attracted increasing attention within the research field of human computer interaction (HCI) and its cognates, and especially for the research with older adults. According to Eriksson et al. (2005), a living lab is considered to be a useful instrument for the careful study of users, their interaction with new IT-artifacts in real life environments, and for longer periods of time. As such, living labs allowed early insights into product design, as shown by von Hippel (1978; 1986), who focused on providing a quasi-naturalistic, but nevertheless controlled environment for product testing by end-users.

Living labs with a focus on older adults and domestic or private sectors can conceive of the notion of a 'real life' environment in different ways. A large part of research in this field involved the building of 'typical' apartments or houses of older adults in test centers and inviting participants for single tests or short-term studies over several hours or a couple of days (Abowd et al. 2002; Panek et al. 2007). In contrast with that, some studies focus on more naturalistic settings and situate their research in participants' everyday life and in long-term field studies spanning several months (Wan et al. 2014; Müller et al. 2015). Nevertheless, to date there are only a few studies which exploit the full potential of this concept and describe the processes of co-creation with older adults in detail (Ståhlbröst 2004; Lievens et al. 2010; Mulvenna et al. 2011). Some

studies, for instance, have reported variations in relation to duration and commitment of participants, the role of researchers, the degree of active involvement, the handling of skill sets and learning needs and the amount of 'structure' in the domestic living lab project (Carroll and Rosson 2013; Ogonowski et al. 2013; Ley et al. 2014). The work we present here had a long term, naturalistic focus, with living labs that were set up in the participants' homes over the duration of six months. In this way, the degree to which physical and mental effects were sustained and what changes in user behavior could be seen, made the concept especially valuable.

5.2.6 Research Question

Relatively little is known about the potential and challenges of long-term use (six months and beyond) of ICT-based fall prevention systems and continuous fall risk monitoring in daily life settings of community-dwelling older adults. In this context, four main questions arose, which we investigated in our research by gathering and analyzing primary qualitative data from the field. We supplemented results with some descriptive quantitative data derived over a six-month period of use. We will focus, however, primarily on changes regarding participants' individual perceptions and their subjective feelings. Our research questions, then, are first, how is the training system used; second, what strategies do older adults use to integrate the system in their daily practice; third, what makes ICT-based fall prevention a valuable experience; and fourth, how does it affect older adults in the long term related to the six-month intervention?

5.3 iStoppFalls: Training System for Fall Prediction and Prevention

In the context of the EU research project, iStoppFalls, for fall prediction and prevention, a Microsoft Kinect based interactive TV (iTV) system for older adults was developed (Gschwind et al. 2015). This section provides an overview of previous design studies in the iStoppFalls project and describes the overall system with its different system components.

5.3.1 Preliminary Work

For designing an ICT-based exergame system for older adults, a living lab as research methodology in the participants' everyday lives was chosen (Ogonowski et al. 2013; Ley et al. 2014). This enabled the project consortium to use participatory design methods and gave participants an active role in the design process.

Right from the beginning of the overall project, the preventive training system was co-designed together with the target group and representatives from academia and industry. Concept and design processes started with a three-month pre-study (interviews and workshops) with 12 participants to understand users' needs and derive first requirements on system design, navigation and functionalities (Meurer and Wieching 2012; Wieching 2012). Exergame concepts were built on the evidence of established concepts in literature and current research discourses (Marston et al. 2015).

Participants were mainly involved in the design of these exergames. Users have, when doing exercises, helped designers to contextualize different training sets and build up scenarios and virtual game worlds.

A first prototype of the exergame, with one balance game and three strength exercises, was evaluated with nine other households in a field study over a period of six months. This work mainly focused on usability, accessibility and user experience. For this, workshops, questionnaires, usability testings' and interviews were conducted to improve the design, gameplay and training experiences and to develop new exergame concepts and social functionalities together with participating older adults.

In parallel with the qualitative evaluation study presented in this paper, the iStoppFalls system was also evaluated with more quantitative objectives in an international multicenter randomized controlled trial (RCT) with 153 participants in Germany, Spain and Australia, in which a significant reduction ($p<0.05$) of participants' fall risk in the intervention group (4 month use of the iStoppFalls system) was proved against a control group (Gschwind et al. 2015).

5.3.2 System Overview

The iStoppFalls system consists of several technical components. Figure 6 gives a detailed overview and visualizes the relationship between several components: 1) a set-top box with controller, 2) a Mini-PC with the exergame (different strength training, balance games and fall risk assessment), 3) a Microsoft Kinect for movement detection and gesture/voice control, 4) a Senior Mobility Monitor (SMM) for mobility tracking, 5) a tablet PC as an alternative input/output device for the iTV system, and 6) a TV with the iTV program. A more detailed description of the system is provided in the work of Marston et al. (2015).

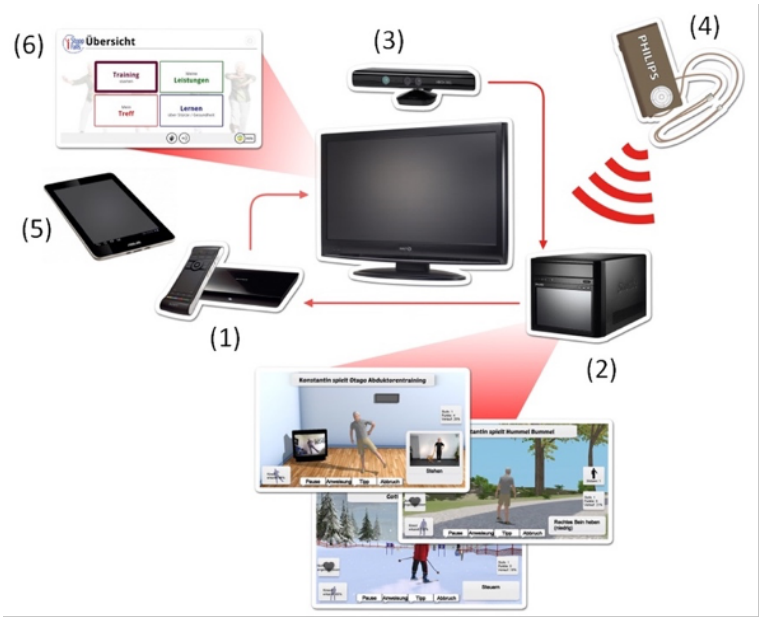

Figure 6: Overview of the technical components of the iStoppFalls system.

5.3.3 System Components

Individualization and Progression

On the server-side, a knowledge-based system (KBS) was implemented for providing a personal training schedule and keeping track of all training results and events. Based on the returned training results the KBS increased the level of difficulty (progression); in case of the included strength training by adding repetitions or weights, and in case of the balance games, by extending the game duration and adding dual tasks. Participants could agree or disagree to increase the difficulty level.

Safety Aspects

For safety reasons the system recommended in the instructions that one or two chairs be used whilst undertaking the exercises. This was the case for every exercise session to ensure that insecure older adults can hold to the chair to feel safe. The Kinect camera was able to distinguish between the moving joints of older adults and the static chair. This recommendation pertained to participants at an early stage, and the option was there to do the exercises without the assistive equipment if they felt more confident after some sessions.

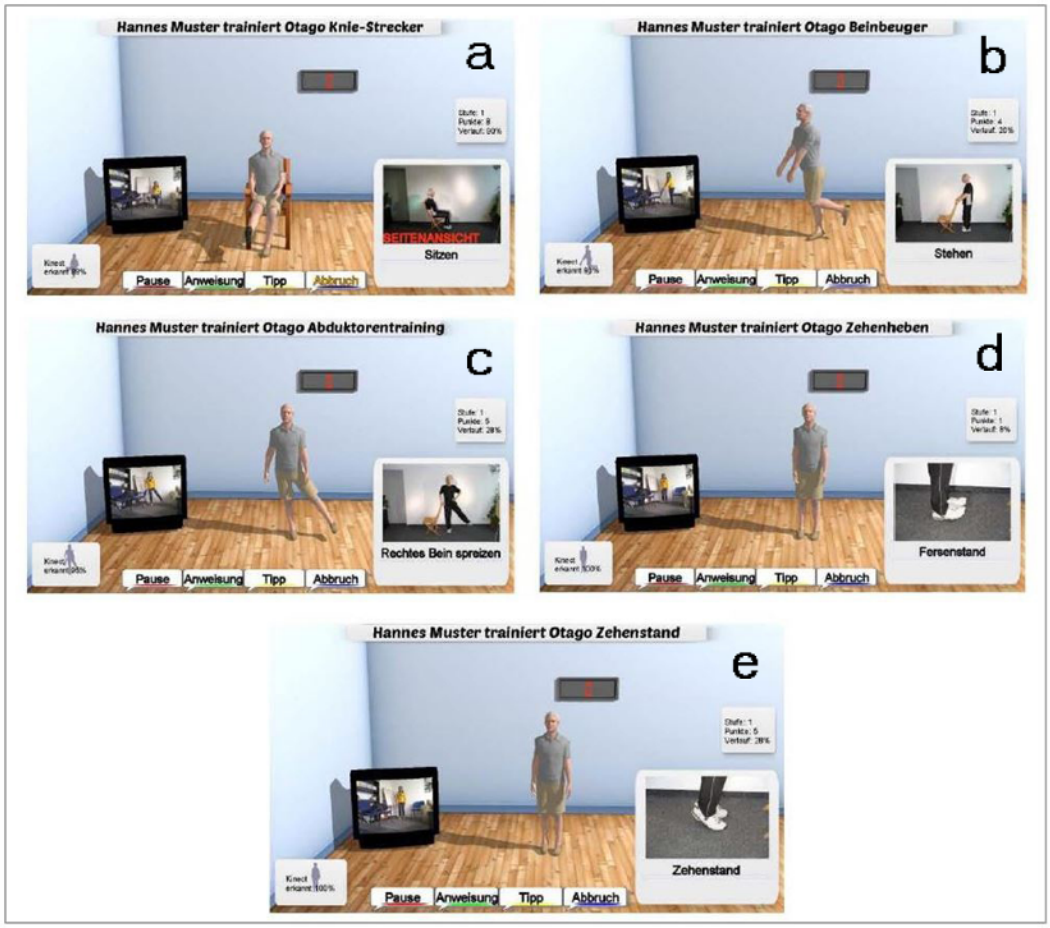

Figure 7: Strength training exercises of the iStoppFalls system:
front knee (a), back knee (b), side hip (c), toe raise (d), calf raise (e).

Physical Training

Exercises from a common fall preventive strength training program (Campbell et al. 1997) and three different exergames focusing on balance with dual tasks are included to provide physical and cognitive training simultaneously. The strength training consisted of various exercises to strengthen lower limbs (Figure 7). After starting the training, a personal training schedule determined individual progression, i.e., the amount of repetitions and weights for the session.

Every balance game had a different priority: older adults had to walk through a park and avoid bees by leaning to the side, ski down a hill and pass gates or perform steps to the side to collect falling ingredients (Figure 8). While doing these elementary game tasks, secondary tasks were additionally presented (e.g., calculating, memorizing, decision speed and inhibition). These extra tasks appeared after the participant had walked or played over a pre-defined distance.

Figure 8: Balance games of the iStoppFalls system to train balance capabilities during stepping (a), bending (b) and leaning (c).

Fall Risk Monitoring

In addition, an integrated fall risk monitoring tool provides older adults the opportunity to track their fall risk continuously over time by means of data about related physical measures (lower leg strength, reaction time for upper and lower limbs and three different balance tests, see Figure 9), together with data about other risk factors like medication, previous falls and fear of falling, collected using a digital questionnaire (Delbaere et al. 2011; Ejupi et al. 2014). The overall computed fall risk score is visualized as a gauge, a visualization which seems to suit the needs of older adults. Each separate component of the fall risk score is explained as well, in order to facilitate a deeper understanding and improve fall related health literacy. The participants can start the fall risk assessment on their own and perform it without help from researchers.

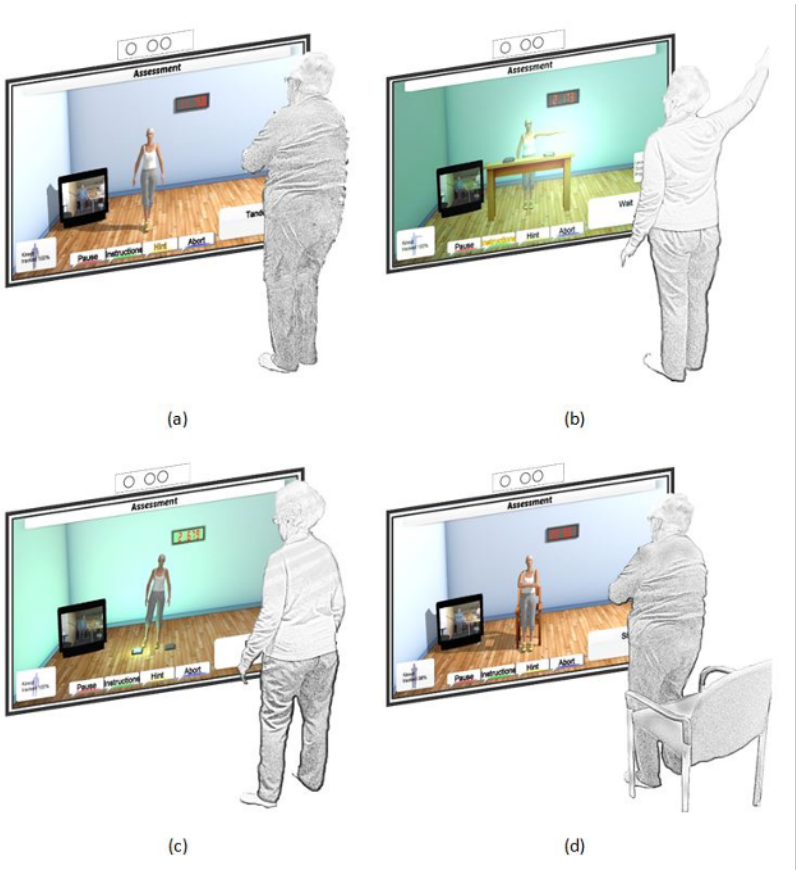

Figure 9: Physical fall risk assessment test of the iStoppFalls system (a: balance test, b: choice arm reaction test, c: choice stepping reaction test, d: sit-to-stand test).

Human Computer Interaction

Different input modalities (gesture and voice control; Android remote, and tablet application) were additionally developed to overcome HCI issues regarding the remote control of the set-top-box (Figure 10). The gesture and voice control used the Microsoft Kinect to track the participants' hands or voice. Recognized gestures or voice commands were sent to the set-top-box application and executed (e.g. "Start training" was a voice command). Participants were advised to train several times during the week (120 minutes in total per week, i.e. 60 minutes of balance games and 60 minutes of strength training respectively), but they could choose which exercise they do and at what time of the day. All results of the risk assessment, strength training and balance games were directly shown to the users in the result screens of the iTV system. Figure 11 provides an overview of different visualizations. Colored smileys were used to estimate training results and graphs to indicate participants' progress.

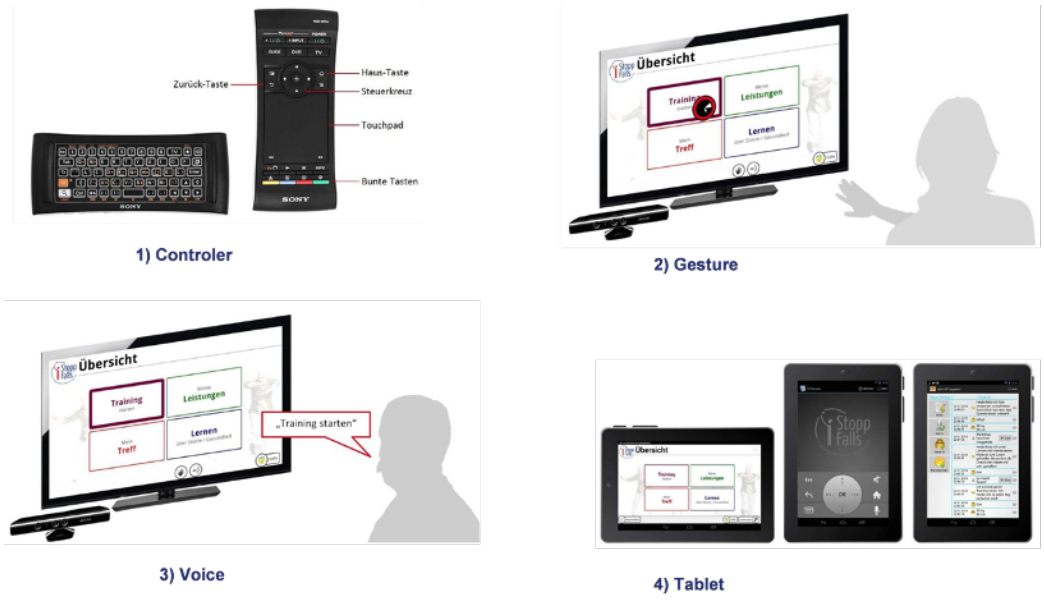

Figure 10: User input modalities of the iStoppFalls system (1: Google TV remote control, 2: gesture control, 3: voice control, 4: tablet PC).

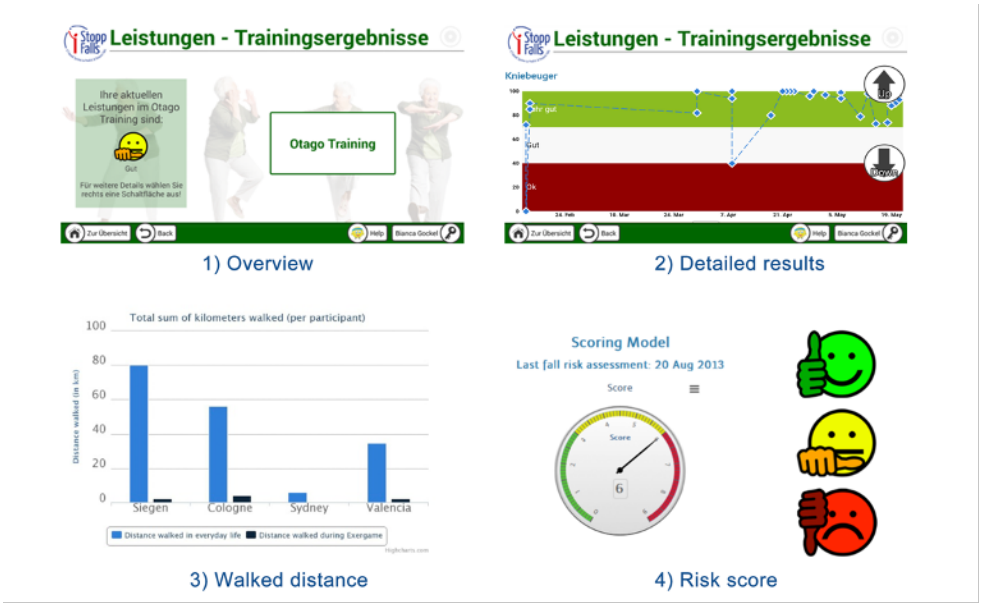

Figure 11: Result screens of the iStoppFalls system (1: result overview of entire strength training, 2: detailed results of one type of strength training, 3: total walk distance grouped by cities, 4: fall risk score).

Senior Mobility Monitor

The Senior Mobility Monitor (SMM) is able to continuously monitor the users' mobility in their daily lives. The SMM is worn on a lanyard (Figure 12). Users were asked to wear the SMM during the day and charge the SMM during the night.

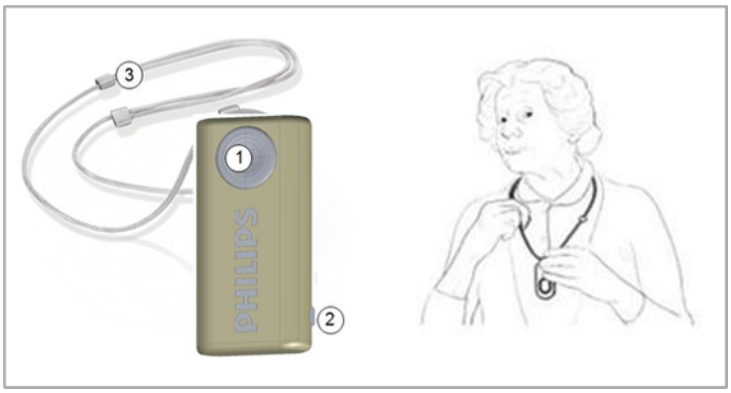

Figure 12: Senior Mobility Monitor (1: SMM Button, 2: USB Plugin, 3: SMM necklace).

During the exercise mode the SMM streams data to the exergame system, which can then be used as part of the fall risk assessment. This way, the SMM provides continuous fall risk and activity monitoring.

Social Media Platform

A social media platform for a closed network of study participants was developed with the intention of strengthening social relationships between older adults. Training results, news, questions and suggestions could be posted to their newsfeed. The newsfeed also allows commenting on these posts. Within the community, participants could meet other users virtually in their surroundings or even across their national borders (from different study centers) and exchange messages about their experiences. For security reasons the platform was hosted at the university, only accessible via our system and strictly separated from sensitive results (e.g. fall risk score and exergame results).

5.4 Methodology

This study was based on previous research in our living lab, conducted around the everyday life of older adults. Our aim was to investigate the integration of an ICT-based preventive exergame into the daily routines of older adults in the long term (six months), to gain a better understanding of appropriation processes, and if and how the exergame affects participant's quality of life and usage behavior in a sustained manner.

5.4.1 Recruiting Requirements

To set up a new user sample for the study, we recruited older adults aged 65 years and older without any major or chronic diseases (e.g. cardiovascular system, cancer and dementia), which could have an influence on participants' physical fitness. Ethical approval was sought and given by the ethical board of the German Sport University Cologne and a physician was asked to confirm participants' aptitude for participation.

We also ask the participants for information about falls experienced during the previous year. Although previous falls were not directly used as inclusion/exclusion criteria, because the ICT-based fall risk prevention system was intended to target all

groups of older adults, we did include both people who had, and had not, experienced falls in that time.

Further minimal requirements were a broadband Internet connection, a high-definition television with HDMI port, at least three meters space in front of the TV, an interest in preventive training (at least three times a week, approximately 120 minutes in total of balance games and strength training together with a monthly fall risk assessment) and the willingness to attend feedback workshops at the university. No financial compensation was offered. Instead, system usage and improvement of fall risk was used as a motivational factor.

5.4.2 Participants

For recruitment, we relied on contacts in local senior organizations, who addressed possible participants directly. We also held presentations at events, organized by local or national senior organizations. In addition to that, we asked friends and colleagues if they knew older adults who would be interested in this topic.

Table 2: Overview of participants of the Siegen living lab (n=12) clustered by influencing parameters.

	Female	**Male**
Participants in total	7	5
Household structure		
Single household	4	2
Two-person household	3	3
Mean age	72 (± 6,08)	73,60 (± 7,06)
Baseline physical condition		
Very good fitness	2	2
Moderate fitness	4	1
Impaired fitness	1	2
Fall risk score		
Before the intervention	0,49	-0,25
Average IT-literacy	4,00 (± 1,88)	3,63 (± 1,66)

Through this opportunity sampling, we recruited 15 participants (9 female, 6 male). During the early phase of the study, three participants dropped out. Two of them (a couple) dropped out right after we installed the system in their home due to personal time restrictions. The other female participant dropped out after one month due to frequent malfunctions of her system. Thus, there were 12 participants who took part over the full term of the study (see Table 2). Six (4 female, 2 male) of the 12 participants lived alone and six (3 female, 3 male) lived together with a spouse. Their age ranged from 65 to 80 years, with a mean age of 72,8 (± 6,57) years. The average IT-literacy of participants was 3,82 (± 1,77), measured on a 6-point Likert scale with

1 being very poor and 6 being very high. We asked participants how they would estimate their personal experience level in regard to exergames and devices similar to the SMM and calculated the average value from that. Another relevant parameter was the baseline physical condition of participants. This parameter ranged from 'very good' fitness, through 'moderate' fitness, to 'impaired' fitness and was subjectively rated by an experienced exercise physiologist.

All participants were located in a local district of Siegen, Germany. This common locality allowed us to guarantee problem-free support during the study. All were socially well-integrated. Most of participants were involved in non-profit organizations, carried out voluntary work and were physically active. With respect to level of education and monthly income (pension), participants broadly represented a typical, if middle-class, sample for this region. To ensure participants' anonymity and confidentiality we make use of pseudonyms.

5.4.3 Study Design and Data Collection

Two official kick-off events, referred to as 'getting to know' workshops in Figure 12, were organized to introduce the research team to participants for the first time and to inform them about the planned study design. Both meetings were held at the university, where a brief overview of the training system was given.

Before we started the six-month intervention, we installed the system in the participants' homes and provided each household with a detailed introduction to the system and the exergame. A baseline assessment of each participant's fall risk was acquired by using the Physiological Profile Assessment (PPA) (Lord et al. 2003) during a first home visit (see Figure 13). The PPA as an independent and generally accepted method consists of five test units (edge contrast sensitivity, reaction time hand, sway test, proprioception and knee extension strength). Fall risk is measured on a scale from -2 (low risk of falling) to +4 (high risk of falling). The PPA was conducted again at the end of the study (PPA II), during the closing event at the university. With this standardized measurement, participants' self-reports and system-based assessment data could be triangulated.

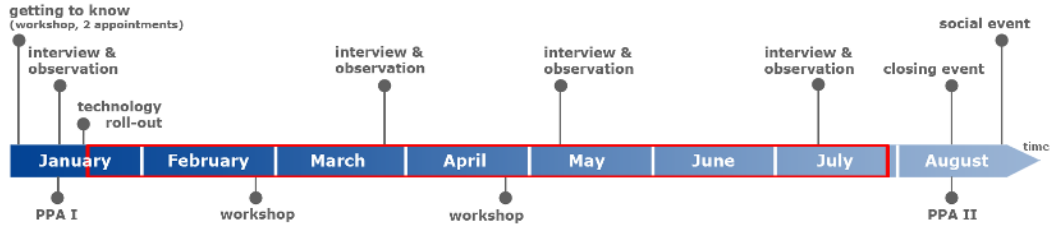

Figure 13: Overview of the study's progression with several interventions within the field.

In addition, over the six-month period, we gained data from four semi-structured interviews with additional observation protocols (before technology was introduced, after 8 weeks, after 14 weeks, after 24 weeks). Interviews lasted between 30 and 90 minutes. The initial interview was used to set up trust relationships, to get to know participants better and to gain insights in their daily routines. We also asked what

participants expected from the study and what motivated them to participate. The second interview focused on usability aspects and the operation of the training system, e.g. experiences with different input modalities and the range of functions. Motivational factors, training routines and system feedback were discussed in the third interview. Finally, the last interview was used to reflect on study progression and to collect data about training experiences, technology acceptance, individual value, and changes in participants' subjective physical assessment over time. We also discussed further long-term usage after the study completed.

Additional observation protocols and notes were gained from two workshops during the study and from the closing event after the study. The first meeting was conceptualized as a question-and-answer workshop. Participants could introduce their problems and we helped by providing useful tips or demonstrating again how to do the exercises. In the second workshop quantitative data from their first three months of training were presented. In order to let participants get a better understanding of their own achievements, we also provided initial data from the RCT, which ran simultaneously and helped to compare performances. Moreover, participants had the opportunity to discuss their training and technical experiences with others. During the closing event the analysis of qualitative and quantitative data regarding frequency of training and changes in the assessment results from the living lab in Siegen were discussed with them.

All data were supplemented by notes with individual experiences and observations from home visits, the social event and regular exchanges with participants via email, instant messaging and phone as well as by logging data of system usage.

5.4.4 Data Analysis

Empirical data was collected and analyzed from 35 interview transcripts and three protocols, one from each of the two workshops and one from the closing event. The data was triangulated with additional observation notes and quantified data of system usage and fall risk results (PPA). All examples used here were translated into English. Quantitative data was only used in a descriptive manner, as our sample size in this qualitative study was insufficient and not designed for statistical analysis. It was mainly used to confirm coded excerpts or to expose conflicts in participants' statements. Regarding system usage data, the exergame data sets were cleaned for later analysis. Only sets with a starting and ending event time stamp were used and the audio/video instruction times as well as explanations of exercises were excluded. Outliers were removed, such as exercise sessions with atypical play period that emerged when users left the system while the exergame was still running or furniture was detected by the Kinect camera.

For the analysis of the predominantly qualitative data we applied a content analytic approach (Mayring 2000), at least insofar as we derived first code categories from the interview guides and evolved them by an open inductive coding process based on the overall material (Corbin and Strauss 2008). Reliability, or in our preferred term, 'trustworthiness' (see Lincoln and Guba (1985)) was enhanced through a process of multiple coding (see Shenton (2004)). In the first instance, two members of the project team coded each document separately to identify relevant passages and codes.

Subsequently, code categories and notes were merged through a process of joint analysis, involving the project team and three additional researchers. In this way, inter-subjective trustworthiness and conceptual consistency of the analyzed data was achieved. Reflecting the longitudinal nature of the study, this joint coding process took place at regular intervals. As a consequence, the coding scheme evolved until the point of "saturation" was reached. This, in grounded theoretical parlance, is the point at which a sufficient and parsimonious number of identified categories prove valid (Corbin and Strauss 2008).

For the purposes of the analysis we describe here, however, we focus on the appropriation of the system, changes in users' behavior and challenges and problems that arose during the study. With regard to these three aspects we generated eight code categories with 147 interview sub-codes in total. These eight categories were context of use; type and frequency of system usage; training; problems in system use; general feedback about the overall system; sustainable effects; conscious and unconscious changes; and project process.

In a final stage, we reduced the number of categories again to five. The *use of the system* comprises code excerpts from the category 'type and frequency of system usage'. *Exergaming habits* contain sub-codes of the codes 'general feedback about the overall system', 'context of use' and 'problems in system use'. *Self-monitoring* and *fall risk control* were derived from sub-codes of 'training' and *sustainable effects* comprises the code categories' sustainable effects' as well as 'conscious and unconscious changes'. The category, 'project process', provides data concerning how participants saw the project as it unfolded.

5.5 Findings

In the following we present findings in relation to these categories, which describe the attitudes and practices of older adults using the ICT-based fall prevention tool with continuous fall risk monitoring.

5.5.1 Use of the System

Adherence to exercise and the use of the system over the six-month period of the study was good but very diverse. Figure 14 visualizes the exergame usage data collected during the study. Based on that data and the usage of the Senior Mobility Monitor (SMM), three relevant user groups could be identified; an inactive, an active and a very active group. However, none of the participants reached the recommended training schedule of 120 minutes per week. Mean exergame frequency and duration for every played exercise session (strength training sets, balance game levels and risk assessments) were 11,65 (± 0,59) times and 21,59 (± 15,08) minutes per week and person respectively. Total kilometers walked per person as measured by the SMM were 445,84 (± 309,65) km in six months, equaling a mean value of 2,65 (± 1,84) km per participant and day.

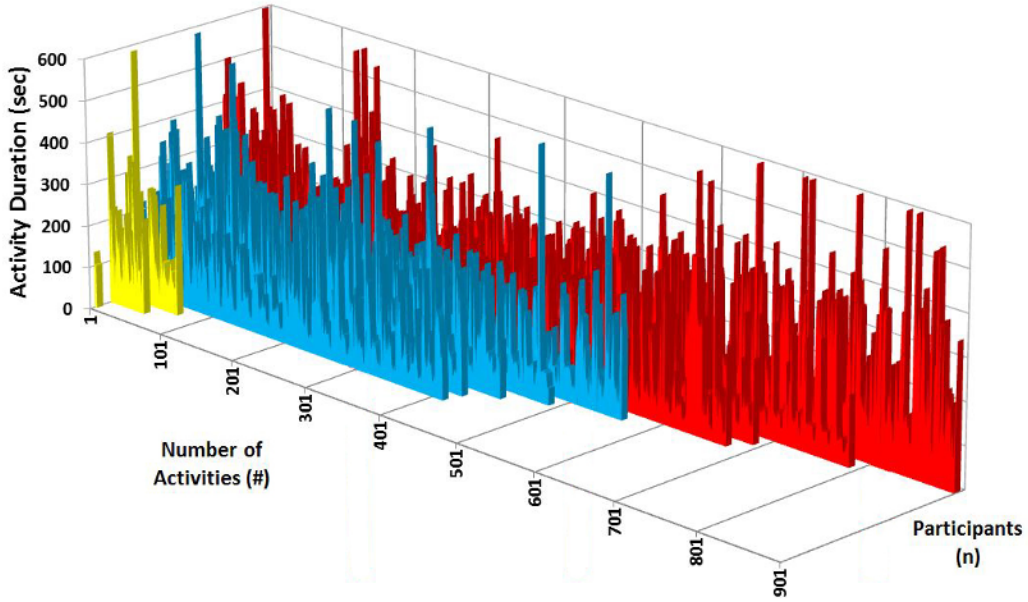

Figure 14: Overall system use per participant (n=12) over six months: Exergames (number of activities and their respective duration (every single peak shows a single set of strength training or a balance game level or a fall risk assessment activity). Colors represent the different system usage groups: very active (red), active (blue) and inactive users (yellow).

The quantitative data analysis of the system use revealed interesting results with regard to exergame and SMM usage. Table 3 illustrates comparisons of balance games, strength training, fall risk assessment and SMM data with respect to the three activity user groups in Figure 14 as well as gender, age and baseline fall risk (split by mean value of user sample). All data in the table are 'cleaned' data and refer to mean values per week and person.

Table 3: Comparison of subgroup characteristics for activity level, gender (male/female), age (±73 years) and baseline fall risk (mean score = 0,18). All data are expressed as mean values per person and week.

Subgroups	Activity			Gender		Age		Baseline fall risk	
	Very active (n=4)	Active (n=5)	Inactive (n=3)	Male (n=5)	Female (n=7)	Mean Age <73 (n=6)	Mean Age >73 (n=6)	Mean < 0,18 (n=6)	Mean > 0,18 (n=6)
(excl. Instructions and outliers)									
Overall number of activities	127,79	97,91	5,29	81,04	149,75	138,96	91,83	145,46	85,33
Balance duration (min.)	10,62	8,59	0,59	4,97	8,9	9,06	5,47	7,89	6,64
Strength duration (min.)	21,82	12,44	0,88	12,32	14,69	17,07	11,13	16,55	8,8
Assessment duration (min.)	2,92	1,47	0,24	1,34	1,86	1,37	1,92	2,14	1,15
Total exergame duration (min)	35,36	22,50	1,71	18,63	25,45	27,50	18,52	26,58	16,59
Cleaned SMM data									
Total distance walked (km)	18,83	22,38	11,89	14,83	21,25	19,60	17,55	14,31	22,84
Wearing time (h)	44,29	39,63	26,39	35,79	39,36	40,70	41,72	32,99	42,76
Total sit to stand number (#)	70,44	63,67	36,26	58,74	59,31	65,11	63,70	55,35	62,8
Fall risk score (PPA)									
Baseline assessment	-0,53	0,68	0,29	-0,25	0,49	0,11	0,28	-0,5	0,86
Final assessment	0,52	-0,03	-0,27	0,17	0,04	0,04	0,17	0,35	-0,16

Table 3 shows that very active and active participants (as initially categorized) used the system more frequently compared to inactive users, who barely used it (Overall number of activities in Table 3). The overall number of activities measures the sum of completed balance games, strength training or assessments within one week. The situation was similar concerning the duration of balance games, strength training and fall risk assessment. In terms of SMM usage, however, the discrepancies between the activity groups were noticeably reduced. While very active and active participants applied the SMM for lengthy periods of time, inactive participants also used the SMM noticeably more than they used the balance games, strength training and fall risk assessments.

In our sample of 12 participants, females used the balance games, strength training and fall risk assessment more frequently than male participants. In terms of SMM, female participants wore the device roughly four hours longer during a week. Female participants also covered more distance within a week than their male counterparts. With respect to the sit to stand transfers, male and female participants achieved almost identical results per week.

Regarding the age subgroups, participants who were younger than the mean age (±73 years) used the balance games and strength training considerably longer than participants who were older than the mean age. In terms of using the fall risk assessment younger and older participants spent roughly the same amount of time using it. Older participants wore the SMM slightly longer. However, younger participants performed a higher number of sit to stand transfers and covered more distance per week.

In terms of baseline fall risk, the results of our sample illustrate that the application of balance games and assessments were very similar for participants with high and low baseline fall risk. Participants with low baseline fall risk undertook strength training for a considerably longer period, compared to participants with a high baseline fall risk. Regarding the usage of the SMM, participants with a high baseline fall risk wore the device longer, covered more distance and performed more sit-to-stand transfers.

Some technical problems at the beginning of the study (during the first month) had a negative impact on system usage. In some cases, it resulted in annoyance and demotivation. As one participant stated: *"In the beginning there were situations (...) I could have thrown the computer against the wall (...) but then, after new software was uploaded, it worked much better, and I enjoyed playing the games again."* (Mrs. Smith, 65). Most of these issues were resolved in the course of time and the system ran much more stably from the second month onwards. Following this, user satisfaction increased and participants even developed their own workarounds to deal with smaller technical problems on their own. Other participants, when they encountered problems, with advice and support, were usually able to resolve difficulties without too much trouble. After initial difficulties, nearly all participants used the system according to the intended aims without major technical problems. One exception here was the social media platform, which was barely used by the participants. Only a few participants posted exercise and game results frequently or got in touch with the research team regarding issues with the system.

