Caring for Technology

Evolving Living Lab Collaboration

Caring for Technology: Evolving Living Lab Collaboration

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Abstract

The nature of technologies and their contexts of use have become increasingly complex, especially in health care and elderly care. In order to exploit the potential of technologies to improve care, we need better technological systems and better ways to integrate them into the work practices and the existing technological environment in the care units. This dissertation seeks to understand the potential of living lab platforms to tackle these challenges.

Living labs are co-design platforms for product and service development situated in real-life contexts. They bring together diverse stakeholders (public sector, companies, academia, and users) and engage them in mutually beneficial learning. In a living lab project users are considered active partners in product development instead of passive objects of study.

By combining document and interview data this article-based dissertation reconstructs the biography of a smart floor innovation. The smart floor is a floor monitoring system and a nursing tool for elderly care. It seeks to prevent accidents and help save resources by decreasing the need for routine checks in residential care facilities. The smart floor was developed in close collaboration with care professionals in a four-year living lab project that took place in a public nursing home in Finland.

Even though approximately 400 living lab initiatives have taken place worldwide since the turn of the millennium, not much is known of the learning dynamics between living lab stakeholders on a detailed level. Research around living labs has been criticized for a lack of empirical studies and overly optimistic attitude towards the approach. The everyday realities of living lab collaboration have remained largely unexplored,

and realization of learning between stakeholders seems to be taken for granted in many studies. This is where the present study contributes.

The dissertation draws from science and technology studies, design research and research on innovation management. The articles of the dissertation focus on learning between project stakeholders, tensions and conflicts, and the role of innovation intermediaries in co-design. The added value of the living lab approach and patterns of user-developer learning on a more general level are analysed by comparing the smart floor case to other innovations.

The work demonstrates that a living lab is not a panacea for information transfer and collaborative learning, and realizing its potential requires a significant amount of work and resources from all parties involved. Skilful and active intermediaries play a crucial role in mediating multi-stakeholder learning. Despite the demands, the living lab seemed to catalyse the resolution of the necessary learning challenges that would otherwise have caused significant strain on the early customer relationships. Through user collaboration a simple fall alarm evolved into a precautionary nursing tool, which ultimately generated more value for its users and the developer company than the original concept idea.

Acknowledgements

Around 2008 I was a slightly frustrated bachelor student and I noticed a poster on the wall of the department of social sciences in the University of Helsinki. The poster promoted a master's programme in science and technology studies (STS), which sounded topical, forward-looking and exotic as I was somewhat uninterested in technology in my everyday life. Nevertheless, I had just joined Facebook and realized that things like mobile phones and the Internet had and would continue to radically change the way we live and love. As a result I ended up spending eight months split between Aalborg University and Lund University studying STS classics.

Alongside my studies, I had some odd jobs and one of those was writing advertorials, which are sort of advertisements in the form of a newspaper article. I was asked to write an advertorial about an elderly care technology product, a wrist monitoring system. The system felt very science fiction; kind of fascinating and scary at the same time. It monitored the sleep, the movements and the health of the elderly and sent an alarm to a nurse or a loved one when something unordinary was going on. I decided to make the examination of that wristcare system my master's thesis study as it nicely brought together questions related to social policy and STS.

The problem was that I could not find anyone in the social studies department who could help me to realize this research idea. After knocking on some doors, it was suggested that I contact Sampsa Hyysalo, who at the time was a young researcher in the Helsinki Collegium for Advanced Studies. Sampsa listened to my thoughts about my master's thesis and informed me that he had already studied all that there is to study about that wrist monitoring system. I remember thinking that his answer sounded a bit exaggerated, but I later understood that his assessment was not so far from the truth. :-)

I am deeply grateful for the rare opportunity to truly learn the craft of research and the art of being a researcher in a master-and-apprentice way from a teacher who has been incomprehensibly generous with his time, surprisingly patient with my limitations and who, in some miraculous way, seems to have an answer to every single question inside or outside his formal area of expertise. It is safe to say that this work would not have been done without Sampsa.

If one is as lucky as I have been, doing a PhD is to a large degree a team effort. Since my licentiate study, I have had the possibility to do research as part of the multidisciplinary INUSE research group, which consisted of – and continues to consist of – amazingly bright, committed and kind individuals: Mikael Johnson, Pia Hannukainen, Samuli Mäkinen, Jouni Juntunen, Cindy Kohtala, Stephanie Freeman and Kaisa Savolainen. Their example, feedback and friendship have been fundamental on this journey.

After getting a licentiate degree, I transferred from the University of Helsinki to the Department of Design in Aalto ARTS to do a PhD. In the department of design, I found a cosy, joyful and curious community, which is much closer to a group of friends than a traditional work community. I want to thank all my colleagues in the department of design, and in particular Patricia Naves, Seungho Lee, Paulo Dziobczenski, Namkyu Chun, Yiying Wu, Karthikeya Acharya, Anna Kholina, Júlia Valle and Yichen Lu, for a truly stimulating, warm and fun working environment.

I would also like to thank all the colleagues who have helped me to improve my work by giving feedback during summer and winter schools, seminars, conferences and as anonymous reviewers. I am especially grateful for the pre-examiners James Stewart and Jo Pierson, who gave me wise, insightful and detailed comments. Their feedback made the last steps of the thesis process enjoyable, helped me to clarify my argument and to understand better what my work has to contribute.

I am very grateful to the subjects of my study who taught me a thousand things about collaboration, creativity and perseverance and believed in me and my study.

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Finally I want to thank my family for supporting my curiosity and for offering a fruitful environment to learn argumentation. I also want to thank my extended family that consists of friends and relatives who have the paradoxical talent of simultaneously accepting me as I am while inspiring me to do my best and beyond.

Helsinki, May 2017

Louna Hakkarainen

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Article 2.

Hakkarainen Louna and Hyysalo Sampsa (2016) The Evolution of Intermediary Activities: Broadening the Concept of Facilitation in Living Labs. Technology Innovation Management Review, January 2016, 6(1): 45–58.

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Article 3.

Hyysalo Sampsa and Hakkarainen Louna (2014) What Difference Does a Living Lab Make? Comparing Two Health Technology Innovation Projects. CoDesign 10(3–4): 191–208.

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Hyysalo Sampsa, Repo Petteri, Timonen Päivi, Hakkarainen Louna and Heiskanen Eva (2016) Diversity and Change of User Driven Innovation Modes in Companies. International Journal of Innovation Management 20(2).

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The Author's Contributions

Article 1.

Hakkarainen Louna and Hyysalo Sampsa (2013) How Do We Keep the Living Laboratory Alive? Learning and Conflicts in Living Lab Collaboration

The author was responsible for the original idea and research design. The author alone gathered the data and executed the analysis. The article was co-written, with the author having the main responsibility.

Article 2.

Hakkarainen Louna and Hyysalo Sampsa (2016) The Evolution of Intermediary Activities: Broadening the Concept of Facilitation in Living Labs

The author was responsible for the original idea and research design. The author alone gathered the data and executed the analysis. The article was co-written, with the author having the main responsibility.

Article 3.

Hyysalo Sampsa and Hakkarainen Louna (2014) What Difference Does a Living Lab Make? Comparing Two Health Technology Innovation Projects

Hyysalo was responsible for the original idea and research design of the paper. The author gathered the data and executed the initial analysis for the floor monitoring case. The comparative analysis was executed together by the both authors. The article was co-written, Hyysalo having the primary responsibility.

Article 4.

Hyysalo Sampsa, Repo Petteri, Timonen Päivi, Hakkarainen Louna and Heiskanen Eva (2016) Diversity and Change of User Driven Innovation Modes in Companies

Hyysalo was responsible for the original idea and research design of the paper. The author identified and reported 25 cases of user-driven innovation out of the 58 cases that constituted the data set of the paper. The four first authors executed the analysis together. The article was co-written, Hyysalo having the primary responsibility.

Abbreviations

ANT	Actor–network theory
BoAP	Biographies of artefacts and practices
ENoLL	European Network of Living Labs
HCD	Human-centred design
ICT	Information and communications technology
PCD	Participatory continuing design
PD	Participatory design
SCOT	Social construction of technological systems
SME	Small and medium-sized enterprise
SST	Social shaping of technology
STS	Science and technology studies
SLTI	Social learning in technological innovation
TEP	Test and experimentation platform
UCD	User-centred design
UDI	User-driven innovation

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1. Introduction

Innovation no longer only takes place in corporate research and development laboratories – thriving businesses need to reach out to sources of innovation outside their boundaries (Chesbrough, 2006; Prahalad and Ramaswamy, 2004; Thomke and von Hippel, 2002). Companies are increasingly interested in the users of their products and services as a potential source of innovation. In some industrial fields, for example that of scientific and medical instruments, users are in fact claimed to be the most important source of new innovations (von Hippel, 1988, 2005).

The innovative potential of users poses particular promise in the fields of health care and elderly care. An aging population is something that affects all Western countries, and technologies are expected to contribute to the equation by improving care while saving resources (Francesca et al., 2011). The amount of technological equipment in nursing homes, as well as their complex and ubiquitous character, has been increasing during recent decades. But exploiting the potential of technologies has proven surprisingly difficult: on one hand users seem to be forgotten in the design of many solutions and on the other hand integrating systems into the work processes and the existing technological environment of the organization remains a challenge. As a result the use of many technologies remains limited, and it is still unclear to what extent – if any – technologies have improved effectiveness in long-term care (Francesca et al., 2011; Hyppönen, 2004; Hyysalo, 2010).

Participatory innovation (Buur and Matthews, 2008) has played an important role in improving the quality of technological systems designed for complex organizational environments like health care and elderly care. Living lab environments are a recent addition to this field, and their number has been rapidly increasing during the last decade[1]. Living labs are promoted as co-design infrastructures situated in real-life contexts, and they bring together public sector actors, companies, academia and end-users. Ideally, during a living lab project the solution, users' needs and practices, and the context in which the solution will be embedded are allowed to mature simultaneously. Users have an active role as partners in the development process and they are not just passive objects of research (Ballon, Pierson and Delaere, 2005; Leminen, Westerlund and Nyström, 2012).

> As information technologies become a more and more pervasive feature of modern workplaces, understanding the relationship between these technologies and the social organization of work, of which they are part, becomes increasingly important for those involved in their creation, deployment, and use. (Voss, Procter, Slack et al., 2009)

In elderly care, and in health care more generally, technologies and work practices make up sociomaterial constellations, which are very difficult to envision or predict when the phases of design and use are separated. The problem is exaggerated by the characteristics of the elderly care field as a design context: there is a wide social distance between developers and users (care workers as well as elderly people) and nursing homes are relatively closed, hierarchical and highly regulated organizations where change resistance is common. In addition, the impacts of elderly care technologies evoke particular ethical considerations. The need for dialogue between different stakeholders is generally acknowledged and thus living labs offer considerable promise for all parties involved.

This article-based dissertation is founded on a longitudinal qualitative case study of a living lab project that was carried out in a large public nursing home in Finland. During the project a simple fall detector evolved into a complex fall prevention system and nursing tool: the smart floor. The study also covers the time period after the market launch of the product, when the company clientele was rapidly growing.

[1] Source: http://openlivinglabs.eu/ (accessed: 28.10.2016)

In this study the smart floor innovation process is approached from perspectives offered by science and technology studies (STS) and more specifically research on the social shaping of technology (MacKenzie and Wajcman, 1985; Williams and Edge, 1996). This dissertation seeks to provide an empirically grounded understanding of the coupling between development and use in a living lab project and after it.

The current literature on living labs is poorly equipped to explain how learning between different living lab stakeholders takes place in practice. A large number of research papers are either still sketching out the potential of living labs and explaining what *should* happen on a conceptual level or they are overly optimistic project descriptions by advocates.

This study seeks to describe in detail how the learning between different stakeholders took place during the living lab project and after it: what was learned and what factors supported or hindered this learning. In addition, the articles of this dissertation focus on questions related to conflict management, the role of individual user-side innovation intermediaries, the benefits of the living lab approach and the relationship between the learning patterns found in living labs and user-driven innovation practices in companies more generally.

The study describes challenges that arise when different professional identities, organizational cultures, values and goals are at play. The smart floor living lab project faced power games between the stakeholders and end-users were reluctant to participate in the technology development. Overall the message of the dissertation is that multi-stakeholder learning in a living lab cannot be presumed or taken for granted: learning *for* interaction is needed before learning *in* interaction is possible. Intermediary actors play a crucial role in realizing user-developer learning.

The data consists of interviews, meeting memos and other documents related to the development of the technology. The dissertation draws from multiple disciplines: STS, innovation studies and design research. The findings of the dissertation will be of most benefit to researchers and practitioners in the fields of living labs, co-design, participatory design, open innovation and social shaping of technology (SST). The research approach is hopefully geared towards producing knowledge that living lab practitioners would also benefit from and that can be applied to planning and managing living lab activities and other real-life experiments, especially in the fields of health care and elderly care.

1.1 Elderly Care and Technology

The previously mentioned demographic transition has and will affect industrialized countries, as well as emerging economies, as growing life expectancy will increase the care needs and degrade the demographic old-age dependency ratio significantly in the coming decades.[2] In the Finnish context, the economic crisis in 2008 accelerated the shift from universalism to the increasing differentiation of social policies (Anttonen and Karsio, 2016).

Beyond Finland this has led to the redesign of long-term elderly care, characterized by deinstitutionalization, privatization and marketization in nearly all post-industrial states since the mid-1990s (Deusdad, Pace and Anttonen, 2016; Karsio and Anttonen, 2013). Deinstitutionalization has aimed at creating high-quality care without continuously rising costs, which in practice has meant "remarkable cutting back on institutional care and strengthening of home first care [...] [i.e.] prioritizing care at home or in homelike environments" (Anttonen and Karsio, 2016: 151). In addition, marketization has resulted in "different, and often parallel, processes such as outsourcing, use of vouchers, or also competitive tendering" (Deusdad, Pace and Anttonen, 2016: 144).

In Finland these changes have meant that traditional institutional care (the care given in the long-term care wards of municipal health care centres and hospitals and in nursing homes) continues to exist, but "access criteria have been very much tightened, the number of places in old institutions being significantly reduced and the whole idea of institution and institutional care having been thoroughly redefined by the government" (Anttonen and Karsio, 2016: 153). The preference is for home care and homelike environments – like (private) intensive service housing – which have seen extensive growth during recent years (Anttonen and Karsio, 2016; Karsio and Anttonen, 2013).

The Finnish publicly funded elderly care service system consists of home care (home help and home nursing) and support services (e.g. meals-on-wheels, washing and bathing etc.), an informal care allowance for persons who are taking care of a loved one and residential care services (long-term care given in nursing homes and long-term care wards in municipal health

[2] Source: http://ec.europa.eu/economy_finance/publications/european_economy/2015/pdf/ee3_en.pdf (accessed: 4.12.2016)

care centres, hospitals and intensive service housing units with 24-hour assistance and care) (Anttonen and Karsio, 2016).

In the redesign of long-term care, technological solutions have come to play a particular role in increasing efficiency and alleviating the growth of expenses – at least on the level of rhetoric (Francesca, Ana and Jérôme et al., 2011; Miettinen, Hyysalo, Lehenkari, et al., 2003). The concept of **gerotechnology** refers to technological solutions designed for elderly care aiming at, for example, preventing problems and accidents, supporting and utilizing the strengths of elderly people and compensating for weakening skills and abilities, as well as improving the quality of care (Graafmans, Taipale and Charness, 1998).

Technologies, and monitoring technologies in particular, are expected to support the de-institutionalization of care and transition to a more diversified elderly care portfolio, whether that means elderly people living at home or in intensive service housing units. But so far the track record of elderly care technologies has not been very flattering: the designs are accused of not responding to user needs and the care institutions have failed to integrate the solutions into their work practices (Miettinen, Hyysalo, Lehenkari et al., 2002; Hyppönen, 2004; Hyysalo, 2010).

For example, in the nursing home studied in the this dissertation, the care workers complained about how elderly people were at risk of tripping on a sensor carpet that was placed in front of their beds and even residents who were suffering from dementia learned to avoid stepping on it as it resulted in a care worker entering their room. In the common area an exercise bicycle for elderly people stood unused.

> [O]ver the years, frustration has been high over what machines (and/or engineers) still can't (or won't) do, why (medical) practitioners fail to appropriate innovations, and why (health) administrations fail to introduce needed reforms. (Hyysalo, 2010: xxiii)

Hyppönen (2004) and Hyysalo (2010) have pointed out that health technology developers are often young or middle-aged, technically oriented men with a university degree and a good income, whereas technology users in care institutions are typically (older) women in a low-income job who are not interested in the latest gadgets and are reluctant to adopt new technological solutions as part of their work. The social distance (Johnson, 2013) between developers and users is thus wide and technology developers cannot rely on their common sense or I-methodology (Akrich, 1995) in designing solutions for elderly care.

For young gerotechnology companies or start-ups with a limited amount of time and resources, accessing relevant information about users and the context of use might become an overly complicated, laborious and risky task as separating relevant and non-relevant information might require an extensive background understanding of what is going on in the institutional context of a nursing home (Hyysalo, 2010). A number of longitudinal studies of Finnish health care innovations (e.g. Hyysalo, 2000, 2004; Hasu, 2001; Hyppönen, 2004; Hyysalo and Lehenkari, 2002) have highlighted the importance of user-developer learning in the success of health and elderly care innovations. Thus the living lab approach, with its emphasis on development in real-life settings over an extended timespan, holds great promise as a design strategy for elder care technology companies. The previously mentioned empirical studies suggest that if anything will work in the face of the pervasive difficulties, it will be this kind of design collaboration.

1.2 The Case of the Smart Floor

The focal innovation of this dissertation, the smart floor, was created in an intensive living lab project that took place between 2006 and 2010 in a public nursing home in Finland. The system was significantly redesigned as a result of the design collaboration and users' feedback and ideas. The smart floor project was one of four sub-projects under an extensive living lab undertaking that took place in the nursing home. At the time the nursing home had over 500 residents, out of which around 70 per cent suffered from moderate to severe dementia. Around 15 per cent of the residents were in short-term care. The overall objective of the living lab activities was to develop new care practices and to explore possibilities to support them with technology. The innovation undertaking was granted 2.7 million euros for five years by the City of Helsinki Innovation Fund, and the majority of the funding was spent on hiring project staff.

The smart floor is a floor monitoring system and a precautionary nursing tool designed to prevent falls in a care home environment. The sensor network of the smart floor system was installed under the flooring in three units during a major overhaul. The system informs care workers of situations where a resident might be at risk of falling down or has already fallen down. The system can inform about six different situations: a resident 1) falling down, 2) getting out of bed, 3) entering the toilet, 4) staying in the toilet for too long, 5) entering the room and 6) leaving the room. The alarms are individually tailored for each person.

When frail elderly people get out of bed, they are at high risk of falling down and injuring themselves. In many nursing homes bed rails are used to avoid accidents. But while increasing safety, these kinds of movement-restricting technologies deteriorate the autonomy of the residents (Topo, 2007). The smart floor system was designed to inform care workers when a frail elderly person was, for example, getting out of bed, so that they could go and oversee such situations and no movement restriction was needed. The system also decreases the need for routine check-ups, which improves the privacy of the residents and has proved to be particularly useful during night shifts[3]. Since the system informs the night nurse if a person gets up in the middle of the night, there is no need to check each room throughout the night in order to make sure that the residents are sleeping. This latter practice disturbs the sleep of the residents and requires more workforce.