When the study came to its end all participants, except some of the inactive older adults, expressed interest in extending the use of the system after the six-month training period: *"Yes, I would appreciate this. It would be nice to have this opportunity. (...) We're all eager to know how it unfolds, and under what conditions we can keep it."* (Mr. Carter, 79).

5.5.2 Exergaming Habits

Activity Levels

With respect to exergaming habits of, and daily activity by, the participating older adults, at least three types of users could be identified: very active older adults (with a high frequency of strength training and balance games, SMM usage), active older adults (with moderate frequency of strength training or balance gaming and SMM usage) and inactive older adults (seldom using strength training or balance games, SMM usage only). The three 'activity groups' are marked by colors in Figure 8, showing the number of exergame activities of all participants during the study. Naturally, this does not include all the other indoor and outdoor exercise of the participants, which were partly measured by the SMM (e.g. walking or other physical training). Moreover, it did not include exercises like swimming or cycling which could not be measured at all.

Very active older adults exercised more often than the training schedule requested. They exercised almost every day of the week and easily integrated the use of the system into their daily routines. In addition, they increased their overall physical activity during the day as demonstrated by the SMM data. Results from interviews and data from system use showed that after a period of time, those older adults even 'missed' their daily training activities if vacation trips or other priorities, for example, interfered. As Ms. Miller (74) explained: "I went on vacation and I didn't think I would care, but I have to say, I missed it in the morning. I really missed it, just jumping around a bit (…). I had other things to do, but I thought, man, now just 15 minutes or so would be good".

Active older adults exercised approximately three times per week but also did not reach the optimum 120 minutes of exercise every week in total. Some of those participants, who had been more or less inactive before, increased their exercise and overall activity level during the study.

The inactive older adults used the SMM the least, despite the fact that they didn't use the exergame. The main reasons that we could identify during interviews and observations were 1) a low IT-literacy, 2) technical problems and 3) an inactive lifestyle. The handling and use of the SMM was described as much easier, and thus those participants preferred to use the SMM alone.

Integration into Daily Routines

Integrating exercise sessions into daily routines is essential for a successful prevention effect. Exercise sessions were not restricted to a specific time slot. Participating older adults decided on their own when they wanted to exercise and without having to leave the home (see Figure 15). Nearly half of the participants exercised right after breakfast,

the other half in the late afternoon. Once they had integrated it in their routines, they tended to repeat it at the same time.

The active and very active older adults, in particular, had no problems finding an appropriate slot during their day. Moreover, other exercises, which were normally done at the same time in their daily routine, were partly or entirely substituted with the use of the system. Almost all participants made us aware of the need for exercises for the upper body as well, in order to avoid a physical imbalance: “I would like to see more exercises for future improvements. I’m not only thinking about legs and feet, but also about the shoulders, arms and neck.” (Ms. Wilson, 79).

Figure 15: Older adult (73 years) using the exergame at home. © Senioren Ratgeber/Bert Bostelmann

User Preferences

Participants distinguished between balance games and strength training. While the balance games were seen primarily as a warm-up, the strength training was executed much more frequently and had a real impact on their condition: “(they) force you to reach your limit” (Mr. Brown, 80). The first levels of the exercises were described as "very comfortable" (Ms. Jackson, 73) and for some they were even "boring" (Ms. Miller, 74), but with higher levels and further progression, the intension and motivation increased: "I have to admit, I started to sweat like hell. I didn't expect this, I even needed a headband." (Ms. Bennett, 65).

At the beginning of the study the balance games were played relatively infrequently. Participants played them for the most part for their entertainment value, with no real acknowledgement of possible impact on their wellbeing. They tended to hold the opinion that "training must hurt" (Ms. Jackson, 73) otherwise it would not be effective. We had to encourage our participants to do the balance games before and after strength training. After they had reached higher levels, even the less exhausting balance games became more challenging, as when participants needed to count or calculate and exercise at the same time.

The combination of cognitive tasks and physical exercises was perceived positively. Ms. Jackson (73) explained it as follows: *“the brain needs training as well”*. Participants preferred balance games that required them to concentrate and to exercise at the same time, e.g. the ski slalom game, where one has to ski down the hill and pass through gates: *"Ski Slalom is my favorite game, it is very challenging. The other ones are too easy. (...) you have to ski elegantly through the gates, but sometimes I missed the gates even if I tried very hard."* (Mr. Martin, 77). Nevertheless, a need for new games was expressed during the study: *"Maybe we can have another game to train your reaction time, this is also very important"* (Mrs. Jackson, 73) and *"we could have more variety, different games and maybe more strength exercises, so they can change every time"* (Mr. Martin, 77).

5.5.3 Self-Monitoring

For most of the participants, the opportunity to track one's training performance and activity level on a regular basis was seen to be a crucial function of the system: *"By tracing the results, one can see that one's personal performance actually improved. I like that!"* (Ms. Miller, 74). However, the incentive for self-monitoring and controlling personal activity varied among the participants.

Very active older adults were usually well aware of their high personal fitness level: *“I just don’t feel like a grandmother - I still outrun all of them!”* and sometimes strove for competition: *“I am a competitive sportswoman, across the board, in all areas. That is inherent and you cannot change that in me. This is related to ambition and honor; to a competitive spirit. (...) when I don't make a target - most people would surrender. But as in sports - never surrender if you want to achieve something.”* (Ms. Bennett, 65). Some were concerned with the site’s results: *"I really like to compete and my main interest is in Siegen’s position in the performance chart [in relation to other sites]. I would go for another walk and put my device (SMM) on [to affect ranking]."* (Ms. Bennett, 65). Others were primarily concerned with their individual personal results; *"I like to see myself improve. If I check the results and realize that I did not perform too well the other day, I get motivated to improve myself. That is what the system is for, isn't it?"* (Ms. Miller, 74).

In comparison to the *very active older adults*, the group of *active older adults*, focused mainly on their personal health (development) rather than on competition, as one participant explained: *"When I check my performance and see the graph is at a particular level, I am satisfied."* (Mrs. Jackson, 73).

The three *inactive older adults* however valued the opportunity to track their activity level via the SMM device, which was more likely to be integrated into their daily routines. Regarding the use of the exergames, statements by some participants were somewhat problematized by the system’s use statistics. One participant stated, for instance, that it was enjoyable to train and play the games, but the system use record showed that there was no such use of the exergames. He nevertheless had a high outdoor activity level and walked several kilometers every day, which was tracked by the SMM. During the interview it became clear that after the system was installed and demonstrated at the participant’s home, he did not use it and do further exercises, because he could not isolate for us when he did the exercises and which levels he

passed. In this context the value of triangulating subjective judgments with objective system use data was evident.

5.5.4 Fall Risk Control

The fall risk of all participants was measured at baseline and post intervention with the PPA. With one exception, all participants had a 'normal' fall risk at the beginning. Overall, all of the 12 participants gained an increased awareness of their health, fitness and fall risk issues. In particular, *"the exercises noticeably increased my fall risk awareness. I take increased care now when walking down the concrete stairs, for instance."* (Mrs. Jackson, 73). Nearly all participants reported (subjectively) that their fall risk was decreased and that they felt more confident and safer during physical activity indoors and outdoors: *"I am more careful now, definitely. I always look at the floor now, which I never used to do before."* (Ms. Bennett, 65).

Nevertheless, the pre-/post comparison of fall risk as measured by the PPA revealed that this was not true in all cases. It is probably not especially surprising that inactive and active older adults benefited most from the intervention in terms of a reduced fall risk. Both groups were able to reduce their fall risk the most: inactive participants from 0.29 to -0.27 and active participants from 0.68 to -0.03. Very active participants were not able to improve their fall risk by using the system (from -0.53 to 0.52), and actually showed some deterioration. The following figure 11 illustrates how to interpret the PPA scores: the lower/negative the value is, the better participants fall risk is and vice versa.

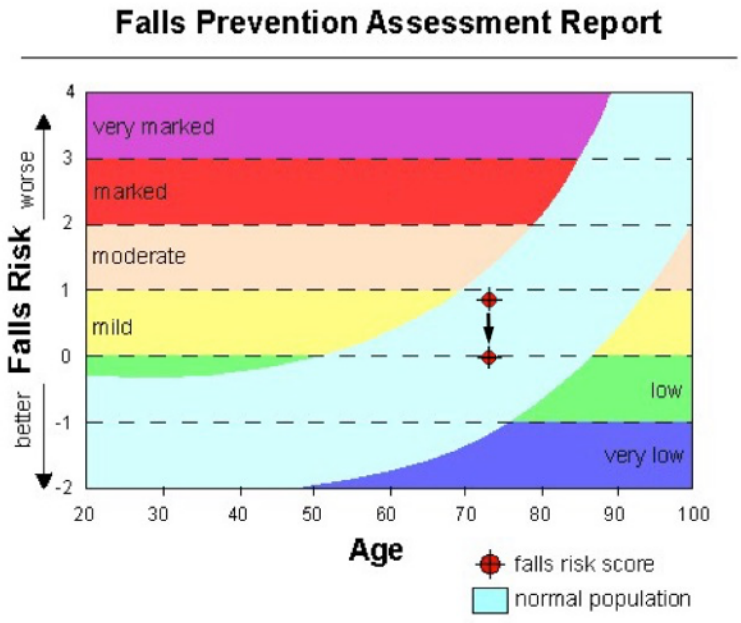

Figure 16: Mean fall risk reduction (PPA score) for participants with a high baseline fall risk of the living lab study (n=6). Visualized by NeuRA FallScreen® The Falls Risk Calculator.

Our data also revealed different intervention effects depending on the participants' gender, age and baseline fall risk. In terms of gender, the 7 female participants were able to improve their fall risk from 0.49 to 0.04 (see Table 3), while the 5 male

participants were not able to improve fall risk (from -0.25 to 0.17). In respect to participants' age, younger participants (<73 years) were able to slightly improve their fall risk from 0.11 to 0.04, like the older participants (> 73 years) who also slightly improved from 0.28 to 0.17. Regarding baseline fall risk, the results in table 2 and figure 11 illustrate that participants with a high baseline fall risk improved their fall risk during the study period (from 0.86 to -0.16), while participants with a low baseline fall risk deteriorated in fall risk (from -0.5 to 0.35).

It became clear that the newly developed fall risk test in the training system was performed quite often (9,38 (± 7,17) times per user, over the entire period of six months). This was more than the scheduled number asked for by the researchers (one time per month) and may be based on the 'fun' of doing these MS Kinect based tests: *"What I very much enjoy doing (...) is the reaction time training with the lamp."* (Mrs. Jackson, 73).

A positive effect of having the opportunity to monitor their own fall risk continuously with the integrated risk assessment tool was reported by most of the participants: "*Yes, assessing the fall risk is great. I think it's really great. – What's so good about it? Well, everything. The reaction test with the hand, the feet. Standing up from the chair. Yes, I enjoy that."* (Ms. Miller, 74). Participants were very interested to see changes in their own fall risk measurements and thus to get feedback as to whether their training and activities had been beneficial. It motivated them doing new exercise sessions and adjusted individual goals, and it was an important issue for the older adults: *"I know that my fall-risk stayed roughly the same. I've done it three times and three times I got 2,0. I'm actually pleased with that."* (Mr. Smith, 65). Even some of the single risk factors of the overall fall risk score were monitored by participants and served as a motivational factor to intensify awareness and training for this specific risk factor (e.g. balance) as Ms. Bennett (65) explained: *"My personal goal had to do with balance. Because this is where I have my problems."*

5.5.5 Sustainable Effects

Technology Access

The first impression for most participants was that the system required a significant overhead in terms of hardware installation, and a number of unfamiliar devices and controlling methods had to be learned. Over the project's course, even participants who expressed a personal dislike of new technology reported that they had gained insights and confidence in dealing with unfamiliar devices over time: "You always learn something, so I've found. (…) all the technical things, the remote control, the tablet PC - and now I've got a new smart phone! (…) This all helped me a lot, in terms of understanding such devices, definitely." (Ms. Miller, 74). Another participant explained: "I got a lot more confident! The telephone support helped me a lot to lose my worries about the devices. I did it all myself! I would never have dared to click any of the settings buttons before! NEVER." (Ms. Bennett, 65).

Improvement of Strength and Balance

Each of the nine active and very active older adults in our sample linked the periodic training activities to an increase in strength and balance. "One would not believe the

effects from doing it (toe/calf raise). I think these exercises are really helpful, especially for older adults who do not move much. (…) Old people have a low activity level and they stick to their regular movements. What you don't like, you don't do." (Mr. Carter, 79). Another participant mentioned an improvement of her vertigo: "I noticed it is in fact helping a lot with my vertigo (…) it is gone, completely gone! I stood on a ladder recently fixing a lamp. I had not been on a ladder for like two or three years. I suppose due to the exercises." (Ms. Bennett, 65). The less active group did not report a noticeable benefit to their personal strength and balance but spoke generously of the benefits of monitoring one's activity level: "This is really interesting, how many calories were burnt and how many kilometers were made. The SMM is not bad, as a kilometer counting device." (Mr. Moore, 67).

Transferring Exercises into Daily Routines

Some participants, suffering from weak balance, report that exercises such as the tandem stand noticeably helped them to improve their balance. As a result, they even started to incorporate these exercises into their everyday practices, for instance 'toe raises' while doing the dishes: "And the toe raise thing, you can easily do it without the instructions and on any occasion. And you do recognize the effect, immediately." (Mr. Carter, 79).

Improvement of Quality of Life and Self-Efficacy

In general, engaging with the training system was rated as having a positive impact on the participant's wellbeing and self-esteem: "I have a very positive sense of life. My credo is: I can't prevent getting older, but I can at least make sure that it can be fun!" (Ms. Miller, 74). Using the system and being part of the study also helped the participants to become aware of their fears. "The fear of falling I had since my accident, I sort of relieved that by talking to the other participants and realizing I am not the only one with that fear." (Ms. Bennett, 65). One participant described the mental benefits of the training. She recognized that her concentration improved. As she explained: "It [the training system] did not only raise my fitness level but also trained my brain! Now I look to see where I can find a handhold in difficult situations." (Mrs. Jackson, 73). Another unexpected finding was reported in that, by using the training system on a regular basis, the incontinence problems of one participant completely disappeared. Her judgment was that she was considerably freer in her movements. A third participant reported a subjectively improvement of the blood flow in his legs. As a result, their subjective feeling of general well-being and QoL improved.

Increased Activity and Social Engagement

Over the course of the training period, awareness regarding the importance of physical activities and mental health, led to increased overall activity by the participants. Statements, especially by active and inactive older adults, indicate at least a shift in their attitudes and social engagement: "All I know is that since I'm doing the exercises, I am much more aware of how important these bodily activities are, especially as an older adult - activity and mobility are of pivotal importance!" (Mr. Carter, 79).

During two workshops, which were held at the university and where participants had the opportunity to ask questions, gain technical or practical training support and

exchange experiences with others, one female participant expressed for instance her positive impressions regarding social engagement: "I think the meetings (workshops at the university) are very important because you get together a bit. Get to know each other. Meetings and exchange are important." (Ms. Bennett, 65). The system tries to address this issue by providing an integrated social media platform, but it tended only to be used after face-to-face meetings. Given our relatively small sample and the fact that participants were in any case socially active, this feature was not regularly used. Based on participants' individual views, virtual communication via such a platform did not seem to substitute for physical meetings and communication in an adequate manner.

In addition, and to address the need of physical meetings, the idea of a combined in-home and a less frequent, but regular, group class training in a gym evolved within workshop discussions. Physical spaces for social exchange seem a promising motivational factor as Mr. Scott (77) stated: *"I think, it is helpful if you are a member of a training class. This is more pleasant than if you only do all the exercises every time on your own."*

5.6 Discussion

Our study presents a range of attributes in different older adults and their lifestyle practices. The sample consisted of older and younger, fit and unfit, tech-savvy and inexperienced, sporty and sedentary community-dwelling older adults. The sample also included a retired couple and older adults with different health and age-related impairments, but without any major acute or severe diseases. Thus, our qualitative study provides results from a fairly heterogeneous user group. As we have suggested, the point of our methodological choices was to identify benefits and possible consequences for the users engaging with our exergame system over an extended period of six months. For this, we gained qualitative context-based data and valuable insights on how such an ICT-based training system was integrated in daily routines and the everyday life of older adults. In relation to unsupervised tests for fall risk at home, our users were able to collect more frequent and detailed insights into their fall risk than with the 'one shot' results associated with typical standard tests for fall risk assessment. In fact, we also collected data from such tests, and thus the more reflective qualitative data of our living lab approach provided a means to mix the different data sources in respect of a more detailed interpretation.

5.6.1 Exercises and Games plus SMM

Overall Adherence and Uptake

Long-term usage is necessary to achieve sustainable effects for exergaming systems and fall prevention (Sherrington et al. 2008; Gillespie et al. 2012). Comparable studies achieved meaningful results in exergaming after three months (Schoene et al. 2013; Uzor et al. 2014; Gerling et al. 2015). However, sustainable effects require a longer study duration comprising at least 48 hours of exercise (Sherrington et al. 2008). Therefore, we extended the study duration to six months with 120 minutes of fall preventive exercise per week as an ideal, in order to gain sustainable results.

In our study not all participants used the training system on a regular basis over a period of six months. Most participants in the group of active and very active older adults used the system on a regular basis but not in the group of inactive older adults. Although the pre-planned exercise ambition of 120 minutes per week was not reached in our study (see Table 3), most of the older adult participants had a high frequency of exergame activities over the entire period of 6 months but did not manage a high duration in the single sessions (see Figure 14). This might have been due to the exergame design (short sets of strength training and balance games levels) but also might have been based on the fact that our duration data has been cleaned for instruction time and other factors, resulting in "pure exercise time" which certainly was not considered in the underlying literature (Sherrington et al. 2008; Gillespie et al. 2012). This outcome corresponds more to the findings of Uzor et al. (2014) that adherence and acceptance of fall prevention exercises may be enhanced by using exergames.

According to the principles of persuasive health (Merleau-Ponty 2002), most of our participating older adults were 'nudged' to deal with falls and associated issues of prevention, self-monitoring and risk assessment. Based on the interview data, all of the active and very active older adults acquired an improved health literacy as described by Sørensen et al. (2012) relating to falls, fall risk and associated prevention issues. Even the inactive older adults claimed for themselves an increased awareness, and interest in this issue and recognized the need to be more active in their life.

Based on our qualitative analysis, we further saw within the workshops together with our participants that the combination of a home-based exergame and SMM together with a weekly physical group training class might fit the needs and preferences of community-dwelling older adults. Participants were interested in meeting with others to exchange problems, share experiences and gain support and felt that such interactions raised awareness about falls and the necessity for preventive interventions. This outcome of our research is in line with the findings of Yardley et al. (2008) and Gerling et al. (2015), and reflects the need for sustainable training boosted by the social effects of weekly personal meetings.

Baseline Physical Fitness and Fall Risk

On the health level, the intervention's impact was clearly linked to the participants' initial physical condition, i.e. fitness level and fall risk at baseline before using the training system. In particular, for users with a high physical activity level and a low baseline fall risk prior to the study, their fall risk did not improve significantly after the intervention. This may be attributed to their general activity level being already very high prior to their engagement in the study and thus, for reasons of time allocation, they had to substitute some of their usual daily life exercise activities for exergame activities with the ICT system, which may have been less challenging for participants with low baseline fall risk due to suboptimal flow conditions and physical stimulus (Csikszentmihalyi 1996). Conversely, those participants with a low baseline activity level and a high baseline fall risk gained the most positive impact on their fitness level and fall risk by performing the ICT based exercises and also by transferring some of the new preventive activities to their daily routines. This indicates that those participants with a low activity level and high fall risk, i.e. those who have a much

higher need for fall prevention activities, benefited most from the system use. A possible explanation for this might be that rather active older adults with a low baseline fall risk and fitness require stronger physical activity stimuli to improve in fall risk and fitness rather than inactive older adults. Therefore, it seems that the iStoppFalls training program did not provide enough stimuli for active old adults to improve in fall risk and fitness but was fully sufficient to achieve this in those participants with a higher fall risk and thus more need of fall prevention activities.

Gender and Age Aspects

Our findings revealed some interesting gender differences. Based on qualitative interviews, female participants of our sample seemed to be more successful in integrating strength training and balance games in their daily routines and activities. They also were more active in playing balance games than male participants, as our quantitative data showed. Compared to balance games and fall risk assessment in women, men focused on strength training the most. Regarding the use of the SMM, female participants wore the device longer and covered more distance than their male counterparts. Regarding sit-to-stand transfers, both groups achieved very similar values. The gained quantitative data as shown in table 2 (section 5.1 Use of the System), illustrates that female participants slightly improved their fall risk (from 0.35 to 0.04), while male participants deteriorated (from -0.25 to 0.17). This gender difference might be explained by the fact that in our study female participants spent more time with the system compared to male participants. Further study might indicate whether our findings are replicated on a wider basis.

Regarding age differences, our results in Table 3 suggest that age does not seem to affect fall risk improvement in a sustained way. Fall risk improved only slightly for both groups. However, age seems to influence the use of the system, as the young older adults used the iStoppFalls system more frequently, and for longer, than the old older adults did (Table 3). We might tentatively explain this effect with regard to IT-literacy, which tends to correlate negatively with age (Eshet-Alkalai and Chajut 2010).

Further, we may assume that the combination of the exergame with its strength training, balance games, the fall risk assessment and the wearable SMM are effective in improving fall risk for those older adults with higher baseline fall risk (see Table 3). However, the data of our limited user sample does not allow for overly general statements, but provides at least pointers regarding the reasons for system intervention efficacy (or otherwise) that can be triangulated over time with more quantitative studies, like the iStoppFalls randomized controlled trial (RCT) did with a larger study population (Gschwind et al. 2015).

5.6.2 Fall Risk Assessment and Self-Monitoring

Giving older adults the ability to monitor their risk of falling continuously provided benefits for the participants in our study and also for researchers and designers. While the monitoring aspect seems to motivate participants to increase their physical activity, for example by going for a walk or doing the exergames more frequently, researchers and designers were able to derive implications for design from long-term user practices in daily life. Here, we argue, that health care systems generally may benefit from such

serious game development in the future when the more tech-savvy baby-boomer generation will become older and the associated demographic demand, burden and costs become more substantial.

The iStoppFalls training system is a unique solution in this field of research. It provides older adults with the possibility of improving and self-monitoring their fall risk in their everyday life. Other research has oriented to persuasive health tools but has not often been directed towards self-monitoring tools. Research such as that of Uzor et al. (2014) or Schoene et al. (2013) provided valuable results. However, their focus was not on a continuous fall risk monitor as a feature to be used by the older adults themselves. This feature was judged as important by the older adults in our sample, especially in the light of the sometimes misleading results of 'single shot' fall risk assessments. For our sample, we illustrated a fall risk improvement only for specific sub-groups of older adults. Considering the small size of our sample the statistic validity of the results is debatable because we focused more on the qualitative aspects of the ICT-based intervention. However, the RCT of the iStoppFalls project provided validated quantitative results in a larger user sample that the use of the system could significantly reduce the fall risk of the older adults as compared to a control group (Gschwind and Eichberg *et al.* 2015).

5.6.3 Improving Quality of Life

A positive impact on the users' perceived QoL was attributed to the exercises. The opportunity to monitor and track one's results, including assessing the current fall risk on a regular basis, helped to create a new confidence in the older adults, especially with regard to participating in physical activities. Other side effects, such as learning how to utilize new technology, supporting their social activities and their self-efficacy, were evident. Moreover, several participants registered health improvements, which were subjectively described as a feeling of conscious change; mostly pertaining to strength and balance but also with regard to other age-related bodily impairments, such as incontinence or blood flow to the legs. By implication, these bodily improvements also positively affect the users' psychological condition. In accordance with Merleau-Ponty's (2002) phenomenological perspective, noticeable embodiment effects confirm users in their preventative activities and motivate users again to continue with training activities, leading to a more sustainable degree of prevention.

5.6.4 Benefits of Long-Term Investigations in Real Life Environments

Due to our long-term investigations in the living lab, further positive effects from engaging with the iStoppFalls system became apparent at various levels.

Although some participants expressed their reservations about the training system in the beginning of the study (e.g. with regard to technical errors, amount of required technical devices etc.), at later stages and possibly due to their close and regular contact with the project staff, they became more experienced, and more confident. Especially at the beginning, the observable behavior of older adults were in line with Mitzner's et al. (2010) argument that the difference between older and younger users was not in

their actual knowledge about computer use but rather in levels of confidence associated with the tendency of older adults to underestimate their knowledge and abilities.

Over time, long-term engagement with an ICT-system seemed to make them technically more confident and tolerant of system behavior in so far that they became more accepting of problems with the system. The long-term nature of the study meant that they were able to recognize the limitations of early-stage prototypes and effectively accepted a personal role as co-developers (testers) of the system. Participants' awareness about preventive measures and their associated sense of their changing physical state evidently evolves over time. Insights and data of this quality and extent can only be gathered through long-term investigations in context of participants' everyday lives, and a living lab as methodological framework provides a promising and helpful methodological resource in this regard.

5.6.5 Limitations of the Study

We had to deal with different methodological issues when researching and working with older adults in this study. During the recruitment phase we had problems finding participants who fulfilled threshold physical and health requirements. Decisions of the ethical board about inclusion/exclusion criteria served to protect the individual in terms of safety, but they posed problems for researchers in terms of sampling. Only participants with a relatively good physical and cognitive status could participate, and we do not know how people with very high physical or cognitive frailty or even patients with several diseases might have fared with this regime.

Despite the heterogeneous group of older adults which was finally selected, it has to be noted that the results of this study should not be rashly generalized to the general population of older adults. Because of the low sample size of the study, all statistics and quantitative results are only descriptive and do not aim for any statistical significance. Also no control group (without ICT-based interventions) was included in the study and the analysis. For more detailed quantitative results of the iStoppFalls project, the reader should refer to the work of Gschwind et al. (2015).

Further, some limitations due to age, coupled with low IT-literacy required a high degree of support for some of the participants and sometimes a contact person for the technical support was needed. The project staff supported all participants quite frequently and with more time allocated (especially in the beginning of the study) than would have been possible outside a research project. Nevertheless, the older adults used the technology in general unsupervised in their own home.

Older adults often saw home visits of researchers as a pleasant interlude, providing opportunities for conversations. These visits, also described by Müller et al. (2015) and Ogonowski et al. (2013), were time consuming although they helped to set up trust relationships and had a positive effect on participants' motivation. Additionally, home visits and workshops as well as overall participation in the research project itself might impact on the study outcomes insofar as that they served as extrinsic factors promoting participants' commitment to the study, possibly encouraging them to exercise more regularly as a result of an 'observer effect'. It is our view, however, that such putative effects tend to disappear over time.

From a more technical point of view, the ICT-based experience has been disturbed occasionally by malfunction of the Kinect sensor, based on occlusion (e.g. by feet in the sitting position), extreme light (sunbeam) and possibly restricted space in the living room environment (3x3 meters), although such problems are not unusual when researching in the wild.

5.6.6 High Level Implications

Even if our sample size was small, our qualitative findings combined with limited quantitative data of system use, allow several implications to be drawn from our study in order to facilitate the design of ICT-based fall prevention systems and also regarding future research projects in this domain. ICT-based fall prevention systems, we suggest, should be designed to allow for integrating the training activities into the daily routines of older adults and should address specific lifestyles, which are nowadays very diverse among older adults.

A combination of additional content (strength training and balance games) with a high level of error tolerance with good usability and accessibility should be implemented to keep motivation levels high. Also the interaction of different devices and approaches (such as exergames and wearables) to support older adults to stay active during the whole day are feasible and desirable. Our study identified different user groups with varying demands and usage patterns. Very active older adults were looking for competition and self-affirmation; active older adults were more interested in monitoring and improving their personal health status; and even inactive older adults were at least interested in using the SMM to track their daily activities. The combination of different devices seems to be a promising route for keeping users with varying demands motivated.

Regarding age and ongoing disability, ICT-based fall prevention systems should be designed to enable progression level adjustments for the younger (and possibly fitter) and to secure maximum safety and low progression for the older (and possibly less able) older adults. We could observe that participants' motivation depended on personal success regarding exercise results and physical challenge. Individual adherence can be encouraged in a number of ways. A more flexible system and customizable options for the exercises especially for the lower progression levels in the beginning of the intervention seem to be indicated. For progression there needs to be an opportunity to skip levels based on individual physical condition, either by individual decisions or based on system recommendations, so that users still feel challenged and motivated for continuous exercising.

Gender-wise, ICT-based fall prevention systems also should be designed to allow for enjoyment of both genders, as with our sample, where women slightly preferred the balance games and men were more prone to like strength training. In contrast, note that both genders were similarly interested and attracted by the SMM. Another very important outcome is the usage of a self-monitoring tool for all personal data including actual fall risk, which motivated our participants to train more often and thus improve their results in relation to fall risk and self-perception.

ICT-based fall prevention systems intend behavior changes in a sustainable manner. This is not based only on the use of technical devices, but also on social dimensions which, our evidence suggests, play a crucial role. During the workshops it became evident that most of our older adults would prefer a combination of more frequent ICT-based training at home (2-3 times a week) and socializing group classes in a gym once a week. Based on their perception, it seems that occasional co-located and group-based physical activity can be a powerful motivator for long-term sustained use, though social media evidently do not provide the same motivations. Moreover, this combined training approach of in-home training and group classes might help participants to reach target exercise times per week and social contacts, we believe, increase the adherence of older adults to exercise regimes. Further research should consider this carefully by designing combined fall prevention concepts which include ICT and social activities.

Our experiences strongly suggest positive benefits accruing from early participation by older adults into the design process from the beginning to promote acceptance within the target group. Our participants (despite some initial reservations) grew to accept the iStoppFalls system over the course of the intervention and with time became more able to learn how to handle the system, and how to avoid problems and possible errors (e.g. with the Kinect camera and pose detection).

Following the evidence and lessons learned from our study, the design of ICT-based fall prevention systems for older adults benefit from a combination of participatory design methods and practice-based approaches (Wulf et al. 2011). This, because the target population of older adults and related real life settings turned out to be appreciably more heterogeneous than is sometimes assumed.

5.7 Conclusion

With ongoing demographic changes in mind, implementation of fall prevention programs and technology support, as with iStoppFalls, has significant potential for identifying older adults at risk and helping them to reduce their fall risk (Gillespie et al. 2012). With the qualitative work presented in this paper, based on a six-month study with 12 participants, we showed that such an ICT-based fall preventive activity like iStoppFalls can feasibly be integrated into the daily life of very different older adults, which is a prerequisite for long-term use and associated efficacy.

The use of the system differed widely, but based on individual strategies and exergaming habits, most participants were able to integrate the system sustainably into their daily life and practices over a longer period of time (6 month). Self-monitoring of results as well as self-measuring of fall risk made the ICT-based fall prevention system a valuable and motivational experience for older adults who participated in the study. We can conclude that a successful integration of the system into daily routines and ongoing interaction led to positive aspects of self-perception and embodiment. Overall, an improvement in quality of life and better awareness about fall preventive measures with improved technical and self-perceived physical confidence can be seen.

A reduced fall risk could be identified in those older adults with a higher baseline fall-risk who used the system sustainably, although the sample size of our more qualitative

study was not sufficiently large to justify general statements about these hard endpoints. Nevertheless, the self-perceived improvement in fall risk and physical abilities (strength and balance), as with the older adults in our study can be statistically proven against a control group in the multinational RCT of the project with a larger study population in three different study sites in Europe and Australia (Gschwind et al. 2015).

The findings reported from our more qualitative study as depicted here constitute promising results regarding ICT support for prevention of falls, self-confidence and the social well-being of the participating community-dwelling older adults and provide them the opportunity to manage their own health and live independently for as long as possible in later life. Putting older adults into a position to monitor and control their own fitness, health and fall risk by means of ICT support, as we have shown, is instrumental in effecting long-term use and producing sustainable benefits.

6 Designing for the Living Room: Long-Term User Involvement in a Living Lab*

Abstract. Living labs provide a research infrastructure for long-term user involvement in Participatory Design processes. Users take part in software co-creation during context analysis, for concept development, reflecting on early-stage prototypes and evaluations in the field. In this paper we describe lessons learned from our living lab in the area of home entertainment, with 27 participants from 16 households, over a 2.5 year period. We show that this kind of long-term participation of users involves various challenges over the lifetime of the project. We highlight several aspects that need to be considered carefully when setting up such a living lab, concerning the selection of participants, maintenance of participants' motivation, establishment of a trust relationship, and the coordination of collaboration.

Keywords: living lab; participatory design; long-term user study; domestic

6.1 Introduction

Participatory Design (PD), particularly what has become known as the Scandinavian approach, has sought to involve users in the co-design and development of computer systems, for many years. This was seen to have a number of benefits, not least the democratization of processes, the improvement of organizational knowledge and ultimately systems which 'fit' working life better (Kensing and Blomberg 1998; Bødker et al. 2004; Bannon et al. 2011). Latterly, PD has moved beyond the work area and became a relevant topic for the domestic context as well. This shift arguably brings with it different choices and new problems concerning suitable users, time of user involvement, choice of adequate methods for the specific purpose, etc. (Randall et al. 2007). This has, inter alia, involved the deployment of ethnographically oriented investigations in order to understand the domestic context (e.g. O'Brien et al. (1999), methods for exploring new design ideas with users (e.g. Bernhaupt et al. (2008), and approaches to understanding how users appropriate new technology and its impact on users' habits (e.g. Harboe et al. 2008; Tsekleves et al. 2009).

One such approach is usually referred to as the 'living lab'. We set up such a living lab to involve users across the entire life span of a development project in the context of home entertainment. The living lab concept itself refers to a methodology where new IT artifacts will be created and validated with users in an open and innovative development process that takes real use contexts into account (Eriksson et al. 2006). The methodology has been deployed in a range of contexts, professional as well as domestic, but has arguably provided relatively few opportunities thus far for reflection on user typologies and their impact on different living lab stages (Schuurman et al. 2010b). We found no substantive descriptions of hands-on experience for the operationalization of such a research framework with which to begin our work. In this

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case study we address these topics and provide insights from our research project that may be helpful for others who are dealing with living labs.

6.2 Related Work

In order to design for the living room, methods and insights from PD should help to create systems that match with users' needs. In this section we reflect on previous work on PD and the meaning of living labs as an infrastructure, where co-creation can be applied in real life environments.

6.2.1 Designing with Users

Research around PD has explored various methods and tools that focus on the involvement of users in (re-)design processes (Greenbaum and Kyng 1991; Muller and Kuhn 1993; Kensing and Blomberg 1998; Bødker et al. 2004; Ehn 2008). Bødker et al. (2004), for instance, highlight the mutual nature of learning processes between designers and users, suggesting that genuine participation requires a continuous user involvement to obtain a shared understanding of problems and needs. Many issues are related to that topic, however, including the organizational complexity, the heterogeneity of tasks and the balancing of different stakeholders' rights and responsibilities.

Various specific methods for stimulating user involvement have been deployed in domestic (and other) environments. Gaver (1999), for instance, introduced the concept of cultural probes, allowing participants to express and reflect in an open and creative manner. This concept was adopted in several ways, e.g. with technology probes that inspired design for and with families (Hutchinson et al. 2003). Crabtree and Rodden (2004) also experimented with different techniques to explore the home and highlighted the importance of self-documentation methods compared to full-time standard recording. Lindquist et al. (2007) described the use of several self-documentation and design methods of a cross-generational long-term project and reflected on their aptitude for domestic settings.

Only a few studies provide insights into the long-term involvement of users for the design of home IT and reflection on this process from a design case stance. Sleeswijk Visser and Visser (2006) argue that returning participants provide a more profound feedback, because they are already familiar with the topic and can reflect on it in a more detailed manner. Even so, how to achieve these results in domestic environments is not well-specified, nor are the contingencies associated with community creation and maintenance in these environments well-examined.

6.2.2 Concepts of Living Labs

According to Eriksson et al. (2006), the term, 'Living lab', was created by William Mitchell at the MIT Media Lab and considered to be an instrument for the study of users and their interaction with new IT-artifacts in real life environments. Depending on the context, the research goal, and the stakeholders involved, the concept is used currently with several different accentuations in user involvement. However, all

directions have a common understanding of a living lab as an open and innovative research framework (Niitamo et al. 2006; Almirall 2008) with a strong focus on user-centric research methods, i.e. methods that can be applied in multiple real life environments for "sensing, prototyping, validating and refining complex solutions" (Eriksson et al. 2006). Users take on an active role in co-creation of the design process by providing ideas and experiences from real use contexts and stimulate research due to long-term involvement. These properties can be seen as the strengths of the concept (Schaffers et al. 2007) and distinguish the Living lab from other research methods.