The origins of the smart floor system are in the Helsinki University of Technology (now Aalto University) where the motion tracking technique that the system is based on was discovered in the early 1990s. The idea to advance the technique into an elderly care solution originally came from a technologically oriented nursing home manager who encouraged the engineers to create a solution for elderly care. A group of students and researchers created the first version of the smart floor, and the innovation concept was awarded in a business idea competition and a start-up was founded around it in 2005.

Before the living lab collaboration the engineers had developed the system based on their experiences with surveillance technologies and they assumed that they had created a more or less ready product, but during the living lab project many of their assumptions about the residents, as well as those about the care workers and their work, had to be changed.

[3] On the other hand, this can mean a decrease in the amount of social contact that the resident has during the day.

The Properties of the Smart Floor

The system consists of 1) sensor foil that is installed under flooring material, 2) mobile phones, which the care workers carry during their work shifts and through which they receive the alarms and 3) a user interface on a computer located in the office.

The sensor foil, which is installed under flooring material, creates a light electronic field in the room. When a human is in the room, her or his body creates changes in the electronic field. By activating specific sections of the sensor network, monitoring the person's movements and body positions becomes possible.

The smart floor can send an alarm when a resident:

- has fallen down
- gets out of bed
- enters the toilet
- has stayed in the toilet for too long
- leaves the room
- enters the room

Alarms are tailored individually to each resident depending on her or his needs through the user interface. The software allows care workers to monitor residents' movements in real time through moving dots on the floor plan of each room on the user interface. The system stores the data about the movements of the residents to a server owned by the company. This allows care workers to, for example, retrospectively assess the events that led to a fall in order to prevent future accidents.

The system can be installed in new nursing homes during the construction phase or in existing nursing homes during renovation. The smart floor is currently installed in more that 2000 nursing home apartments, mostly in Nordic countries. The system is basically invisible to the residents, and it can be integrated with light control, used as a burglar alarm or used to inform when a person enters the terrace or stays there for too long.

Project Participants

The main participants in the smart floor project were the public sector actors (nursing home staff and management, IT experts from the city social and health care department), the living lab project workers who were care professionals by education, a university spin-off company, researchers from the university of technology (the department of electrical engineering) and indirectly the residents of the living lab units. The goal of the collaboration (as stated in the funding application) was to increase patient safety and to prevent falls.

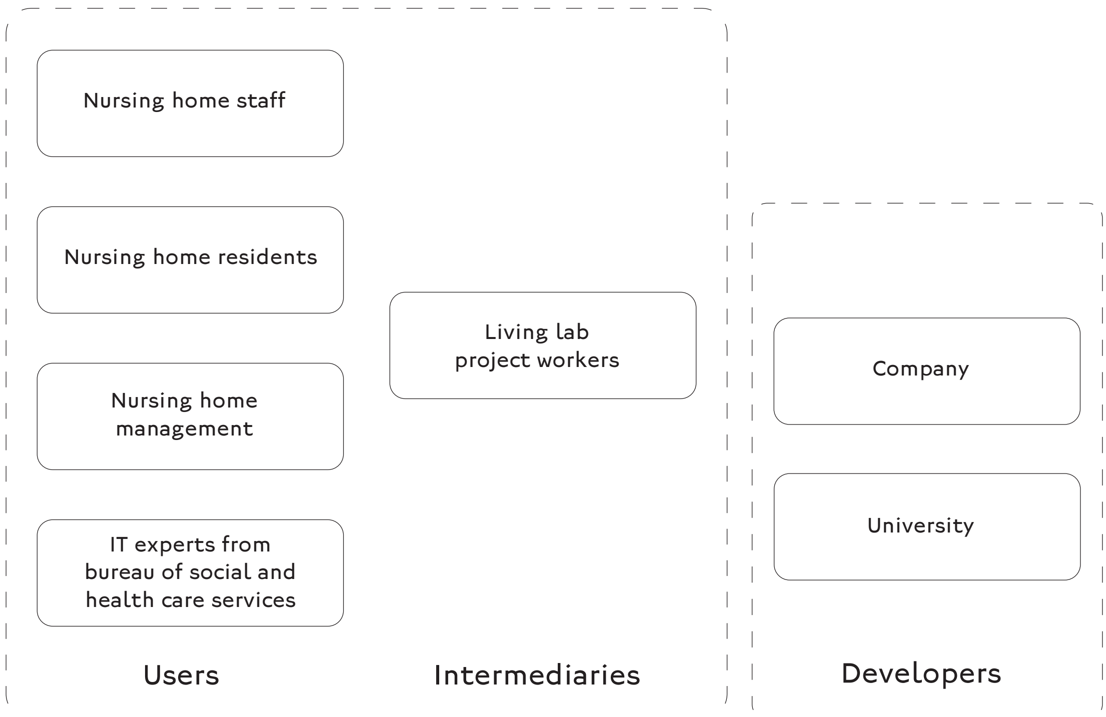
The role of the technical university staff was primarily to study the technical and organizational requirements of the installation and implementation of the smart floor. In addition, they carried out studies about the benefits and effectiveness of the system by interviewing the care workers before and after the implementation. For the smart floor company, the primary goal was the realization of a proof-of-concept, and in addition, the nursing home was also a crucial reference site. Instead of creating a tailored system for a particular user site, the company wanted to create a generic product that would fit as many use contexts as possible.

In the case of the smart floor project, the majority of the residents in the living lab units suffered from dementia and thus were not able to actively participate in the living lab activities – they were the subjects of those activities. Rauhala and Topo (2003) discuss the ethical questions related to elderly people participating in technology research and development activities and criticize the lack of ethical guidance in the field. In the smart floor case, the participation of the elderly was mediated by the care workers and the project staff, who regularly observed, evaluated, reflected and discussed what kinds of immediate and long-term effects the system had on the residents.

The objective of the smart floor project changed during the four years. The initial focus was on exploring optimal ways to utilize the system in the everyday life of the nursing home, but as the project evolved, technology development became a new priority. The project was thus characterized by the simultaneous development of technology and work practices, aiming at supporting more individual care and increasing residents' safety, independence and mobility.

In the original project plan the emphasis of the smart floor project was on implementation, testing and the development of new care practices, instead of on co-design and technology development, and for this reason the innovation project manager – a former head of a nursing home – decided to hire people whose educational background was in nursing, physiotherapy and nursing sciences as project workers. She thought that care professionals would have the best resources to counterbalance the strain caused by the project for the care workers, for example that they could participate in the everyday care duties in the units if needed. During the first couple of months, when the collaboration agreements were being negotiated, the newly hired project staff worked in the living lab units in regular care work, so they had profound and personal understanding of the context of use and elderly care work.

Figure 1. Living lab project stakeholders



The Methods of Collaboration

The smart floor project consisted of two phases: in the first phase (from the end of 2006 to the end of 2007), a prototype was installed in two two-person rooms in a dementia unit. In the second phase (from spring 2008 to the end of 2009), the rollout of the system was extended to three whole units, which altogether had 47 rooms and 64 residents. Two of the units were dementia units and one was for residents who were in better condition but in need of short-term care.

Learning between developers (company, academia) and users (care workers, nursing home management) was condensed in regular face-to-face meetings. After an initial workshop for all the project participants, the project workers made a conscious decision to meet with the developers and users separately. One motivation for this arrangement was the lack of a "shared language" and it also allowed the care workers to more openly express their frustrations. In addition the project workers carefully observed the use situations on a daily basis and tested the system themselves. The care workers were also asked to generate knowledge, for example by carefully documenting the technical problems or benefits of the system. Alongside daily interaction with the project workers, the care workers had the possibility to write down development ideas, critique the technology and add comments in notebooks left in the units.

The project staff, who mediated the collaboration between the developers and users, had their educational background in nursing and nursing sciences. They did not have experience or expertise in formal co-design methods. At the beginning of the project, the project staff participated in the regular care duties in the units for a few months, and their office was located in the nursing home premises. The project workers also spent time in living lab units on a daily basis during the most intense parts of the development and were able to support the care workers in work duties when needed. Thus, they can almost be seen as "members" of the user community and as user-side innovation intermediaries (see Stewart and Hyysalo, 2008).

The tools and methods of the collaboration were negotiated between the parties throughout the project. The methods grew from the needs of the project, and their aptness and impact on the care workers was evaluated throughout the collaboration. The most important methods were regular face-to-face meetings among different assemblies, observation of the use

Figure 2. The project timeline

2013 — Smart floor is installed in over 2000 rooms in residential care facilities, mainly in Finland

2009
- Fall: Living lab project ends and the smart floor is launched
- May: Startup company merges with an established electronics company
- April: User interface version 2.2; new alarms are added to the system

2008
- September: User interface version 2.0
- June: New alarms are added to the system
- May: User interface version 1.1
- April: Implementation is extended to three full units

2007
- November: Use of the system begins in the pilot room
- August: User interface version 1.0

2006 — Sensor foil is installed in the nursing home building; user collaboration begins

2005 — Smart floor receives an award in a business idea competition; spin-off company is founded