However, several studies (e.g. Følstad 2008; Obrist et al. 2008) emphasized the fact that context exploration and long-term co-creation were often neglected in current living labs. Moreover, living labs with a focus on domestic or private sectors conceive the notion of 'real use' environment in different ways. They either collaborate with users in real world testbeds or in controlled artificial environments in test centers. For example, MIT PlaceLab (Intille et al. 2005) and Phillips HomeLab (de Ruyter and Aarts 2004) have conducted short- and mid-term evaluations in large scale controlled domestic settings. In contrast, Bergvall-Kareborn & Larsson (2008) and Schuurman et al. (2009) conducted evaluations in more naturalistic contexts and collected in-situ feedback on user experience, usability aspects and appropriation processes. Living lab Skagen (Kanstrup 2008) involved their users in an early design step for idea generation. They conducted multi-day workshops with first prototypes and discussed these under real world and under lab conditions. Obrist et al. (2008) investigated their users in their homes for several weeks at the beginning of the design process to get a deeper understanding of the context and the users' needs. In contrast to MIT PlaceLab and Phillips HomeLab, these studies usually involved smaller user samples. There are, nevertheless, relatively few studies that exploit the full potential of the concept – relatively long-term and 'naturalistic' studies insofar as they involve the use of technologies in daily routines (Ståhlbröst 2004; Lievens et al. 2010; Mulvenna et al. 2011) – and fewer which describe in detail the processes of co-creation that do, or do not, take place. Few studies reflect on the difficulties and challenges one has to deal with when building up and running a living lab effectively. Schuurman et al. (2009) are an exception, providing a SWOT (strengths, weaknesses, opportunities, threats) analysis in the context of mobile TV. Living labs, they argue, are time and cost intensive in realization and limitations in the design of new technology; users can be over-accepting of early prototypes, and reluctant to use prototypes in public places. In Schuurman et al. (2010b) they investigated different user typologies, their roles and aptitude for living lab processes. They supplement the concept of the 'lead user' (Eriksson et al. 2006; Almirall 2008) with additional categories, such as 'Pro-Ams' or 'bystanders', that can help us better understand how users work in different stages of the design process. From a more general stance, Bergvall-Kareborn et al. (2009) derived five key principles (continuity, openness, realism, empowerment of users, and spontaneity) for success the concept design. Certain features e.g. trust, transparency and user acceptance were emphasized, but their handling in practice less well described. Papers that present evaluation studies and point out corresponding limitations provide further insights. For example Bergvall-Kåreborn and Larsson (2008) and Lievens et al. (2010) described how prototypes in everyday life have to compete with other devices and services. Outside influences can affect user behavior

as well as acceptance. In this regard, Lievens et al. (2010) emphasized the importance of added value to the user.

6.3 SocialMedia Experience and Design Lab

Our case study is based on a four-year research project. The aim of the project is to develop a cross-platform framework including TV, PC and Smartphone to support a more flexible and integrated media consumption and use of social media applications.

Motivated by this, we designed a living lab research framework and involved stakeholders from industry, academia and participating households. We named our living lab *SocialMedia Experience and Design Lab (SMEDL)*, because user experience and the design of home entertainment concepts are strongly related to each other (Hess et al. 2011a). A close collaboration with users in their real life environments and their continuous involvement in the design process during the entire research period was an elementary aspect of this living lab concept. For this purpose SMEDL consists of two environments: a real world testbed and an artificial lab setting. Both serve to collect qualitative as well as quantitative data by using various research methods. SMEDL.Local is a real-world testbed including households from the region of Siegen, Germany, which makes up the core of our living lab. This setting provides an entry into the domestic field to explore real world contexts in detail as well as in-situ feedback and user experiences from long-term field studies. Households were equipped with various devices (TV, Media Center system, smartphone) that could be used in their everyday life. Within SMEDL.Local we can investigate the integration and appropriation processes of new hard- and software, media usage behavior, social practices and its changes over a longer period of time. In contrast, SMEDL.Stat as a stationary controlled test setting reproduces a standard living room at our university and is used for short-term evaluations and first user tests. In this environment we can measure concrete user behavior and gain comparable data.

6.4 Method

This study based on our previous research in our living lab, drawing on user studies conducted within SMEDL (see Figure 17). Data comes from three diary studies with interviews after each study, observation protocols and notes from two creative workshops during the concept design, an online survey, data and observations from two user tests and one field evaluation, with protocols, audio and video recordings. Data sets were supplemented by notes with individual experiences and observations from two social events, home visits, casual meetings with participants in our free time and regular exchange with users via email, instant messaging and phone.

For the analysis of the predominantly qualitative data we applied a Grounded Theory oriented approach, at least insofar as ‘theoretical sampling’ and ‘constant comparison’ were utilized (Glaser and Strauss 1967). Empirical data was continuously analyzed throughout the project. In respect of substantive data, reported elsewhere (Hess et al. 2011a; Hess et al. 2012b), diary studies, creative workshops and user tests, coded interview or discussion transcripts were triangulated with additional video material,

observation notes or entries of diaries in order to confirm coded excerpts or to expose conflicts in the participants' statements. For the purposes of the analysis we describe here, however, we went no further than 'open' coding of the users' behavior, challenges and constraints as well as the contingencies that arose at different stages in the process.

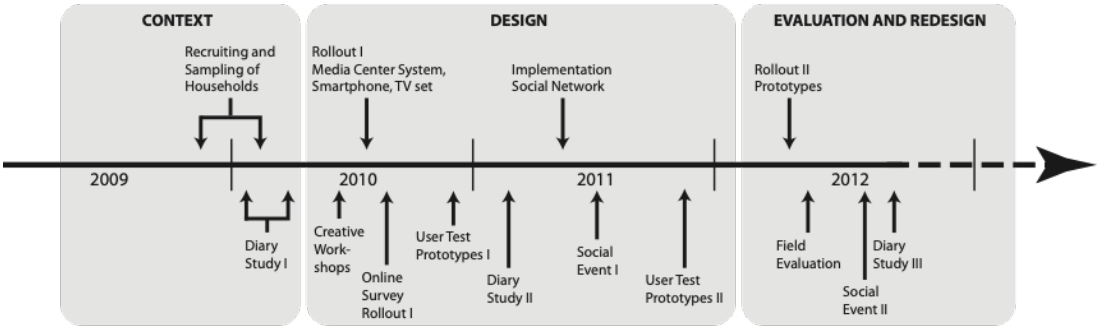

Figure 17: Overview of the project's progression (above the timeline: interventions within the field; below: research methods)

6.5 Designing the Design Process

Below, we identify interesting phenomena and challenges regarding user acquisition, context analysis, designing with users, field evaluations and the communication with participants.

6.5.1 User Sample and Motivation

To find appropriate participants to set up a small-scaled local real-world testbed (SMEDL.Local), we started a call for applications via local newspapers and radio. Applicants had to fill out an online questionnaire with information about their demographic background, technical equipment, and personal motivation for participating. We further conducted 30-minute telephone interviews with each of the 32 applicants to find out additional socio-demographic facts, more about their media usage, technical experiences in dealing with Media Center systems and smartphones, and gain some insight into how communicative and self-reflective applicants might prove to be. Based on this, we focused on applicants who lived in the proximity of our university to reduce the costs and time of later home visits. In order to involve users with varying levels of experience and with different household structures, which is important for a heterogeneous design domain, we clustered applicants into four household structures: couples with or without children and single with or without children. In a first round we selected 8 households, two from each category, with 15 participants in total (6 male, 9 female). One of the two households of each category was very experienced and the other less experienced with smartphones and Media Center systems.

In a second step, we asked the households to recruit friends or colleagues who were also interested in participating. We aimed at a sample consisting of both participants that knew each other and those who did not. The reasons for this had to do with our interest in seeing how users communicate about their media usage and how new integrated community functionalities could support the establishment of new contacts.

In the second round, we selected 8 additional households with 12 participants in total (8 male, 4 female), 5 of them with higher and 3 with less technical experiences. The final structure of SMEDL.Local consisted of 27 participants (14 male, 13 female) divided into 5 couples with children, 5 couples without children, 2 singles with children and 4 singles without children.

Selected participants at the outset were strongly motivated and interested in the next steps. Apart from the fact that the households were equipped with new devices, we identified further reasons for participating depending on the participants' technical experiences, personal attitudes and individual expectations: curiosity, self-reflection on their media usage behavior, learning, participation, communication and new contacts. One participant described his motivation quite enthusiastically: *"I can express my visions and discuss novel concepts together with others, in the hope that some of my ideas will be implemented. If not, it does not matter. Anyway, if the system is available on the market, I can tell my friends that I contributed to it."* (male 31, couple without children, high technical experience). However, during the project progression, participants' motivation and their willingness to participate, changed depending on whether their expectations were satisfied.

6.5.2 Understanding Users

Within the first phase of our project, after compiling our sample, we started empirical work, focusing on exploring and understanding current media usage behavior and social practices in domestic environments. The advantage of SMEDL.Local lies within a profound understanding of household structures and their media usage behavior to identify requirements for new integrated social media concepts. To understand the daily media usage of our 27 participants and to increase their understanding for our research activities, we conducted a three-week diary study (Diary Study I) between February and May 2010 (Hess et al. 2011a). We designed boxes that contained one media diary for each participant in the household, a camera and some sweets for motivation. The diary contained semi-structured pages on which the participants were told to document every single media usage with information about the usage context. Furthermore, we included several special pages to understand more about the participants' regional, national and international social networks, pastime activities and additional insights on how they live. With the camera, participants could document aspects of their media usage to give us more visual insight. The diary study was also supposed to help to establish a trust relationship between participants and researchers. After the three-week self-documentation process, we collected the boxes and conducted additional interviews with each participant in the household to reflect on their current media usage, on the relevance of specific media (TV, PC/Internet, mobile phone) and the diary study itself. During the entire project progression we equipped the households with new technology twice (Rollout I & II). To understand how the new technology was appropriated and how media usage changed, we repeated the diary study after each intervention. Diary Study II was performed between December 2010 and January 2011 and Diary Study III between July and August 2012.

While the motivation for completing the diaries was relatively high in the first study, we realized that this assiduousness subsided with the second and third study, and most

of the participants were obviously perturbed when we asked them to complete the diary again. During one home visit, a participant rolled her eyes and welcomed us with the words *"Oh no, not again!"* (female 44, single with children, low technical experience) when she spotted the documentation box we wanted to hand over. The point here is that, from the subjective point of view of participants, nothing much had changed in their media usage behavior over the course of the study, despite the fact that other data demonstrated that changes had in fact taken place (Hess et al. 2012b). When we asked the same participant in the interview about any changes regarding the new devices we had introduced, she answered: *"I always do the same. Because until now the Media Center system doesn't offer much new."*. Although she was aware of the new devices, for her, no changes happened when using same functions (e.g. browser games, Internet) on different devices (PC at the desk or TV screen). Her daughter, nevertheless, claimed that her mother's usage behavior had changed insofar that she now used the Media Center system much more: *"When I come home from school, I use the Media Center system to watch animes on the Internet until 8 p.m, then my mother chucks me out."* (female 17, single with children, low technical experience).

In our view the content of the interviews gave us a much deeper and more precise insight into the participants' media usage behaviors than the diaries did. Nevertheless, for many participants keeping the diary was a very helpful resource when it came to reflecting on their own habits when prompted during interviews.

6.5.3 Designing Together

One important aspect of our living lab is the active involvement of the participants during the entire design process. Following Diary Study I and an initial analysis of the collected data, we conducted two creative workshops together with living lab households (Hess et al. 2011a). The aim was to co-develop and discuss first concepts and ideas for an integrated and flexible usage of TV, smartphone and PC. Relating to the superior project goals and the results of the diary study, we moderated the workshops based on predefined topics. Due to the large amount of registered participants (18) and the wide range of technical experience between them, we decided to arrange two workshops. The first workshop had 8 participants with higher technical expertise and the second 10 less technically adept participants. In the first workshop we began with a brainstorming session along the predefined topics where the participants had the opportunity to discuss current usage behaviors, problems and how new concepts could be designed. In the second part of the first workshop we discussed concepts and mock-ups we had developed subsequently to the diary study. Because of the participants' lack of experience in workshop two, we omitted the brainstorming part and gave a demonstration of current smartphones and media center devices.

The separation of the technically experienced users from the less experienced was motivated by the assumption that less experienced users might be embarrassed or otherwise reluctant in front of others whereas very experienced users might be bored in discussion. However, as a result of scheduling difficulties, two less experienced users were invited to the first workshop and we observed an unanticipated and interesting behavior. The more experienced users had a clear conception of new concepts based on their know-how. Their ideas, however, were strongly oriented to

current marketable products- realizable, but not necessarily highly innovative. In contrast, the ideas of the less experienced users were either outdated, or they were utopian and not yet realizable. Even so, and against our expectations, interactions turned out to be synergistic, with experienced users being excited by 'blue sky' thinking and less experienced users by learning more about real prospects.

After the workshops we concreted first concepts and developed a low-functional early-stage prototype. We invited our living lab participants to our stationary lab (SMEDL.Stat) and conducted 13 individual user tests (User Test Prototypes I), where we put the application design and the underlying concept up for discussion. Besides a scenario-based walkthrough, participants could contribute their suggestions in a subsequent open interview with the designer. Afterwards we analyzed the tests, redesigned the application in regard to the users' comments and implemented the functionality. Another 13 user tests (User Test Prototypes II) were conducted after finalizing the implementation of our applications. This time we conducted both single and group tests to better observe the users' roles and their interactions. Depending on the households size a maximum of three participants (adults and children) were involved in a test. The procedure of the tests was similar to the first testing phase and the aim was to identify substantial usability issues before setting up the applications in the field.

We have determined that experienced participants were very confident when they got in touch with our prototypes and tried to appropriate them in an exploratory way, whereas most of the less experienced users were nervous and inhibited when dealing with the applications, because they were afraid to break something or to do the given tasks wrong. We even observed this in User Test Prototypes II, although the participants and the researchers had by then known other for almost two years.

One interesting realization from our PD studies was that the participants had a divergent understanding of their project's role. While some of them saw themselves as potential users who were interested in providing requirements for the applications to satisfy their individual needs, others liked to see themselves more as a designer. As an example, one female, less experienced participant, who worked as an architect, wanted to apply herself as an expert in visual design but was not interested in using the applications later on. In an email she wrote: "*I can not contribute in the community/Facebook/new stuff – my friends have no palate for it and me neither. […] I guess I am a prime example of a dinosaur in your young social community […]. For the development I could possibly help a bit with my viewing patterns […] I can perceive no sensibility for this topic.*" (female 47, single, low technical experience).

6.5.4 Setting Up New Technologies

After the first user studies, we undertook the first technical intervention (Rollout I). The main objective of Rollout I was to equip our living lab households with up-to-date hardware, so that they could get familiar with it and prepare themselves with basic knowledge of contemporary home IT. In a later phase, our software was developed for this hardware platform. We equipped each household with a Media Center system and an Android-based mobile phone. Households with a tube television were additionally

equipped with a high-definition flat-screen TV set. As software we set up the Windows Media Center so that the users could watch live TV using our system.

We planned to carry out Rollout I in April 2010. Prior to that we had informed our households about it and they showed great excitement and anticipation about the coming equipment. However, the actual rollout happened 4 months later, because the ordered smartphones were out of stock. During these 4 months we continuously received emails and phone calls from our households asking about the delivery status. While we still felt great anticipation from them, we also sensed some impatience due to the long wait. After we finally received all the equipment in August, we contacted the households by phone and fixed appointments for home visits. We came with the hardware as planned and set it up during our visits. After that, we gave a brief introduction to the system and its functionalities but didn't ask them to do any specific tasks or force them to use the system. Whether or how they might use it was totally up to them.

We invested a huge amount of time carrying out Rollout I. To arrange an appointment with each household was not easy. In most cases we were not able to fix a date on the first try. This was either because we were not able to reach them, or they were unsure whether they would have time in evening or canceled the settled date some hours before. The installation in each household took at least one hour. For some households we had to pay them more than one visit to finalize the installation. For example, in four of our households, we had to set up additional equipment on a second visit for the hardware to work.

Even after the rollout, maintenance required a huge amount of management effort. Almost every household had at least one piece of hardware that had stopped working; these were mainly the input devices, such as the remote controls or the wireless keyboards. In each case we had to pick them up, send them back to the retailer, deal with the warranty issues, and bring them back to our households after we received the replaced or fixed pieces. We also observed an interesting phenomenon during our home visits. Participants, especially with low technical experiences, tended to ask us for help installing or configuring their own hard- or software. Although not directly related to our project, we always tried our best to solve their problems. Another household had problems with the TV-signal. We tried to fix the problem remotely, but we had to visit them several times to get it running and although it was not a problem of our hardware, we fixed a broken signal cable. Unfortunately, some of our households saw us as a 24/7 helpdesk rather than as research motivated.

6.5.5 Testing in the Field

The objective of Rollout II was to deploy our software prototypes on the hardware that was already running in our living lab households. The prelude of Rollout II was the launch of our SocialMedia community (see 'Implementation Social Network' in Figure 17 in the middle of 2011. The social network served as central channel for our households to communicate with each other, and also a basis for further software development. The actual Rollout II happened in early summer of 2012, where we installed our prototypes in each household. We sent an email containing the download

links to smartphone apps and FAQs to each participant as a first step. We then fixed appointments for remote installation with each household.

The installation itself was less smooth than anticipated. Although the prototype ran quite stably in our pre-test, we faced a lot of unpredictable difficulties in the real-world environment, e.g. incorrect display ratio of TV image, no or unstable TV-signal. We called a halt after four installations to solve these issues and resumed our rollout some days later. Because of these difficulties, the planned rollout was postponed from 2 weeks to 7 weeks.

In the following home visits, we realized that most of the participants neither used the installed TV prototype nor installed the mobile application, although the FAQs provided a detailed description. We also developed and rolled out a feedback application (Hess et al. 2012c) to report critical incidents or feature requests in-situ with the smartphone, but this application was also not installed or used by most of the participants. One reason for this lack of interest was the one-year period between the first and second Rollout where nothing much had happened. Another demotivating factor was the instability of prototypes and some of the participants blamed themselves when something went wrong: "*The biggest problem was that, when it doesn't respond, you think that the reason that it has stopped working, is because you did something wrong to it.*" (female, 39, single with children, low technical experience). Although we informed the households that the prototype might not be stable and might crash, the users' patience for the prototype-malfunction turned out to be very low. One participant uninstalled our system and connected their old receiver to watch TV, because the prototype was not stable enough and the user experience was such that his wife and daughter could not just "easily" watch TV using the prototype. Another participant argued that *"[a] field test, to my opinion, only makes sense when the solution works as promised and does not continuously crash. I would like to give you feedback, but it's no fun. When I come home, I just want to watch TV and it must work. When I have to wait for it to boot up again, then I have to sign in to watch, I have no interest at all"* (male, 32, couple without children, high technical experience).

The project had the goal of developing innovative home IT solutions, rather than just re-implementing existing functions of other commercial systems. On the one hand, the lack of certain functions led to user frustration in integrating it into daily routines. On the other hand, the ambition of innovative ideas, such as how to flexibly consume TV content on various platforms, has received positive comments from the users: *"When I lie in bed in the night and still want to watch something (…) When this is theoretically do-able, then it would not be bad at all!"* (male 51, couple with children, low technical experience).

6.5.6 Staying in Touch

Participants of our living lab were continuously informed about the current project status and the next steps within the field in a formal way by email and during official appointments. However, participants expected more transparency and information in a shorter space of time, e.g. results of empirical studies or evaluations and monthly emails on the project status, so we introduced a regular newsletter which focused on this information.

Informal communication also played an important role within the project. Participants identified with the living lab, they talked to their friends and colleagues about it and showed them the official project website. However, they were disappointed because the website did not offer any details about project staff. Participants opened up and gave us insights into privacy but in return, they also wanted to know more about us-how we thought; what interests and hobbies we had, and so on.

Households who did not know each other were also interested in getting in contact with other living lab households. They wanted to know their reasons for participation and how they used the technologies. The organized workshops provided an opportunity to get into a conversation with others, but participants did not always interact to their satisfaction. One participant described his perception as follows: *"(...) during the workshops everybody was focused on the project discussion so that personal conversations did not arise out of the situation. The same applied to the user tests. Conversations with others were almost impossible, because the tests were executed one after another."* (male 37, couple with children, high technical experience).

In response to the users' suggestions, we tried to create new spaces for informal conversations. We implemented a project-based social network site, where all project members, including the research staff and the participants from the living lab, could register and create their user profiles. The platform provided communication tools like chat or messaging and a discussion forum that also served as an information platform and helpdesk in the way that users can support each other. We also used the platform to spread project related snippets from various external news portals. However, the usage of the platform was quite moderate and friend requests were not sent to the expected degree because participants did not want to become friends with people they had only met briefly. This is also a reason why they would not ask others in the community if they had any problems with our prototypes.

Furthermore, we arranged social events on neutral locations. The first event was a BBQ, but unfortunately, not all households could participate due to private commitments. Conversations between attendant households indeed arose hesitantly in this situation. For the second event, we organized an informal get-together in a bar. In order to ease the situation, as we knew from the BBQ that 'ice breaking' was necessary, we prepared a speed-networking round at the beginning of the event. Everyone had to talk to everyone for three minutes. After this, conversations continued automatically. Later on, we observed increasing activities in our social network, friend requests were sent. Besides the positive feedback at the end of the event, one participant wrote a comment in the discussion forum. *"To all who could not join: (...) The get-together was awesome, the atmosphere was great, the speed-dating (grin) was really interesting. I'm looking forward to the next one – it was a great idea!"* (male 44, single household without children, low technical expertise). Another participant argued that *"the project should have started with an informal come together. Then you can get in contact with other households [...]"* (female 42, couple with children, low technical expertise).

6.6 Lessons Learned

Based on the above, we can identify some lessons learned. We discuss some of the challenges identified, specific points where this dynamic process of co-creation is problematic, and how such issues can be resolved.

6.6.1 Finding the Right Users

The user selection process was time consuming and entailed various challenges. The approach of involving users during a long-running project requires participants with social competences and well-marked self-reflecting skills. They needed to be willing to give researchers a deeper insight into their own and their family's life and to be interested in the research topic itself. They needed time and readiness to participate in regular research activities after work and on weekends and they had to deal with the new technologies they received during the project. Retrospectively, we have to admit administering a questionnaire, combined with a telephone interview, was not the right way to proceed. A more personal face-to-face interview and a visit to applicants' homes might have given some better indication about the participants appropriateness for the project. However, establishing a personal relationship might raise participants' expectation to get chosen which makes it harder to decline an application for both the applicant and the researcher.

We agree with Schuurman et al. (Schuurman et al. 2010b) that the combination of diversified users can be useful, and we need to think beyond 'lead users' as the focus for enquiry. However, while they arranged the different user typologies primarily in the area of evaluation, we also had good experiences with our heterogeneous sample in the preceding design steps, e.g. empirical studies, PD workshops and user tests. Especially during workshops, non-experienced users contributed many interesting and innovative ideas due precisely to their lack of knowledge about marketable technology. We also identified another type of participant whose motivation for participation is not grounded in developing solutions that enrich personal usage behavior, but more in the participation itself and the desire to contribute with personal expertise even if there is no obvious interest in using the developed solutions. Those participants can, depending on their competence, contribute interesting and helpful ideas during the design phase but – and this bears emphasizing – their skills are variously displayed or volunteered depending on methods adopted. For example, where individuals with visual design expertise have much to contribute at specific points, there is little purpose in involving them throughout the process when they have no interest in using the prototypes.

6.6.2 Keeping Users Motivated

Retaining participants in a living lab over a long-term period is a big challenge. While changes in participants' routines (e.g. workload, relocation, family status) are inevitable and may result in exit from the project, decreasing motivation is also an important aspect that may influence a premature departure. Keeping the participants' motivation on the same high level over the entire lifespan of the project is an essential task for the operator of a living lab.

We identified a decreasing motivation in several phases of the project. The participants' expectations were high at the beginning of the project and their frequent involvement in various studies kept their motivation at a good level during the first half year. However, our participants got really impatient when Rollout I & II were delayed. The fact that we announced dates that we could not meet caused displeasure to many participants. Therefore, it might be conducive to make such date arrangements more carefully and flexibly within a time frame as a cushion against unrealistic expectations. This is also relevant against the background of stability and usability of the rolled-out prototypes as we could not fulfill the users' high expectations on our applications. Although we never promised any stable and market-ready product, users were sometimes bitterly disappointed by the results. We dealt with the question about the reasons for these expectations and identified four essential aspects:

Comparing with other products: When we rolled out the devices, we installed a mature Media Center application (Windows Media Center) on the users Media Center system to introduce users to current marketable solutions. Non-experienced participants were pretty excited by the system and its "new" features and adopted them into their daily media usage. Due to the missing adaptability of this system, for our prototype we had to implement the basic functionality of the Media Center from scratch to build up a new platform for innovative concepts. As it was not the aim to re-implement an existing system, we focused on relevant basic features. For the users it felt like a retrograde step as many features they had grown to like were not available in the new system. These experiences confirm similar observations from (Bergvall-Kåreborn and Larsson 2008; Schuurman et al. 2009). Thus, rolling out similar software beforehand should be done cautiously to avoid cannibalism. A possible solution could be to extend an existing application with new concepts instead of developing something completely new. However, this only works on the condition that there is a system that provides an appropriate way for adaptability or expandability.

Watching TV is relaxation: Most of the participants watch TV in the evening after work or on weekends and its purpose of relaxation is an important user experience for them. As the stability and the handling of our prototype was still immature, the system needs to be restarted after a crash and the response of the UI was also not as expected. The effect was that the users could not relax as they wanted and they quickly switched back to their previous solution, which underlines challenges of the domestic domain.

Waiting period: During the implementation of the prototypes, the users had almost no insight into the stage of development. Due to the long wait, they expected something huge. However, most of the implementation work we had done went into the development of the underlying framework and had no immediate effect on the user interfaces. Thus, we determined a great disappointment on the part of users when they finally came to use our prototypes. For later design steps we decided to give participants more insights and information on current implementation work in order increase transparency.

Missing benefit: Several participants mentioned that the prototypes did not provide any apparent benefit with regards to their previously used solution. In the case of social network functions, for instance, this turned out to be quite a dilemma, as our small

sample could not readily make maximum use of them. Equally, some users failed to identify the existence of some new features.

We agree with the reflection of Lievens et al. (2010) that users have to feel attracted by a new system, but in addition, we also identified several influences with regards to the communication within the project as well as important social aspects. The implementation of a regular newsletter about project progress was well-received by all of the participants. In this context it was also of importance to give participants feedback from study results (How far do my statements contribute to the project? How do other lab members think and how do they consume media?). We think it is necessary to give participants the feeling that we need them. This can be done by sharing study results as well as by getting in personal contact with the participants and by conducting joint social activities.

6.6.3 Building Trust Relationships

The living room is a private place, where residents feel secure and where they relax. Entering the domestic domain for research requires one to be sensitive and empathic when dealing with the users. Furthermore, to making users open up to researchers is an artful business and we should not underestimate the need for social skills among researchers as well as participants.

Our experiences have shown that both formal and informal communication, as well as specific empirical methods are of importance in this context. The deployment of self-documenting methods helped gain user insights and formed a first common ground for further interactions. Regular conversations and discussions were also relevant in building up trust. It was important to value each and every participant and take his/her statements seriously, even if they were of varying benefit or significance for the project. This also applied to discussions, e.g. during workshops, when participants went off topic. While interviews are always purposeful from the point of view of the researcher, these purposes are not necessarily shared by interviewees. We learned over time the need for a relaxed, friendly and ‘social’ attitude on our part. In doing so, user motivation was positively influenced as well. Rollout II revealed the importance of a trust and friendly relationship in relation to giving feedback. Participants who felt they were ‘on the same wavelength’ as us, gave us substantially more feedback from their experiences than others. Moreover, they were not ashamed to give us prompt feedback concerning their problems with our software, and give us their honest opinion, not least about our own failures.

At the beginning of the project only one staff member was responsible for the communication with the households and the field studies. With Rollout I and the occurrence of the first technical problems, it was necessary that households were contacted by different staff members. This resulted in participants being confused about who was working in the project, who was part of the academic staff and who was a student assistant. We improved the transparency by introducing our social networking site and by arranging social events. Nevertheless, a permanent contact person that participants can come to is important in building a trust relationship. Communication on a personal non-project-related level also played an important part in this context. Giving the participants insight into our own lives (e.g. interests or

hobbies) in exchange for the obtained data from the field, created trust and emphasized that we, the researchers, are also only ordinary people.

All these aspects seem to be trivial, but our findings indicate that they are rather important for long-term collaborations in living labs. In this context, we can confirm the general conclusions concerning trust, transparency and user empowerment mentioned by Bergvall-Kåreborn et al. (2009) that we extend with our own practical insights into the process of building that is entailed, and what the relevant parameters might be.

6.6.4 Coordination of Collaboration

The coordination of several collaboration steps, e.g. workshops, user tests, interviews etc. turned out to be quite time- and resource-consuming. We often had the problem of making appointments at the university or the participants homes and it was impossible to bring all 27 participants together at the same time. However, appointments were also often canceled right before the meeting or participants did not appear or were not at home. For example, one household failed to turn up for a date four times. This often led to delays in the project progression and should be considered in the planning process.

Unpredictable technical problems, device errors and other external influencing factors were additional barriers which we had to deal within a real-world context. We always tried to fix problems as soon as possible. While most of the households appreciated that, some of them saw us as a 24/7 helpdesk and called us in all urgent and less urgent cases. We assumed that a strong network of participants could reduce non-prototype specific enquiries such as how to customize a web browser on the TV or to update the Smartphone, which could be solved among the users themselves by sharing existing knowledge. Therefore, a common exchange platform and informal get-togethers are supportive for getting in contact with other participants. Due to this, ‘getting to know each other’ should be supported right from the beginning of the project, if ambitions for a participants-driven helpdesk can be realized. Sharing knowledge and providing help, in this context as in others, requires more than mere technical competence.

6.7 Conclusion

In this work we presented our experiences from a 2.5 year long-term living lab study with 27 participants from 16 households in the context of the development of new concepts for home entertainment. We drew on various empirical data from our research and identified phenomena and challenges in dealing with users during a long-term collaboration process in real world contexts. We tried to follow principles of co-creation but the dynamics of the project meant that this was sometimes more problematic than we anticipated – despite best intentions. Our aim was to show how co-creation for designing with users can be problematic for contingent reasons and that the lessons we learned were arrived at over time. We categorized these aspects concerning finding and selecting participants, their motivation, the establishment of a trust relationship between participants and researchers, and the coordination of user involvement over the entire project progression. Even if some of these aspects are

already mentioned in related work (Kensing and Blomberg 1998; Bergvall-Kåreborn et al. 2009; Schuurman et al. 2009; Lievens et al. 2010; Schuurman et al. 2010b) we could neither find any recommendations for application nor any investigations and reflective descriptions that focus on the entire process of user involvement during a long-term living lab study. We have not, however, considered contexts where divergent interests span commercial, industrial or public policy partners as well as researchers. That additional complexity awaits further research.

7 At Home with Users: A Comparative View of Living Labs*

Abstract. Living labs provide a 'human-centric' research approach for the design of new ICT artefacts. In living labs users participate over several design stages, providing insights into unexpected ICT use, co-creation and evaluation of new IT solutions. Although this approach is becoming more popular, there is little comparative and reflective work on its practical dynamics, problems and possibilities. In this study, we analyze two 4-year living lab projects in Lancaster, UK and Siegen, Germany within the domain of SocialTV, and compare experiences. We focus on documenting the purposes, methods and user dynamics that affect the trajectory of such long-term research initiatives, focusing inter alia on the dynamics of researcher/user interaction and the developing issues of trust and managing expectations; emphasizing some often neglected ethical issues and the impact of users' individual characteristics and their role in the community dynamics of living labs.

Keywords: user studies; field studies; empirical studies in HCI; interaction design process and methods; Participatory Design

7.1 Introduction

7.1.1 The 'Turn to the Social' and the Living Lab

The turn to the 'social' in interdisciplinary fields such as computer supported cooperative work (CSCW) and human computer interaction (HCI) has been accompanied by a developing eclecticism on such matters as domain, method, analytic choice, form of 'design' and so on. This has led to extensive revision and innovation in the methods used, and arguably for good reason, in the past few years. It originates in the recognition that practical organizational and academic 'social science' interests do not always coalesce. One aspect of this is a view that academic methodological and theoretical reflections seem to have little to do with practical design problems, and a developing recognition that the term, 'design' covers many different possibilities. Not least, as HCI and CSCW's interests have turned to domains such as the home and public spaces, with a concomitant interest in the design of 'products' rather than 'systems', so the search for new methods and best practices has continued. The approach we discuss here is the so-called 'living lab'.

Living labs provide both a specific research infrastructure, either as a natural living space (e.g. families home, public spaces) or as a mock-up living space (e.g. an apartment that participants occupy for periods of time), and a research methodology for the design of new ICT artefacts. They have sprung up in a number of contexts, but originated in a concern for methods which would work in relation to product innovation, notably in the domestic arena. They were initially associated with

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consumer products, subsequently with 'smart home' research and then to investigate a variety of domestic and mobile products. They include, for brief mention, Orange At Home (Randall 2003); the Philips HomeLab (de Ruyter and Aarts 2004); Placelab (Intille et al. 2005); and the Helsinki Virtual Village (Eriksson et al. 2005). They have been associated more generally with product innovation (Kusiak 2007) as a possible solution to problems of innovation failure through processes of user involvement. As Eriksson et al. (2005) suggest:

> *"The Living Labs Concept refers to an R&D methodology where innovations, such as services, products or application enhancements, are created and validated in collaborative multi-contextual empirical real-world environments. (...) The user experience focus involves areas of user interface design and ergonomics as well as user acceptance, extending to user co-design process, finally leading to service or product creation. The human-centric approach in Living Labs conceives of human beings, citizens and the civic society as a source of innovation and not just as users or consumers in a narrow sense being an object for R&D activities."*

One of the points we wish to make in the comparative study we discuss below is that hitherto the ambition to demonstrate that living labs are 'human-centric' has not yet been fully realized. In methodological terms, Følstad (2008) argues that living labs typically fulfil four functions which are described as evaluating or validating new IT solutions with users; gaining insight into unexpected ICT uses and new service opportunities; experiencing and experimenting with ICT solutions in contexts familiar to the users, and enabling medium to long-term studies with users. Again, and as we will suggest, there are a number of implications that surround the notion of the 'long-term' in living labs that are not always adequately discussed or investigated in comparative works.

Reasons for adoption are many but might include, depending on the particular vision of living lab being used, that they involve the user; get relatively quick and low-cost results; may constitute a permanent testbed; allow for 'mixed method' approaches to data collection, and of course, put the user at the center of an iterative design process. They are in some sense participatory, 'real world', and involve the iterative testing and evaluation of products over some extended period of time. It is, in other words, an approach to evaluation and thence to iterative design with users. Having said that, and as the participatory design literature has made abundantly clear over many years, 'involving the user' can mean many different things (Vines et al. 2013). Certainly, when von Hippel (1976) first argued that the 'needs' of users could and should be placed at the center of the innovation process, he made little attempt to discuss the contingencies that might affect the process. Bergvall-Kåreborn et al. (2009) delineate some principles that might determine effectiveness, but provide no account of the long-term, evolving dynamics of the living lab.

7.1.2 The Living Lab and Research Methodologies

There are a number of methodological choices that might be made once something that looks like a living lab is established. As Schuurman et al. (2009) point out there are two different ways in which the living lab can be constituted. Firstly, 'make the

technology or product available in the home of the users' and secondly develop, 'a home where the technology or product is available and where users come to stay for a certain period'. They have also been used in the more specific context of interactive television specifically 'mobile TV' research:

> *"When a product is designed for users, data and theories regarding the users are used as a knowledge base for design. A design with users denotes an approach where user studies are included, together with feedback from the users on different solutions or concepts."*

Having said this, a number of quite specific methods might be appropriate for living lab research. They include, for instance, diary studies (e.g. Bolger et al. 2003; Carter and Mankoff 2005; Hess and Wulf 2009) interviewing, observation, focus groups, cultural probes (Gaver et al. 1999), technology probes (Hutchinson et al. 2003), and so on. Indeed, such methods have been deployed for the investigation of domestic life and the use of technology over a long period of time (e.g. Gilbreth 1938, Hindus 1999). Few studies, however, provide insights into the long-term involvement of users for the design of Home IT and fewer provide reflection on the practical dynamics of research and the developing relationships of researchers, users and other involved actors in this context. Sleeswijk Visser and Visser (2006) suggest that returning participants provide more profound feedback and can reflect in a more detailed manner. Even so, how to achieve these results in domestic environments is not well-specified, nor are the contingencies associated with community creation and maintenance well-examined.

We draw extensively on a version of the living lab perspective for our own work on Social TV but it bears repeating that the notion does not come circumscribed by methodological rules. There are many possible sources of variation, since such a lab can be located in a specific research setting where people might stay for very short or very long periods of time (e.g. Abowd et al. 2000; Jago et al. 2011); can be specifically targeted towards one kind of user group or to many; can entail the regular use of the same group of users, or can enlist new groups; can be constituted in geographical terms in areas with state-of-the-art facilities, and finally can be more or less 'naturalistic'. On this basis, then, we can see living lab research as containing elements, which might be described as 'ethnographic' as well as elements, which have to do with user participation and -more explicitly- participatory design. Having said that, in our view there are two elements, which make living lab research distinctive. Firstly, it aims directly to provide mechanisms for sustained participation over a long period of time, often across more than one project. In one of the cases we report on below, this participation has now extended across several years and a number of different projects. Secondly, the living lab offers an opportunity to introduce existing technologies – prototype or otherwise – which can be used as testbeds for further work. That is, they provide an infrastructure in which to embed technologies at various stages of development.

We would suggest that given the possibilities inherent in living lab work, it is surprising that there is little *comparative* work demonstrating how these varying decisions might dynamically influence outcomes. The importance of this lies in what Brown et al. (2011) call the 'messy details' of field trial practice, focusing on some key issues that they identify as under-rehearsed. They further suggest that an

'interdependence of methods and results' has important consequences. They make a number of suggestions as to how field trial design might demonstrate some sensitivity to these issues. They suggest, for instance, treating 'investigators as participants' in various ways and, conversely, treating 'participants as investigators'. Perhaps most tellingly, they argue that:

> *"To truly embrace the distinctiveness of trials we propose that this additional context is extended (...) and documented in greater detail. Methods sections should be more explicit about the natural contingencies and events that happen while a trial is carried out. These are not signs of a 'Bad trial', but are important details that 'let us understand better the differing contexts of particular trials".*

Vines et al. (2013) address these issues more from a perspective of user participation and its impact on the design process. They argue that integrating users entails some ambiguity in relation to sharing control of research processes and that the methodological foundations for such work are often under-specified. They argue that it is necessary to reflect on pragmatic and conceptual challenges, ethical issues and the preconditions of interacting groups and make procedures comprehensible for others.