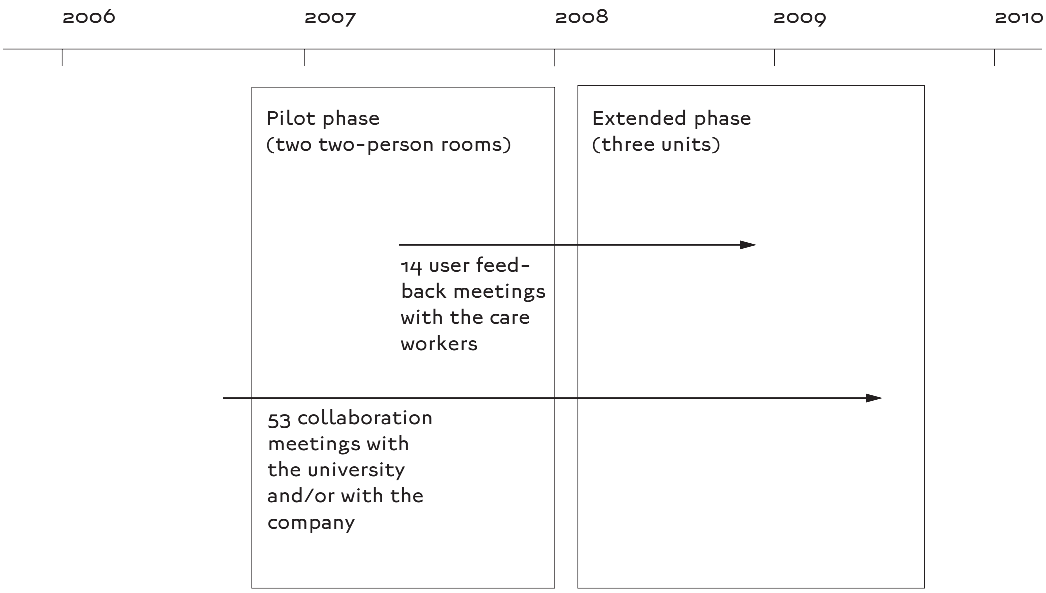
1990s — Motion-tracking technique is discovered at the Helsinki School of Technology on the units by the project staff and documentation of problems, benefits and development of ideas in forms and notebooks.

The notebooks for collecting feedback and development ideas from the care workers were situated in the living lab units' offices, but they did not prove to be very popular. Information about the details of technical problems and false alarms was collected systematically through specific forms. Also information about the benefits of the system was collected, and formal effectiveness research was carried out by documenting falls on the units before and after implementation. The majority of the meetings were held in the nursing home premises. Between the meetings, the project staff and the engineers communicated through emails and by phone. Pictures were drawn, when necessary.

The most important meeting types with respect to the development activities were the collaboration meetings (between the project staff, the company and academia) and the user feedback meetings (between the project staff and the care workers).

The **collaboration meetings** between the project staff and the engineers began in February 2007. In the most intense phase of the development, collaboration meetings were held every two weeks (later, less often). Between the meetings, the project staff and the engineers communicated by phone and email. In a typical meeting the project staff described a current challenge with the system and the participants ideated a possible solution to the problem collaboratively. The engineers in turn informed the project staff about both the current state and future steps of the development activities. The project staff told the developers how the system had been used, which alarms had been activated, how the care workers had experienced the system and working with it, what kinds of problems had been encountered in use, and what kinds of false alarms the system had produced, how often and why. Also development ideas from the care workers or project staff were reviewed regularly. The ideas were collected on an Excel spreadsheet, which acted as a communication tool between the engineers, the project staff and the care workers. The engineers' responses to the development ideas were added to the spreadsheet for the care workers to see. In later phases of the collaboration, the project staff informed the engineers about the accidents that had been prevented thanks to the smart floor. Also the methods of collaboration and user research were discussed: the engineers informed the project staff about the type of feedback or information that they needed.

Figure 3. The user feedback meetings and collaboration meetings held during the living lab project



User feedback meetings between the project staff and the care workers began at the end of 2007, when the smart floor had been implemented in the two pilot rooms. In the most intense phase of the development the user feedback meetings were held weekly (later, less often). The meetings typically began by discussing the care workers' general feelings towards the smart floor as well as the project more generally. How to deal with the troubles and hurdles caused by the incomplete system was an important and recurring topic of discussion, as were the frustrations and doubts that the care workers had towards the system and the project. The care workers reported to the project staff about how the system had affected their work, how the appointed ways of using the system were working in practice, how the residents had reacted to the system, how the system affected the residents and how the alarm combinations were working for individual residents. Also the benefits of the system and the ways they were achieved were analyzed continuously from the perspective of the employees as well as the residents. Issues relating to improving the care practices more broadly and the role of the smart floor in the transformation were also discussed. The project workers and the care workers also regularly went through the "rules" of using the system, for example when the system should be turned on, how the alarms should be distributed among the care workers, which alarms should be activated for each resident, what to do after receiving an alarm and how to act when receiving two alarms simultaneously. Because of the resistance towards the system and the project in the units, the project staff ultimately made the decisions about how the system should be used and these decisions were to be followed. However, the care workers' experiences were regularly discussed in the user feedback meetings and the rules were changed when needed, based on the user feedback.

The project coordinator evaluated that **observing** the use of the system in the units was the most important way to gather relevant information for the development. During the implementation and design-in-use, the project staff spent time on the units on a daily basis and participated in the care work and used the system themselves when needed. Project staff presence on the units allowed the care workers to give feedback and express development ideas as part of informal chats and alongside care duties.

1.3 The Changing Landscape of Innovation

Living labs relate to several interlinked and paradigmatic shifts in the field of innovation research as well as that of innovation management practices. The concept and understanding of innovation has evolved from a closed, linear process to an open, distributed and dynamic phenomenon, which is approached from systemic and network perspectives. A theoretical understanding of innovation, innovation management practices and innovation policy measures can be seen to form an interlinked whole.

According to Ortt and van der Duin (2008) the history of innovation management has experienced an evolution from technology push and market pull models to open innovation and more contextual management styles. During the period between the Second World War and the mid-1960s, attitudes towards scientific progress were generally positive and innovation was seen as resulting in a linear fashion from scientific discovery (the **technology push** model). From the mid-1960s to late 1970s the needs present on the market were considered as the primary source for technological change and innovation (the **market pull** model) as many markets became more competitive. The period between the late 1970s to the early 1990s was characterised by two oil crises, inflation and rising unemployment. Innovation management strategies combined the technology push and market pull models and focused on network formation between internal and external partners (Ortt and van der Duin, 2008).

In 1962 Everett M. Rogers published a seminal book, **The Diffusion of Innovations**, which presented a theory of how innovations diffuse into society. Rogers (2003: 5) defines diffusion of an innovation as "the process by which an innovation is communicated through certain channels over time among the members of a social system". Through a mental process an individual forms an attitude towards an innovation and, by going through a series of steps, ends up either adopting or rejecting an innovation. Rogers (2003) presented five adopter categories: (1) innovators, (2) early adopters, (3) early majority adopters, (4) late majority adopters, and (5) laggards. This categorisation is part of mainstream innovation talk even today. The diffusionist understanding of innovation adoption continued to dominate the innovation research field until the mid-1980s (Berker, Hartmann, Punie et al., 2006: 5). Later, researchers studying the processes of social shaping of technology, domestication and innofusion (see chapter 4), among others, have criticized diffusionist explanations as being overly rational, linear and simplistic.

Van de Ven et al. (1999) describe the mainstream view of innovation in the academic and professional literature of the early 1980s in this way:

> Conventional wisdom at the time [...] treated an innovation idea as a single project that maintained a stable identity during its development. It was assumed that all parties to the innovation share a similar view of the idea. Stakeholders may have differing or opposing viewpoints, but consensus among key members of the innovation team was viewed as necessary. In addition, common views held that the role of innovator was clearly different from other organizational roles and people assigned to an innovation team were dedicated to the project as their primary, if not only, responsibility. The network of other stakeholders with whom innovators interacted was also considered fairly stable. The environmental context of

> the innovation was viewed as a relatively stable source of both resources and constraints during the innovation development period. The innovation process itself was typically seen as unfolding through definable stages (e.g., inception, development, testing, adoption, and diffusion). Progressing through this series of phases or stages resulted in producing an outcome that was clearly interpretable: success or failure. (Van de Ven et al., 1999: 7–8)

An important turn in the history of innovation research took place in the 1980s, when a variety of different types of real-life innovation processes were observed from the concept development phase to implementation or termination by fourteen research teams under the Minnesota Innovation Research Program. The researchers wanted to understand how changes in ideas, outcomes, people, transactions and contexts in the innovation process unfold over time. These studies radically changed the way innovation was previously understood: Van de Ven et al. (1999) found no support for the idea of innovation as a linear or orderly process with predictable stages, nor did they find that it was random and unpredictable. Instead the innovation journey seemed to be nonlinear and dynamic:

> The innovation journey is a nonlinear cycle of divergent and convergent activities that may repeat over time and at different organizational levels if resources are obtained to renew the cycle. (Van de Ven, 1999: 16)

The Minnesota Innovation Research Program identified twelve key process characteristics for innovation observed in the fourteen case studies (Van de Ven et al. 1999: 23–24):

The Initiation Period

1. Innovations are not initiated on the spur of the moment, by a single dramatic incident, or by a single entrepreneur. In most cases, there was an extended gestation period lasting several years in which seemingly coincidental events occurred that preceded and set the stage for the initiation of innovations.

2. Concentrated efforts to initiate innovations are triggered by "shocks" from sources internal or external to the organization.

3. Plans are developed and submitted to resources needed to launch innovation development. In most cases, the plans served more as "sales vehicles" than as realistic scenarios of innovation development.

The Developmental Period

4. When developmental activities begin, the initial innovative idea soon proliferates into numerous ideas and activities that proceed in divergent, parallel, and convergent paths of development.

5. Setbacks and mistakes are frequently encountered because plans go awry or unanticipated environmental events significantly alter the ground assumptions of the innovation. As setbacks occur, resource and development time lines diverge. Initially, resource and schedule adjustments are made and provide a "grace" period for adapting the innovation. But, with time, unattended problems often "snowball" into vicious cycles.

6. To compound the problems, criteria of success and failure often change, differ between resource controllers and innovation managers, and diverge over time, often triggering power struggles between insiders and outsiders.