Taken together, these observations constitute a critique of the casual assumption that standardized methods produce standard results. There is, in other words, purchase in rehearsing both how social arrangements influence trial results and how the same can be said of how researchers and 'subjects' interact. Here, then, we take data from two settings, both of which can be characterized as living labs, and seek to identify both the 'contingencies' of our approach and the degree to which the 'troubles' that Brown et al. identify extend to this type of work.

7.1.3 The Living Lab in Comparative Perspective

The aim of our work, then, is to present and compare experiences of two cases with a similar 'domain', in this case Social TV, using what are, on the face of it, very similar stances. The two cases are those of a research project based in Siegen, Germany and one based in Lancaster in the UK. We argue that problems and possibilities are brought into relief through this comparative lens. Based on our research, we argue here that a number of factors are important in considering the trajectories that living lab research might take. They include the founding purposes of the research; the users enlisted, their characteristics and their motivations; the geographical and social network entailed; collaboration policy and practice; user involvement in different design stages; data collection methods; and most importantly, communication and feedback, privacy and ethics. We draw conclusions relating to how and when design, redesign, evaluation and collaboration between different stakeholders might be organized to produce satisfactory results.

7.2 The Two Projects

The Lancaster project was and is intended to focus on interactive television, and specifically the problem of the iterative design and evaluation of an interactive television system. Interactive, or social, television is a new generation of 'digital'

affordance for television and represents whole new possibilities for the viewer experience. The IPTV system provides single-click access to live TV, live radio, catch-up and on-demand content; a filter, to present the user with the ability to order and personalize the content list based on a range of contextual and social factors; an embedded video player to provide access to video content (windowed); and social widgets which are capable of providing access to a range of services (e.g., Facebook; YouTube; Twitter). The project entailed a partnership between the university, a hardware provider, a public media company and eight participating households from a local village over a period of four years. The Siegen project is also located in the domestic domain and aims to develop a cross-platform framework including TV, PC and smartphone to support more flexible and integrated media consumption and use of social media applications. To pursue these research goals, a living lab research framework was designed and involved several stakeholders from academia (two research institutes), industry (two media agencies) and 17 participating households representing future users, which were actively and continuously involved into the design process over a period of four years. It can be seen, then, that the two projects contain broadly similar elements in terms of partnership, method, domain, and local contexts (see Figure 18 & Figure 19). Nevertheless, there were both similarities and differences in the way the projects were set up and evolved, as we shall see. As a first brief outline Table 4 provides an overview of the investigated parameters in this work.

Figure 18: Installing prototypes in a participant's home in the UK.

Figure 19: Using prototypes in a family household in Germany.

Table 4: Comparison table of both living lab projects.

	UK project	German project
User sample	Heterogeneous sample structure, different age groups (young children to older adults, single households to families)	
Sample size	Eight households	17 households
Project duration and involvement of households	4 years	
Geographical and social distribution	Village community, participants knew each other	Regional dispersed sample, participants did not know each other
Incentives for participation	Broadband internet, test devices, lotteries (vouchers)	Provided device infrastructure (Media Centre PC, smartphone, HD TV set)
Contact person (mediator)	Two persons from the village	One academic staff member from the university
Study design	Less structured research process	Strong structured research process
Methods	Diary studies, interviews, focus groups, field tests	Diary studies, interviews, creative workshops, online survey, user tests, field tests

7.3 Method

This study based on previous research of both living lab projects. Data from the UK living lab project comes from interviews with six families and with two ‘mediators’ who had been involved in previous projects. Two focus groups also took place, where members from the families were present. Interviews took place in users’ homes or in a local café. All interviews were recorded, with consent. Data from the German living lab project comes from three diary studies with interviews after each study, observation protocols and notes from two creative workshops during the concept design an online survey, data and observations from two user tests and one field evaluation, with protocols, audio and video recordings. Observations of two social events, home visits, casual meetings with participants in the researchers’ spare time and regular exchange with users via email, instant messaging and phone supplemented these data sets. In addition, researchers from both groups interviewed each other and group discussions were held when both groups came together. The interviews focused on the different tasks of project members, the methods used in design studies and the

challenges that arise from user participation within real-world contexts. Within group discussions experiences and findings have been brought together in order to analyze common and different phenomena. In total, four interviews, each with two research staff members from Lancaster and Siegen, and two group discussions, with representatives from both groups were conducted.

For the early analysis of the predominantly qualitative data, researchers of both projects applied an inductive coding method (Corbin and Strauss 2008). Comparison of the challenges of setting up and running long-term living lab studies involved re-examination of substantive data from both projects, reported elsewhere, for instance Taylor et al. (2007), Hess et al. (2011b), Ogonowski et al. (2013), Ley et al. (2014), in order to strengthen the analyzed categories.

7.4 Comparison of Both Living Lab Projects

7.4.1 Purposes and Methods

While it is true that 'mission creep' is found in many research partnerships – goals may often be vaguely expressed or may become moderated over time – it is apparent that initial 'framing' will have an impact, not least because it impacts on the participation of the partners involved. Thus, one partner to the Lancaster case said, "*actually, one of the things you need to bear in mind is that we weren't that interested in users at the beginning. Our interest was primarily technical. We were concerned to produce a system that was platform independent"*. The consequence was that project members were initially enlisted for their technical expertise while sociological expertise – though present throughout – was not systematically deployed. In turn, while there was a general commitment to the idea of user 'involvement' to begin with, this required no explicit methodological stance other than a reliance on an existing field site. In contrast, the Siegen team had a strong predefined user involvement philosophy from the beginning. The design and evaluation process were seen as an iteration cycle whereby prototypes were iterated step by step. At different project stages appropriate empirical methods were chosen to involve participants in the design process and encourage active co-creation based on their experiences (Wulf et al. 2011). Two living lab environments were combined for this purposes – a local real-world testbed at the participants' homes and a stationary lab setting at the university (Hess et al. 2011a).

Initially, the relationship between the Lancaster University and the local village was established some ten years ago. The origins of the relationship were serendipitous and developed from community 'push' rather than research 'pull'. As one very active member said, *'we knew there was funding available for self – help rural broadband and we wanted to build a network. We heard that a Lancaster researcher was involved in a project and invited him along to talk to us. Initially, he said he had no funding but we wouldn't let him leave and we rather bullied him, so they cobbled something together for us.'* The initial collaboration, then, was informal and involved the acceptance of responsibility on a more or less personal level. In contrast, in the German project the researchers initiated the collaboration between participants and university.

This meant that user recruitment took place in very different ways. In Lancaster, recruitment was undertaken by a 'mediator'- a woman with a long- established role in the village community who had, over time, developed both technical and management (or leadership) skills and had proven adept at enlisting members of the community for project participation. Six families were recruited in this manner. In Siegen, the approach was more systematic. Firstly, a call for applications via local newspapers and radio was broadcast. Applicants were asked to fill out an online questionnaire with information about their demographic background, technical equipment, and personal motivation for participating. Telephone interviews with the 32 applicants were conducted with a view to ascertaining additional socio-demographic facts, media usage, and technical expertise in dealing with Media Centre systems and smartphones. Attention was paid to representativeness in relation to family structure (couples with or without children and single with or without children) and technical competence (none/low and high experiences in Smartphone and/or Media Centre system usage). Initially, 8 households were selected, two from each category, with 15 participants in total (6 male, 9 female). Proximity was also a factor, and applicants were in part selected to minimize costs. A second stage of recruitment aimed at finding participants who formed part of existing social networks and so 'snowballing' techniques were used to find additional households. Eight additional households were recruited with the result that in total there were 27 participants (14 male, 13 female) divided into 5 couples with children, 5 couples without children, 2 singles with children and 4 singles without children. The end result was a sample in the urban area of Siegen, which had a degree of representativeness, but a certain geographical dispersal so some of the participants were not known to each other. In contrast, the Lancaster sample had no real claim to representativeness, but was drawn from a village where effectively all participants formed a close-knit community and knew each other. In both projects participants did not get any money for their efforts but were incentivized by the provision and the self-determined usage of technology (broadband, smartphones, Media Centre PCs, set-top boxes, TV sets) but also by more intrinsic reasons like curiosity, self-reflection on their own media usage behavior, learning, participation in research, communication and new contacts. This led to different expectations on the projects and had also a significant impact on the users' motivation and engagement. While some were just happy having the technology, others were more interested in contributing to the design and development process.

In respect of method, again there were some differences. Both projects made use of diary studies, of focus groups and of interviews in order to elicit information about user behavior and attitudes. In Lancaster (see Figure 20), some early focus groups were organized with a view to obtaining initial 'sensitizing' results, and one organized later, shortly after the project moved to iPhones as a second screen resource. Subsequently, all data collection was done by two researchers, in the form of interviews. Lengthy interviews (approx. 1-2 hours) took place in family homes and in a local café. Interviews were, with permission, recorded.

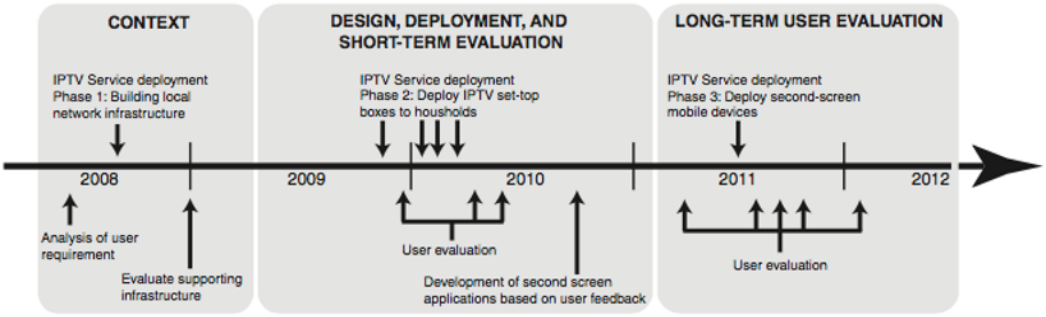

Figure 20: Progress of the Lancaster project (above the timeline: interventions within the field; below: research methods).

The Siegen approach was more structured (see Figure 21); with active involvement of participants 'designed-in' during the entire design process. In Siegen, an initial three-week diary study was conducted. The diary contained pages on which the participants were asked to document every single media usage with information about the usage context. Several additional pages were included with a view to understanding more about the participants' regional, national and international social networks, pastime activities and so on. Using a camera, participants documented aspects of their media usage to give researchers more visual insight. The diary study was also intended to help to establish a trust relationship (see below) between participants and researchers. After the three-week self-documentation process, the materials were collected and additional interviews conducted with each participant in the household to ascertain their current media usage. During the entire project progression households were equipped with new technology twice (Rollout I & II). To understand how the new technology was appropriated and how media usage changed, the diary study was repeated after each intervention. Following Diary Study I and an initial analysis of data, for instance, creative workshops were conducted. The aim was to co-develop and discuss first concepts and ideas for an integrated and flexible usage of TV, smartphone and PC (Hess et al. 2011a). Following this, a low-functional early-stage prototype was developed and users invited to the university's lab for evaluation. Besides a scenario-based walkthrough, participants were able to contribute suggestions in a subsequent open interview. After re-design, more laboratory-based user tests were conducted both with individuals and with groups. Following this, the prototype was revised again and rolled out to the households (Ogonowski et al. 2013).

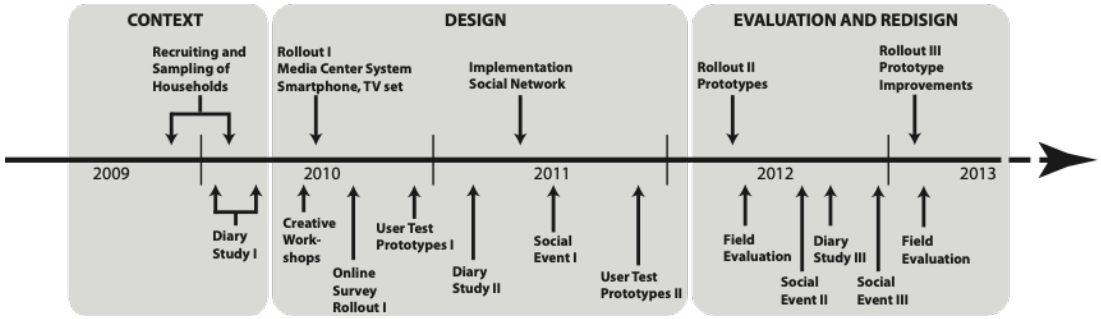

Figure 21: Progress of the Siegen project (above the timeline: interventions within the field; below: research methods).

This relatively high degree of structure, then, had certain advantages in relation to links with users and the regularity of feedback. It also, however, came with a certain cost – 'user fatigue'. This was evident, above all, in the diary studies. While the motivation for completing diaries was relatively high in the first Siegen study, this assiduousness subsided precipitately with subsequent studies, and most participants were visibly vexed when asked to complete diaries again. During one home visit, for instance, one participant rolled her eyes and welcomed the Siegen team with the words *"Oh no, not again!"* on seeing the documentation box they wanted to hand over. Again, this raises an important question concerning self-reporting of behavior. The point here is that there was a divergence between the self-report conclusions and other, more objective data. There were also differences to be found in the views of different members of the household. Thus, when Siegen researchers asked a participant about any changes regarding the new devices they had introduced, she answered: *"I always do the same. Until now the Media Centre system doesn't offer much new"*. Her 17-year-old daughter, nevertheless, claimed that her mother's usage behavior had changed insofar that she now used the Media Centre system much more. The Lancaster experience was similar, but even less successful. Unless continually prompted, participants proved unwilling to continue with diary work for more than a limited amount of time. Our view is that, in this context at least, diary studies had limited value. Quite how reliable they were over an extended period of time remains unclear. Diary studies are not unreliable per se, but clearly need to be triangulated with other data.

7.4.2 Participating Users

Participatory design philosophies and practices have entailed various methods and tools that focus on the involvement of users in (re-)design processes (e.g. Greenbaum and Kyng (1991), Kensing and Blomberg (1998), Bødker et al. (2004)). The focus has often been on the mutual nature of the learning process with attention to the long-term and continuous nature of user involvement for shared understanding. This, however, is not necessarily easy to achieve. Certainly, in respect of long-term involvement, changing expectations need to be considered.

7.4.2.1 Geographical and Social Distribution of Households

In relation to the different user groups and environments, the diverging nature of the two groups had certain consequences. In the village of the Lancaster project, all participants were known to each other and often lived close to each other. This density of local and regular face-to-face interactions was not duplicated in the geographically more dispersed German sample. For them the living lab was initially a relatively formal and impersonal institution. This became obvious during the first workshops where many participants were aloof and nervous. Moreover, the structured workshop program did not allow participants contact on a more personal level:

> *"(...) during the workshops everybody was focused on the project discussion so that personal conversations did not arise out of the situation. The same applied to the user tests. Conversations with others were almost impossible, because the tests were executed one after another." (male participant, Siegen)*

This means that a more dispersed group of participants required a greater effort from living lab coordinators to provide a social space for participants to get to know each other. Later on, several social events (e.g. barbecue, visits to a Christmas market and beer garden) were organized for this reason.

The way in which user populations were selected and structured in the two cases had one further, and quite important consequence. This had to do with our ability to evaluate social media use. Results with different user populations relying on different methods suggest a willingness to use social media when watching television. Barkhuus (2009), for instance, reporting on the 'social' or 'interactive' experience in a small study of young college students found they were very likely to communicate synchronously. For reasons to do with the friendship patterns or geographical dispersal in our groups, we did not find this. As a participant in the Lancaster sample said when asked about 'chat' functions:

> *"Not really ... I chatted with Carol about it ... but not on the system [laughter]... I can't see why you would ... I talk about it with people on the street when I meet them ..."*

Even though the user sample in Germany was more dispersed, we obtained similar results. In this context the Siegen living lab had to deal with two barriers. Firstly, existing friendship networks in the sample were very limited as mentioned above. Second, sending friend requests has a moral implicature, and people were reluctant to do this:

> *"I should have applied directly together with friends rather than on my own. It would make things easier. I noticed that some participants did this and I don't wanna get on the others bandwagon. I also couldn't join the BBQ which didn't make it better." (mother, Germany)*

And another said:

> *"That's my personal view of social networks – I would like to know the people with whom I am connected. On this basis, I'm able to make use of friendships. However, most of the time when I was online, no one else was there. I would like using this chat functionality." (Germany)*

That is, sample size, location, and method of selection all played a part in a failure to achieve any critical mass in relation to social media use. Arguably, this was the most significant failure in both projects.

7.4.2.2 Heterogeneous Roles

Research has shown that particular users can be much more influential than others in participative research (Brown et al. 2011). For the most part, however, consideration of this has been limited to understanding the role of 'lead' users. Our experiences suggest that users, and hence their commitments concerning the reasons why they participate in research projects, vary a great deal. As a function of both the deliberate policy of selecting a structured sample, and of a more systematic commitment to communication with users as well, it was possible to identify variations in expectations and motivations over time in Siegen. Some participants, for instance, expressed an enthusiasm for the research process itself. As one technically experienced male participant put it:

> *"I can express my visions and discuss novel concepts together with others, in the hope that some of my ideas will be implemented. If not, it does not matter. Anyway, if the system is available on the market, I can tell my friends that I contributed to it."*

Others, in contrast, felt their role to be very limited and specific. As an example, one 47 years old female, less experienced participant, who worked as an architect, wanted to apply herself as an expert in visual design but was not interested in using the applications later on:

> *"I cannot contribute in the community/Facebook/new stuff – my friends have no taste for it and me neither. (…) I guess I am a prime example of a dinosaur in your young social community (…). For the development I could possibly help a bit with my viewing patterns (…)". (female participant, Germany)*

One of the major differences in the two projects, we discovered, was the role of mediators. In the village near Lancaster, the researchers relied heavily on a small number of people – over time this became a single person – to enlist participants for this project. Their relationship with certain members of that community goes back a long way. As a living lab, the population of this small village have been extensively studied (see e.g. Taylor et al. (2007)) as various technologies, such as public displays, have been trialed there and this fact, along with the different kind of social arrangements to be found in a small village, may explain some differences in the results which were obtained.

There are advantages to this, notably that this long-term relationship means a partnership with someone who – over time – developed an understanding of research and its issues, a level of technical competence and who can, in principle, communicate this to other participants. This person not only acted as a proxy for the Lancaster University in explaining the purposes of their research activities, but also acted as an intermediary in a more practical way, informing the research team when faults occurred, explaining to participants how certain functions worked – even providing support for the network. Now, 'Carol' as we shall call her, did not watch very much television. Indeed, she suggested that the only time she makes an effort to watch television is when her daughter recommends specific programs, or when her grandchildren are in the house. On the face of it, this is quite different from the kind of 'lead user' reported by Brown et al. (2011). Here we have someone who makes little or no use of the research technology in question but nevertheless makes huge efforts on behalf of the research team:

> Carol: *"It's got to fit into your life (…) it's got to be of some use (…) but for me, it's a way of paying the university back for the broadband (…); they still fall by the wayside cos it depends on how busy you are, what you're interested in, how much trouble it is (…) but it's my role to encourage them. What I would do, if we could get the chat working better, would be to use it to help (…) give people instructions."*
>
> Researcher: *"Working with the community, do you get frustrated?"*
>
> Carol: *"No, I love it (…) it's so rewarding, I can do it all day (…) showing people how to do things. They'll come to you if they want something. To be entirely honest- I know you work for them- if anything*

is frustrating, it's the university (...) [goes on to detail various problems she has to contend with when working with researchers]"

Certainly, this made recruitment easy. At the same time, this relationship was not always straightforward. Lancaster's mediator was, and remains, highly committed, but there is little doubt that this role has proven very demanding. We should note that, because the village has been used several times as a testbed for various prototypes, researchers had originally relied on two people who voluntarily performed this mediating role. One, who had completely dropped out after a period of time, was very candid about her reasons:

"it just got too much (...) to be honest, I found the demands unreasonable and I didn't find the university very helpful (...) I didn't think it lived up to its responsibilities (...) and I'm not like Carol, I'm not so motivated (...) let's face it, she's the reason things get done here."

It arguably has a further consequence, which is that of distancing researchers from participants in the early stages. It meant that sometimes the mediator took it upon herself to solve simple technical problems and was the first port of call when more difficult matters needed resolving. As implied above, the user population here had a fairly homogenous view, which was that they were happy to participate as long as they perceived some benefit. It was the mediator who saw her role as entailing a commitment to research. One lesson became very clear to the Lancaster researchers, which was that the involvement of social scientists was less systematic in that they never took the specific role of 'point of contact'. Indeed, no one really did. There is some evidence that the role of social scientists was at least as important when it came to evaluating the project as it was in relation to collecting data about use. Certainly, interview sessions often prompted reflection on the project, its purposes and its successes and failures. This was different in the German project where there was no such mediator within the group of participating users because of the previously mentioned geographically dispersed lab structure. Here it was necessary to allocate a person from the university staff as a 'point of contact' right from the beginning. This person however did not have a strong personal relationship to users and it took an effort to establish trust relationships. However, this academic staff member acts as a 'boundary agent' in different ways. In a way, she mediated between participating households, industry and researchers itself. For the users, the staff member served as a help desk that supports the appropriation of new technologies. For the industry as well as for academic partners, she served as a translator of the users' needs and facilitated mutual learning between users, designers and researchers. In contrast, Carol in the UK project functioned more specifically as a community representative and organizer. Both roles implicate ethical issues, which are further discussed below.

7.4.3 Trust and Expectation

7.4.3.1 Trust and Research Relationship

Here, our main interest lies in relations between participants and academics. There are significant differences between both groups of actors, differences that are not always made explicit. These differences mainly have to do with the expectations that tie into

the ordinary, day-to-day rhythms of family life. They can be summarized in the following ways.

Firstly, users often have work with background assumption that 'repairs' can be enlisted from outside and, if so, repair work will be timely. The participants in Lancaster, for instance, sometimes complained that it might take several days before someone from the university came to deal with system problems. It was not unusual, in the UK case, for the 'mediator' to take work of this kind on herself so as to forestall complaints. The point here is that user expectations were and are formed out of their everyday experience of breakdown and repair and not by what the working priorities of academics might be. Participants expected quality service and became frustrated when they did not receive it. They were rather intolerant of the ability of academic partners to deal with breakdowns in a timely way. Inevitably, given the prototype status of the technology, these breakdowns were more common than one would expect from commercial equivalents. More importantly, this is a technology that forms a fundamental part of most peoples' lives. Of course, academics have other priorities and certainly do not see themselves as repairmen. In Siegen, this even extended to asking for assistance which had nothing to do with the system itself. Researchers in this latter case, for instance, were enlisted to repair a broken satellite cable or in another case to set up a Wi-Fi connection for the daughter's laptop. As one researcher said, *"some of the participants saw us as a 24/7 help-desk"*. Our point here is not that users are 'right' or 'wrong' to make such demands, or that academics are 'right' or 'wrong' to prioritize their efforts in different ways, but simply to point out that these expectations are embedded in quite different routines. Diverging presuppositions arguably need to be managed very carefully.

Similarly, routine expectations are grounded in existing experience of technology. One reason for the relatively high level of acceptance in the UK village, at least to begin with, was that experience with TV and Internet resources had previously been poor. The village is in a very rural area where broadband facilities and TV reception had historically been very poor. This slowly changed as commercial networks become more available (and reliable). The initial rollout in Siegen had been based on Windows Media Centre, which had been both robust and reliable. It fitted the routine demands of family life. *Rollout 2*, which users had waited some time for, while technically more innovative, was less robust and engendered frustration. Hence:

> *"The biggest problem for me is, that most of the functionalities can be used in a limited way or didn't work. That leads to disuse and you want to go back to the Windows solution. That's why I couldn't give you more than a little feedback." (male participant, Germany)*

Some participants felt guilty if they did not or could not fulfil the given tasks. Even when frustrated and negative, they felt obliged to provide feedback:

> *"I feel so bad that I did not use the feedback app and that we do not do enough for the project although we have gotten the devices from you. But I always tell my kids that they have to use the TV application!"(Mother, Germany)*

There is, put simply, a moral implicature in respect of participation. Participants react in various ways, but all recognize a degree of accountability. Users often felt obliged to participate in workshops, interviews, diary studies and testing in return for the received technology. Some occasionally spoke negatively about the less-than-wholehearted participation of others:

> *"Where are the other households? It cannot be the case that we attend with three persons and others are always absent. They also have got the devices." (Mother, Germany)*

Where participants dropped out, justification often had to do with perceived failures on the part of university staff, either because they (in the eyes of participants) did not understand local concerns or because they failed to provide and maintain adequate hardware/software. That is, accountability was seen as reciprocal. This 'moral universe', we discovered, is quite separate from formal ethical considerations. Most participants confessed they did not read the ethical guidelines given to them in written form or available online. As one said:

> *"We're not that interested. If we didn't want you doing this work we wouldn't have anything to do with you. We get something from it and, as long as we do we're happy with you."*

As another said:

"My relationship with the university is brilliant, excellent. I don't really care what you're up to as long as I can see the benefit".

7.4.3.2 Trust and the User

Here, again, there is an important point to be made. When recruiting users, there is a tendency to think of them as 'units'. That is, they are recruited as individuals, or 'households' or as 'communities'. Treating them this way ignores the dynamic inside the unit – the normativity's and 'rhythms' we are interested in. In both our samples, it was often the case that there was a prime mover for participating in the project. This person was often male, had a strong interest in the project, was motivated to participate and act as contact person. This is evidenced in the UK sample in the following exchange:

> Researcher: *"How about the fact that people tend to be fairly private about their phones (...) if you're using it as a remote it can't be that private, can it? If there's more than one person wants to use it, I'm just wondering if there are any issues about who's using it or where it is, or who gets to choose, or can I borrow it?"*
>
> Father: *"I haven't, because I'm the only one using it (...)"*

Again, other household members – in particular wives and children – can sometimes show less interest in research aspects. This was the case, for instance, in three of the participating households in Siegen. Involvement in the project did not necessarily mean enthusiasm on everyone's part. When new input devices and software interrupted familiar usage behavior and sometimes meant that users could not switch on the TV, then unwilling participants could get very frustrated. This even led to the

point that other household members could not or limited satisfy personal needs. One family father described the situation as follows:

> *"Based on the fact that I work in shifts I often come home very late and I have to put up with [moaning] (...) it makes no sense testing your system any longer. It would mean to me that I have to replug all cables every night, so that my wife and my daughter can watch TV in a normal way next day. I don't want this!"*

As we have seen, family dynamics vary considerably. This underlines the challenge when dealing with new entertainment concepts on shared family devices like the TV set in the living room. Multi-person households, especially with children of different ages, need to be seen in terms of the ongoing management of family relations.

We will suggest here that we can think of these differences in expectation as having to do with trust. There is a considerable literature on 'trust' which we have no space here to discuss, relating to matters such as its cognitive and social aspects (see Möllering (2006) for an overview). Perhaps surprisingly, there is relatively little on trust as a practical matter. That is, what factors lead in practice to the presence or absence of a trusting relationship over time, especially in the context we are describing. Trust in this instance has two important, and distinct, elements. These are trust in the research relationship and trust in the research technology.

7.4.3.3 Trust and expectations of the research technology

We found some differences concerning developing technologies and applications. In the UK village, although the technology in question was not especially robust – especially in its earliest incarnations – there was a significant degree of fault tolerance. Thus, and for instance:

> *"I really like it (...) I've been missing it on holiday (...) I've found, with perseverance, that it's much better now than it was when we first got it. (...) yeah, there are lots of things that are not altogether perfect like I can't see the writing (...) I've tried to wear glasses and I've found it quite difficult (...) we've got a little telly and it really does make it a problem (...)"*

Similarly:

> *"I found that, a program you begin to watch one day (...) you can't find the next (...) that happened yesterday (...) but on the whole I use it much more than I used to use the iplayer (...) It's just easy to use (...) from my point of view, I just go on to the searches, browse it, and find things I haven't seen (...) I know it's on the box and I can watch when I like, and it's good."*

In comparison to that, in the German project we found a lower degree of fault tolerance. One reason was the long waiting period before first prototypes were rolled out. During this period marketable solutions were integrated into participants everyday life and influenced further expectations. Even though the Siegen researchers stressed the given prototypes are not so stabile in usage, participating households expected a proper solutions and lost trust in our technology in a way not using the prototype to record or watch interesting TV programs.

Our researchers further indicate that trust in the research process in the context of living labs is largely predicated on the intensity, frequency and 'personalized' nature of the interactions that take place. As stated above, trust is to some extent a function of timeliness – the ability of academics to intervene in ways and at times that meet users' ordinary, everyday, perceptions of 'how things should be done'. Further to this, however, when such repair work was undertaken, participants in the Lancaster sample sometimes reported that they did not feel engaged in the process when, *"some young man turns up, hardly says a word, fixes the thing and then disappears never to be seen again (...)"*. Some aspect of this is evidently to do with personal contact. As participants said in an informal group discussion (in a café) during the latter stages of the UK study:

> *"we enjoy talking to you guys. It's always nice when you come here and show an interest in what we're doing, buy us coffee and cakes. We get to know you that way (...)".*

This is brought into sharper relief in the German case, where the project was structured so that there was always a single point of contact. In addition, it was a matter of policy to punctuate the more formal research stages with informal get-togethers, which were primarily social in their function. The intention here was to allow users to get to know each other (with the idea of strengthening network possibilities – something that was hardly necessary in the village scenario) but there is little doubt that they served equally well for participants to get to know researchers. Here, we identified the same problem as in Lancaster. Participants often wondered who it was doing the technical configuration during home visits. Project staff members changed during this time and this changing circumstance was noticed and remarked on by users. That is, in both projects, the importance of continuity was evident. Trustful relationships were, in this instance, built over a relatively long period of time.

Taken together, the cases indicate to us very strongly that communication, in and of itself, was not enough. Participants needed a regular point of contact, to feel that their requests and complaints were being dealt with, and to feel that these communications were in some sense 'personal'. That is, even though participants were aware that 'research' was the objective, they nevertheless wanted to feel they were more than simply the objects of research.

7.4.4 Implications of Time

In consequence, one obvious feature of a long-term relationship of this kind is that, and unlike other projects, it is not possible or desirable to 'parachute in' researchers. Obligations of a subtle nature are often evident. These include a willingness to be available at times relevant to the needs of participants, a need for technical expertise and support beyond the life of individual projects, and a nuanced view of entitlements in respect of 'kit'. It also involves recognition of the efforts made by participants. In the UK project it was interesting to see the different perceptions of two leading figures in the village, both of whom have been heavily involved in research projects with the university and with other initiatives. While one, for reasons she identified as being to do with her own character, continued to view work with the university very positively, for the other frustrations over the amount of work she had had to do, and the

communication difficulties she perceived meant that she had more or less ceased to collaborate. Both intimated, to differing degrees, that there were times when they felt 'taken for granted'.

The early involvement of participants in the design process and idea generation in the German project aroused definite expectations on the prototype development. Participants were curious about the results and became impatient concerning completion and rollout of the software. During the time it took to develop the prototype the users' motivation and interest in the project strikingly decreased, as they could not track the development and its progress.

Besides that, in consequence of the long-term collaboration, the German project had to deal with several social and market dynamics, which influenced the project process. Varying and changing interests over time alongside changes in participants' daily routines (e.g. job change or moving house) resulted in poorer availability and dropouts from the project. In Siegen, for example, academics were facing changes in the household structures insofar as a single household became a couple household and finally a family household. In another case a couple broke-up and we had to source additional hardware to equip an additional household. Another couple moved to a new location, which was further away from the university and did not provide a satellite TV connection, so the project team had to switch the tuner hardware for cable reception. Next to these social dynamics one major challenge was the continuous advancement of the markets in the area of home entertainment and smartphones. For one thing, in both projects the hardware provided (e.g. smartphones) became outdated over time and participants either started to buy newer devices by their own as it was the case in Siegen or had newer kit provided in Lancaster. This led to a heterogeneous device environment at the users' homes and software prototypes became less robust. For another thing Smart TVs with manifold features entered the market and became increasingly popular and affordable. As a result, some participants in both projects stopped using the hardware and software provided, preferring more robust commercial solutions.

The aim of both living lab projects was to embed rolled out devices into participants' everyday life to obtain realistic use settings. Although the conditions under which research will be undertaken are made clear and available to participants, it is not easy to remove equipment from them at the end of the project cycle, especially if one has to rely on the same constituency again in the near future (see also Taylor et al. (2013)). This has led to a degree of negotiation concerning rights over equipment. As one interviewee in the UK project said to us in response to a question about this, *"I told [him], you'll have to shoot me if you want to take that away. I rely on it and my kids need it. You can't have it"*. Similar experiences were found in the German project where some participants asked to buy the devices from the university, even those participants who left the project prematurely.

7.5 Conclusion: Lessons Learned

In 'Deploying Research Technology in the Home' (Tolmie and Crabtree 2008) examine the ways in which research deployments interact with and occasionally

disrupt the routine organization of the home and how this in turn, because of its impact on the domestication or the 'taming' of the technology has implications for any analysis of the processes of domestication and design. They suggest, quite rightly, that research participants invariably have a set of existing relationships with technology that are, to some extent 'breached' during the research process. In particular, existing ideas about the positioning of technologies within the home and ideas about ownership and responsibility for maintenance and repair, affect attitudes towards the technology and hence any analyses we might wish to construct thereby creating the interesting dilemma: "how are we to understand the deployment of technology in the home to be research into how technology is oriented to and treated as an integral part of the home, when research is focused on eliciting the remarkable rather than the mundane qualities of the technology and its use?" We believe the living lab as we have practiced it goes some way to resolving this dilemma: firstly, through the long-term nature of the deployment whereby the technology was given the time to be 'made at home' with the rest of the domestic space and thereby overcome some 'anthropological strangeness'; secondly, because the technology introduced, the set-top box for example was regarded as largely complementary to an existing TV technology that remained in place at the end of the research; and thirdly, because of the careful consideration of aspects of the ethical relationship between researchers, participants and the technology. The approach of the living lab as adopted and documented in these two deployments is a method whereby, as Tolmie and Crabtree suggest, design teams can "develop and exploit a sensitivity to the real world, real time character of technology installation in the home and to user expectations". While obviously aware of some of the problems of the research relationship, we suggest our current living lab studies contribute significantly to avoiding or overcoming what Stewart and Williams (2005) call 'the design fallacy' whereby particular and unchanging values are attributed to users, users responses to technology are ignored and, in consequence the system or application becomes increasingly divorced from and irrelevant to users circumstances and needs.

We observed some differences in the ramifications of the two studies, largely based on the different degree of systematicity and which came with both costs and benefits. The German study was more highly structured and had more carefully organized research 'intervals' with which to collect feedback data. This arguably produced more nuanced conclusions in respect of user heterogeneity and its relationship to feedback about design issues. At the same time, 'user fatigue' seemed to be more pronounced. Certainly, diary studies had a pronounced diminishing return. This systematicity also varied with regard to relations between academic and commercial interests, and created problems of their own. There were evident differences in terms of judgements about the roles each partner should adopt, what they might expect from each other and specifically about the value of methods used. It is unclear whether a more explicit definition of role, method, etc. at the outset would have made any difference. As best we can tell, from both studies, some of the tension resulted from the very rapid way in which commercial interests have to respond to external factors, notably the market.

Much more importantly, however, we spoke above of the unrealized ambition to render living labs 'human centric'. Our purpose was and is not to argue this has not been done, but that it has not been shown to be done, particularly when 'human centric'

includes some notion and some understanding of the long-term ethical issues that face research. It is a large part of our argument that living lab research depends on a sophisticated grasp of the moral universe that researchers and their participants inhabit. There is, to our knowledge, very little discussion of the ethical issues surrounding long-term collaboration with users (however, see Taylor and Cheverst (2012), Taylor et al. (2013), Vines et al. (2013)). Again, the intention here is not to sermonize about the need for an ethical stance, but to show that ethics have a very practical dimension. The obligations that researchers have towards their partners in research should not be considered in the abstract but as a recognition of the very practical ways in which partners can feel 'let down', ignored, undervalued, and so on. Formal ethical guidelines, 'informed consent' etc. while necessary, do not adequately encompass the 'real' issues. Indeed, we might go so far as to say that issues of 'informed consent' etc. were of little interest to the participants, even when explicitly pressed on the matter. Moreover, the precise character of these ethical issues is determined in part by the long-term nature of the projects in question.

If living labs are to be a successful long-term instrument, then we would suggest we very much need to understand what the 'human' processes entailed might be. Perhaps the most significant result from the researchers' point of view, because it infuses everything we have rehearsed above, is the importance of what we can call, 'practical ethics'. It is no great discovery that relations between human beings are normatively founded – it is, after all, a founding principle of Sociology and, methodologically speaking, fundamental to participatory design processes (see Greenbaum and Kyng (1991) for a classic rendition of this theme. Nevertheless, in the context of a research methodology that is intended to implicate a long-term relationship we have seen few reflections on how this works out in practice. The main purpose of this paper is an attempt to rectify this and draw some conclusions from our comparison.

7.5.1 Researcher-User Relationships

We have argued that there are various ways in which trust relations are successfully established and maintained. Not least, we see how the specificities of a relationship with a local mediator in the Lancaster case as against a more directed approach to the 'point of contact' shift the interactional balance. The mediator has proven enormously useful as a point of contact and as acted as a normative force in the sustainability of research efforts. At the same time, it is easy to allow a transfer of responsibility in such a case and the result, arguably was a lower degree of tolerance over academic involvement. It is important that the role of mediation cannot be over-stressed. The success of the long-term collaboration in the UK village depended almost entirely on the ability of one, possibly two, people to recruit, persuade and engage. As ought to be clear, the level of commitment and expertise demonstrated by such volunteers is remarkable, and collaborations of this kind could not succeed without their work. It is notable that successive projects have 'piggybacked' on this goodwill, but efforts to maintain good relations and show the requisite appreciation have not been consistent (this might be because different research groups are involved). We argue that 'mediators' here do not perform the same role as 'lead users' as they are sometimes described. This has both positive and negative features. A mediator can accept a very significant role in the process, often taking on functions beyond those that were

originally envisaged. In the Lancaster case, this had positive consequences in terms of ease of recruitment, and as an immediate resource for answers to questions and dealing with simple technical difficulties. The cost, however, was a more distant relationship between researcher and user. Our own feeling, based on our interviews, was that users do not always feel 'championed'. They comment, as we have pointed out, on the somewhat reticent behavior of (for them) anonymous people who *"come out, fix the equipment, say nothing and then disappear [...]"* They express some frustration at the inability of researchers to understand the demands of family life and its routines, and their inability to identify exactly who they need to be talking to. Clear allocation of responsibility for communication with participants at timely moments helps a great deal. In the Siegen case there was always a nominated point of contact. For that person, an academic rather than a community member, that entailed other kinds of difficulty. As she said,

> *"(...) sometimes, I'm dealing with people that I know very well. They are my friends. I have to make decisions about what 'data' is, what I can say about their attitudes when, for them, it is not always clear when we are in an interview situation and when we are just talking."*

The downside here lay in the fact that users had overly high expectations of academics as a result of that more personal approach and were arguably more easily disappointed as a result.

In conclusion, what is clear is that issues of responsibility, including those of how we identify what our responsibilities might be; who holds them; what they entail, and how we discharge them, are matters of the negotiated order. It has long been the case that engaged researchers have argued for the treatment of participants in a more reflexive way and we fully subscribe to such commitments. Nevertheless, in a context where research relationships are predicated on lasting commitment, they cannot, they will not, be determined by us alone. They evolve over time and in delicate relation to the needs and desires of our partners.

7.5.2 Project Dynamics and Expectations

The moral universe encompasses user expectations and the ways they change over time. We noted that the mediator in the UK project developed a considerable degree of technical expertise over the years and often involved herself in significant repair and development work. She was also an expert in, and very reflective about, interaction in the community. As she once said, *"there are people in this village who cross the street when they see me coming (...) they're afraid I'm going to ask them to get involved"*. The support that is provided in projects of this kind is all too often only technical. This is largely, we think, predicated on the assumption that the 'user', as argued above, is an individual unit and, as a result, little thought has gone into the dimensions of family, community and participant-researcher interactions in relation to their long-term moral implications. For some users, participation brings its own reward. More than one person reflected on the pleasures of participation, but equally that this was enhanced when *"the university takes some interest in us"*. Having said that, some frustration was expressed over the time it took to fix problems; the disappearance of technology at the end of projects; and over 'being taken for granted'.

One respondent, involved during the whole project cycle we report on, commented as an aside, "*I've never received a single penny for what I've done."* One further observation has to do with community-identified needs. Although there are evident limits on what researchers can do outside of the formal remit of the research, it is noticeable that appreciation of efforts made 'above and beyond' was significant. Hence, *"[X] helped us a lot with the setting up of the mesh network, even though there was no funding at that time. He's a very nice man"*.

Overall, 'taking users seriously' is a function of not only regularity and intensity of interaction, but also of a conceptual shift. Living lab research depends, we suggest, on a vision of the user as engaged in a web of interactions in the family, in the community and with researchers. This is particularly significant when we consider 'time' as a factor. Even though we are describing long-term collaboration, time is a relevant factor in the short term as well. The lives of most people are governed by a series of interactional routines, and the lives of the participants in the project are no different. What is evident is that the routines of university researchers and those of participants are not necessarily contiguous. On the one hand, users clearly appreciate care and commitment when they experience it but on the other that level of intervention, if not accompanied by equally effective innovation and prototype management, can lead to disappointment. An alternative consideration could be the deployment of a dedicated 'user engagement' member of the research team that fulfils a similar role as the mediator. This may provide deeper insights into the research field and a stronger relationship to all involved participants. However, this is significantly more expensive and requires embedding with the local circumstances.

The same normative features are visible in the fact that users in both instances have to manage relations with each other – visible in the management of family life and of networks of friendship. It became apparent, with the benefit of hindsight that both projects were relatively poorly set up in the first instance for the investigation of social media use. The reasons, however, were different. The fact is that village life involves a dense network of face-to-face relationships and as such there was little perceived need for any synchronous use of the social media with television watching. In the German case, again it probably had more to do with the very systematic approach adopted. An attempt to 'design in' social media functions was at best only partially successful. The reasons had to do with the fact that existing biographies have a powerful impact on the kind of interactions people are willing to take part in. In the absence of existing friendship patterns and a high density of use, critical mass was never reached. In much the same way, making sense of patterns of use necessitates attention to the ordinary day-to-day, sometimes moment-by-moment character of family routines. The general point here is that arguments about 'types' of user, and understandings of the use of the living lab approach, should incorporate not only individual characteristics and motivations but also the way they intersect with other, family and community dynamics. These, to reiterate, are not primarily problems of method, at least narrowly considered, but problems which have to do with our understanding of the moral universe we inhabit and how it is shaped over time by changing practices, expectations and reciprocal awareness.

8 Sketching a Narrative Map: Reflections on User-Researcher Relationships and Project Progression*

Abstract. In this paper we present the ethnographic method of narrative mapping to investigate user-researcher relationships and to reflect on project progression. We conducted this method in two workshops together with participating users and academic stuff members of a four-year research project in the domestic domain. This method, we argue, is useful to gain an in-depth understanding of participants' benefits, experiences and barriers. It helps the understanding of users, their domestic contexts, and can strengthen the quality of relationships between users, researchers and other stakeholders especially in long-term participatory design processes.

Keywords: long-term study, domestic domain, qualitative method, living lab, pragmatic challenges, participatory design

8.1 Introduction

Designing new and innovative ICT concepts and solutions, especially for the domestic context, requires a proper understanding of users' daily routines and habits. It also implies a level of participation on the part of the same users in the design process. Understanding users' ideas and experiences, however, can be challenging. Several works exist that describe and reflect on fieldwork and participatory design (PD) methods, for instance (O'Brien et al. 1999; Crabtree and Rodden 2004; Randall et al. 2007; Dick et al. 2012). But fewer works examine these methods and project processes from a meta-perspective (Taylor et al. 2013; Ogonowski et al. 2013). Vines et al. (2013), for instance, discuss the influence that users actually have when using PD methods and argue that it is necessary to reflect on pragmatic and conceptual challenges, ethical issues and make procedures comprehensible for others. The type and quality of relationship between researchers/designers or users/designers is an essential aspect for running projects successfully, especially for long-term investigations. Getting an understanding how project members and participating users feel during the research progress, how they experience interactions with each other and what additional work is necessary, whether or not it is directly related to project tasks. This can furnish important insights, which are otherwise often neglected in empirical as well as design case studies. By applying the method of narrative mapping we have addressed these issues. The results from this and lessons learned are described in this work.

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* *Ogonowski, C. and Ley, B., 2014. Sketching a Narrative Map: Reflections on User-Researcher Relationships and Project Progression. In: CSCW '14 Workshop: Designing with Users for Domestic Environments: Methods, Challenges, Lessons Learned. 1–5.*

8.2 Narrative Mapping

Narrative mapping is an ethnographic method to reconstruct the individual habitats of participants and their relevance for themselves in order to examine relationships between humans and their immediate social world from a biographical perspective. The method was invented in the context of educational- social studies with children in Germany and was originally used as an instrument of current research as well as retrospective biography research (Behnken and Zinnecker 2010).

Narrative mapping combines cartographic sketching and narrative elements. Participants will be invited to sketch an imagined or remembered timeframe and explain it by recounting details. This first step should be conducted without any intervention from the researcher. The only task is to embed the participant into the timeframe you want to investigate. The researcher should note the order of the objects, which are drawn on the paper (including places, persons, activities), and the questions, which come up during this process. After the sketch is finalized, they can ask additional questions and clarify misunderstandings or ask for detailed explanations. As results, the following material will be gained for the analysis:

- An improvised sketch;
- Additional comments from the participant, (audio taped) and;
- A protocol with the order of the sketched elements.

The analysis of data can either be focused solely on the objects of the final sketch (seize, style, colors, details places, barriers, paths, biographical experiences and how they are related to others in the sketch) or on the process of sketching and narrating (chronological order of sketched objects are following an inner psychological order). In a final step, the data should be triangulated to reach an overall and complex understanding and to validate first findings.

8.3 How We Applied the Method

In our case, we applied the method in reflecting on the progression of our four-year research project, where we developed a cross-platform entertainment concept. In this project we used a living lab as a methodological approach and as an infrastructure for participatory design studies and for the appropriation and evaluation of ICT in real-use contexts. We continuously involved 27 participants during the entire project duration (Ogonowski et al. 2013). This long-term process was associated with technical and motivational challenges.

In order to get a better understanding how researchers, industrial partners and users experienced collaboration processes and activities, we conducted two workshops after the project ended (One with the group of researchers and another one with participating users) Participants were asked to sketch a map that describes the path with all ups and downs they experienced during the four years, how collaboration has changed and how individuals felt associated with the project. During step one (see Figure 22) we had to intervene in both workshops, because participants needed some support on how they should visualize the processes. We gave outline hints about how to describe their

expectations and which route they took at the end. We recorded both sessions and created protocols with sketched objects. During step two we asked additional questions concerning the participants' roles in the project, personal limits and noticed frictions between or in several stakeholder groups.

The analysis of the data from both sessions was conducted in two steps. At first, we analyzed sketches, protocols and interview transcripts individually for each group. After that, we have brought them together in order to find shared experiences (problems and highlights) as well as contradictions between the groups. This helped us to gain a more profound understanding how individuals felt during the project.

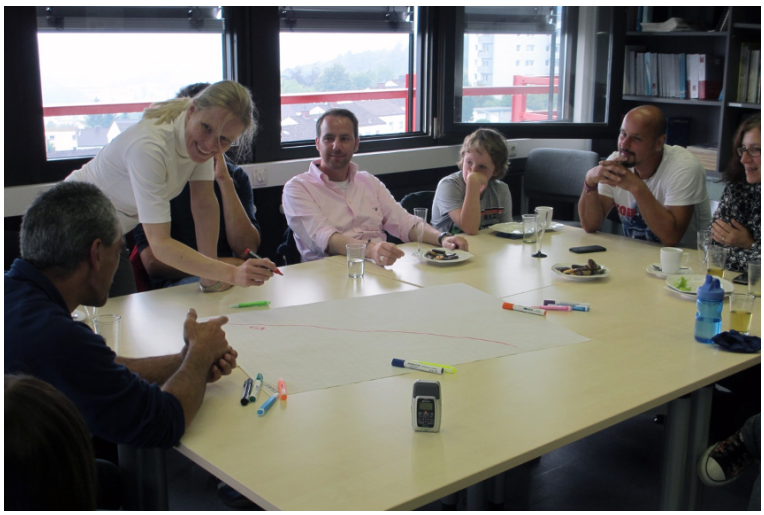

Figure 22: Creating an improvised sketch together in the group of users.

8.4 Lessons Learned

The method of narrative mapping has motivated participants to start thinking on the past in a more detailed and reflective level. Sitting together and solving a task by drawing a bigger picture led to a more conscious reflection for instance on ups and downs, collaboration and information processes. During prior interviews, interviewees gave superficial answers to questions concerning how they felt about a specific method or a process. Narrative mapping provided for much more nuanced reflection, as sketches prompted memory and subsequent discussion. Reflection on the process was, in other words, generated in more detail by this process.

This information was very helpful to get an in-depth understanding of the situation and the relationships within the project. For example, when the users reflected on their individual role within the project, one participant explained that for him it was interesting becoming a part in the project and exploring new TV functionalities and concepts, but it was hard to continue testing because the prototypes were not usable enough for other family members. Another participant was surprised much of his feedback was implemented in a later version. In contrast to that another participant felt like a guinea pig: "A happy guinea pig because I received a TV and other stuff (laughing) but I quickly got the impression that I had no clue how much of my feedback and my wishes will be forwarded to the industrial partners. I've the feeling

that they are faster than we. I got my hay, my food and a clean cage." Other participants agreed that they felt that they had not been able to assess their contribution previously.

From this situation we learned twice, first, the university as a mediator between participants and industry has to meet all user roles and needs to be more transparent in forwarding information and giving feedback to others as well as participants who have made immediate contributions. We addressed this issue, for instance, in a regular newsletter (see Figure 23, bridging the pitfall). The second aspect was the effect that addressing these feelings allowed for negative sentiment to be made explicit and encouraged others to comment. We assume that prior to this intervention, participants had been bound by rules of 'politeness', which prevented them from being too critical. Group discussions thus have the advantage of revealing the relevant problems of involved participants. In order to reach a better relationship between users and researchers as well as between users themselves, we organized regular social events where everyone had the chance to get to know each other better (see Figure 23, green marked objects).

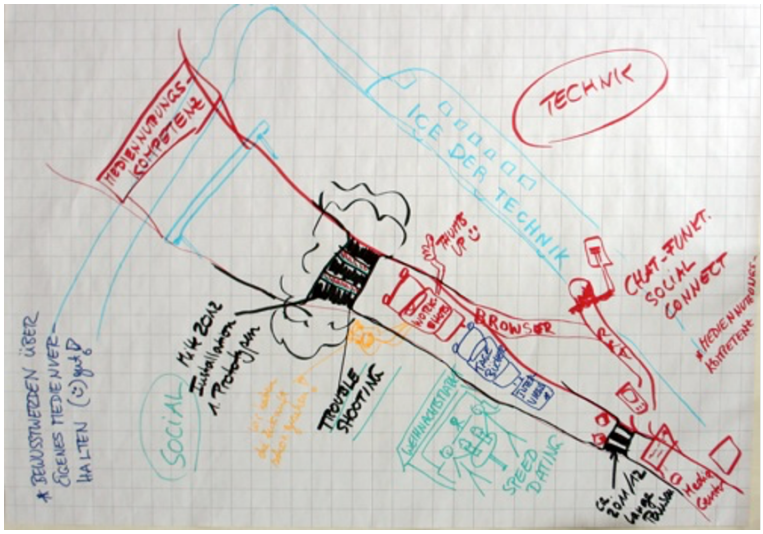

Figure 23: Improvised sketch of participating users.

Another lesson we have learned was to do with the actual benefit that users gained merely by participating in the project, and regardless of outcome. We were originally convinced that it was the fact of having some influence on the design and features of the system that prompted participation (see Figure 23, the symbolized goal at the end of the path on the left corner) but narrative mapping shows that their main benefit was the awareness of their individual media usage behavior and the growing competence in using new media and technologies. The same applies to the session with the researchers. The sketch shows a number of problems and barriers that researchers had to deal with (see Figure 24). However, in the discussion afterwards it became apparent that these barriers were seen as 'interesting results', which provided material for publication.

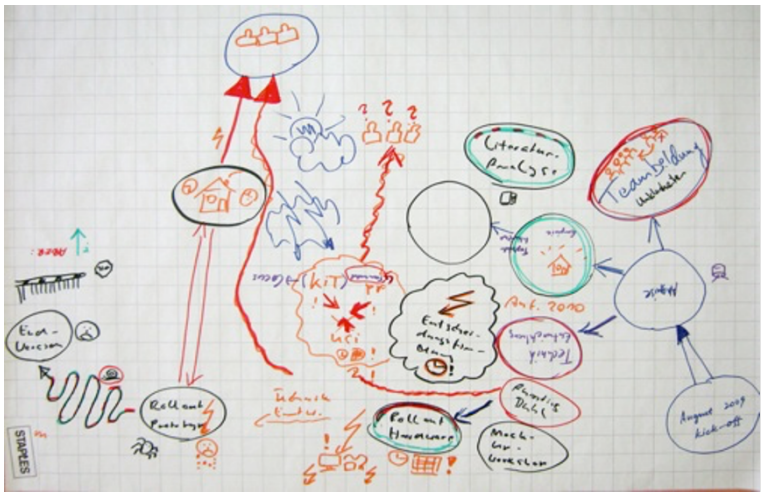

Figure 24: Improvised sketch of researchers.

8.5 Conclusion

The method of narrative mapping is an effective technique to prompt reflection with different groups or single persons on specific timeframes from the past. Reconstructing the project progression revealed interesting in-depth information about what was perceived as successful and what went wrong. Well- balanced user-researcher relationships are essential for running projects successfully. It follows that identifying deficiencies during early project stages rather than later would help project progress and possibly furnish more effective design interventions. Therefore, the understanding of users, their thinking about their role and their expectations need to be made clear. In domestic contexts especially it should be the basis for PD projects. As a result, it should not be the goal that users feel like guinea pigs. Instead, they should feel themselves as an important source of knowledge and experience for researcher, developer and designer.

9 Managing Viewpoints: Maintenance Work in Sustainable Living Lab Research*

Abstract. Living labs are dynamic networks in which several stakeholders participate for various reasons and in which technical-oriented innovation emerges by bringing together these diverse perspectives. In this paper, we present a case study of a living lab that was set up in a publicly funded project to design home IT-solutions. In this context, we investigate practical management fostering cross-stakeholder interactions and relationships that facilitate consistent and continued collaboration in a living lab We analyzed the project documentation, emails, etc. and conducted semi-structured interviews with all participating stakeholders including industry, academia and involved users. Based on the generated data corpus we reconstructed the formation process of the living lab project as well as the diverse perspectives of the stakeholders and subsequently analyzed how they are connected with each other, which communication practices has been established and how long-term collaboration processes are managed and maintained to local needs and constraints of several actors. The analysis of the different viewpoints, nevertheless, uncovers asymmetries and some difficulties in achieving these aims. These are seldom discussed in literature and are negatively associated with strong user engagement. Our results suggest that a shift in traditional user perspectives is needed to realize the full potential of the living lab approach. In addition, our study reveals the emergence of an essential role that we define as living lab agents. Agents serve as facilitators within a living lab and undertake necessary (but often unrecognized) maintenance work for all stakeholders. The paper further discusses the possibility of systematizing this role and the opportunity to provide a living lab infrastructure as professional service for external clients.

9.1 Introduction

The development of innovative technology and products is a risky endeavor, as is well-attested in the literature. The risk of market failure for consumer goods for example, is estimated by Haber (2008) to be in the region of 80 to 90 percent. More recent studies show decreasing numbers. Dijksterhuis (2016) references a failure rate of 50 to 75 percent in that domain. It has been suggested that this has to do with the fact that the routine social practices and rhythms of everyday life are inadequately considered in design processes (Frissen and Lieshout 2006). Allied to this, there is the obvious fact that ordinary users may not be knowledgeable or motivated enough to express their needs and desires with regard to these new technological opportunities. Innovation development therefore faces a "symmetry of ignorance" (mutual incomprehension between designers and users) (Fischer 2000). Moreover, new needs often emerge only in reaction to technology appropriation (Orlikowski and Hofman 1997; Swiderski 2008). Because of this, it is sometimes suggested that new

* *Ogonowski, C., Stevens, G., Hess, J., Randall, D., and Wulf, V., 2018. Managing Viewpoints: Maintenance Work in Sustainable Living Lab Research. In: International Reports on Socio-Informatics, 15 (1), 3–37.*

technologies or products need to be developed in an iterative and evolutionary manner, such that their appropriation by users 'in the wild' is recognized as an integral part of the process (Rohde et al. 2009; Stevens 2009; Wulf et al. 2011; Wulf et al. 2015b). Whatever the specific solutions envisaged for dealing with these issues, it is clear that there remain a series of methodological challenges. Although the role of ethnography, or fieldwork (see Randall et al. 2007), is by now established and has been put to the service of design in many different contexts (see e.g. O'Brien et al. 1999; Crabtree and Rodden 2004a; Grinter et al. 2009), it is by no means clear how this is to be adopted in domestic usage contexts (there is extensive debate about whether methods which have proven adequate for the understanding of work settings are equally useful in the context of non-work settings, for practical and/or analytic reasons. We do not propose to engage in this debate for reasons of space but see Laurier et al. (2001), Brown and Bell (2004), Grinter et al. (2009), Schmidt (2011). Specifically, however, there may be issues for immersive forms of enquiry like ethnography in situations where technological innovation is rapid, where it may potentially change behaviors quite radically, where domestic environments are implicated, and where users have, at best, only rudimentary understandings of what is possible. A related, but distinct, approach is associated with Participatory Design (PD), which originates with concerns for workplace democracy, but has been further elaborated in recent years to integrate people and their context into more generic design processes (Ehn 2008), transforming the "symmetry of ignorance" into a complementary "symmetry of knowledge" through symmetries of participation and symmetries of learning (Fowles 2000). People thus become 'co-creators' into the design process.

In the HCI community, for instance, diary studies (Bolger et al. 2003; Carter and Mankoff 2005; Sohn et al. 2008) and probes (Gaver et al. 1999; Crabtree et al. 2003; Hutchinson et al. 2003; Boehner et al. 2007) were developed as approaches to give designers access to people, contexts and peoples' individual experience to foster their reflections about possible futures and to inspire design for and with ordinary users. For product development in and with online communities, for instance, standard web technologies and collaboration tools were applied that link usage situations and an actual development environment to support communication and collaboration processes between members of established online communities (Hess et al. 2013). Other methods have also been adopted in a broadly PD context which - to some extent - address these issues.

Nevertheless, challenges remain when multidisciplinary actors come together. One of the main challenges is to create a basis for mutual understanding as a starting point. Soini and Pirinen (2005), for instance, examined workshops as a means to generate infrastructure for collaboration and idea or knowledge sharing by various actors. Based on these insights, they derived three distinct modes of collaboration within workshops: creating shared insights, discovering common denominators and clustering competencies. Soini (2006) further focused on the role of industrial designers as facilitators. She found that facilitation requires specific skills such as ideation, visualization, social and research skills if participants were to fully realize their potential. In a slightly different vein, Vines et al. (2013) scrutinized conditions of collaboration with respect to the configuration of participation in HCI research – including different forms of user participation, real benefits for users and initiators,

and the degree of sharing the control with users. They emphasized critical issues of a conceptual, ethical and pragmatic nature that arise when involving users in such processes. In addition to designer-user-interactions Dachtera et al. (2014) approached cooperation processes in joint research projects by focusing on conflicts between academic and industry partners. They identified three aspects: the mismatch between companies' internal and the projects design approach; the rhetorical framing of research interests based on the political point of view (funder); and the view on each other's work and the outcomes associated with it.

While all of these approaches can be shown to support an understanding of the dynamics of innovation in context, they arguably do not wholly encompass the organizational realities of rapid product development, nor those of building and maintaining long-term relationships with users in domestic environments so as to support *sustainable* participation, collaboration and mutual learning. Further, domestic contexts pose a specific challenge in the design of new artifacts, because accessibility for researchers and designers to private spaces remains something of a problem, which requires special sensibility in dealing with the user. Tolmie and Crabtree (2008), for instance, point to practical and methodological challenges when deploying research technology to private households. Users often did not see any need for taking ownership or responsibility for keeping technical systems running. They rather expect this as a practical service from researchers (Ley et al. 2015). Moreover, prototype technology is seen as a kind of 'foreign object' that disrupt domestic routines and has somehow to be 'made at home' in these circumstances. This requires a certain open-mindedness on the part of users and, equally, of researchers, one which, it turns out, is not always easily arrived at and might require a degree of sophistication in relation to understanding the possible consequences of deployment (Tolmie and Crabtree 2008).

In recent years, living labs (Eriksson et al. 2005; Niitamo et al. 2006; Almirall 2008; Følstad 2008) have become a more popular approach, aimed at addressing the issue of bridging the interests of divergent stakeholders; for instance academia, public institutions, industry and users. They have been deployed in various contexts, but were specifically designed as an approach, which would work in relation to co-creative product innovation, notably in the domestic arena. They include, for brief mention, Orange At Home (Randall 2003); the Philips HomeLab (de Ruyter and Aarts 2004); Placelab (Intille et al. 2005); and the Helsinki Virtual Village (Eriksson et al. 2005). As Eriksson et al. (2005) suggest:

> "The Living Labs concept refers to an R&D methodology where innovations, such as services, products or application enhancements, are **created** and **validated** in collaborative multi-contextual empirical real-world environments. (…) The user experience focus involves areas of user interface design and ergonomics as well as user acceptance, extending to user co-design process, finally leading to service or product creation. The human-centric approach in Living Labs conceives of human beings, citizens and the civic society as a source of innovation and not just as users or consumers in a narrow sense being an object for R&D activities. (…) the Living Lab approach then strives to break the trial-and-error process of product development previously described, and change that into a co-design process where users and developers actively work together (…)".

Living labs have been adopted widely for a number of reasons, which include that they involve the user; get relatively quick and low-cost results; may constitute a permanent test bed; allow for 'mixed method' approaches to data, and of course, put the user at

the center of an iterative design process. As Schuurman et al. (2009) point out there are at least two ways in which the living lab can be constituted. Firstly, they can 'make the technology or product available in the home of the users' and secondly one can develop, 'a home where the technology or product is available and where users come to stay for a certain period'. Schuurman, De Moor et al. (2010) specifically discuss 'mobile TV' research through a living lab perspective. They suggest, "(w)hen a product is designed for users, data and theories regarding the users are used as a knowledge base for design. A design with users denotes an approach where user studies are included, together with feedback from the users on different solutions or concepts."

In principle, then, living labs are a promising candidate to provide a considerable framework supporting innovation processes and collaboration among the stakeholders involved. However, currently we have relatively little information about the processes of knowledge transfer that would have to take place between 'users', professionals, and researchers if living labs are to prove a useful and sustainable addition to our methodological armory. Not least, and as we discuss below, there are management issues of a quite practical nature that are under-described. There is, then, a good case for examining a long-term case of living lab participation in order to enrich our understanding of how processes might be arranged, changed and negotiated over time to provide maximum benefit for all stakeholders. We will argue that the inter-linked dimensions of knowledge, expectation, practice and time are critical to this understanding.

The paper contributes to these issues by presenting a case study of a living lab where participants had the use of a new cross-platform entertainment infrastructure for interactive television and social media applications on mobile devices. Our focus here is, however, less on the technology than on the way in how 'interests' and 'expectations' are managed. In doing so, we draw on the notion of 'Community of Interest' (CoI) (Wenger 2000; Carlile 2002). The concept has the analytical advantage of not presupposing that a shared goal and understanding among participants of a living lab must exist, but rather investigates empirically how varying viewpoints and interests are negotiated over time to produce such a community.

The paper is organized as follows: Section 2 presents a review of the existing literature on living labs and examines the concept of CoI to study processes of change within such a community. Section 3 describes the partners to this research and outlines some methodological concerns. Section 4 outlines the way in which our living lab was conceived. In Section 5, we emphasize the perspectives of the various stakeholders in the work and reflect on the issues that arose. Finally, section 6 discusses the findings with regard to the relevance of practical management of maintenance work in long-term collaboration projects and the importance of specific roles in such a complex innovation environment. Furthermore, based on our results, we will make suggestions as to how innovation processes and collaboration within a living lab can be fostered and sustained.

9.2 Related Work

9.2.1 The Living Lab Approach

In recent years the term, 'living lab' (and its methodological possibilities) has attracted increasing attention within the research field of ICT. According to Eriksson et al. (2005), the term was created by Mitchell at the MIT Media Lab and was considered as an instrument to carefully study users and their interaction with new IT-artifacts in real life environments and for longer periods of time. As such, it drew on early insights from product design where, for instance, von Hippel (1978; 1986) focused very much on applying a quasi-naturalistic, but nevertheless controlled environment for product testing. Since then, and depending on the context, the research goal and the stakeholders involved, the term has been used with varying emphasis. Underpinning all approaches, however, is a common understanding of the concept as an infrastructure with a strong focus on user-centric research methods, i.e. methods that can be applied in multiple real life environments for "sensing, prototyping, validating and refining complex solutions" (Eriksson et al. 2005). According to this, living labs basically can be understood as an infrastructure where different stakeholders from several sectors – public institutions, academia, industry and citizens – may interact in an open innovative process that takes real use contexts (domestic and working environments, public and urban spaces etc.) into account (Niitamo et al. 2006; Almirall 2008).

These characteristics of a living lab were additionally influenced by the research and development funding of the EU Commission for piloting the 'European Network of Living Labs (ENoLL)'. ENoLL was founded in 2006 to build a sustainable strategy for innovation processes in Europe, and established the principle that a living lab is qualified for four main activities:

(1) the exploration of user behavior in context, and of market conditions;
(2) the co-creation process between users and designers;
(3) experiments within scenarios and
(4) the evaluation of products and services within real life environments (OpenLivingLabs).

Følstad (2008) also emphasized similar characteristics in his comprehensive literature review. He identified nine characteristics, and four that are valid for all the labs that were analyzed, namely: gaining insights in unexpected ICT-uses and new service opportunities; evaluating or validating new IT artifacts with users; experiencing and experimenting with such solutions in contexts familiar to the users; and enabling middle- or long-term evaluations with users. In particular, the early and constant involvement of the users into the co-creation processes of IT artifacts is seen as an important characteristic of the approach (Schaffers et al. 2007). Long-term and sustained collaboration thus enables, in principle, the capturing of both the ideas and the experiences of users in real usage contexts. Whether this is always achieved in practice is another matter.

Quantitative empirical investigations of TRAIL (Translating Research and Innovation Lab) has indicated that living lab operations do not always result in the successful transference of knowledge about empirically observable usage patterns and social behavior as well as direct user feedback and ideas into new services and IT artifacts (Mulvenna et al. 2011). They also indicate uncertainties about collaboration strategies and over best practice in engaging with users. Therefore, based on study results, TRAIL has published a toolkit with practical advice (Beamish et al. 2012). Here, it is shown again that there is no common understanding of the concept as a research framework, something that Schuurman and De Marez (2009) had pointed out earlier. That is, there is a need to deconstruct the concept in such a way that a practical and nuanced understanding of the negotiated relationship between different stakeholders and the consequent barriers to useful collaboration is possible. The stakeholder problem, as Ponce de Leon et al. (2008) have emphasized in this context, is a critical challenge to the living lab concept.

The living lab approach and its putative qualities are discussed from a range of different theoretical perspectives. Schuurman et al. (2009 and Schuurman, De Moor, et al. (2010) adopted SWOT analysis (a strategic planning method that focus on strengths, weakness, opportunities and threats of business ventures and projects) in order to identify advantages and disadvantages with regard to research on Mobile TV, and specifically in relation to the qualities of participants and their roles at different stages in the living lab process. Again, Kusiak (2007) investigated empirical approaches to fostering the innovation process and ascertaining user requirements. With a slightly different emphasis, Almirall and Wareham (2009) analyzed applied research methodologies associated with the living lab concept in order to explore how users could be involved into a more user-centered design process to expose the potential for innovation and co-creation. Følstad (2008) also focused on the perspectives of multiple stakeholders and, again, identified a strong focus on user-participation in design processes. Nevertheless, and with few exceptions, little has been written about how co-creation and collaboration of the disparate groups involved are actually managed - successfully or otherwise - and what kinds of problem have to be surmounted if knowledge transfer across these groups is to be successfully coordinated in a continuous and sustain way.

One of the few examples studying cross-organizational collaboration within living labs is the work done in the ITAIDE project (Baida et al. 2007; Frößler et al. 2007; Tan et al. 2010; Klein et al. 2011). Frößler et al. (2007) applied a practice-theoretical lens to study the network relationships in the case of the Beer Living Lab (BeerLL) – a pilot project where four living labs were set up as real life experimentation platforms for handling the export of excise goods and their movement in supply networks. They concluded that living labs are dynamic, open-ended environments in which the lack of clearly defined goals requires a willingness for continuous sense making and negotiation from participants. Collaboration could only be partially specified by fixed contracts, so that social capital was crucial for the actors to deal with the inherent uncertainties of innovation development (Klein et al. 2011). In another four year living lab project Hakkarainen and Hyysalo (2013) reflected on mutual beneficial learning, rating it as one of the key values of the approach. They specifically examined power issues between different stakeholders and end-user reluctance in the co-design process.

Based on that, successful mutual learning is at the mercy of so called 'innovation intermediaries'. Such key persons can help actively to chart different priorities and to find compromises in situations of conflict. Johansson et al. (2011) approaching living lab processes as innovation boundary contexts and describe living labs as an interaction of different 'Communities of Practice' (CoP). From this perspective, they analyzed the dynamics of boundary situations, their influence on the innovation process and their facilitation by different support mechanism. Based on the analysis, they derived a process model that distinguishes between 'boundary objects-in-use', 'process brokering' and 'product/service brokering' in innovation processes. 'Boundary objects-in-use' provide a basis for 'brokering processes', which do not just arise between objects and individuals, but rather between members of several CoPs and can be described as constant iterative feedback and reflection processes enabling mutual understanding. 'Product/service brokering', however, focuses on processes of perspective making and perspective taking between CoPs with respect to innovation and design processes, e.g. idea creation, concept development, evaluation. In contrast, 'process brokering' focuses on maintaining basic communication and interaction processes.

As previous research indicates, in order to understand sustain and successful collaboration processes within a living lab in more detail, therefore, it is essential to understand how living labs work in practice as a dynamic, multi-contextual and long-term existing infrastructure for innovation development and with different stakeholders following diverging practices, interests and expectations. The work we detail below is a contribution to this recently emergent research concern. In particular, we will investigate the practices of participating groups in making sense of the available infrastructure and how these practices support inter-organizational knowledge transfer and how it may change over longer periods of time, affect collaboration processes between the different stakeholder groups and lead to negotiation of specific role takings that provide the basis for the living lab approach.

9.2.2 Learning through Interaction of Communities of Interest

Conventionally, organizations can be thought of as having both formal (rules, procedures, structures) and informal (conventions, habits, cultures, practices) elements. At the risk of simplifying complex arguments about the conceptualization of the 'formal' and the 'informal', we will simply suggest that formal structures are typically held to ensure stability and continuity and to be efficient for the structuring of repetitive tasks. Informal elements ensure flexibility when dealing with the contingencies of situated work. These informal elements, of course, are not randomly enacted. They orient towards some kind of skillful, knowledgeable work and provide a base for the building of social capital within organizations (Putnam 2001; Huysman and Wulf 2004). Living labs, then, are - in significant ways - distinct from classic conceptions of the organization. While there may be elements of the 'formal' to be found - some common procedures, rules, etc. - they will nevertheless not be mature and neither will there be any of the normal organizational sanctions, which underpin their existence. Similarly, although from the outset we might identify informal practices, they will not be mutually constituted in any stable way. It is only when they result in the building of affiliations, trust, and motivation that they can be thought of

as entailing social capital. Overall, living labs are better conceived of as networks and, moreover, specific types of organizational network whose characteristics decisively differ on several dimensions from classical networks (Frößler et al. 2007). They are dynamic, fragile and complex collaboration networks in which multiple actors with different interests, expectations, cultures, practices and languages etc. come together to participate in interdisciplinary projects for a limited period of time. In order to deal with the uncertainties of innovation development, the elements of trust etc. that define social capital need to be fostered (Klein et al. 2011). How this is to be done within the fragile conditions of a living lab in a reliable and sustainable way remains an open question.

From a practice-oriented point of view, then, the concept of CoI seems to be appropriate for the investigation of living lab processes. A CoI commonly represents a network in which members from different CoPs come together temporarily in order to solve a common problem or to share a common interest in a certain domain (Fischer 2001). In a CoP, learning mainly takes place through legitimate peripheral participation and is predicated on shared assumptions about the nature of expertise. In contrast, learning in a CoI is rather a complex process across the boundaries of diverse knowledges and experiences. The diversity provides a high potential for innovation and collective creativity through the interaction of different CoPs (Fischer 2001). In order to realize the innovative potential, knowledge has to be managed, translated and transformed from one context to another and artifacts adapted for these tasks (Stevens et al. 2009). Common understandings evolve incrementally over time in people's minds, by the help of external artifacts (Fischer 2001) and through persons with key roles shaping practices between different CoPs (Lee 2007). Accordingly, externalization is key for collaboration in CoIs (Bruner 1996).

Applying these considerations to the case of living labs, we suggest that living labs present a kind of a project-oriented CoI, in which 'boundary negotiating artifacts' (Lee 2007) emerge and become more stable over time. That is, processes of collaboration, which constitute the founding purpose of the CoI are mediated by negotiating artifacts which, in turn, become more stable and predictable in their use as more stable collaborative forms take shape. These iterations are, however, not smooth. Taking this evolutionary character into account, the concept will further prepare us for taking a closer look at the formation of the living lab and how artefacts and roles appear and become stabilized.