7. Innovation personnel participate in highly fluid ways. They tend to be involved on a part-time basis, have high turnover rates, and experience euphoria in the beginning, frustration and pain in the middle period, and closure at the end of the innovation journey. These changing human emotions represent some of the most "gut-wrenching" experiences for innovation participants and managers.

8. Investors and top managers are frequently involved throughout the development process and perform contrasting roles that serve as checks and balances on one another. In no cases were significant innovation development problems solved without intervention from top managers or investors.

9. Innovation development entails developing relationships with other organizations. These relationships lock innovation units into specific courses of action that often result in unintended consequences.

10. Innovation participants are often involved with competitors, trade associations, and government agencies to create an industry or community infrastructure to support the development and implementation of their innovations.

The Implementation/Termination Period

11. Innovation adoption and implementation occurs throughout the developmental period by linking and integrating the "new" with the "old" or by reinventing the innovation to fit the local situation.

12. Innovations stop when implemented or when resources run out. Investors or top managers make attributions about innovation success or failure. These attributions are often misdirected but significantly influence the fate of innovations and the careers of innovation participants.

Already prior to Minnesota Innovation Research Program, in the 1970s, ideas about the sources of innovation had been challenged by the pioneering work by Eric von Hippel (1976, 1977, 1988), who argued that instead of the manufacturer company, the source of innovation is surprisingly often the user (see chapter 2).

Chesborough (2006a, 2006b) developed the idea of distributed innovation further and in his work he has focused on the paradigmatic shift from closed innovation to open innovation, describing a change in the way companies generate new ideas and bring them to the market. In the era of closed innovation companies' strategies for success relied heavily on internal R&D and hiring the brightest people, who would discover the best ideas and get them to the market first. Intellectual property was aggressively controlled. Profits were invested in more internal R&D, which was expected to lead to more discoveries and more profit. Towards the end of the 20th century, this virtuous cycle of innovation and the closed innovation paradigm began to be eroded. What followed was the open innovation paradigm, where companies can generate value by commercializing external ideas in addition to the ones discovered internally and by deploying in-house pathways to the market (as well as outside pathways to the market), for example through start-ups, licensing agreements or joint ventures. The boundary between the firm and the environment has become more porous (Chesborough, 2006a, 2006b).

In the field of innovation management between the early 1990s and the early 2000s, globalization increased international competition, ICT changed business processes and external partner networks became more important for companies. Ortt and van der Duin (2008) argue that after the early 2000s companies have adopted a **contextual** or **portfolio approach** to innovation, where previous practices continue to exist but instead of a single mainstream strategy, companies tailor their approach according to contextual and situational factors (Ortt and van der Duin, 2008).

Living labs are part of this long-term landscape shift from closed to open innovation and from manufacturer-driven innovation to user-driven innovation. The emergence of living labs also presupposes questioning the passive and linear nature of innovation diffusion. Rather it is seen as an active and fruitful site of innovation.

The next chapter will contextualize living labs in the field of collaborative innovation by giving an introduction to lead users, and the participatory design and human-centred design fields as well as by mapping the future directions of these fields in which they will move towards real-life experiments and design-in-use. Chapter 3 will present the living lab concept and its raisons d'être and bring forth recent critique towards living lab research and practice alike. Chapter 4 will go through the branches of STS that formulate the theoretical framework of the dissertation as well as introduce the concept of innovation intermediaries and their role in social learning. Chapter 5 describes how the study was executed, and chapter 6 includes summaries of the four papers. Chapter 7 presents the crosscutting contributions of the four papers, implications for practitioners and outlines directions for future research. The last chapter is followed by the original papers.

2. Involving Users

Research on users can be traced back to a myriad of academic fields like informatics, social and behavioural sciences, economics, ergonomics, philosophy and political sciences.

The first steps in user research were taken in early marketing and consumer research. In the late 1920s a series of methods such as consumer surveys were developed to gauge the preferences and to gain feedback from consumers. By the 1960s interviews carried out on the streets had been joined by large-scale phone polling, sophisticated statistical analyses, and psychological and sociological research methods like focus groups. The interests of companies had shifted from targeting advertisements to understanding the reasons behind consumers' choices between different products and brands. During the first decades of the 20th century, the field of industrial design started to take shape, along with developments leading to the mass production of goods. Industrial designers began to mediate the advancing production capabilities and ever-changing wants of consumers. In order to do this successfully, designers and engineers began to study how people used products and sought to design products that fitted the physical and cognitive properties of the users. Later the fields of ergonomics and human factors emerged from these grounds. (Hyysalo, Jensen and Oudshoorn, 2016b; Schot and de la Bruheze, 2003)

Social experiments and field trials with ICT – carried out in Europe and especially in Scandinavia during the 1970s and 1980s – and European digital city initiatives from the 1990s onwards are considered important predecessors of the living lab movement (Schuurman, 2015; Ballon, Pierson and Delaere, 2005).

Social experiments originated in the field of psychology and – like living labs today – brought together multiple stakeholders: public actors, private organizations and end-users. These experiments took place outside the laboratory: they were less standardised and had a longer duration compared to experiments held in the laboratory setting. The role of end-users could be anything from that of tester to co-creator. **Digital city initiatives** in the 1990s covered a large variety of different themes related to city life. They were also characteristically multi-stakeholder collaborations. The **smart city** concept, which highlighted the role of citizens as active collaborators, evolved later from the concept of the digital city. Digital cities originally had a very technology-driven character that later gave way to a more social and mutual shaping focus. (Schuurman, 2015: 137–143)

Ballon, Pierson and Delaere (2005) position living labs in the "broader constructivist framework of Science and Technology Studies and within the tradition of Constructive Technology Assessment, now being reapplied in the context of user-oriented technology design (Ballon, Pierson and Delaere, 2005: 9)." They also see the living lab approach as having strong links with the human–computer interaction research tradition, referring to notions like participatory design and experience prototyping.

The theoretical traditions most often referred to in the living lab literature are those of co-creation and users as innovators; STS; human–computer interaction and human factors; and the test and experimentation platform (TEP) framework (Følstad, 2008a: 115).

In this thesis living labs are contextualised with respect to work of Eric von Hippel, participatory design and human centred-design, which are presented in the next subchapters as well as science and technology studies (see chapter 4).

2.1 Innovative Users

Eric von Hippel's pioneering work on the innovative activities of users was among the first to remark about the distributed nature of the innovation process (see subchapter 1.3). von Hippel (1976, 1977) claimed in the 1970s that users are in fact an important source of innovation and a growing number of empirical studies have shown this to be the case ever since.

According to von Hippel (2005) large proportion of users (from 10 per cent to nearly 40 per cent) develop or modify products, and he even claims that users are the first to develop a large part of new industrial and consumer products.

von Hippel (1986) introduced the concept of **lead users** in the mid-1980s and defined them as users (individuals or firms) "(1) who are at the leading edge of [an] identified trend in terms of related new product and process needs and (2) who expect to obtain a relatively high net benefit from solutions to those needs" (von Hippel, 1986: 798). Users' needs are highly heterogeneous, and many are left unsatisfied by the solutions available on the market. If users cannot find a solution to their needs and they have the resources to create a solution on their own, they are likely to innovate (von Hippel, 2005).

The idea at the heart of von Hippel's theory (2005) was that other users will be interested in lead users' solutions in the future, and thus manufacturers have an interest in commercializing these inventions. Lead users were originally seen as a "need forecast laboratory" (von Hippel, 1986), but later a method and the tools to utilize their insights in product development more directly were created (e.g. Urban and von Hippel, 1988; von Hippel and Katz, 2002). The lead user methodology for concept developing and testing described in Urban and von Hippel (1988) includes four steps: 1) **Specifying lead user indicators**, which requires definition of the market or technological trend for which the identified users have a leading position, and definition of the measures of the potential benefit for the lead users, which can be evidence of product development or modification for example. After the indicators have been specified, 2) **the lead user group is identified** for the relevant market. Finally, 3) **a concept is generated with the lead users** and 4) it is **tested** with the lead users and more typical users of the target market.

Henkel and von Hippel (2003) and von Hippel (2017) suggest that user innovations produce more **social welfare** than manufacturer innovations. An essential reason for this is that user innovations are often freely revealed to others, potential intellectual property rights are voluntarily given up and the information becomes a public good. Von Hippel (2017) calls these freely shared innovations that aim for improvements in social welfare "free innovations". **A free innovation** is a "functionally novel product, service, or process that (1) was developed by consumers at private cost during their unpaid discretionary time [...] and (2) is not protected by its developers, and so is potentially acquirable by anyone without payment, for free" (von Hippel, 2017: 1).

Innovative users are distributed widely, and they are seen to actively collaborate with each other in different ways. User cooperation can be the informal exchange of information or it can take place in a more organized way, in networks and communities, as in the case of free and open source software projects or sports equipment. Users also benefit from freely revealing their innovation to manufacturers, for example so that their solution will evolve from a "home-made" device into a commercial product (von Hippel, 2005).

Advances in computer and communication technologies have improved the possibilities for users to contribute to innovation: nowadays users have better access to professional tools and components, they can utilize richer innovation commons and they have new kinds of ways to network and form innovation communities (von Hippel, 2005). In addition, fab labs and makerspaces decrease the cost of building prototypes for solutions that fit their specific needs.

2.2 The Problem of Sticky Information

The concept of sticky information is closely related to living labs as living labs bring the problem-solving activities related to product development to a potential use environment instead of collecting relevant information and transferring it to the manufacturer's site. Additionally, users are considered co-developers instead of the objects of research, which means that the information possessed and embodied by the users about their needs and the context of use is brought to product development process more directly than in traditional HCD or participatory design projects (see subchapters 2.3 and 2.4).