9.2.3 Research Gap

As previously described, bringing together heterogeneous stakeholder groups and applying collaboration infrastructures like living labs, require for mediation and negotiation activities especially in long-term projects in order to perform successfully and provide valuable and sustain output where every single stakeholder can be satisfied. However, relatively little is known how living labs operate successfully in long-term perspectives. This leads to two main questions, which we investigated in our research by analyzing qualitative data from the overall project with a practice-oriented analytical lens to study the overlapping boundaries as well as management and negotiation processes among diverse stakeholders. How do inter-relationships

between several stakeholder groups need to be managed and maintained? What importance attaches to specific roles or artefacts, how can they be defined and in which way they will be applied?

9.3 Method

This case study presents the living lab called 'SocialMedia Experience and Design Lab' (SMEDL). The living lab was set up within a publicly funded, four year research project that aimed to develop a cross-platform framework including TV, PC and smartphone to support more flexible and integrated media consumption and use of social media applications (Hess et al. 2012a). The project consisted of three academic partners, two from different departments at the University of Siegen, Germany (one from the information systems department and one from the media research institute), and one external research partner with focus on user-centered design; two industry partners (media agencies); and a regional user sample of 16 households representing future users. The users are not core members of the project consortium, but are an essential part of the living lab. Additionally, there are some associate partners (like a private TV broadcaster) that are interested in the results of the project, but do not actively participate in the living lab. The academic partners are fully funded, while the industry partners are co-financed on a matched-funding basis. The participating users do not receive any direct payment. As incentive, they were equipped with current marketable technologies they could use individually over the whole project time.

The work we report here can be thought of broadly as action research and as such confronts the same dilemmas known from action research and from ethnographic practice: On the one hand researchers should being a member of the setting in question allows a privileged access to the setting and the detailed interactions it contains, providing firsthand data and in-depth insight. At the same time, this involvement threatens the neutral, 'critical realist' stance on research that outsiders can more easily take (Mathiassen 2002). Our response is pragmatic. We take the view of participant observation associated with the likes of Clifford and Marcus (2010), which accept the inevitability of partiality and recommends a reflexive process in which researchers consider their role in the production of the ethnographic narrative. Having said that, although two of the authors have been directly involved in the project from the beginning, three others have no direct involvement. Their critical external view supplements insider knowledge and acts as a 'sanity' or 'reality' test of claims.

In our study, we applied the (loose) method of focused ethnography (Knoblauch 2005), where the focus is typically given by a particular research interest and/or by a theoretical perspective. In our case, the focus was given by our interest in the multiple perspectives on living labs, and the way in which different stakeholder groups collaborate in long term. The data corpus we collected includes documents like the project proposal, the consortium agreement, project deliverables and minutes of project meetings as well as the email exchange between the directly involved representatives. Since the users' perspective is only marginally expressed by these documents, excerpts of email exchanges between households and responsible living lab staff members, and interviews with all participants formed the main basis for data collection. We also conducted semi-structured interviews with two of the industry

partners and two of the representatives from the university. The other academic partner from the media research institute as well as the external research partner have no active involvement within the living lab and therefore were not interviewed. Table 5 lists the interviews we conducted.

Table 5: Sample of interviewed persons involved in the living lab project.

Stakeholder	Institution	Function/Characteristics
Academia	Institute for information systems (university)	Research associate *(overall project coordinator)*
	Institute for information systems (university)	Research associate *(project assistant)*
Industry	Media agency A	Manager for innovation projects *(sub-project coordinator A)*
	Media agency B	Chief executive assistant and manager for special projects *(sub-project coordinator B)*
Users	SMEDL - regional test bed	27 participants out of 16 households

Both members from industry are sub-project coordinators and are responsible for the work in the project and for innovation and funding projects within the companies. One representative from the university - author and overall coordinator of this project - was directly involved in acquisition, planning, organization and coordination. The other representative from the project staff is responsible for the technical development and technical support of the participating households.

The four interviews with academic and industry partners were conducted in person and lasted up to 90 minutes. We asked questions about the living lab setup process, personal views of the project and collaboration issues. Of particular interest was the degree of mismatch between individual and professional practice as against the demands of collaboration. As part of the project, several empirical studies were conducted to explore IT practices, domestic media usage and social interactions of the participating users. In addition, we conducted 64 semi-structured interviews at participant's homes – four in each household: one before the technical intervention and one every year with respect to long-term phenomena. Interviews were also conducted in person and lasted up to 60 minutes each. The interviews included questions about individual motivation, the personal understanding of the living lab concept, their own role in the living lab process and collaboration with others.

All interviews with participating household members, industry and academic partners were recorded and transcribed afterwards. The analysis of the whole data corpus was conducted by qualitative techniques. In a first analytic step, we structured the data by its content (Mayring 2000) to provide an overview and to identify interesting extracts for a subsequent detailed analysis. We derived categories from the interview guides (motivation, definition of living lab, understanding of one's role, conflicts of collaboration etc.) and the concept of CoIs (expectation, communication, established

practices, artifacts, common intersections within living lab work etc.). After that, we analyzed identified excerpts in detail by following an inductive coding method (Corbin and Strauss 2008) and triangulated identified phenomena of several stakeholder groups (work and life practices; and mediating roles) with contrasting examples from others. Both phenomena are interrelated with each other and reveal which negotiating and maintaining activities seemed prominent for long-term collaboration in living labs. We further analyzed the stakeholders' deals with the heterogeneity of interest and worldviews and how they manage the dynamics of the innovation development process. In particular, we were interested in how the perspectives are mediated across the local sites and coordination is reached within the living lab.

9.4 The Formation of the Living Lab

Understanding the formation process helps to understand how subsequent activities in this kind of CoI emerge and how interactions can be coordinated in order to achieve an agreeable outcome. Hence, based on the data corpus, we will reconstruct this process in the following sections, starting with the setup of the living lab and finishing with collaborations between the participating stakeholders.

9.4.1 Formation and Setup

Before the actual start of the research project, representatives from academia and industry discussed the goals they wanted to reach, and identified their own interests in relation to project outcomes. These stated aims fed into work packages by the overall project coordinator who summarized feedback to project members and used that to structure the division of labor. The main goal - as stated in the proposal - was the common development of an integrated home IT platform. The basic framework of the platform was to be developed by the university. The main duty of the industry partners, in turn, was the development of client-side applications using the framework, for instance, by developing adequate interfaces for smartphone and TV.

To benefit from real use contexts in the design and evaluation processes, the project adopted the concept of living labs as infrastructural and methodological framework. In the planning phase, it already became clear that a well-designed infrastructure would be necessary to facilitate collaboration with all stakeholders over a time period of four years. As a crucial document, the project plan served as a basic guide to structuring the entire process and for the establishment of the required infrastructure. The project plan was elaborated together by involved partners and contained descriptions about tasks and work packages, internal milestones for each partner and external milestones for the whole consortium as well as the planning of events like creative workshops where all stakeholders including users came together for review.

The first stages of the project itself had to do with the setup process of a regional test bed for involving users from the earliest possible stage. The test bed was intended to enable the co-creation of new ideas, the discussion of concepts and the evaluation of prototypes in a continuous manner. The project consortium decided at a workshop that the university should primarily take on this task along with the hosting itself, because of its acknowledged expertise in and experience of fieldwork. In this context, it was

also decided to identify and build a regional user sample near the university to ensure technical support and close collaboration with participants in order to foster the user-centered research strategy. Even though the setup, hosting and basic user involvement was planned to be managed by the university, it was also agreed that other living lab partners, notably industry partners, should become involved in further processes, for instance, by discussing ideas in workshops or reflecting on early mockups with participating households.

Hence, the university took responsibility for the application and selection process of the household sample, based on criteria that were collectively identified by project partners. The sample, in other words, was in no way random. As well as being situated in the local area, household members were expected to demonstrate high personal interest in new media, home entertainment technology and services, high frequency media usage as well as an ability to reflect on their own experiences both as media consumers and as project members. Households also needed to have the appropriate technical infrastructure within their homes. Additionally, the sample, if at all possible, needed to reflect certain typical family characteristics. Thus, couples with and without children, and singles with and without children had to be found. Concerning the users' experience with new marketable technologies, an agreement was achieved about the selection of participants with different levels of expertise, for instance, ranging between more experienced participants, who already had used specific technical systems or devices (media center system and/or a smartphone) before and others who had not. The consortium stressed that feedback from a broad range of heterogeneous users was needed in order to design for a broader user community. Thus, 27 participants (14 male, 13 female) out of 16 households (5 couples with children, 5 couples without children, 2 singles with children and 4 singles without children) were selected according to the described characteristics. The multistage setup process of the local user sample is described in detail in Hess and Ogonowski (2010) and Ogonowski et al. (2013).

9.4.2 Establishing Collaboration Between Stakeholders

The project plan required university partners to take responsibility for the development of a suitable protocol for user participation, defined by one of the work packages. It was decided that this should be done through a mixture of methods, reflecting both practical issues such as available time (for researchers and households); the need to establish and maintain a more personal level of contact; the need for 'rich' data about usage and the need to reach some comparative conclusions. Above all, from the researchers' point of view, there was a desire to understand how media usage was mediated by the structures and rhythms of household life. Initial user studies were predicated on the use of media diaries and semi-structured interviews, in order to obtain an early understanding of the users, their current media usage and related social activities in domestic environments (Hess et al. 2011a). This work package also included the identification of initial requirements to be established before further work was undertaken. A part of the project plan was to equip participating households with new, marketable, technologies. The technologies (a media center system, a smartphone with Android OS and a high-definition television) were selected in accord with a common decision made by members from the university and industry, but without

involving participants of different households. The university carried out the installation of all necessary additional equipment in the households, and was responsible for the technical support of deployed technology as well as for the installation of software updates.

In line with the project plan, project assistants at the university organized creative workshops simultaneously. In the first instance, workshops with users with a relatively high degree of technical knowledge were conducted at the university. The aim was to discuss current media usage and to examining possible new ideas (Hess et al. 2011a). Representatives from industry also joined the discussions in order to gain a first-hand understanding of the needs and demands being expressed at this point in time. For this, the industry partners had developed initial mock-up concepts on paper and with PowerPoint, which were discussed in several test sessions afterwards. Later on, participants from the regional user sample were invited again to test an early prototype on a mobile device provided by one of the industry partners. The tests were conducted by the university staff who also subsequently edited the data (which had been recorded and analyzed) with respect to usability aspects and fed back information to the respective partners. In a second step, the improved and fixed prototypes for smartphone, TV and PC were tested again in an artificial domestic lab environment at the university, before the entire home IT concept (with its initial functions already defined) was rolled out in the living lab households. Responses to these functionalities which were obtained from these tests, were again fed back to the industry partners in a structured manner, including a rating of the significance of mentioned usability issues. A suggestion for the design was provided as well.

As stated in the project plan, the university was responsible for establishing a collaboration between the future users, for exploring the context of use and finally for conducting more focused user studies. In addition, they were also asked to mediate between users and industry partners. To foster the information transfer between stakeholders, the university presented summaries of empirical results in consortium meetings. Additionally, empirical findings were fed back to the participating households. Again, the industry's part was more confined to technical development. They were required to deliver corresponding sub-goals such as mock-ups or prototypes for evaluation by the university with its regional living lab user sample. The results from the empirical studies concerning user requirements or their individual feedback were taken into account for further development steps. In comparison with the researcher's side, industry partners had relatively little in the nature of contact points with the regional user sample. As already indicated, users had no formal role in the project structure but were nevertheless seen as a key part in the co-creation process. As we will discuss, their pivotal role in the process measured against their lack of a formal status had consequences.

Hence, the living lab embodied the interests of several stakeholder groups from academia, industry and users. As above, we refer to this constellation of practical purposes as a CoI. Altogether, while they collaborated in order to reach a common project goal, developing an integrated home IT platform, each single group or even single members aspired to follow their individual interests and purposes.

9.5 Perspectives and Reflections of Stakeholders

In this section we will describe the individual perspectives of the three stakeholders - academia, industry and users - uncovering their motivation, individual interests, expectations and their experience with the living lab as a complex infrastructural and methodological toolkit. Further, we will describe the way in which the various methodological choices imposed a variety of challenges on the consortium, challenges, which altered in character over time.

9.5.1 Academic Perspective

The academic partners, and especially the university already had a strong expertise in the field of home IT and were therefore already familiar with the state of play in technical and market terms. Besides the common project focus, one of the researcher's motivations was to understand how technical systems and devices work in practice in order to use this information for further design processes.

> "The point is to identify a gap and therefore develop specific functionalities (…) to implement things and evaluate them in practice. Later on, writing a nice paper, to make a contribution to the research field. Therefore applied computer science, but also with a strong research focus." *(project coordinator)*

Further, they had a familiarity with methodological traditions, which emphasized the analysis of 'practice' – the so-called 'turn to the social'. In previous work, members of the team had undertaken more orthodox ethnographic work, entailing the study of users in 'naturalistic' environments. Nevertheless, they recognized that the study of users in household contexts presented particular difficulties. Not least, the study in question lasted four years, and entailed the progressive installation of different versions of the technology in that time. The orthodox ethnographic route did not seem especially promising as a methodological vehicle in these circumstances. There were other issues which also framed the progress of the work, and which need to be understood in respect of a collaboration, which was predicated on different interests. One of them is the need for clear documentation of processes. Industry partners were not minded investigating user behaviors themselves in any great detail, but nevertheless oriented to some form of 'requirements' which might emanate from the study. The project plan was framed in a way that enabled academic partners to explore the users' current media usage in domestic environments and their related social activities before and after technical interventions. Such a process enabled academic partners to understand appropriation processes and technology use in daily life over a longer period of time:

> "You get other data then by a usability test. If you frame it as usability evaluation you quickly can check how to modify the interface. With a living lab it is rather the case that one can explore with long-term perspective. There are rather fundamental facts if technical artifacts were accepted or that households accept them in a way other than intended. (…) We had seen the potential long time before. Therefore, we had pushed it." *(project coordinator)*

Conducting long-term empirical work in the context of emerging technological development, and in a context where methodological issues need to be identified before they can be resolved turned out to be appreciably more difficult than originally envisaged. The approximate model that the university researchers were working to,

and embodied in project plans, was that there would be early 'pre-studies' which would furnish initial insights into the context of use, would involve design exercises with users to identify interesting technological concepts and which would allow observations of changes in media usage. These would in turn generate prototypes, which could be further evaluated and appropriation processes investigated. What researcher not anticipated was the sheer expenditure of time, effort and resources that resulted.

> "It is a lot of work, not expected in this domain. For example, the introduction of new technology, a lot of things happened that no one could have imagined before. On paper you plan a study, conduct an interview, put technology in place, make a study again and that's it. In practice many wiked things happen. (…) Participants have different [technical] problems; appointments have to be planned. The effort is much higher than expected." *(project coordinator)*

One of the unexpected elements of this had to do with mismatched expectations concerning the nature of the university's role and the status of a prototype technology. University staff was responsible for rolling-out and maintaining these technologies, but understandably did not see themselves as a service hotline for any and all types of technical support. Users called them on numerous occasions for a quick rectification of a problem, which sometimes had little or nothing to do with the prototype technology, instead of solving the problem on their own.

> "One example was the TV-signal within a household that did not work correctly. We started to solve the problem via telephone and remote servicing, then made a home visit and identified a defect signal cable. (...) The problem was the cable, not our technique. In such a situation, one does not call a technician, because of the cost thereby incurred. (...) Calling the university is for free and they can solve the problem. Instead of using another cable, they call us." *(project assistant)*

The point here is that the maintenance of relationships with users is such that simply refusing to conduct minor service work has consequences for the relationship. Academics, although they do not see routine maintenance work as part of their daily duties, still have to factor in judgments about how to deal with requests of this kind given that they are entirely dependent on the goodwill of participants. This is particularly important given that research involved not only the observation of people in their homes but also the conduct of workshops in the university to which participants were to be invited. Their input was a central aspect of these methodological choices.

Similar ambiguities in the nature of the relationship were evident between academic and industry partners. Academic members were responsible for the transfer of design understandings to a common development strategy with industry partners in what, as they had been at pains to point out, was a dynamic and fragile environment. As the project coordinator explained, at this time, companies do not necessarily have expertise in such dynamic, cyclical and experimental exploration and user-centered design strategies. As a solution, he stated that it was a quite fundamental and important principle that the university performed the moderation:

> "What became visible for example at those creative workshops was the necessity to moderate certain things. For them [industry partners] it is the first time that they worked with mockups, with PowerPoint and paper to build mockups quickly and test them in workshops together with users." *(project coordinator)*

This also had consequences in relation to feedback processes. Academic interests concerned more than simply the production of requirements for technical innovation. Unsurprisingly, they had an interest in the social interactions that underpin media use and in the way in which empirical methods were to be deployed and managed. Nevertheless, in a project with partners from industry, these interests have to be negotiated, particularly when it comes to the reporting process. For industry partners, specific results, which center on innovation strategies and evidence that they are worth pursuing, are the main - almost the exclusive - point of interest. This again has certain consequences for researchers. They had to learn how to select and translate often complex and subtle information into a form that was relevant to the companies' individual needs and in a language, they understood. That is, and put simply, there were problems of relevance for all partners. What were relevant matters for users, for academic and industry partners were not always mutual, nor adequately shared. This can be expressed as a heterogeneous and not always well-understood set of priorities on the part of different interests. Not least, there was a divergence between interests of project members who saw ideas as 'cool' or 'exciting' and those, which were concerned with mundane matters such as what was doable and at what cost. As a solution, a priority list was established, and divided into 'basic functionalities' and 'advanced concepts' in order to build a common ground for further work. Thus:

> "What is even of importance is the feeling for an innovation, what are interesting functionalities and even to rate them with priorities. (…) An idea, even if really cool, may not be implemented, because less technical affine persons do not understand them or are not interested in them. We should rather give ok to other ideas, even if this function is not highly innovative, we should rather do basics, because most are interested in them. (…) We tried this for the first version … and then later on, we will try to explore more interesting and innovative things." *(project coordinator)*

9.5.2 Industry Perspective

As described above, industry partners in this project had very little experience in methods which implicated some kind of 'co-creation'. In neither of the media companies who were partners to the project was any history of working with users on design, although they did have evaluative mechanisms in place, which sometimes (though not always) involved users as test subjects. Moreover, such evaluative strategies were typically conducted in-house and had no naturalistic elements. Media agency B thereby described the process as follows:

> "We have our internal test groups. We have the quality management group, some testers from the administration department, who are not necessarily technical forerunners and our programmers (...) when we use third party providers than we always have testers on their side. So we get the results of the test or we test everything on our own and we also write the cold review, when we have the third party provider." *(sub-project coordinator B)*

If requested by the companies' customers, extensive testing was normally outsourced to external providers, because of limited internal resources. Oddly, the involvement of users in the design process ran counter to company philosophy in at least one important respect. Since, it was argued, these companies represented themselves to clients as already being expert in their understanding of user needs, it would sit oddly if clients saw that they needed to have users involved in the design process. The sub-project coordinator A explained that the companies' philosophy would be negatively affected.

> "We have a long experience in business and our customers expect that we know what users want and respectively what we are doing. It would turn out badly for us to say that we let users participate in design." *(sub-project coordinator A)*

Despite these difficulties and barriers, the living lab was seen from both agencies as an interesting option to learn about new user-centered methodologies and to enlarge their expertise in receiving aggregated knowledge about relevant user demands. This was not the case at the outset, but rather was an emerging realization following some of the early workshop discussions with relatively experienced users. As underlined in the following quote, the sub-project coordinator of media agency B was rather surprised by the value of such group-based brainstorming sessions. Ideas from the participants were considered to be really innovative.

> "I liked it very much to brainstorm with the participants; it was a lot of fun. They already used new techniques in their homes and were creative in brainstorming processes. I was really surprised. For me, it was interesting to pick up on given ideas, some of them were equivalent to our visions and some were really innovative. For me, I picked up one brilliant idea!" *(sub-project coordinator B)*

At the same time, industry partners did not want to bear the cost of setup and management processes in relation to the living lab on their own, because they realized that moderating, coordinating and maintaining the whole process would be burdensome. Instead, industry partners viewed the living lab with respect to user involvement as a kind of service provided by the university:

> "I realized that it is a lot of work to do [at first]. Within the workshop you must coordinate the discussion, but also you have to make sure not infantilize people (…) and afterwards the analysis of the amount of data (…) I'm happy that you [university staff] handle this and give the results to us." *(sub-project coordinator B after a creative workshop)*

While both industry partners expressed a high degree of interest in evaluating their prototypes over a longer period of time, they were appreciably less interested in research questions to do with the way in which technologies change standardized practices of media usage over time. For them, the chance to check and improve innovative concepts, to understand their usability in everyday life in order to better design user-oriented and more marketable products and services were valuable. They tended to accentuate the direct acceptance of new technical solutions. Here, for example, one of the partners requested options and techniques to gather feedback in-situ in order to simply analyze it afterwards. From their point of view, user feedback needed to reach developers and designers immediately and with a degree of 'objectivity' and simplicity of information to keep usage processes and occurring problems comprehensible.

> "We will support the users' feedback process on a short and easy way so that it is ensured in-situ feedback will be actually produced. Instead of participating households taking paper and pen, it would be much easier to track their navigation given that users agree to usage tracking at home. Additionally, screenshots and voice records would perfectly match their input. For us, problems or bugs will be much more easily comprehensible. All of that in combination would be the optimal." *(sub-project coordinator B)*

9.5.3 Users' Perspective

It is almost a truism to say that selected participants were motivated and excited to become involved in the project. They were, after all, volunteers. The opportunity of

being equipped with new 'state of the art' technology was a strong extrinsic motivation. Nevertheless, more intrinsic satisfactions became apparent. As one participant said:

> "[I]t is very interesting and exciting to be part of this living lab. I can express myself and discuss novel concepts together with other households in the hope that some of my ideas will be implemented. If not, it does not matter. Anyway, if the product or system is available on the market, I can tell my friends that I contributed to it in the living lab." *(m 31, couple without children, high technical experience)*

In summary, the diverse motivations of the users included curiosity (the interest to explore new things), self-reflection (to understand and reflect on their own media usage), socializing (to get in contact with others), participation (to express own ideas), learning (to update personal expertise) and the support of research in general in order to influence the design of new products or services with respect to functionality or usability aspects (to act as co-creator) (Hess and Ogonowski 2010).

In general, the users had shown strong involvement and interest in events where new ideas were brainstormed, first mockups discussed, or the usability of workable prototypes tested. For example, within small groups of creative workshops, users also started to sketch their ideas on paper and liked discussing them with partners from the industry and university. In order to make their contribution to the technology development, users further remarked that it was necessary for them to make real experience by testing new functionalities in their everyday life.

> "Yes, if I tested it [in practice], I would have further ideas that I can provide. Actually, we did not test it but it was only shown to us. If one can test it, we can experience how functions are integrated in our daily lives and then we can evaluate aspects that are exciting or if settings are too difficult and have to be simplified." *(m 43, couple with children, high technical experience)*

The motivation to explore technology and to try out new functionalities was also expressed by the users with regard to marketable solutions. Nevertheless, the study has shown that the concrete level of engagement differs substantially from household to household: While some started to experiment with the technical equipment on their own, others wanted to be guided step by step. Users with low technical experience in particular were troubled when, for instance a problem with a device, smartphone or TV remote control, occurred. High technical experienced users were more likely to search for a solution on their own and subsequently confide their results to the academic staff. To begin with, there were high expectations when it came to getting into contact with the university staff when problems occurred or simply in relation to information seeking about possible uses of the new technologies.

> "Partly I was frustrated, because I thought there are so many functionalities and I do not get them at all and I wanted to have a small event with introductions, so that I knew what was possible. That would be nice. (…) Maybe this only affects me (…) because there are many new things at once." *(f 37, single with children, low technical experience)*

Participating households were also interested in the current state of the project's progress and normally wanted a more or less regular update from their contact person, who is a project member at the university. Minutes of casual meetings or telephone calls about technical problems indicated that, for users, it is important to get clear feedback about project status and, especially, about the way their contributions feed into the design process. Co-creation here means more than asking users to feed ideas

into the process – it also involves giving non-experts a clear sense of what their contribution is, not least because their continued motivation to participate in the living lab depends on it. Most of the participants also expressed the wish to get in contact with other participating households and to be given the possibility to exchange experiences:

> "Probably there were several households that had problems with the television reception and with the remote control. There it would have been calming if others had confirmed same problems and I would not have believed that I was the only fool not to get it running. Even to discuss solutions for problems directly would be helpful." *(m 37, couple with children, high technical experience)*

Furthermore, while participants opened up to the researchers, they also wanted to know more about the persons behind the project. They expected more details from the project members such as their work tasks, interests and some personal information, thereby demanding a higher degree of transparency:

> "That would be great, if for example the homepage [of the research project] would be enriched. (…) I wanted to show it to my mom, but then you only can read 'we do it in that and this way', but this is (…) that sounds as if it is written for specialists only. That is incompatible to normal households that have no clue. Or to introduce oneself with a photo [would be fine]." *(f 23, couple without children, low technical experience)*

The university responded to this by including users' suggestions and providing general feedback via a digital newsletter where results from empirical studies were summarized. In a more informal way, participating households were also invited to join a barbecue and annual get-togethers at the Christmas market, which were organized by the university staff. The social events helped to generate a better sense of the roles of university staff, the project's progression and provide 'faces' to names, and further helped households get some sense of other participants and their interests. Additionally, the university set up an online social community as a common reference point so that all participating households and project members (from academic and industry side) became part of it by completing their own profiles and in principle getting connected to each other. Such a common platform also helped to provide a shared understanding of the current stage of development as well as to share formal and informal news and information between all living lab members.

9.6 Discussion

Above, we have outlined the structure of the living lab, showing how it served both as R&D methodology and as infrastructure where various expectations, interests, working practices and learning experiences were brought together in order to deliver results on the topic of interactive television and social media. In this section, we will discuss the case by using the outlined CoI concept as a practice-oriented lens for understanding viewpoints and collaboration processes within living labs by taking a closer look at the emerging practical management of maintenance work and its corresponding roles.

9.6.1 A Living Lab Project as CoI

There is no doubt that, from the outset, all partners and involved households to the project had a clear sense of objectives beyond their immediate interests – they understood that it was a common project, developing and evaluating new entertainment concepts within a living lab setting. This common project interest was anchored in the project proposal and framed the consortium, and all partners contributed to the common development. However, this recognition did not preclude an emergent negotiation of roles predicated on more specific and situational objectives. These distinct forms meant that nothing like a CoP could ever be discerned. Instead, the common living lab project was structured weakly enough to accomplish individual interests and to allow the partners to remain rooted in their own expectations and practices. Rather, we feel, the idea of a CoI fits this dynamic and emergent situation better. The living lab therefore provides a specific framework that brings together these different practices to foster interactions, allow for the negotiation of common values and space for innovation and learning. Referring to Johansson's et al. (2011) investigations, a living lab can be characterized as an emergent CoI, comprising several stakeholder groups (researchers, ICT developers and users), which share experiences and work together in order to solve a problem. We agree more or less with the assumption that living labs consist of several heterogeneous CoPs. Nevertheless, that heterogeneity is also present to some degree within single groups. Our experiences have shown that companies can be very heterogeneous concerning their worldviews of user empowerment and they can be competitive in their interactions. The same can be applied to users with varying motivation for participation, technical expertise and practices to handle technical issues. This group could not be considered as a 'naturally grown' CoP right from the beginning of the project. It evolved over time and throughout the project's progression but did not happen without external mediation work. Participating households were selected by academic staff members after consultation with industry partners. Community building was, in this specific case, artificially arranged and required practical management for bringing participants together. A lot of so called 'invisible work' was done by academic staff members, for instance informal meetings were organized to setup trust and get to know each other in person in order to also trigger the virtual exchange via messenger and social media communities at a later stage. Bringing participating users together was not easy as thought and was time consuming. This extra work was not anticipated, being independent from research work as such, but it was crucial for building the ground for further investigations. To paraphrase, it can be thought of as 'the work to make the project work'.

The same extends to the formation of the project consortium as a CoI. From a theoretical point of view, we argued the concept fits for emerging constellations like living labs. Having said this, it is clear that a living lab project is not really a CoI in its original understanding (Frößler et al. 2007) either, at least at the outset. It rather needs a lot of maintenance work in several areas to become a CoI. For instance, academic partners provided the user with possibilities for face-to-face exchange and a further social media platform. The 'getting to know each other in person' was important but time consuming to manage. A mix of physical and virtual exchange possibilities turned out to be a good use of available resources but could not have been assumed at the

outset. Without the practical work of determining how interactions and project outcomes might be successfully managed, we argue there would have been no success. Such efforts were not basically considered in the project proposal but, with the benefit of hindsight, need to be recognized as a necessary part of coordination work packages and should be calculated in staff costs. Hence, there is an evident need to understand the extent to which negotiation and the management of processes produces the appearance of a CoI - come to constitute it - over time.

9.6.2 Negotiating Asymmetries in Stakeholder's Engagement

We further observed that the engagement and collaborative activities of the diverse living lab members constituted an asymmetrical structure. The living lab infrastructure provided for specific roles and responsibilities, which nevertheless had to be delivered (and negotiated) in practice. Exactly how was determined over time as all members learned what the costs (in terms of effort, time and resources) might turn out to be; what expertise were required; what challenges had to be handled; and what possible rewards might result.

One result of this was that by far the most active roles were those of the academic partners, especially those of the university. In the pre-project phase, it was mainly the subsequent project coordinator who formed the consortium. Academic staff members were responsible for the user acquisition and selection. In the initial project phase, the criteria for the selection of households were developed together with industry partners but academic staff were then responsible for finding appropriate candidates. Furthermore, due to the common agreement between academic and industrial stakeholders, the university served as the operator of the local test bed and became the de facto service provider for industry. Figure 25 provides an illustration of the resulting asymmetric structure of the living lab, where the university mediated between users and researchers and moderated their interaction. This role of the academic partner is expressed by the large intersection of the users and industry sides. In contrast to this, there was no direct intersection between industry and users regarding long term interactions. Industry had direct contact only within creative workshops and the first testing of mock-up concepts, and did not seek further possibilities for collaboration.

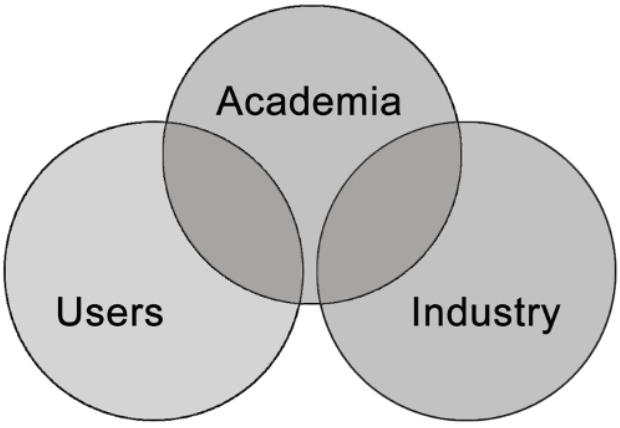

Figure 25: Asymmetrical structure of the interaction where the academic partner functions as a mediator and moderator between users and industry.

The asymmetry is also expressed by the different interests evident. For industry, households mainly function as a test bed for the developed prototypes and were seen as having a very minor function as co-creators in the ideation process. Researchers were more interested in understanding media usage practices on a socio-technical level, and in how long-term technology appropriation happens. In addition, researchers had and have an abiding interest in the research process itself, its methodologies, and in the way in which the principle of co-creation turns out in practice. Users, for the most part, while they express some interest in these matters at the outset show themselves over time to have a much narrower set of interests. Their understanding of the research process, always secondary, became more subsumed by practical interests as time went by. Above all, they wanted the technology to work. They tended to perceive researchers, who had a motive to be in regular contact with them, as a help desk, responsible for any issue that might arise in the context of the deployed technology. The delicacy of this situation became apparent when, for instance, researchers had to make explicit statements to the effect that they would not respond to requests for help at weekends.

This underlines again the evidence of an emerging role of living lab members who are sensitized to the need to be aware of different point of views and to the necessity of being in charge of negotiating the diverging expectations of stakeholders, transferring information from one group to another and being a locus for communication. Johansson et al. (2011) briefly thematized this kind of emerging role in the context of process brokering activities based on boundary objects. Maintaining interactive dialogues between several group activities requires boundary-spanning competences. Those competences were attributable to experts in process brokering and they observed that researchers as operators of the living lab took them over spontaneously (Johansson et al. 2011). Hakkarainen and Hyysalo (2013) described such key persons as ‘innovation intermediaries’. Ley et al. (2015), with regard to researcher-user relationships, see these ‘brokers’ as mediators with a function as point of contact and troubleshooter. In this case, this role was identified for one academic staff member. In their studies, Ley et al. (2015) showed such roles can be situated both within the community of participating users and as a part of a research team. In any case, it is relevant to ensure responsibility for heterogeneous stakeholders’ concerns and to become a trustable person. In this case and it is even observable in other constellations, this work is typically dependent on one single person who does practical management between stakeholder groups. However, there is an obvious need to reflect more precisely on the expert’s role, possible associated obstacles and necessary attributes in order to understand how mutual understanding between several living lab members will be established and maintained.

The challenge in this context is that we are dealing with subjects that have their own perspectives, attitudes and distinctive behaviors. With regard to boundary spanners, the characteristic feature is that they mediate between two communities of practices to which they belong (for instance, a boundary spanner would be a designer that works in the media agency, and at the same time, a participant of (for instance) a focus group. Therefore, Soini (2006) argues for the role of industrial designers as facilitators because of their knowledge of both design and of user groups. Even so, there is little discussion of the possible barriers to this mediating role – the nature of language used,

of background assumptions, of heterogeneous and sometimes disguised interests, and so on. Mediation, put simply, is challenging. This task implies both specific social (sympathy, empathy etc.) and research skills (visualization, ideation etc.).

For want of a better word, we name this emerging role, a *living lab agent*. With the boundary spanner, the role requires that s/he understands each stakeholder's perspective in order to successfully coordinate and mediate between them. In contrast to a boundary spanner, this understanding is not naturally given but has to be developed over time and is directly connected with a lot of invisible work which depends on basic social competencies, as well as an information strategy for developing and maintaining appropriate channels and materials, e.g. digital newsletter, social media community and further documents. The case study showed that these maintaining and mediating activities were essential for bringing together users, researchers and representatives of the industry in order to create spaces for common collaborations and for the transmission of bundled information to the industry partners, to the users, as well as to others in the research group. Users should be able to directly address the boundary agent for any questions or support, which strengthen the trustful relationship between him/her and the individual user. In addition, as a moderator and network manager, a living lab agent functions not only as an inter-organizational actor mediating and maintaining between the different partners, but also as a reflexive participant, handling of their own, intra-organizational perspective, taking into account their own value system, personal interests and organizational demands.

9.6.3 Physical and Digital Artifacts in Use

The case study further shows that pre-defined work packages and milestones are important artifacts for the basic orientation of management and cooperation and the alignment of perspectives. Having said that, the project plan, by definition, underspecified the realities of practice. It is possible to see this as a 'failure' of planning certainty, but we do not take this view. We see this, not as a deficit, but as a necessary feature of the plasticity required for evolving projects to function fairly smoothly. This plasticity functions in two dimensions: structurally and temporally. Structural plasticity helps to shape activities such as workshops or milestone deliverables, so that each representative knows what he/she has to do, and is weak enough that individual interests, flexibility and work processes can be negotiated and managed. If those activities are structured too weakly or too rigidly, collaboration becomes more difficult as different work practices, languages and general interests or the limitations that are determined by brand identities and companies' philosophies within the customer market, create frictions. Temporal plasticity (typically neglected in the literature on boundary objects (Star and Griesemer (1989), Carlile (2002) or Stevens (2009)) is especially important in the case of distributed innovation development where diverse processes have to be coordinated. Representatives with diverging temporal requirements, predicated on the radically different routines and rhythms of academic, domestic and business life, need to accommodate. In this case, the work packages were designed with temporal plasticity in mind, e.g. partially decoupling technology development through a component approach as well as decoupling the development thread from the empirical thread, using a probing approach (Gaver et al. 1999).

In particular, the design of work packages shows that structural and temporal dimensions are not independent from each other and therefore they have to be planned together. While the project plan serves as a basic orientation, essential elements of innovation cannot be planned, but are informal in nature. Good examples are the creative workshops that serve as negotiating artifacts. As a place where all representatives come together, it allows them to acquire a feeling of what may be of relevance for future developments and to re-prioritize work. The process of compiling a technical prioritized feature-list was a valuable process for participation, discussion, reflection, analysis and learning. This was stressed for instance by the industry partners, who admitted to being inspired by early brainstorming activities with users.

These negotiating artifacts became an object of shared interest, but were not adapted to local needs and constraints. In the observed case, the official project website developed into such an object. The intention of the providers (project coordinator and academic research group) of the site was to create a common representation for all partners. Nevertheless, while users recognized that the website was intended as a common object containing information about project status etc., they could not identify themselves with the design, content or language. The university considered criticisms and suggestions from the users, so that a social community supplemented the object. It was set up in order to moderate online discussions and to support the exchange between households and project.

This example demonstrates that the processes of mediation are critical to the role of negotiating artifacts. At various points in their development, such artifacts function only because of the mediating work done - in this case - largely by university partners who played a major role not only in knowledge transfer but also in maintaining motivational levels, 'taking care' of users, providing technical support, translating into more functional language for industry partners, and so on.

9.6.4 Cognitive Shifts as a Basis for Co-Creation

A general issue of the living lab approach is that "members of each organization have to perform a cognitive shift away from the traditional perspectives of their own institutions (…) towards the formation of a new perspective in which each institution played a crucial role in the overall network" (Frößler et al. 2007). In the literature (Følstad 2008; Schuurman et al. 2010a; Mulvenna et al. 2011), the users' role within that network is also typically diffuse. This is not just a theoretical, but also a practical problem. Vines et al. (2013) described this phenomenon of gloss in respect of 'how to involve users into design' from a general HCI perspective, but it is transferable to living lab research. 'Participation' is, unsurprisingly, a term which is extensively used in HCI literature but it is "rarely articulated how user participation in design occurs in different forms of interaction and engagement" (Vines et al. 2013). We found in the living lab literature that users are typically treated as co-creators at a theoretical level and that degrees of user engagement are recognized to be diverse, but that there exists little work (e.g. Schuurman et al. 2010b; Ogonowski et al. 2013) that actually describes different participation roles and how they emerge. Even less work concerns what kinds of user might be suitable for different design stages and how they can contribute to that. This gap in the literature has to do with a casual assumption about users as co-

creators and is the result of too few attempts to examine the actual process and role expected of users. These under-investigated participation issues thus constitute barriers for the stakeholders involved, particularly with regard to their cognitive shifts in the design process and the degree of user engagement. This leads to uncertainty in conceptual research design, over sharing control with users, and ethical issues. There are undoubtedly pragmatic challenges associated with how one selects users and the concomitant possibility that multiple design perspectives are not adequately reflected (Vines et al. 2013; Ley et al. 2015). It is, we argue, important to recognize the individuality of user perspectives and to see design choices which are ultimately predicated on heterogeneous user input as reflecting something more than an averaging process. This is related to the fact that users, as has often been asserted in the PD literature, should be treated as active agents in the design process and not merely as sources of information. The recognition of agency is critical, in our view, for an understanding of the living lab as being significantly more than a product testing ground. That agency is constituted precisely in the personal relationships we aimed to realize. They are constitutive of the social capital that the living lab should generate.

From this perspective, the living lab asks for a shift from the scientific or engineering perspective which otherwise seeks an objective solution to the problem of design. Action researchers, in contrast, do not consider neutrality and objectivity as the important qualitative criterion and hence can orient to a more nuanced understanding of user participation. In addition, the case study also shows that the problem of engaging users is also related to norms within specific expert roles like UI or industrial designers. Traditionally, the designers' competence is to know and to understand users, while the living lab asks for a new competence – being an expert in 'working with' the user as a co-creator especially for ideation and concept creation. Media agencies, their customers and industry are sometimes locked into a traditional view of users, which, at worst, treats them as irrelevant at this design stage and at best as a source of data. A core competence, we suggest, of the living lab is the ability to make use of the full potential by creating spaces in process models for integrating users as co-creators and fostering ideation, negotiation processes and experience sharing. This is anything but trivial. In this work, we do not give a final answer to whether the indicated cognitive shifts are ultimately achievable. The aim of this line of thought is rather to articulate the theoretical as well as practical difficulties of user engagement and the shortcomings of grounding the cross-boundary collaboration in social capital.

9.7 Conclusion

Living labs present a promising innovation concept in which design is carried out in close interaction with real life environments (Eriksson et al. 2005). It serves as an infrastructure and as a research methodology in which multiple stakeholders including representative users can collaborate in the long term (Niitamo et al. 2006; Almirall 2008). The diversity of the people interacting in the living lab, it is argued, fertilizes innovation development through collective creativity (Fischer 2001). However, by its very nature the emergence of innovative ideas is difficult to plan for, so that there is typically a lack of well-specified goals and operational steps (Frößler et al. 2007). This

raises the question of how knowledge transfer and management activities across the sites works in practice and especially over a longer period (Følstad 2008).

Within our work we provided insights into negotiating and maintenance work in living lab processes, their importance for emerging artifacts and the mediating role that has to be undertaken to bridge between divergent communities. By using a practice-oriented lens, we presented the case of SMEDL – a living lab that served as infrastructure for academia, users and industry to design a home IT platform and related applications. We especially focused on the formation process, the structuring of interactions, the practical management of maintenance work and the different perspectives of the stakeholders in that process. Our case study confirms the finding that the living lab presents a dynamic, fragile network, in which participating stakeholders have to react to new experiences and continuously changing conditions (Frößler et al. 2007; Klein et al. 2011).

We demonstrated how artifacts needs to be redefined so as to account for temporal dynamics. The case study reveals that in project-oriented living labs (Frößler et al. 2007) the project plan as well as user workshops can and should be designed from this stance: plans should be well specified in order to give a basic orientation to the diverging stakeholders, but they should also provide enough temporal and structural plasticity to be adaptable to local needs and constraints as well as to deal with the contingencies of innovation development. It is the temporal plasticity that we feel has hitherto been under-examined. Generally, we argue that these artifacts help to shape collaborative activities between the diverging parties when, and only when, mediating work is done.

In addition, if mediation, as we assert, is crucial for emerging artifacts to function as such, this has consequences for the way in which we think of user participation in the context of living labs. Although in the literature (Følstad 2008; Schuurman et al. 2010a; Vines et al. 2013) there is a strong focus on user-participation, our study reveals that in practice the role of the user remains ambiguous and, to an extent, contradictory. In our study, there is clear evidence that there are a number of different views in play of what it is that users can be expected to do, not least on the part of users themselves. The living lab approach, our evidence indicates - and confirms earlier findings of Johansson et al. (2011) - requires a strong mediating role when commercial, academic and domestic interests are in play.

With regard to managing the complexity of setting up and maintaining living lab infrastructure and processes over long term, our case study further observed the emergence of a specific role that we have defined as *living lab agents*. In the described case, this new role was taken by the university to mediate between participating households, industry and researchers itself. For the users, they not only serve as a help desk that supports the appropriation of new technologies, they also were responsible for conducting empirical studies and have to enforce the merging process of participating households to a community. For the industry as well as for academic partners, the university serves as a translator of the users' needs, they do a lot of persuading in user participation during the design process and facilitate the mutual learning between users, designers and researchers. In contrast to Frößler et al. (2007), who describe the living lab as a kind of a project-oriented CoP, the case we present is

best described as a moderated and evolving CoI characterized by these specific roles. Referring to the statement of Ponce de Leon et al. (2008), our investigations contributed to the analysis and identification of a possible living lab key role, that of the agent, which is highly relevant for successful collaboration and knowledge transfer in practice as well as for non-research related maintenance work. These tasks are evident but not typically considered in the planning and setting up of living lab processes. Nevertheless, we suggest they are key for conducting successful projects and need to be taken into account.

Considering the efforts of setting up and keeping a living lab alive after single projects end, it gives pointers to the professionalization of the role of the living lab agents. In particular, hosting a local test bed can be considered as a service infrastructure for research and development where a key competence of the service provider is to adopt a living lab agent role. Central to this role is having skills to mediate between the different social worlds, to compensate asynchronous technology development and appropriation processes as well as to manage the diverging interests of the various parties within a living lab.

Part III
Conclusion

The third part concludes the thesis by summarizing the main research outcomes from a meta-perspective and by discussing implications regarding the study's overall objectives on the setup and maintenance of living labs from a praxeological and managerial perspective in the context of designing ICT for domestic environments. Chapter 10 (Summary of Findings) summarizes major findings and focuses on key empirical outcomes pertaining to methodological challenges, stakeholder management, and infrastructural settings. Chapter 11 (Implications) highlights findings derived from the fieldwork and involved stakeholders and users and connects them to the discourse on living lab research. Chapter 12 (Closing Remarks and Outlook) summarizes the thesis by highlighting its main contributions and concludes with an outlook on aspects that could be interesting to address in future living lab research.

10 Summary of Findings

Designing ICT applications for domestic contexts is ultimately a complex endeavor. Accessing private places and understanding established usage patterns and attitudes that inform ICT design or changed usage behavior through ICT adoption over time were not the only relevant factors. It was also challenging for living lab operators to involve participants in the design process and align different stakeholder perspectives in the long run. This section summarizes major findings of both presented case studies and provides answers to the research questions.

The questions address the setup and maintenance work of living labs as practical approaches for ICT design in domestic environments. Two main characteristics have emerged. The first one contains infrastructural aspects that concern two questions:

Which kind of infrastructural settings are applicable for long-term collaborations?

What is needed to make the best use of infrastructures?

The second characteristic stems from a managerial point of view and can be broken down into the following questions:

What values and challenges arise from stakeholders and users collaborating over a long period of time?

What are the roles of stakeholders and users in living lab settings?

What are the stakeholders' and users' expectations?

How do living lab operators address these expectations and maintain relationships?

These questions will be addressed and verified by examples from the field in the following section.

10.1 Selection of Right Users

From the beginning, one of the challenges for both projects was acquiring and selecting the right users. This process clearly took up a large share of time. The summarized aspects of this subsection provide answers to the research question on the infrastructural characteristics of living labs and what is needed to make the best use of different infrastructures when seeking long-term user involvement. For the user sample, potential users had to do more than meet the project-related minimum criteria. Certain personality traits were also required, as they were indicators of a potential user's long-term collaboration potential and helped avoid dropouts. Depending on the target group, either local newspapers and radio stations or local and national senior organizations were used to address interested participants. Both projects also used the "snowballing" technique, which targeted the personal social networks of already selected participants. This method resulted in high commitment among those who decided to apply and participate in the projects.

To gain a better overview of applicants and to inform them about participation requirements, online forms were used to collect sociodemographic data, information on existing technologies in households, and self-assessments of media usage. Further

interests and users' willingness to participate in different research formats were also asked. First, interviews via phone or at local senior organizations were conducted before the final selection decision was made. These interviews helped identify applicants' real motivations, their willingness to participate in long-term research and to reserve time during evenings and on weekends, their technical and communication skills, and their ability to reflect on their own behavior. These soft skills have had a great influence in successful long-term collaborations and needed to be reviewed carefully. Site visits were not conducted but would have been helpful in understanding household situations and perhaps in identifying individuals' real reasons for participating. Motivations were unclear among some households in the SocialMedia project and only after the first home visits did it become clear that some participants applied mainly to have the new devices installed. In addition, face-to-face interactions encourage applicants to be more honest compared to on the phone. Non-verbal communication offers living lab operators additional indicators of potential participants' motivations. Telephone interviews unfortunately only allow one to speak with one household member, usually the one who initiated the application, but future research should consider households' whole social construct, as doing so could help researchers gain a better understanding of households' overall enthusiasm for a project. Another argument for early face-to-face meetings is that, the earlier they occur, the higher is the commitment individuals have for long-term participation in a given project. Participants will be less likely to drop out because they develop personal attachments to living lab operators. Reaching this collaboration state costs a significant amount of extra time, more than expected.

In addition to sociodemographic, technical, and physical requirements, all participants had to live near the university for two reasons. One was to make regular home visits easy for academic project members, who had to conduct empirical work and provide technical support. The other was to maximize household members' participation in workshops and tests at the artificial user experience lab. These decisions were made to reduce time and monetary costs for all stakeholder groups.

The heterogenous user sample was another aspect that was highly appreciated in both projects. Diversity in household structure, age, sex, technical knowledge, and other criteria better reflected the real world and are consistent with findings from Schuurman et al. (2010b) when conducting appropriation and evaluation studies in the field. However, experiences made while conducting the projects have revealed further benefits of co-design processes. One argument for them is that the lead user approach (von Hippel 1986) is not always the best option. Diversity within the target group of the user sample has helped open and expand the design space to involve as many different users' perspectives as possible. The more diverse a user sample was, the more flexibility for living lab operators and stakeholders arose by involving different user types into different design stages and making use of their values. However, this flexibility went in line with the increased challenge of bringing users and stakeholders all together in one stage. From a managerial point of view, the main challenge was identifying participants' expertise and expectations from the beginning to keep them motivated for participating in later stages. During the first telephone interviews, we found it helpful to ask questions that required more detailed explanations from users, such as questions regarding consumed content or used applications on mobile devices,

and to have personal chats in between questions. However, these methods did not result in the complete exclusion of non-compatible users. Actual users' expectations only became clear over time.

10.2 Users and their Social Situations

The home is characterized by its residents and social structures. Users were influenced through interactions with others, social trends, the media inside and outside the home, and one's age also has an impact on behavior and mindset. These aspects had been elicited and considered carefully with respect to the design. Living labs provide a practical approach for contextual long-term studies and for an in-depth understanding of how devices and services are integrated into everyday life and how they influence individual routines and social structures.

In our long-term study on social TV, a changing role of devices was observed. For instance, the laptop was connoted as a working device separate from the living room that was perhaps not even used on weekends. Some devices became more prominent and accepted for leisure activities. The introduction of smartphones to households – as a new device – was interesting to observe. Functions such as quick information searches, email communication, or social media activities shifted from PCs and laptops to smartphones, which became established as second screens following the TV set.

Thus, smartphones established new routines not only regarding functional aspects but also regarding temporal aspects. When and where participants consumed private information (emails and instant messenger), public information (news), or video content moved from a defined time during the day to a more flexible "always-on" mentality. Another behavior regarding consumed content was also observed. Video content became no longer related to certain devices. There was a shift to mobile devices (tablet PCs and smartphones). In the past, video was typically consumed through the TV set or, for some, the PC or laptop. With new devices, consumption became far more flexible and customizable.

Moreover, the increasing number of digital devices reduced barriers to consumption and offered new possibilities for each household member to access digital content. This phenomenon was observed in both studies. Former negotiation processes about who can use a device and when or about what content to watch dissolved. Moreover, legal, ethical, and social requirements regarding, for instance, consumption and content control for children evolved. These finding are unsurprising today (see recent research from Zaman et al. 2016; Müller and Röser 2017; Rigby et al. 2017), but in 2012, one could learn much from these early consumption movements.

Regarding the ICT-based training for older adults, participants had the opportunity to do exercises without leaving the home. New routines were established. Exercises had a specific timeslot during the day in order to guarantee regularity. These slots were either right after breakfast or in the late afternoon. Some older adults had formerly exercised at home and substituted their previous routines with our balance games and strength exercises. Others had not exercised before and thus had to find a suitable timeslot.

IT literacy increased among less tech-savvy persons in both studies. With the SocialMedia project, it became clear that participants consumed more media because of improved access options with different devices and reduced anxiety about breaking devices. Older adults in the other study found games more attractive than the exercises at the beginning because they were more fun. This observation confirms findings from Uzor et al. (2014). As our study progressed, there was a shift to strength exercises. These exercises challenged participants, and participants felt a direct impact on their conditions. These feelings significantly increased their motivation.

Based on the observed changes in consumption behavior, one can argue that qualitative long-term studies in the home helped identify and understand social phenomena and their changes over time in a more detailed way. For instance, one could observe how changes were induced through new devices and how they influenced households' hierarchies. These insights could not have been gained without these longitudinal studies on the participants' everyday lives. These observed changes emphasize the value of long-term collaboration in living labs and shed light on the corresponding research question. Especially in today's fast-moving society, valuable product and service design must incorporate knowledge of usage behavior and the mindsets of target groups, which is not just characterized by households' internal social structures but also by external social factors. Living lab environments as instrumented places as well as instrumented people, as Alavi et al. (2020) framed it, means households and their residents are equipped with technical infrastructure. Insights from inside and outside the home can gathered, which offer a rich data base, often reveal unexpected findings, and help shape ICT design with important details. As shown with the social TV project, switching between devices while consuming the same media content demands similar services and navigation concepts for all devices to support users' consumption behavior and to ease handling between different devices. Instrumenting participants by providing mobile devices, for example, mobility trackers exposed divergent activity behavior and mindsets in different age clusters of older adults, which should be considered carefully for future design. This finding of instrumented participants confirms the argument of Alavi et al. (2020). Moreover, one must bear in mind that there are other physical and social influences outside the home that impact how ICT design is perceived and used in the home. Various infrastructural settings, as described by Alavi et al. (2020) in their concept of five strands of living lab environments, help researchers gain valuable insights beyond the home in long-term studies. The importance of combining different environmental strands is demonstrated by the studies' results of this thesis. These results contribute to answering the research question on which infrastructures are suitable for long-term interactions.

10.3 Individual Perception of Change

An observed phenomenon related to research questions on managerial aspects and the handling of participants was how participants perceive and reflect changes on their own usage behavior and their individual mental or physical feeling over time. Both case studies revealed that the integration of new ICT systems and devices, which are related to new opportunities of use within the everyday life, were more consciously

reflected by participants than services or functions for existing devices. One reason for this, existing devices did not fundamentally change established usage scenarios.

In the iStoppFalls project, older adults added gaming devices to their TVs. This was a new and completely different way of using the TV. Classic media consumption was supplemented by physical exercise that resulted more or less in direct physical and mental improvements. Very active and active participants noticed explicit improvements in their physical wellbeing (less fear of falling, improved concentration, fewer problems with dizziness and incontinence). Less active participants did not identify any physical effects but were addicted to monitoring their activity level. This device was new for every participant in the study, making it easy to talk about. In the SocialMedia project, it was clearly the smartphone that produced the most changes comprising the new always-on mentality. Users can now easily access media content when and wherever they want. It is no longer restricted to physical places such as the living room or to certain times. The media center systems also made TVs web enabled. This usage was more unconsciously applied in daily routines. Users considered the TV as still the same device for media consumption.

In comparing both studies, the iStoppFalls project has the advantage of increasing participants' self-awareness through the system functionality of showing the individual progress. The study mainly benefited from an integrated self-monitoring approach that had a positive effect of visualizing information to participants as well as to projects' stakeholders and did not require additional self-documentation methods. Participants saw the opportunity to track one's activity performance and to monitor training effects as a crucial function of the system. This kind of personal monitoring does not only fostered participants' awareness with respect to the risks of falling and the importance of mental health, which is in line with findings from Sørensen et al. (2012); participants also became motivated to reach goals and became more active to achieve further daily goals. Some participants – mainly the active ones – activated an inner competition within themselves by monitoring their reached personal fitness levels. The very active participants were intrinsically motivated and were more affected by competing with other participants or groups. Becoming more self-reflective was a positive side-effect of the introduced ICT system.

10.4 Technology Access

When designing with different target groups in living labs, where different technological setups and applications were implemented in users' homes, living lab operators as well as participants themselves had to occasionally face various challenges. The observed phenomena below are examples related to the research questions regarding the managerial and maintenance work in living labs.

In the field, we found that some of the devices were unfamiliar to the users, prototypes were unstable compared to marketed software and hardware, and moreover all were items on loan. When technical problems occurred, some of the participants were afraid they had broken something. They tried to fix problems on their own, and when they could not fix them, they stopped using the items. Less tech-savvy participants were directly in contact with the university via the living lab operator. Project members tried

to first solve problems together with participants via phone or email. Because users were asked to try to solve problems on their own, they gained technical confidence and reduced their fear of destroying hardware. Participants from both projects highly appreciated this gain in competence. In general, we recognized a reserved attitude toward technology from participants at the beginning of the studies, especially from older adults and participants inexperienced with technology. As the projects continued, participants became more tolerant regarding technical errors and the limitations of early prototypes. The opposite was found in tech-savvy participants in the SocialMedia project. Their expectations ground on routined experiences of technology. We expected these participants to have a higher fault tolerance level, but they were the first ones to deinstall the test system. Unstable prototypes with limited functions that were intended to replace existing systems resulted in demotivation and social conflicts within households, especially when household members who were not the one who initiated participation in the research project, felt disturbed and constrained in their daily routines. Tech-savvy users accepted instability only in test settings, but if prototypes were to be integrated and used in everyday life, they expected and accepted only properly running systems. A kind of cannibalism between marketable solutions and rolled out prototypes was thus observed, and this experience can be confirmed by experiences observed by Bergvall-Kåreborn et al. (2009) and Schuurman et al. (2009).

What seemed to be challenging for participants was also a challenge for researcher as living lab operators. It became clear that providing access to new technologies in domestic contexts was more complicated and time consuming than expected. Although prototypes ran stably in pre-tests, each living room was unique in its conditions and created problems during technical rollouts. Almost every household needed to be visited twice to make systems operational. This was especially the case in the SocialMedia project. Living lab operators also had to resolve technical malfunctions after rollouts. Maintenance required significant managerial capacities. Faulty devices had to be collected and replaced or, when an item had a warranty, sent back to the retailer and then returned to households.

Workshops and informal get-togethers were organized to allow participants to contact each other. Such meetings were used to ask questions and to enable participants to learn from one another. At the beginning of each project, appointments were also used to introduce products' functions. In the iStoppFalls project, these appointments were mostly used to explain how to do strength and balance exercises. In the SocialMedia project, they were combined with co-creation workshops and informal get-togethers. Over time in both projects, questions arose regarding smartphone and tablet PC functions and apps. In the case study with older adults, members from the university organized so-called "off-topic" workshops to show best practices regarding smartphone use and to answer technical questions. With the SocialMedia project, a similar need was identified but on a higher, technical level. Tech-savvy participants mainly wanted to discuss technical or media-related trends. Only less tech-savvy participants showed similar behavior to the group of older adults. In addition, these participants assumed that university staff would help them with any problems regarding the PCs and Internet because the university staff were trusted. As described in the summary of findings section, it was appreciated that university staff were seen as having technical support competencies, but project members from the university did

not see themselves as technical support for cross-cutting topics, which only touch the technical setup peripherally, such as the quality of the WiFi signal. To prevent participants from being disappointed, university staff provided support for technical problems that were unrelated to the study once per household upon request, and if the problem could not be fixed via phone, staff also visited participants' homes. Households were given a friendly explanation of how staff from the university would help only by technical problems with the implemented system. This technical support cost a considerable amount of extra time.

Both projects also revealed that age impacts IT literacy, but age did not correlate with individual technical skills. We corroborated Eshet-Alkalai and Chajut's (2010) finding that older participants were more likely to find it challenging to keep the technical setups running and to address technical problems. This tendency was shown, for instance, when systems did not boot correctly or froze during use whereupon some participants did not try to restart them. A positive aspect of very tech-savvy participants was that they took the role of technical advisor in the projects. These households tried new things regularly and shared their experiences in an instant messenger group that all participating households were a part of. The very tech-savvy participants helped each other with problems as well.

Another positive side effect of rolled out technology was increased awareness and curiosity about new ICT devices and applications. This awareness resulted in improved IT literacy and increased consumption behavior. With the increased usage of new devices and applications, however, other activities were done less frequently, which was reviewed critically by one of the participants in the iStoppFalls project. Exercising at home meant that there was less time for non-domestic sports activities, which was regretted by one of the participants. Nevertheless, the awareness of participants' individual usage behavior was seen as a main motivational factor and a real benefit of partaking in the study. This raised awareness also prevented dropouts. The feedback workshop conducted at the end of the SocialMedia project using narrative mapping helped uncover users' perspectives. However, the identified individual values of IT literacy led to the observation that participants purchased additional devices such as smartphones for all household members, tablet PCs, and so on.

10.5 Roles and Expectations

In taking a meta-perspective and examining various actors, we found clear roles with dedicated expectations among academic and industrial stakeholders, the living lab operators, and the group of users. The following comparison of both research projects will provide preliminary answers to the research questions regarding the roles and expectations of stakeholders and users within a living lab.

The user's role was ultimately one of the most varying. Participants had divergent understandings of their contribution to the studies depending on their personal background. Some participants were addicted to using new technology and saw themselves as potential users. When using such solutions they argued from their personal point of view and reflect how satisfied they are and how solutions address their needs. Their feedback was valuable for improvements and extensions. These

users could be divided into two subgroups: one group was satisfied and became engaged by simply having the technology, and the other group had an additional strong interest in contributing to the design process. There was another group who noticed during the study that they were less interested in features the system provided. This group was instead motivated by the opportunity to become acquainted with others and to gain individual knowledge. For example, one participant in the iStoppFalls project was only interested in monitoring the number of steps he took, and another wanted to assist the SocialMedia project by contributing with her professional expertise to the design process. This participant was an architect with skills in visual design. As examples have shown, users' expectations can change over time. They also were slightly different than anticipated by living lab operators, who assumed that the role of co-creator would be a strong motivational effect. Instead, the main motivational factors for participants of both projects were learning more about one's own media usage or physical changes and learning more about the use of technical equipment.

At the end of the SocialMedia project, a workshop was conducted to reflect on the whole project and the collaboration process. The workshop demonstrated that users were a key part of co-creation processes but that they had no formal role in the project consortium. Consequently, users had no active part in the creation of the project proposal. This observation is in line with findings from Følstad (2008), Schuurman et al. (2010a), and Mulvenna et al. (2011) regarding the value of active user involvement and described not only a theoretical problem of the living lab approach but also as a practical problem when conducting living lab studies. Users are considered co-creators at a generic theoretical level regarding how living lab research works; however, with the exception of the work of Schuurman et al. (2010b), practical investigations that describe both users' participation roles and the actual process of how their role was shaped over time are lacking. In both projects, the co-creation process revealed that participants were very surprised by the extent to which their feedback was incorporated into redesigns. This incorporation was partly unexpected by participants and boosted their motivation, as they received the feeling of being esteemed by both academic and industrial stakeholders. In contrast, other participants had the feeling of being an experimental animal for the academic and industrial stakeholders of the projects because, as the projects progressed, less interaction with participants occurred. These waiting periods were because the prototype design process was slower than the evolution of the market, and nothing innovative could be made available for everyday use. Participants felt like industry stakeholders were no longer interested in their experiences and contributions. For some participants, this experience resulted in frustration. Hence, the value of being a co-creator was lost. This was especially the case in the SocialMedia project because living lab operators had to manage long waiting periods for the user sample due to delivery problems with technical devices at the beginning of the study and slow technical development in the further course of the project.

Another interesting finding regarding the user's role concerns the sensitization with the usage of prototypes and their design process. At the beginning of the project, first user interactions with prototypes in the participants' homes were disappointing due to lacking performance of the system and not fulfilled support from the university for technical breakdowns in time. Participants became more sensible, and an

understanding evolved slowly over time that artifacts would not always run stably and researchers were not a 24/7 support hotline. To some extent, it is obvious that the nature of long-term investigations fosters the user's understanding for research and the technical challenges involved, but addressing such artifacts in different design stages also resulted in surprising moments for some participants, as described above, when their feedback was implemented in a new release. Ultimately, the user's role as co-creator in the design process evolved positively.

When the projects finished, participants wanted to further use the devices and applications because of adapted usage behavior and their accompanied values to the participants, for instance flexible TV consumption or activity tracking. They expected to continue using the introduced technologies because they accepted being a part of the studies and because they integrated prototypes into their everyday lives. Some participants even asked to buy devices from the university. In the SocialMedia project, participants continue to use market technology after the project ended, which means only the devices without prototypical applications. By contrast, all devices were collected at the end of the iStoppFalls project because the university could not provide further technical support for the designed training system. In this case, it was especially difficult to remove the technology from the homes because participants were strongly engaged in their daily exercise and were disappointed that they had to stop because the technology directly concerned their health and avoiding falls.

The role of academic stakeholders was negotiated with the industrial stakeholders before the projects started. They both discussed their individual aims in comparison with the overall project goal and derived corresponding tasks in communication with the project coordinator, who was a staff member from the university in both case studies. Beyond the ICT design tasks, academic partners from Siegen were responsible for assembling and maintaining the user sample and the associated research strategy. It became clear that academic stakeholders intersected the most with participants in the living lab. In both projects, researchers were the ones responsible for the technical rollout and all empirical investigations in the field and in the lab. Conducting field investigations means getting access to the field and gathering valuable contextual information, which is particularly more than asking and observing participating households. Researchers had to take a 'guest-like' role as described by Ogonowski et al. (2018). Being guest-like means that researchers had to not only be interested in participants' experiences but also had to be open to small talk and discuss their own private lives to build personal relationships. This role was one that researchers learned over time.

In both projects, academic staff were also living lab operators. They were therefore central contact persons who, on the one hand, had the social tasks of establishing trust relationships and being available to participants. These tasks were underestimated and were consequently not considered in the project plan for setup and maintenance work at the beginning. On the other hand, living lab operators distributed relevant project information to participating households and to academic and industry stakeholders. Academic staff members were also "boundary agents" or what Hakkarainen and Hyysalo (2013) called innovation intermediaries. In this role, staff were responsible for problem solving and translating users' needs to other project stakeholders and

facilitated mutual learning among the participating groups. This role was not explicitly assigned from the beginning. It rather emerged over time as academic staff became aware of other stakeholder perspectives and needs. Another role of academic staff was as the first contact person in cases of technical problems, and the provision of technical support was distributed among several researchers. Researchers were also responsible for the prototypes in participants' homes, but they could not provide timely technical service. In addition, the "technical help desk service" that provided technical support for further private devices of the participants was not expected and scheduled in advance. Researchers had other priorities compared to what users expected, and researchers did not see themselves as repairmen.

Whereas the living labs in Siegen were well structured, and researchers had many interactions with users, the living lab in Lancaster used a more unstructured but also successful approach. Researchers were not that closely connected to the users because they established a representative – a person from the user sample who was intrinsically motivated to fill this role and also passionate to volunteer work – in the beginning of their first projects within the community. This participant unified the following two roles: a contact for when technical breakdowns occurred (which were then forwarded to the university) and a mediator of information between users and research staff. The person acted as a proxy for Lancaster's researchers, informed participants about current research progress and new insights, explained how the technical setup works, and motivated participants to keep at the project and to use the provided technologies. In the other direction, the representative provided insights into the research teams in terms of organizing information more than interpreting information.

Industrial stakeholders defined their project role based on the project plan and the defined tasks within and see communication significantly with academic stakeholders. In both projects, industrial stakeholders' main duty was co-developing the technical frameworks and additional applications. Industrial partners especially from the SocialMedia project also participated in ideation workshops and evaluations together with participating users. They were curious to learn about user-centered design methods and to enlarge their expertise on user demands. At that time, in 2010, industry partners had no experiences with iterative design processes with significant user involvement. As media agencies, they only conduct user tests at the end of their projects if customers demand them, and they outsource these tests to external service providers. As a result, they distanced themselves from managing tasks concerning the local user sample. The adjunct operator's responsibilities such as setup and maintenance, moderation, coordination, and mediation processing were seen as burdensome and costly. They saw the university as a kind of service provider.

10.6 Collaboration Practices

Both projects were characterized by continuous and longitudinal interactions and the involvement of users in different design stages in living lab projects. Findings discussed in this subsection shed light on the research question regarding how living lab operators address the expectations of stakeholders and users and maintain relationships. Even if the SocialMedia project could provide a many-faceted overview of the whole project progression and examine all stakeholder perspectives in detail,

the iStoppFalls project also provides insight into the interactions of older adults and academic stakeholders as living lab operators.

Based on conducted research and presented findings regarding roles and expectations from the previous section it became clear that the living lab projects cannot be considered as naturally grown communities. Naturally grown communities are characterized by topic specifically moderation from one of the community members. Instead, the community building process was initiated by academic stakeholders as living lab operators. This setup process can rather be described as research pull because participants were selected with caution based on the interests of the consortia. This process needed considerable moderation. Therefore, communication, both formal and informal, had a significant impact on the success of user-researcher relationships and thus on the project results. A central contact person was mandatory to keep in contact with participants so they could provide feedback or relay technical issues. Regarding the latter, it was shown that changing the academic staff members who visited participants at home to fix technical problems led to some distrust.

The so-called "social work" – which seemed trivial – was exposed as extremely important for long-term collaboration. Researchers sought participants with social skills during the recruitment process, and researchers who remained in direct contact with users were expected to have the same skills. In order to maintain participants' enthusiasm for the projects, each user's feedback was taken seriously, even when doing so did not benefit the research. This kind of social work often cost time, especially discussions of that went off topic, but this helped establishing a trust relationship. We observed that, when participants felt they were "on the same wavelength" as researchers or were understood by researchers, they provided more prompt and honest feedback.

Moreover, participants had to be kept informed of the research steps. Email proved suitable for this purpose. One of the lessons we learned was to communicate relevant dates more carefully and to be more flexible regarding timeframes. From the participants' point of view, technical rollouts were seen more or less as milestones because new experiences or changes in their habits were anticipated. When the project timeframe was not adhered to, participants were disappointed and demotivated, especially when there was an increasing number of delays, as occurred with the SocialMedia project.

In general, participants were highly interested in the results following the different research and design steps. On the one hand, they were interested in matching their own self-perceptions with study results, for example, insights of an interview study, in order to classify themselves. On the other hand, participants desired to share findings with further family members and friends to leave their own mark and obtain social reputation. Both projects responded to the participant's need of keeping them up to date via regular newsletters sent by email, online posts from the project consortium, and formal meetings at the university where academic stakeholders presented findings. Both projects also introduced an own social network platform for sharing information about the projects in a condensed way. On these networks, participants could also connect with each other, but participants did not use it as expected. Either friend requests were sent to people they had only come to know very superficially via co-

creation workshops nor were they interested in another social network in general. At the time this research was conducted, Facebook and an additional German social network were used by participants, and they seemed to be enough for them to handle. In both case studies, the introduced social network was an artifact of the designed ICT solution and evolved to have this "double function" as community builder. Nevertheless, the introduction of a new platform as a tool was a failure in both projects because no critical mass with respect to social media use was reached. This finding was further confirmed by the living lab study from Lancaster. While the Lancaster living lab has a connected social community, participants did not used it because they preferred to talk to each other in person.

To improve relationships between participants and researchers and among locally dispersed participants, speed networking exercises such as ice breakers were conducted during after-work meetings in the SocialMedia project. Learned from this ice-breaker method, the iStoppFalls project began with such an introduction. This introduction was incredibly helpful for becoming acquainted and building mutual trust. To further strengthen relationships and to gain deep and honest insights into the participants' everyday lives, feelings, and thoughts, researchers also spoke about their private lives. Regular informal meetings, such as BBQs or after-work drinks at a bar or at the Christmas market, or project-related events, such as walking tours for older adults, cost extra time but were valuable for strengthening user-researcher relationships.

Presented formal and informal communication of both projects confirms general statements made by Bergvall-Kåreborn et al. (2009) in the context of trust and transparency. Compared to Bergvall-Kåreborn's et al. statement, this thesis provides practical advice for building and maintaining trust and transparency. Furthermore, our results emphasize the necessary competencies stated by Soini (2006) regarding the facilitator's social skills. Although she discussed the facilitator's role with respect to industrial designers, this research has shown that the same need exists with respect to living lab operators.

Regarding the co-design processes and the diverse user samples of both projects, ideation and concept workshops were organized and conducted using separate user groups. This separation follows the argument of Ogonowski et al. (2018). Especially with the group of older adults, there were good reasons to separate participants according to different design phases. In both projects, groups were made in the same way. Participants with high technical expertise were separated from those with low technical expertise. Consequently, the focus and methods in workshops were adapted to the participants' skills. Mixed co-creation sessions comprising individuals with different skills and experiences, which were not intended before but have arisen due to scheduling conflicts among participants, were also valuable and generated unexpected results. More experienced users were sometimes too realistic, followed a problem-oriented way of thinking, and focused on technical feasibility. These characteristics often limited these users' ability to engage in so-called "blue sky" thinking. By contrast, less experienced users thought in a more unrestrained but less innovative way because they often lacked knowledge about current developments. The projects benefited from bringing both views together in workshops. The less

experienced participants learned from more experienced participants, and less experienced participants helped the more experienced participants focus less on technical restrictions and be more creative.

Collaboration in the field revealed that tools are needed to foster and support spontaneous in-situ feedback. The barrier to making contact should be kept as low as possible for the participants, in accordance with the low-effort principle. Users could send feedback or requests quickly, easily, and pleasantly. Email was an established medium in user groups, but when the number of requests increased, a more structured form was demanded from researchers. In the SocialMedia project, for instance, an app-based feedback tool was designed. It offered a pre-structured feedback form in accordance with the low-effort principle (Hess et al. 2012c). The feedback tool including a corresponding backend system allowed researchers to structure and categorize user feedback in order to address it systematically.

As mentioned regarding the technical rollouts, managing appointments for home visits or bringing all participants together for a workshop at the university was more resource and time consuming than expected. It was nearly impossible to find a suitable date to bring all participants together. Consequently, workshop appointments were offered twice. Another insight was that a handful of participants (at least five) were adequate for generating valuable outcomes. Regarding home visits, appointments were often canceled shortly before their scheduled time, or participants were not at home. The former occurred when something else came up on short notice, and the latter, when the date was forgotten. These issues led to delays in the planned timeline and project progression.

Long-term collaboration required the management of additional time-specific dynamics. User preferences changed over time due to external social influences such as address changes or employment changes. They were also influenced by internal changes. Examples of such changes include one couple splitting up and some households having babies. Such user changes resulted in users' decreased motivation and availability to participate in the study or even to dropouts. Another factor was the base technology and the related market dynamics. Technical devices become outdated over time, which leads to technical heterogeneity within participants' homes as household members update their technical equipment. Depending on the new device, technical research results were hard to compare because prototypes did not run stably on new devices such as smartphones. Participants also stopped using the new technologies and switched to commercial solutions that were more stable.

When examining work practices in living labs, one can see there are not only user-researcher interactions but also interactions between several other stakeholders. In both projects, decisions were made only between academic and industrial stakeholders regarding the hardware used as the base technology. However, users were involved in the workshops. The SocialMedia project in particular had workshops where all three groups came together to discuss designed mockups. Practitioners thus received the possibility to gain first-hand experience on user interactions and their needs. They appreciated these opportunities and participated even on Saturdays, but compared to the researchers, they had few interactions with users and focused more on technical developments. This fact does not mean they were disinterested in user feedback but

means they mainly preferred consolidated feedback regarding their developed ICT devices in the form of reports or mediated by the university in a way that was actionable for industry. Work practices that included users as co-creators in early design stages had not been established in the industry's daily business practices at the time of this research. After participating in workshops, industry representatives were surprised by the output and developed at least one new idea further. Nevertheless, they found half-day workshops too time consuming and thus decided to not take part in further workshops. Another argument against participating in workshops was the role they had to address as service providers for ICT solutions in the market. They argued that clients charged them with jobs because of their expertise on users' needs. Industrial stakeholders in the SocialMedia project assumed that the market perception of their competencies would be negatively affected if they enforced a cognitive shift and start to ideate with users. By contrast, Newell et al. (2006) insisted that stakeholders change their mindsets in order to establish user-centered design processes in a sustained manner. The given mindset of industrial stakeholders also showed the "dilemma" of the relationships between academics and practitioners in living lab settings.