Von Hippel and Tyre (1996) identified reasons for the complexity that makes the anticipation of future problems in product development so difficult. "[T]hings often go wrong" when new products, processes and services are transferred from research and development laboratories to use for the first time (von Hippel and Tyre, 1996: 33). Challenges arise because both the context of use and the (technological) solution contain myriad attributes that can potentially interact and cause problems. Also the decisions made by the designer in the design phase result in different information needs related to the context of use and users' behaviour, which attributes might also change (von Hippel and Tyre, 1996). Additionally the real-world problems that new solutions are expected to fix are usually what von Hippel and Tyre (1996) describe as "ill-structured", meaning that they "involve an unknown problem space, unknown or uncertain alternative solution pathways, inexact or unknown connections between means and ends, or other difficulties" (von Hippel and Tyre 1996: 326). Because of the complexity described above, the idea of "getting the solution right the first time" is in practice unrealistic and unfeasible.

The information about users' needs that is required for product development is often difficult and costly to transfer from one place to another. Users often have an excellent understanding of their needs and the context of use relevant for the potential solution, whereas manufacturers, in order to acquire that same information, would have to evaluate what is relevant, collect the relevant information and transfer it to the site where the solution will be developed. On the other hand the manufacturers might have an excellent understanding of the technical possibilities required to solve the problem. Thus, the information needed for product development is often "sticky" by nature.

> [T]he stickiness of a unit of information is defined as the incremental expenditure required to transfer that unit of information to a specified location in a form usable by a specified information seeker. (von Hippel, 2005: 67)

Sticky information affects the locus of innovation: when information is costly to acquire, transfer and use, innovation-related problem solving tends to take place in the locus of the sticky information (von Hippel, 1994; Ogawa, 1998).

Information stickiness results in **information asymmetries** in the development of new solutions: both users and manufacturers draw from the sticky information they already possess. Users have better information about the needs and context of use, whereas manufacturers have better solution information. Because users and manufacturers have different types of information, they tend to create different types of innovations: users have a tendency to create solutions that are functionally novel, whereas innovations by manufacturers tend to be incremental improvements based on well-known needs and rich solution information. User innovations often fill small niches of high need that are left open by the manufacturers (Ogawa, 1998; Henkel and von Hippel, 2003; von Hippel, 2005).

> Information needed by product and process developers is often very “sticky” – very costly to transfer from place to place. When this is the case [...] it is often cost effective to transfer problem-solving activities to the site of the sticky information rather than to attempt to transfer that information to some other problem-solving site. (von Hippel and Tyre, 1996: 328)

In the 1970s an emerging field of participatory design (PD) also began to change the relationship between the technology developers and the users: users were not only considered as objects of research anymore but they were seen to possess knowledge that was increasingly relevant for product design. According to Schuurman (2015: 137) the Scandinavian pioneering projects of cooperative design, and later participatory design and user-centred design (UCD), brought the user-centeredness, real-life context, multiple stakeholders and iterative nature of the innovation process to the living lab concept.

2.3 Participatory Design

The PD field began to form in close collaboration with the trade union movement from the 1960s onwards through a number of politically charged initiatives that took place in Sweden, Norway and Denmark. Rapid structural and technological change was taking place in the Scandinavia in the late 1960s, which caused worry to the trade unions as well as to employers. Trade unions were worried about deskilling, a decrease in job satisfaction, safety risks and job loss due to technological development, whereas employers experienced problems in recruitment, absenteeism, efficiency and work quality. From these grounds grew the first sociotechnical experiments in Norway and Sweden. The beginning of participatory design had a strong political motivation as it raised questions related to democracy, power, resources and control at the workplace. In the early 1970s the sociotechnical approach gave way to initiatives that were more equipped to democratize the design and use of computer-based systems – namely DEMOS, UTOPIA and other projects – which brought together researchers, workers and shop stewards and generated several methodological innovations, for example mock-ups, which are widely used even today. (Ehn, 1993; Floyd et al., 1989; Bansler, 1989; Törpel et al., 2009)

Hyysalo, Jensen and Oudshoorn (2016b) see the legacy of participatory design in three areas: first, it demonstrated that all people possess viable knowledge about their work and everyday life that can become a valuable resource of design with competent facilitation; second, hundreds of collaborative set-ups, methods, tools and techniques have been developed within the field; and third, participatory design has played an important role in drawing attention to the political and critical dimensions of design as a force that shapes societies.

> [C]ollaborative design has played an important role as a critical and political endeavour. It has been a forerunner in emphasizing design as a social force that shapes our society hence emphasizing that democratic societies should not leave design processes to narrow managerial and technical elites. This political vision was closely affiliated with the broader stream of antiauthoritarian social movements that came into prominence in the 1970s. (Hyysalo, Jensen and Oudshoorn, 2016b: 11)

Today a growing number of PD researchers and practitioners argue that user-designer collaboration should not be limited to ideation and concept design and that it needs to continue after the initial launch as the full potential of the innovation only becomes visible through exploration in real-life setting (e.g Hess and Pipek, 2012; Simonsen and Hertzum, 2012; Botero and Hyysalo, 2013; Björgvinsson, Ehn and Hillgren, 2010; Hillgren, Seravalli and Emilson, 2011).

Living labs and other real-life exploration environments can be seen to be part of this stream of research and experiments, where design activities have been shifted to the sites of use and to users, alongside perpetual beta tests, crowdsourcing and many other approaches. The key novelty in living labs is that they extend these ideas to physical products and bring the focus from the workplace to the public sphere and everyday life.

2.4 Human-Centred Design

The **human-centred design** (HCD) approach, previously the user-centred design (UCD), emerged in the field of systems design in the mid-1980s. It was some time before the Internet, personal computers and mobile devices, but early computing had already expanded the possible functions of and interactions with digital machines (Johnson, 2013).

Usability evaluations, laboratory-based user observations and controlled user studies were common methods in early UCD, which grew from the grounds of ergonomics. The UCD emphasizes the importance of letting user needs drive the design process, and it eventually replaced previous requirements capturing techniques like surveys and interviews with selected key users. The multidisciplinary field of human–computer interaction emerged at the same time as a mainstream academic and industry practice. (Johnson, 2013; Koskinen, Zimmerman, Binder et al., 2011; Hyysalo, Jensen and Oudshoorn, 2016b).

In the 1980s, UCD was influenced by sociology and anthropology as the early methods and approaches were not adequate to cater for multi-user systems. **Ethnomethodology** was applied to inform design about the mundane ways people get their work done. This later influenced the emergence of the research field of **computer-supported cooperative work**, which focuses on the ways technology can support collaboration. In the early 1990s **contextual design** was born out of the need to take situational and contextual factors into account when designing systems. Mobile phones, personal computers and digital games transferred the focus of design from the workplace to private spheres of life, which eventually contributed to the emergence of **interaction design** and **design for user experience**. (Johnson, 2013; Szymanski and Whalen, 2011; Beyer and Holtzblatt, 1998)

In the late 1990s the principles of UCD were formalised into two engineering standards: ISO 13407 (Human-centred design processes for interactive systems) and ISO 18529 (Human-centred design lifecycle process descriptions).

Koskinen, Zimmerman, Binder et al. (2011: 18) argue that the user-centred turn in industrial and interaction design was based in the idea that "everyone has expertise of some kind, and can hence, inspire design". According to Hyysalo, Jensen and Oudshoorn (2016b: 12) "[t]he key contribution of usability research and HCD [human-centred design] to the twenty-first century has been to normalize the view that new information technologies need to be worked into contexts of use before and during their wider uptake".

As with participatory design, HCD has also recently come to question how its project time spans should reflect different development contexts, such as digital service creation and social media, where development activities continue after the initial market launch (Johnson, 2013; Friedrich, 2015).

2.5 Extending Collaborative Design into Real-Life Experiments

The previously discussed approaches to involving users in product and service development have been criticized from two directions: firstly, building extensive knowledge about the users and use contexts into the design has not lead to significantly different or better products (Stewart and Williams, 2005; Williams, Stewart and Slack, 2005). Secondly, it is increasingly acknowledged that designed and launched products should initially be best seen as advanced prototypes that need to be exposed to the contingencies of everyday life in order to enable the exploration of evolving user needs and the potential of the system. This cannot be done without the extended interplay between users, artefact and context. In this development digital technologies have led the way through perpetual beta tests and web 2.0 business models. (Botero and Hyysalo, 2013; Voss, Hartswood, Procter, et al., 2009; Voss, Procter, et al., 2009; Johnson, 2013)

Williams, Stewart and Slack (2005) talk about **design fallacy** and argue that the linear and design-centred model of innovation – where artefacts are seen as largely fixed in their properties and where the solution to meeting user needs is to build ever greater amount of knowledge about particular users and contexts into technology design – should be replaced with an understanding of innovation that recognizes the active nature of appropriation phase. Voss, Procter, Slack et al. (2009) sketch out the problem area related to UCD practices – particularly the ethnographies of everyday work:

> No matter how well we design a system to match a set of requirements determined using conventional methods, there will always be a need for change. First, our understanding of the situation into which a system is to be introduced will inevitably be bounded by our limited experience and subject to certain assumptions we necessarily make. Second, the introduction of the system will give rise to new requirements being formulated as people learn more about its potential uses and opportunities to change practices around the new socio-material arrangements. Finally, the situation of use changes constantly as the world keeps turning. We might say that requirements are "moving targets" and that change is an inevitable part of IT systems development. (Voss, Procter, Slack et al., 2009: 32–33)

Extending co-design activities from concept design and ideation to design-in-use has been seen as a solution to the previously mentioned challenges (e.g. Hartswood, Procter, Slack et al., 2002; Hartswood, Procter, Slack, Voss et al., 2002; Hyysalo, 2010; Hillgren, Seravalli and Emilson, 2011; Botero and Hyysalo, 2013; Aanestad, Driveklepp, Sørli et al., 2017).