Thus, it was sometimes challenging for academics to decide what information was relevant for other stakeholders because they were more interested in long-term contextual changes and social effects that had a strong impact on design processes that the industry was not yet aware of. This diverging interests in the details of gathered data shows how heterogeneous the priorities, interests, and understandings of iterative design processes were, and academics had to confront this heterogeneity in their roles as researchers, living lab operators, and service providers for industry partners. This phenomenon is in line with what Dachtera et al. (2014) described as uncertainties regarding practitioners' capacities for participation in co-creation formats and their performance, for instance, regarding the quality of prototype design.

10.7 Living Lab Infrastructures

As the studies have shown, different infrastructural settings were valuable for different design stages, and combining them within one project has its own value. Examining them more closely will provide initial answers to research questions regarding living lab structures and applied environments and how they can add value to long-term investigations.

To understand participants' everyday lives and changes in their ICT usage behavior in the domestic context, a local user sample providing access to private spaces was highly appreciated, especially for these long-term studies. Even if access to and research within participants' living rooms came with several challenges regarding trust, candor, and data comparability, this access helped us develop a more holistic picture of the design space and allowed us to consider social, infrastructural, and technical influences. The participants' homes were particularly suitable for gathering qualitative data as applied in both projects based on interviews, observations, and additional context-sensitive methods. Diary studies were used and combined with cultural probes, which included the use of a camera, conducted by the participants themselves to document media usage behavior and settings. Cards were included in the probes box

to sketch the home and document hobbies, social network activities, and how participants stay in contact with each other. The cultural-probe box only evoked joy at the first time when we handed them over to participants. Working with provided materials was time consuming and exhausting because it required self-reflection, but it helped researchers make participants more aware of habit changes. Interviews provided a deep and nuanced understanding of users and usage contexts. Regular home visits complete this context understanding by observing participants as they appropriate marketable solutions and prototypes over time. However, domestic settings were also used for gathering quantitative data on software and device usage for the iStoppFalls project.

Moreover, certain settings proved their worth in living labs. Controllable and neutral settings were used mainly in qualitative ways. At the university, the user experience lab had the same installed technical setup as each project. The lab was used for early evaluations of mockups or low-functional prototypes before they were implemented in the field. Participants were invited to come to the university and give feedback on concepts. This early user feedback helped identify the main usability and UX problems that still existed. The controlled lab setting was also used to involve users continuously and to test more complex prototypes and use cases within later iteration phases and within the redesign process. What was valuable for the lab also applied to meeting rooms at the university. They were used for kick-off meetings, co-creation, and feedback workshops with participants and other project stakeholders to discuss current experiences and problems, and how to address both in future design.

The combination of different "worlds" – the real world, lab settings, and neutral meeting rooms – are perceived as valuable for the design of ICT solutions. From a long-term perspective, the home setting revealed how participants integrated devices into their daily habits and how their habits changed and also revealed unintended usage patterns or use cases that would not have been discovered in lab tests in artificial living room settings. In addition, living lab research also needed neutral spaces and controlled test environments to better know each other, establish trust, and approach new applications. However, what is perhaps more important to less experienced users was to relieve the anxiety that they might break something. This anxiety was observed in early user tests or presentations where participants interacted with prototypes for the first time. They were nervous about breaking the prototypes and therefore, refrained from exploring the devices. When technical problems occurred with the first rollouts in the field, some less tech-savvy participants were more confident and initially tried to solve problems on their own and did not stop using the technology.

11 Implications

Based on previous summarized findings, lessons were learned through longitudinal living lab research on ICT design in domestic environments. Methodological and structural recommendations were derived for future operations with stakeholders and users in living lab settings, and they thus further answer the research questions regarding the setup and maintenance of living labs.

11.1 Considering Managerial Aspects

Conducting living lab studies means collaborating with several stakeholders and, more importantly, with users in the design of ICT solutions. Collaboration must thereby be complemented with essential project management practices addressing aspects such as the project plan and its related work tasks, technical requirements, stakeholder expectations, and infrastructural settings. To maintain living lab projects long-term nature and to sustain access to users' everyday lives, further managerial aspects are helpful that were not necessarily obvious at first. The case studies presented in this thesis have shown that some lessons learned were directly applied in subsequent projects, as was the case with the iStoppFalls project, where, for example, the speed networking event was used as an ice breaker for participating users to become acquainted with each other beyond the project topic. Other aspects only became clear when taking a step back and reflecting on processes from a meta-level. Some of these aspects are additional tasks for which stakeholders were unprepared for. To positively promote these aspects, a more systematic approach to the organization of the technical rollout, the quality of prototypes, social networks, and user management are described in the following section to provide answers to the research questions concerning what is needed to the make best use of local and technical infrastructures for long-term collaborations and why these aspects are important.

- *User and data management*: Two main tasks must be done when setting up a local user sample for a living lab project, which is built from scratch and does not draw on an existing local community. First, one must find appropriate users, and second, one must provide them with the necessary technical infrastructure. An Excel file for managing the setup and related documentation tasks works well in handling applicants at the beginning, and in further steps to select users and record their sociodemographic data. However, when data sets become more complex by including more data from the field and transcripts and more information about individual participants, the more a central user data management is needed to decrease administrative efforts. The value of storing different files in one data base is obvious in particular when several persons will work with this data at the same time. The described efforts should also increase if one must establish a permanent regional testbed or an online community to make use of user data beyond single projects and in a sustained manner. When one decides to start developing a user pool, one can "reuse" participants and previously used technical infrastructure in further projects or make recourse to applicants that were not selected for previous projects. There are clearly managerial tasks where customer relationship management (CRM) systems can help systemize user management in living lab research, especially for living lab infrastructures that evolve over time (see

Ogonowski et al. 2018). A CRM system is what we have established in Siegen with the Praxlabs approach and with our focus on sustainable research infrastructures (for more information, see Ogonowski et al. 2018). If successfully established, a CRM system supports the search for potential users according to filter criteria and allows one to easily contact them. This system saves time in the acquisition and selection processes because announcements in local media are only necessary if required screening criteria cannot be covered by the user pool. A closer look reveals several advantages in storing all information in one database. It allows for data to be compared and personal contact information to be kept up to date. Another advantage is that several staff members of a living lab operator's team can access and maintain data sets simultaneously. Data can be stored at a central place, and version control of an Excel file is thus no longer needed. The more data such a database can track, the more it becomes scalable. Tracked data can include data on, for instance, loaned technical devices, privacy policies, information on user participation in research projects, dates of the latest user interactions (interviews, workshops, etc.), and even research results from analyses and reports, Scalability of data is becoming an increasingly important requirement. Since 2018, the discourse on research operations (ResearchOps) has emerged in context of scalability of research and user data, especially in companies that already apply user-centered design methods (Wilczek and Schneidermeier 2019; Kaplan 2020). ResearchOps approach the researchers need to systematize research designs and processes and to improve the quality and efficiency of qualitative research within companies. Research on ResearchOps is motivated by the overall question regarding how to use methodological best practices and the results of qualitative user research across studies and teams. With that said and depending on researchers' requirements and purposes, a CRM system could become relevant for making living lab user recruitment efficient. A CRM system could help further making research insights and data reusable within research groups or organizations and also sharable between different institutions. The same applies to living labs with regard to data and insights sharing between multiple stakeholders and their collaboration with each other. This discourse has also been viewed from an academic perspective (Randall et al. 2018; Stevens et al. 2018). Although there are few publications, they reinforce the current presence and need for user-centered design of ICT solutions. Based on DCS of practice-based research, Li et al. (2020) have started developing an "e-portfolio" that documents such case studies in a systematic manner to make research findings comparable and accessible to both academic and practitioner communities.

- *Management and maintenance of technical infrastructure:* As discussed in previous chapters, conducting research in the wild is a complex endeavor and is resource consuming. It requires time to coordinate and conduct the rollout of both technical infrastructures and designed prototypes. Possible delays can occur due to canceled appointments that have to be postponed. Also from a technical point of view, each home is different and thus special. In living labs, one has to address many unpredictable factors to operationalize technical infrastructure, as the case studies have shown. Too little space, poor lighting, a bad WiFi signal or issues with other devices, and architectural and physical barriers can all be challenge during the rollout of prototypes and for continuous data gathering. Regarding the question of what is needed to keep technical infrastructure operational, technical help desks are an answer. They have

emerged as necessary and need to be considered early in a project proposal. Another challenge one has to address is the expectation of users that researchers should always be available as support. This expectation is not wrong because of their presuppositions, but in living labs, academic stakeholders must address various presuppositions and do not see themselves as just-in-time support. These expectations must be kept in mind when starting a technical roll out. In order to not disappoint participants in the beginning, one should clearly communicate to users what they can expect when asking for support. To provide further answers to the previously mentioned research question, living labs as practical approaches should consider three basic aspect regarding the management and maintenance of technical infrastructure: (1) The project plan should include extra time for technical management a technical help desk; (2) Experiences from the field should be critically reflected upon on a regular base; and (3) One should retain the flexibility to react to certain circumstances, such as unforeseen appointment cancellations or changing household constellations.

- *Refinement of prototypes for the home*: As the phenomenon on technology access described in section 10.4 has shown, users' tolerance varies depending on the environments they are in. There is a difference between testing protypes within the lab at a certain time, and using them in their everyday lives. Lab settings do not affect daily routines. In these artificial settings, users have shown a higher tolerance for not-quite-functional prototypes and their instability. By contrast, users have not shown this kind of error tolerance in their homes. Instead, they demand performant prototypes because the home is seen as place for recreation and social affinity, and technical hiccups and functional limitations are undesirable when prototypes are integrated into daily routines. Beyond participant's mindset and as mentioned by Bergvall-Kåreborn and Larsson (2008), prototypes are in direct competition with established solutions in everyday life and, in the worst case scenario, a prototype can be rejected. To avoid this and to keep users' motivation high, prototypes must provide added value. This point confirms reflections from Lievens et al. (2010), who stated that users have to feel attracted to stay motivated to use prototypes. Prototypes also have to reproduce or offer at least established market functions so that participants do not feel restricted in their use. This is relevant particularly when a prototype will replace established systems in the home. Nevertheless, designing innovations that are similar to what is on the market should be avoided. Doing so could lead to the case where technologies in the market overtake research endeavors and negatively affect users' motivation, as occurred in the SocialMedia project. A better scenario is when prototypes supplement existing functions, as they are then less likely to be rejected by users. Another aspect to consider is UX. Interactions in the home should be refined in detail and in general be accompanied with a low cognitive load for the user. To conclude this point, trust in technologies is also relevant. Continuous releases of redesigns can foster users' acceptance for more-or-less buggy prototypes.
- *Social network activities:* Another implication can be derived for dealing with activities in social networks. As experiences have shown, social networks are not suitable for qualitative living lab studies aiming to develop applications for social networks, nor for studies aiming to use characteristics of social networks to build a user sample. Even if projects involve natural local communities, as

was the case in the Lancaster living lab, or try to establish communities with participants and their friends, like in the SocialMedia project, both projects failed to reach the critical mass such cases need. Therefore, living labs should not claim to empirically and quantitatively investigate phenomena and effects of social networks. Instead, social networks can be used to gain insights into early evaluations of prototypes in a qualitative way and only within lab settings. The longitudinal appropriation of social network-related applications in the field is more suitable for quantitative beta testing.

11.2 Cultivating Partnerships

What seems trivial for typical research consortia that bring together academic stakeholders and practitioners and assume that obligations are regulated within contracts for project cooperation does not apply in long-term collaborations with users. Users' obligations are not formally defined and have to be conveyed as Frößler et al. (2007) mentioned. This thesis raised the issue of "practical ethics." This term means that, for successful and productive collaboration, there is not only a need for project management regarding timelines and other managerial tasks. There is also a need for trusting relationships in order to access private spaces in longitudinal field studies and to better understand how human relationships work. This aspect has scarcely been discussed in the literature (except Taylor and Cheverst 2012; Taylor et al. 2013; Vines et al. 2013). However, from a methodological point of view, it is a fundamental characteristic of participatory design processes (Greenbaum and Kyng 1991). Based on the conducted research and with a practice-based view, having a *regular point of contact* when interacting with a living lab user sample in a long-term study is advised. This finding thus provides answers to the research questions regarding stakeholders' roles and responsibilities as living lab operators addressing expectations and maintaining relationships. The role of a regular point of contact can be realized in practice through three different people (see Figure 26):

- An *academic member* as living lab operator, as was the case in both case studies;
- A trustworthy *person in a local community,* as was the case in the Lancaster study; or
- A *person responsible for a community center* where users groups, which are difficult to recruit, in particular can be reached, as discussed by Ogonowski et al. (2018).

Regardless of which type of person is chosen for this position, the person acts as mediator and negotiates between users and other living lab stakeholders. Special characteristics of these persons include strong user engagement and an effort to go beyond the "usual" tasks. As a regular point of contact, these people fulfill normative tasks, responsibilities, and expectations that ensure that users, for instance, are timely, are prepared for the next project steps, and maintain manageable expectations in order to avoid disappointment. They must also be available should any participant share technical problems that need to be solved. Simple technical problems can be handled by the contact person themselves; more complex problems should be coordinated with the stakeholder group responsible for prototypes. When dealing technical problems in

the field one of the lessons learned was to keep the pool of living lab stakeholders transparent and contained to the user sample in order to avoid user discomfort during home visits. One can keep the following rule of thumb in mind: the more familiar and personal the contact is to users, the less distrust or rejection is to be expected.

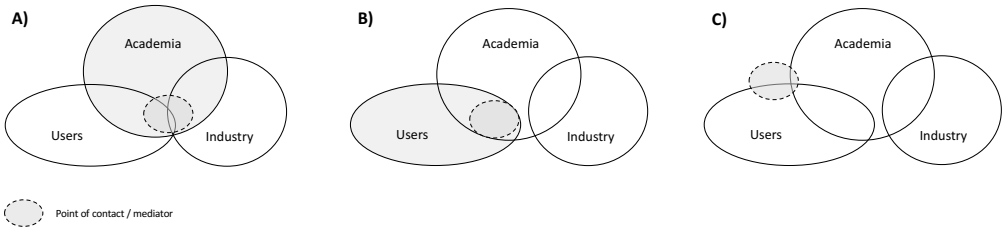

Figure 26: Different characters and their intersections as users' point of contact: A) academic member, B) member of user community, C) third-party person.

The role of these contacts should not be reduced to technical support and project management, because users were often seen as an important entity, but were not considered as stakeholder group within the project consortium. However, as Newell et al. (2006) have already pointed out a necessary mindsets shift on a project level, research conducted in this thesis suggests the need for a general conceptual shift on how other stakeholders in the living lab should accept and interact with users. This answers how the user's role in a living lab setting can be constituted and managed. A first step to overcoming the perspective that users are technical units is to consider their families and individual characteristics through regular and interpersonal interactions. This regular exchange was indicated as additional efforts during the living lab projects and describes tasks and actions mentioned as invisible work before. To value users means taking them seriously in discussions and interviews, providing extra technical support beyond what is required for the prototypes, and being interested in more than just research-related topics. Informal work covers social aspects of field research, and social events such as after-work drinks or season-specific activities help strengthen participants' relationships among themselves and user-researcher relationships and build trust. Informal social exchanges resulted in positive effects and impacted users' motivation to participate in addition to their main motivations of learning more about their own behavioral patterns and improving physical, cognitive, technical or social skills through the use of ICT solutions.

However, being the contact person is challenging. One the one hand, one must find a balance between formal tasks and social care with users. On the other hand, one has to handle the inter-organizational role – the role of moderator and mediator between stakeholder groups and one's intra-organizational role – "daily" work with its associated tasks as researcher. For the latter, one has to consider the handling of the organizational obligations and demands and its associated value system and one's own personal interests. Which type of contact person best suits a given living lab depends on the aim of the project. The more living lab operators give these tasks to community members or other organizational units, the less direct contact they will have with users. One argument for giving these tasks to someone else concerns costs of time, money,

and effort. These resources are often not calculated to a sufficient extent in project proposals but are absolutely necessary for cultivating relationships and guaranteeing successful collaboration and outcomes.

To conclude, each project has an asymmetric structure shaped by stakeholders' interests, and these largely define the obligations that must be mediated. The contact person thus functions as the main contact for the user sample and obtains deeper insights into the field of research and establishes and strengthens necessary personal relationships with users. Academic members more specifically can act as service providers for industry even if they are not the only persons responsible, and although they interact with both industry and users, but they are the ones who have the deepest experiences with users. The quality of this role will evolve over time in each living lab project and in relation to different user and stakeholder needs.

11.3 Managing Viewpoints

Longitudinal collaboration with different stakeholders and users entails much more responsibility and managerial effort in living labs compared to short-term field investigations. In living labs, mutual learning is one of the goals and a key benefit of the approach (Hakkarainen and Hyysalo 2013). Ensuring transparency helps realize this goal and also helps answer the question regarding how living lab operators address expectations and maintain relationships. In general, achieving transparency is relevant in two ways:

- *Pushing information* means to keep all stakeholders and users continuously well informed about research insights, current and planned project activities, challenges, and even failings; and
- *Pulling information* means to demand regular feedback from both stakeholders and users to compare individual expectations, current emotional states, and satisfaction levels to react if single stakeholders or groups are imbalanced and to ensure smooth collaboration and productivity within the project.

Pushing information is relevant as the analysis brought up the fact, research projects as described in this thesis, can be understood as CoI. Collaboration in living lab projects were managed in the same way as in classic projects, but with a peculiarity regarding the involved user sample. Users were acquired after the consortium was defined and had no chance to actively contribute to the project design and definition. Therefore, the user samples were artificial communities in the case studies conducted in Siegen. In contrast to the naturally grown community in Lancaster, living lab projects in Siegen required more management and articulation work from living lab operators. In Siegen's user groups in particular, the need for a common understanding with the other stakeholders arose. Frößler et al. (2007) have stated the common understanding of all involved living lab actors as a common denominator for successful collaboration. This concretely means that especially users partaking in long-term investigations with fieldwork should have the opportunity to track development progress, be informed of the current state of development, and know when the next release is; if a release is delayed, users should be provided with an explanation. For the rollout of redesigns, one should communicate to users what visual and non-visual

changes have been made, such as changes in the performance of the backend system. A recommendation for releases is to communicate changes and advantages to participants in a way how they are familiar with, for instance how app developers communicate new features in app stores.

The “asymmetry of knowledge” as described by Fischer (2000), has a strong impact on the community spirit, knowledge transfer and collaboration practices among all living lab stakeholders, as this thesis showed. On the one hand, stakeholders from different organizations came together to work on something new, and they learned from each other’s experiences. On the other hand, different understandings, work practices, and cultures are opposed to the common project aim. Living lab projects in particular need profound project management. Management should use a project plan that offers flexibility, methods, and tools for knowledge transfer, and moreover, project managers need to create an atmosphere that strengthens interpersonal relationships. This atmosphere can be reached through invisible work, such as technical support, and through social events and articulation work, which can be summarized as all verbal and non-verbal communication that is relevant to the design process. As stressed before, articulation work is crucial for successful long-term collaboration and the attainment of research goals. This work comprises many managerial tasks that unfortunately are often underestimated and neglected by living lab operators. In Strauss’s sociological framework of articulation (Strauss et al. 1985; Strauss 1988), he, among others, stressed that informal communication with stakeholder groups is not just necessary to coordinate tasks and divide labor. It also helps identify and address interpersonal conflicts in early stages or even prevents them from becoming barriers for future collaboration. Such soft skills should therefore be some of the core competencies required for operating longitudinal living lab studies.

These skills also positively impact practices of information pull. Pulling information is at least as important as pushing information, as the analysis of individual stakeholder expectations has shown. Expectations can change over time and have to be adequately addressed. For continuous and successful collaboration, current expectations and sentiments of stakeholders should be compared regularly. As shown with the SocialMedia project, each participant was asked about their project experiences and expectations in each interview and at the end of the project. The final project workshop applied the method of narrative mapping, which gained insights on the overall project progression and helped users reflect on past activities and changes over time in a conscious manner. Such a workshop was conducted only once. However, this workshop was fruitful, and we observed that participants expressed their negative sentiments more explicitly and honestly here than in interviews. This user behavior sparked other users to join in and provide their opinions. In the interviews, we observed that participants were more reserved and too polite to give too many negative comments. Moreover, the focus of the interviews was different than that of the final workshop, which had the specific purpose of having participants reflect on their own collaboration expectations. In the interviews, users’ expression of less obvious feelings was more coincidental.

Based on made experiences with the participants group, it can be stated that regular feedback from groups is valuable regardless of whether the feedback concerns

development progress or the collaboration. Allowing feedback gives users the chance to react immediately if something develops contrary to their expectations. Therefore, organizational awareness regarding the allocation of time and space is needed. Living lab operators can benefit from established co-creation processes for generating ideas together and make use of this ideas to define solution approaches based on common commitments. Moreover, agile software development methods (Schwaber 2004; Cockburn 2007; Rubin 2013; Sutherland 2014), review meetings, and retrospectives all seem to be suitable for reflecting more broadly on the progress of ICT design and stakeholder collaboration.

Review meetings should be understood as informal meetings where, in the case of agile software development, the development team presents the current state of a development and where, if possible, all stakeholders in contact with the development team are also present. These meetings are intended to uncover potential forgotten requirements and to check the logic of the developed artifacts using "multiple eyes." In addition, these meetings promote transparency in the development process and enable all relevant stakeholders to be heard. For living lab projects, these meetings could be used to present research insights from field studies or lab tests and the current state of a prototype design. This meeting format thus can be used to bring all project stakeholders including users together, but these meetings are perhaps best conducted with single-stakeholder groups, such as with users, industrial partners, or academic partners on a regular basis for instance every two months, whereby time intervals should be determined together with respective stakeholders. To ensure transparency in the overall project's progression and the equality of all involved actors, reviews can be conducted at longer intervals, for instance, one or twice a year, but here, too, same applies as described above scheduling should take place together with all actors of the living lab project.

The other mentioned format is the so-called retrospective. Retrospectives foster reflections on fixed time periods and events. In living labs, they can be organized in a similar way to the review format (as single-stakeholder group sessions) and also as multi-group sessions with different living lab actors. The format can be decided based on the intensity of the collaboration between stakeholder groups. No matter which composition is chosen for the review format, a moderator (i.e. a so-called scrum master, which is the term used in agile environments, or, what Hakkarainen and Hyysalo [2013] called an innovation intermediary) is mandatory for this. Ideally, a moderator should be someone who is neutral but still has a certain relation to the group of the living lab operator, such as an academic staff member who works on another research project. Retrospectives help successfully control and manage projects and processes within changing settings by following one of the principles of the agile manifesto: "responding to changes is more important than following a plan" (Agile Manifesto). What works well in agile and scrum teams could work in living labs as practical approaches, given their complex stakeholder management and user-centered design approach. One of the minimum requirements for conducting retrospectives is thus to establish a moderator, and in general build trust relationships within the project, create an open mindset, and promote a positive feedback culture.

11.4 Empowering Users

The importance of users for living labs is undisputed. This section clarifies users' role, answers why integrating users in co-creation processes is challenging, and explains how to use their potential by empowering them. Although users are key for living labs, their involvement is not uniform, as the comparative research of this thesis and theoretical discourses in the literature (Følstad 2008; Schuurman et al. 2010a; Mulvenna et al. 2011) have shown. We identified some barriers in interactions with industry regarding time-benefit expenses for co-creation workshops or the allocation of competencies in user expertise from their clients, which can explain in part stakeholders' reluctance in user interactions at that time. To increase productive collaboration through user empowerment, both cognitive and normative shifts from traditional work practices toward new collaborative practices are needed in the long run. The design of ICT should not necessarily follow an objectivistic approach in early stages, and research objects should not be influenced by researchers. Rather, proximity to users is recommended in order to gain a better understanding of them and to take advantage of user interactions for technical development. This rethinking is facilitated by approaches such as action research and, to a certain extent, agile working practices. Nevertheless, this rethinking still requires time to fully make use of the living lab approach throughout the whole design process, from the early stages of context understanding, over co-creation, to appropriation studies within the field. During the design process, living lab operators and stakeholders with significant user interactions should especially keep some things in mind to gradually empower users and to strengthen them as an "equally considered" stakeholder group. Ultimately, users have to be accepted as contributors and should also be encouraged by all stakeholders in the living lab.

In general, a shared understanding of the user's role as co-creator should not be assumed at the beginning of a project. Tasks and opportunities for users need to be carefully established in the group of users. Users' motivations are triggered by different personal values and benefits regarding the usage of new systems and applications and not necessarily by the participative design process, to which they need to become familiar with. As has been shown, these motivational triggers apply to both naturally grown user communities and artificially built ones. Artificially built communities, in comparison with natural communities, need more "care work" to develop into a kind of CoI, where members share knowledge and feel responsible for others in the CoI. To reach this status, most tasks as for instance informal meeting will organized first by the operator.

As mentioned before, long-term investigations in domestic contexts encounter many challenges, especially concerning users. There are some things that cannot be foreseen or even influenced when one begins to work with users over a long period of time. For instance, changes in family status, address, or work result in habit changes or dropouts at worst. Participants' motivations, however, represent a central factor in their commitment to the project. Preece and Shneiderman (2009) emphasized that one only has to work with users who are generally interested in participating in collaborative projects, and thus, one excludes those who may be unable or unwilling to participate in such projects. Nevertheless, even participating individuals' motivations must be

kept high. There are small aspects to consider regarding the way people are motivated. These aspects can be simplistically divided into intrinsic and extrinsic factors (March and Simon 1958). Intrinsic factors are those that are anchored in persons themselves, and extrinsic ones arise from external influences. Batson et al. (2002) distinguished motivational factors according to four extrema that relate to different goals: egoism to increase one's own wellbeing; altruism to increase the welfare of a single person; collectivism to increase a group's welfare; and idealism to strengthen moral rules. All factors are marked by positive and negative characteristics, and the positive connotations should be fostered. It is not uncommon that people contain several of these extrema within themselves, such as idealism and collectivism. In both our case studies, all four extrema were identified in the group of participants. To keep participants motivated, one must identify which type a user represents. For instance, users can be identified based on the typology from Schuurman et al. (2010b), which includes Pro-Ams, Power Users, and bystanders. One must address users' intrinsic motives. Besides these intrinsic motives, extrinsic factors are also helpful to keep users motivated. Based on experiences from the studies, some methodological implications for empowering users are listed as follows:

- *Value users' contributions:* As stated above, it is essential to communicate to users what it means to be an active part of the design process and a substantial stakeholder in the overall living lab project. To communicate this information, it is helpful to always listen carefully to users and show appreciation. Demonstrate that the project needs users by valuing their inputs by, for instance, permitting them to digress to an extent in discussions, sharing information and research results to ensure knowledge transfers between users and stakeholders and to create transparency, and providing information to users regarding what has changed with new releases and why changes were made. Appreciation can also take place through informal events, where the project's aim is not necessarily in the foreground. Rather the users are in the foreground here – pay attention to their voices.
- *Conduct regular in-person work:* Regular physical face-to-face dialogues at participants' home or in groups during workshops, for instance, at the university are well suited for personal interactions that offer users communication space and strengthen relationships and users' commitment to a given project. Workshops provide even more opportunities, especially regarding the push and pull approach to information. Topics and tasks can be discussed in workshops or worked on collaboratively. Moreover, participants should have opportunities to simply exchange experiences among themselves. The more users can interact with others, the more they are triggered to reflect themselves.
- *Reflect on a regular basis:* Self-reflection is generally relevant for all stakeholders in co-creation processes. It addresses negative sentiments and helps continuously improve collaboration processes and related outputs, as mentioned in the previous section on managing viewpoints. It is most important for users organized in artificial users' communities. Users' self-reflections are necessary for living lab research for two reasons. On the one hand, they are needed to assess collaboration processes and to formulate the user's role within the living lab. On the other hand, they are needed to better reflect on unconscious and conscious individual changes such as changes

regarding social activities, usage behavior, and psychological and physical conditions. Unconscious changes are especially difficult to uncover for researchers and participants. It is unclear how intense changes must be to be noticed by users or how reflective participants must be to notice them. Long-term investigations in living lab environments make changes visible over time. Integrated self-monitoring functions, as were used in the iStoppFalls project, help participants become aware of their own usage behavior. Based on their nature of documentation, self-documentation methods such as diary studies trigger users to think about their behavior. They can be repeated in regular intervals, for instance, as conducted every year within in the SocialMedia project. Interviews and regular exchanges in long-term relationships helped researchers know participants better, estimate their feedback in sense of what the users say and what they actually mean, and interpret their behavior. Moreover, self-documentation methods provide access to the field by keeping private spaces private. Simultaneously, they can be used to create trust relationships.

- *Improve IT literacy:* Our analysis revealed that the improvement of IT literacy influences users' participation and motivation. This finding is in line with the analysis of Leonardi et al. (2014) and can be supplemented with practice-approved concepts that address the demand for technical training during the projects. Depending on the involved target group and their general level of IT literacy, single workshops or workshop series helped improve participants' IT literacy. As a rule of thumb, the older participants are, the more technical support is needed. Technical support can be divided between project-related training that improves one's handling of digital devices and decreases one's fear of breaking a device, and training that overlaps with the research focus that more deeply addresses technical knowledge, such as training on how to best use and configure devices and applications or training regarding the best smartphone apps for everyday life. Training that is less related or unrelated to the project helps keep users motivated to participate because such training conveys to users that they are not just subjects of research.
- *Strengthen the "users-help-users" approach:* As described on a general level by Carroll and Rosson (2013), the idea behind the users-help-users approach is to make skills visible in a community in order to reuse them for successful collaboration. The case studies of this thesis have shown that user samples were comprised of individuals with varying levels of technical expertise. Active and tech-savvy participants were often helpful when other users had technical questions in group discussions. Establishing a "users-help-users" approach implies that users are empowered to function as technical assistants. Such users received prestige from participants, took over responsibility, and used this role to share their own experience and knowledge for the project. The users-help-users approach reduces organizational efforts and expenses for living lab operators and also helps shape the user community. An instant messenger group for technical support proved useful for users. Moreover, users could conduct certain technical trainings that address topics beyond the projects' scope.
- *Create synergies through different user types:* The different levels of tech-savviness mentioned above are not only relevant with respect to technical support. The variation in tech-savviness also aids the co-creation process. As described in the section on collaboration practices in the summary of findings,

a mixed co-creation session, which was not initially planned in the SocialMedia project has proven to be a valuable strategy for further co-creation sessions. Bringing together tech-savvy users with less tech-savvy users results in synergies freed from status quo-thinking that are creative but realistic enough to be usable. However, such creative sessions need appropriate methods to support them. For instance, within ideation phases, it would not be fruitful for every participant to write down their ideas and present them afterwards. Association techniques such as brain walking, the 3-6-5-method, or the catchball method (where participants creativity is provoked by a previously written or spoken idea of another participant) seem more suitable. Each of these methods focuses on ideation in a collaborative way.

Nearly all of the implications derived here that empower users in a living lab are strongly interwoven with what is called invisible work. Particularly for living lab operators, invisible work connotes work beyond “normal” tasks of field research. This means a strong social responsibility to the involved users and additional efforts in terms of time for relationship work. However, these efforts have been shown to be absolutely necessary in long-term, co-creative field research for ICT design precisely because, from a user’s perspective, they result in their greater involvement in the project and foster successful stakeholder collaboration and user-centered design processes. This invisible work can therefore be assumed as given, regardless of whether participants receive additional monetary compensation. Again, the argument here is complementary to the stated roles of living lab operators and regular points of contact. These efforts need to be clearly described and calculated in project proposals and scheduled in research agendas, so they become visible work in the future.

12 Closing Remarks and Outlook

This thesis has provided detailed insights from a meta-perspective regarding longitudinal living lab research on ICT design for domestic environments. Practical investigations were conducted on two living lab projects. These investigations focused on the technical and infrastructural setup of the living labs and the social interactions between users and stakeholders and between academic and industrial stakeholders. The investigations have revealed strengths and challenges of the living lab approach that need to be considered when collaborating and maintaining relationships over long periods of time.

The evolving trend towards long-term living lab studies that incorporate an increasing number of actual use contexts has made the main benefits of using the approach more relevant over the last decade (Alavi et al. 2020). Consequently, analyzing these benefits and collaborative practices from a meta-perspective and understanding what is important to consider in such settings have become relevant. This thesis has shown that iterative product design with multiple stakeholders in the field is costly with respect to time and associated managerial and social aspects. These time efforts in particular became obvious during the selection of the user sample, when conducting ethnographic research in the field, when implementing and maintaining technical infrastructure in households, and in co-design processes. In return, the living lab approach with its focus on actual use contexts has allowed us to better understand the research context and user perspectives because we could access the field of application before and after new technologies were introduced. The improved contextual understanding and the proximity to users have fostered iterative co-creation processes and mutual learning as further key advantages of the approach. However, living labs also came along with the challenge of reconciling work practices, expectations, stakeholder perspectives, and users' own roles in these practice-based research and development settings.

This thesis contributes to four essential managerial principles addressing methodological, structural, and social issues of long-term collaborations in living labs that should be considered during the writing of a research proposal or when setting up infrastructure and establishing interactions with users. These principles can be framed as the practical management of maintenance work and were derived with the aims of reducing costs, optimizing processes, and strengthening collaboration between involved stakeholders and users in living labs. In context of derived implications, issues for future research arise.

The first managerial principle refers to overall project management in living labs. Long-term collaboration with users requires that one pay extra attention to the following aspects: the quality of prototypes because artifacts compete with other established technologies in the field; the maintenance of technical infrastructure, including the provision of a technical help desk that supports technical problems in the field; and the administration of the user sample, especially when the living lab approach is applied or planned to be extended to further projects in the domestic domain or beyond. Further investigations on CRM systems that systematize and share empirical data among those in living lab operator groups or among academics is needed. However, requirements on CRM design are unclear and could benefit from

best practices of living lab project management. In this context, the opened discussion about the aptitude and value of a CRM system in the context of ResearchOps (Wilczek and Schneidermeier 2019; Kaplan 2020) and regarding the concept of an e-portfolio (Li et al. 2020) should be continued. This discourse provides valuable and underrecognized potentials with respect to the scalability of the living lab approach and its sustainable establishment for practical research on ICT design in domestic environments.

The second principle addresses the practical ethics of cultivating user-stakeholder relationships. Trust relationships are essential for accessing the field of application and users' private spaces. The use of a central contact person has proven successful in fostering trust relationships. This person takes on a mediator's role, which therefore requires negotiation skills when transferring information between stakeholders and users. This thesis has analyzed three different characters and how they can be anchored within the living lab setting. However, further investigations are needed on the rights and duties of this role. Another underrepresented aspect is the practitioner's role as living lab operator and how they could transfer the living lab approach to their day-to-day businesses. It will be interesting to investigate potentials of the living lab approach from a stronger economic perspective where designed solutions ultimately need to be sold to users.

The third principle refers to managing individual viewpoints by ensuring transparency through information push and pull. Pushing and pulling information are essential managerial practices foster mutual learning, which is key in living labs and helps identify and mediate conflicts at early stages. Pushing information acts as catalyst to establish a common project understanding. Information pull mainly refers to gaining insights on users' and stakeholders' expectations, emotions, and current satisfaction with a project. Regular feedback is essential for living lab operators to establish strong and successful collaboration. Therefore, agile software development methods were discussed to promote regular reflections. Agile methods show promise for strengthening relationships and fostering collaboration processes in living labs, but how agile methods work in practice and how to address the neutral moderator's role remains to be researched.

The fourth and final principle addresses the users' role and their empowerment in co-creation processes. Users indisputably provide insight for ICT design. Consequently, a conceptual shift regarding the users' role is necessary, as they are still seen as technical units rather than individuals representing an equal stakeholder group. In this context, the living lab paradigm should be adjusted, and related stakeholder uncertainties and challenges of collaborative practices should be addressed. Motivational factors were found to be relevant for long-term participation in living lab projects. They can be used to increase users' commitment to projects. External factors can be used to impact intrinsic motives. Some of the practice-approved measures are self-documentation methods, the "users-help-users" approach for technical support, and involving users with differing expertise and technical skills in co-creation processes in order to stimulate each other's creativity. Invisible work and articulation work have an underestimated impact on user motivation and help keep living labs operating. These kinds of work should be further investigated with respect to tools and

methods for classifying different user types in living labs. For instance, questionnaires can be used to involve users more specifically in different phases of living lab processes.

In summary, this thesis exhibits detailed insights into living labs as practical approaches for ICT design in domestic environments and highlights the value of long-term field studies. Based on two conducted research projects, critical reflections on collaboration processes from a meta-level were made, and relevant aspects regarding living lab infrastructures and the management of setup and maintenance work in long-term studies was investigated to a further extent than previous research. The derived implications provide practical descriptions and recommendations for future living lab projects and emphasize the need for a user-centered mindset and the role of users as an equitable stakeholder group. In addition, this thesis opens new perspectives that make the living lab approach more scalable and usable for ICT design for domestic contexts.

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