One such approach that seeks to extend the design activities into implementation and use is **co-realisation**, which emerged in the field of computer-supported cooperative work. Co-realisation is described as a synthesis of ethnomethodology and participatory design, and the approach aims at the co-evolution of IT systems and work practices. Co-realization emphasizes the importance of IT specialists "being there" at the workplace and becoming "members" of the user community (Hartswood, Procter, Rouncefield et al., 2000; Hartswood, Procter, Slack, Soutter et al., 2002; Hartswood, Procter, Slack, Voss et al., 2002).

> Only when technologies get translated into systems, only when these get used "in anger" and encounter the contingencies of the workplace, can we effectively assess their "fit" with the work that gets done. This poses an important question given that "design" and "use" are often separated in time and space as well as being undertaken by different people with different skills, concerns, and under different sets of constraints. (Voss, Hartswood, Procter et al., 2009: 32)

Co-realisation seeks to “move from intermittent and over-formalised participation to a situation where informal interaction between users and IT professionals becomes a part of everyday experience and the basis for the constitution of a shared practice” (Hartswood, Procter, Slack, Voss et al., 2002: 14), which includes among other things changing processes, developing and sometimes transforming relationships between existing stakeholders and introducing new actors (Voss, Hartswood, Procter et al., 2009).

Aanestad, Driveklepp, Sørdi et al. (2017) present the notion of **participatory continuing design** (PCD) to describe ongoing design-in-use processes which seek to integrate ICT into the work processes of an organization. PCD refers to design activities that take place after the system has entered “ordinary use”. Instead of requirements specifications and software functionality the approach aims at creating working sociotechnical configurations. PCD takes a longer temporal perspective and shifts the focus from system design to the design of services and work processes, and it concentrates on the possibilities of changing the ways systems are used and services are delivered. PCD presupposes a collective mindfulness, which allows the organization to reflect the use of technology as part of its work practices. Compared to participatory design, which traditionally takes place before use, PCD can be described as improvisational, which means that it relies on emergent insights and possibilities rather than planning and specification (Aanestad, Driveklepp, Sørdi et al., 2017).

In summary, in recent years there has been a growing number of voices calling for broadening our understanding of collaborative design and HCD from the concept design phase towards implementation, use and design-in-use and from short-term projects and workshops towards longer-term collaborations. Living labs can be seen as one of the key reactions to these calls, and indeed, along other extended collaborative design arrangements, they have become part of participatory design efforts. Indeed, the description of Malmö Living Lab by Björgvinsson, Ehn and Hillgren (2010) defines living lab as “an open innovation milieu where new constellations, issues and ideas evolve from bottomup longterm collaborations amongst diverse stakeholders.” The following chapter will continue with the theme of real-life experiments by focusing on living lab research and practice more closely.

3. Living Labs

Living labs are part of wider re-organization of the relationship between users and producers, a progression towards the extended co-design described in subchapter 2.5. Living labs can be seen as a reaction to critiques of linear and design-centred innovation models, which overlook the appropriation phase as an important arena of innovation (Williams, Stewart and Slack, 2005).

Living labs are co-design infrastructures situated in real-life contexts. They facilitate collaborative learning and introduce innovations to the unpredictability of everyday life. In living labs users become the co-creators of value (Ballon, Pierson and Delaere, 2005; ENoLL website[4]; Leminen, Westerlund and Nyström, 2012).

Like a wet bar of soap, the concept of a "living lab" is difficult to grasp. The reason for this is twofold: first, there is a large variety of definitions used in the living lab literature. Leminen (2015) found over 70 definitions for a living lab through a systematic literature review. Dutilleul, Birrer and Mensink (2010) have recognized five different meanings for the living lab concept in the literature – it can refer to 1) an innovation system consisting of organized and structured multi-disciplinary networks, fostering innovation and collaboration; 2) the in-vivo monitoring of a "living" social setting, generally involving experimentation with a technology; 3) an approach for involving users in the product development process; 4) the organizations facilitating a network, maintaining and developing its technological infrastructure and offering relevant services; and 5) the European living lab movement.

[4] ENoLL website: http://openlivinglabs.eu/ (accessed: 7.12.2016)

Second, there is an even larger variety in the actual living lab initiatives: from lighter test bed-like arrangements to more profound and long lasting co-design partnerships. The living lab approach has been applied to countless different domains: e.g. ICT (e.g. Følstad, 2008b), smart cities (e.g. Müller, Hornung, Hamm, et al., 2015; Prendinger, Gajananan, Bayoumy Zaki, et al., 2013), assisted living (e.g. Panek and Zagler, 2008), health care (e.g. Agogué, Comtet, Menudet, et al., 2013), developing areas (e.g. Baelden and Van Audenhove, 2015), media (e.g. Schuurman, De Moor, De Marez, et al., 2011), energy (e.g. Bliek, Van den Noort, Roossien, et al., 2010), agriculture (e.g. Bilicki, Kasza, Szucs, et al., 2010) and mobility (e.g. Agerskov and Hoj, 2013).

Thus, different academics have different implicit understandings of what an ideal living lab is and what the most fundamental features are and so do practitioners. As a result, there are numerous projects that call themselves living labs, but in fact do not fulfil even the most humble requirements. And then there are initiatives that fulfil and exceed the living lab criteria but do not call themselves living labs. And then there is everything in between.

The assessment of living labs is hampered by too large a variety of initiatives with too little noticeable results and poor understanding of the added value: according to Schuurman (2015) living labs are too heterogeneous in terms of approaches, methods and goals, and many living labs initiatives struggle to become sustainable in the long haul. Because of this ambiguity we need to take a closer look at what living labs are and to clarify how the concept is understood in this thesis.

3.1 The Promise of Living Labs

The nature of many living lab definitions, especially in the pioneering papers, is visionary and the tone rhetorical, reassuring and even self-congratulatory. Many papers sketch what living labs potentially **could** be or what they **should** be, but it is still unclear how these visions have played out in practice.

Living labs have been promoted to stimulate interactions between multiple stakeholders, create institutional support for innovation and reduce innovation failures (Pierson and Lievens, 2005); to offer governance and structure to user contributions, enable the sensing of user insights, provide solutions to the user request filtering problem, create societal involvement and promote user entrepreneurship (Almirall and Wareham, 2008); to synthesize the human, social, economic and technological processes of innovation (Niitamo, Kulkki, Eriksson et al., 2006); to offer new social configuration for organizing innovation (Dutilleul, Birrer and Mensink, 2010); and to contribute to the challenges related to the mass deployment of ICT solutions as well as to bring...

> users/consumers/citizens into the system of innovation, thereby leveraging on a larger mass of ideas, knowledge, and experiences etc. and thereby substantially boosting the innovation capability (Niitamo, Kulkki and Eriksson et al., 2006: 1).

Through a literature review, Følstad (2008a) clarified the field by identifying seven different characterizing purposes for living labs:

- to research context of use, users and the environment
- to discover unexpected uses and service opportunities
- to involve users as co-creators
- to evaluate or validate new solutions with users
- to conduct technical testing in a realistic environment
- to experience and experiment with solutions in contexts familiar to users
- to experience and experiment with solutions in real-world contexts

Ballon, Pierson and Delaere (2005) offer three rationales for establishing living labs or other kinds of test and experimentation platforms (TEPs):

> TEPs may be relevant in three major ways: by enabling industrial research, pre-competitive development and other innovation activities; by introducing innovations in a specific competitive milieu; and by spreading and mitigating the cost and risk associated with innovation activities (Ballon, Pierson and Delaere, 2005: 5).

Ballon, Pierson and Delaere (2005: 6–9) further argue that TEPs are expected to be useful in overcoming some of the systemic failures related to innovation (the suboptimal degree of interaction, missing institutions, path-dependency and lock-in). TEPs in general and living labs in particular enable the involvement of users in the innovation process, which is expected to minimize risks in the introduction of the technology and to enable mutual shaping of technology, as well as that of the behaviour and needs of the users.

3.2 Living Lab Typologies

Several academics have created different kinds of typologies based on analysis of literature and initiatives in order to make sense of the cacophony around the living lab concept.

Schuurman's (2015: chapter 5) typology reflects the historical and geographical evolution of the concept. MIT's PlaceLab, which is often seen as the first living lab, represents the **"American" living lab** type. These are basically constructed laboratory environments that resemble real-life contexts and in which users behaviour can be carefully observed and recorded. In American living labs, users do not actively participate in the product or service development, but their role is closer to that of passive test subjects or research subjects. **European living labs** are usually short-term and small-scale co-creation projects that take place in real-life environments, like the focal case of this study (if not so short term in its duration). In addition there are **test bed-like living labs**, which are characterised by moderate user involvement, a large user sample and a longer time period. **Living labs for collaboration and knowledge sharing** have their roots in South African initiatives and they usually have relatively low user involvement and low emphasis on testing.

Living labs are typically maintained by municipalities, universities, regions or companies, and Leminen, Westerlund and Nyström (2012) have categorized living labs based on the driving actor in the living lab network to **utilizer-driven, enabler-driven, provider-driven** and **user-driven living labs**. Utilizers are firms that launch and promote living labs in order to develop their businesses; enablers are public-sector actors, non-governmental organizations and financiers, such as towns, municipalities or area-development organizations; providers include various developer organizations, such as educational institutes, universities or consultants; and user-driven living labs are usually established around user communities and seek to solve everyday-life problems.

Ballon, Pierson and Delaere (2005) have clarified the distinction between living labs and other types of TEPs (see table 1). In living labs users are typically confronted with the prototype early on in the innovation process and new solutions are tried out in a real-life environment. Compared to living labs test beds are closer to standardized and laboratory-like environments. In field trials testing takes place in a real-life environment, but with respect to living labs they are less open, smaller scale and users' role is less active. Market pilots are more closed and exclusive compared to living labs and the solutions are more mature. In societal pilots, the solutions are highly mature and their scale and scope are generally more limited.

> The living labs [...] are characterised by a large scale, a vertical scope, and a medium- to long-term time horizon. They offer the possibility of bringing the end users as active co-producers of value into a large-scale real-life testing and design environment. As such, they are capable of providing more user-centric and context-specific insights on development and acceptance processes than traditional methods. (Ballon, Pierson and Delaere 2005: 16)

Table 1. Typology of test and experimentation platforms (Ballon, Pierson and Delaere, 2005: 3)

Prototyping platform	A design and development facility used prior to mass production and resulting in the first proof-of-concept of a new technology, product or service
Testbed	A standardized laboratory environment used for testing new technologies, products and services and protected from the hazards of testing in a live or production environment
Field trial	A test of technical and other aspects of a new technology, product or service in a limited, but real-life environment
Living lab	An experimentation environment in which technology is given shape in real life contexts and in which (end) users are considered 'co-producers'
Market pilot	A pilot project in which new products or services that are considered to be rather mature, are released to a certain number of end users in order to obtain marketing data or to make final adjustments before the commercial launch
Societal pilot	A pilot project in which the introduction of new products and services into a real-life environment is intended to result in societal innovation

3.3 The European Network of Living Labs

The living lab phenomenon revolves around the European Network of Living Labs (ENoLL), which is an international non-profit association of benchmarked living labs founded in 2006 under the Finnish European presidency.[5] The European Commission – still a central actor in the network – allocated 40 million euros to set up the network. ENoLL was founded around 20 living labs in 15 member states, and it has grown in so-called waves (Schuurman, 2015; Helsinki manifesto, 2006). Throughout the years, the total number of registered living labs has risen to 395, out of which around 170 are active at the moment.[6]

In The Helsinki Manifesto (2006) the inception of ENoLL was seen as contributing to a renewal of the European innovation system by creating "a new open, user-centric and networked innovation environment in Europe". The purpose of the network was seen as enabling the development, testing and validating of emerging knowledge-intensive services, businesses, markets, technologies and industries for jobs and growth (Helsinki Manifesto, 2006).

> [ENoLL] is a cross-regional, cross-national and pre-market network, which creates multi-stakeholder co-operation models for public-private-citizen partnerships [...]. The European Network of Living Labs establishes a European platform for collaborative and co-creative innovation, where the users are involved in and contribute to the innovation process. Living Labs will provide a platform and infrastructure for innovation services to SMEs, international corporations, public sector agencies and individual citizens. (Helsinki Manifesto, 2006)

Living labs wanting to become part of ENoLL need to go through expert evaluations and match set criteria that has changed over the years. In a recent definition by ENoLL, living labs are considered...

[5] Source: http://openlivinglabs.eu/ (accessed: 31.10.2016)

[6] Source: http://www.openlivinglabs.eu/aboutus (accessed: 22.4.2016)

> user-centred, open innovation ecosystems based on a systematic user co-creation approach integrating research and innovation processes in real-life communities and settings. [...] [L]iving labs place the citizen at the centre of innovation and has thus shown an ability to better mould the opportunities offered by new ICT concepts and solutions to specific needs and aspirations of local contexts, cultures, and creative potentials. (Robles, Hirvikoski, Schuurman et al., 2016: 12)

As a response to the critique that there is too large a variety of initiatives, ENoLL tightened its admission procedures in 2010, which together with a decrease in new applications has resulted in declining numbers of new living labs from 2011 onwards (Schuurman, 2015).

Evaluation criteria for the 11th wave of ENoLL membership:[7]

- Experience of Living Lab operations
- The strength and maturity of multistakeholder partnership (quadruple helix)
- Robust organization, management and governance
- Reality usage contexts in which the Living Lab runs its operations
- Interest in participation in EU and international innovation systems
- Commitment to open innovation practices
- Respect and appropriate protection of author's rights
- The openness of the stakeholder partnerships
- The effectiveness of communication and media usage
- The availability of appropriate equipment and infrastructure
- The effectiveness of the Living Lab business model (sustainability)
- The ability to access national and international funding
- Appropriate and qualified staff
- Appropriate methods for user engagement
- The concreteness and reality of usage contexts
- The adoption of user-driven service design methods
- The quality of user-driven innovation methods and tools
- Co-created values from innovation processes
- The visibility of the benefits of participation to Living Lab stakeholders
- A lifecycle approach
- Coverage of the value chain (the different roles of the ecosystem)

[7] http://openlivinglabs.eu/ (Accessed: 31.10.2016)

Living labs benefit from the ENoLL network membership by being able to use the official label with publication on the website and the official network contact point in Brussels for inquiries. They can also utilise ENoLL communication and promotion services and receive support in project development in initiating and applying participation in collaborative projects. In addition ENoLL offers brokering services between living labs or other parties, policy and governance services, and educational services through workshops and conferences (Schuurman, 2015: 153).

3.4 A Critique of Living Lab Research and Practice

Based on the growing number of criticism, it seems like the living lab concept has reached the point where the initial optimism, enthusiasm and idealism have passed and the audience wants to see results. In fact, as stated previously, the number of new living labs joining ENoLL has declined since 2011. This is partly due to tightening of admission criteria but the number of applications has also gone down. (Dutilleul, Birrer and Mensink, 2010; Følstad, 2008a; Schuurman, 2015)

The lack of detailed and longitudinal case descriptions of living lab projects is a major problem in the field. Without them it is very difficult to evaluate how well the real-world living labs match the definitions or even to determine what are the most important features in defining the living lab concept. A large number of the living lab papers are partisan reports of events, possibly written with financiers in mind, where the level of description is coarse. As a result they are likely to be positioned as pro-living labs and there is possibly a legitimization bias. Living lab research should evolve in a direction where the focus is on the evolving engagements and learning between people, instead of producing instrumental project descriptions where the focus is on the methods.

According to Schuurman (2015), living lab research has not been able to describe the benefits of the approach convincingly. Authors are often overly optimistic, and a large proportion of research papers are not well grounded in empirical research and are merely project descriptions or conceptual papers.

Additionally there is a strong tendency not to describe the methodology used or user characteristics in detail, but to present the living lab as an "everything is possible" approach or as an empty box. The general methodology for involving users is missing and guidance for managing living lab projects is scarce.

The role of co-creation as a characterizing element of the living lab approach seems to be unambiguous in many living lab definitions, but in practice co-creation or co-design seems more an ideal than a realized mode of operation (Følstad, 2008a; Schuurman, 2015). Sanders and Stappers (2008) define co-creation as "any act of collective creativity, i.e. creativity that is shared by two or more people", whereas co-design refers to "collective creativity as it is applied across the whole span of a design process [...] Thus, co-design is a specific instance of co-creation". They use the concept of co-design "in a broader sense to refer to the creativity of designers and people not trained in design working together in the design development process."

Careful description and detailed analysis of co-design activities in living labs is still largely missing in current literature, with a few exceptions (see Binder and Brandt, 2008; Binder, Brandt, Halse et al., 2011; Ogonowski, Ley, Hess et al., 2013; Scott, Bakker and Quist, 2012; Scott, Quist and Bakker, 2009). Ogonowski, Ley, Hess et al. (2013) state that:

> [t]here are [...] relatively few studies that exploit the full potential of the [living lab] concept—relatively long-term and "naturalistic" studies insofar as they involve the use of technologies in daily routines [...]—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. (Ogonowski, Ley, Hess et al., 2013: 1540)

Schuurman (2015: 157) points out that the ENoLL admission criteria has actually been in conflict with its own, previous living lab definitions, where co-creation, exploration, experimentation and evaluation were regarded as the most important activities.

Drawing together the key insights of the previously presented living lab research and theoretical literature presented in the next chapter, I conclude that in this dissertation, a living lab is seen as an arrangement which 1) brings together multiple stakeholders; 2) allows the simultaneous maturing of an artefact, usages, user needs and the context of use; 3) makes the exploration and utilization of both the realized and unexpected uses possible; 4) exposes the artefact to the uncontrollability of everyday life in a real-life setting; 5) involves end-users in the product development as partners; and 6) supports and sustains collaborative learning between project stakeholders.

I want to further clarify the framing of my study by referring to Schuurman's (2015: 184–5) distinction between three different levels of analysis: 1) a living lab **constellation** (the macro level) refers to the whole network of different stakeholders that carry out living lab research and projects; 2) a living lab **project** (the meso level) refers to the project carried out within the constellation; and 3) **activities** (the micro level) refers to research activities deployed in a living lab project. The focal point of my study focuses on the lower two levels: living lab projects and the activities of the project stakeholders.

Why Is This Case a Living Lab?

During my study I have on several occasions encountered a question that nicely exemplifies the overall confusion around the living lab concept and practice: "How come you call this case a living lab?" The educational background of the project staff was in nursing, and thus they did not have any formal training in co-design, participatory design or service design methods. The project stakeholders were not originally prepared for the demanding re-development of technology since the project was supposed to be about testing and implementing new technology, not developing it. And finally, the concept of a living lab did not feature prominently in the everyday realities of the project stakeholders and they did not interact with ENoLL or Helsinki Living Lab. So, why is this case called a living lab?

The goal of my study from the beginning was deliberately to find out what really takes place in a living lab environment or in a living lab project. I found my way to the website of Helsinki Living Lab,[8] one of the first living labs in ENoLL, where the nursing home in question was listed. At the

[8] www.helsinkilivinglab.fi (accessed: 6.4.2017)

beginning of 2006 the city government had granted a five-year funding for turning this public nursing home into a living lab environment, where technological solutions could be tested. The overall goal of the undertaking was to develop care practices, which support the independency, autonomy and activity of the residents, and in addition, to implement and evaluate technology that would support this goal.

When visiting the nursing home, I found out that one of the four sub-projects that comprised the living lab activities had turned – rather unexpectedly – from mere technology testing into a collaboration that closely resembled the idealistic living lab definitions, with users and developers co-creating technology together as equals. During this collaboration a simple floor monitoring system transformed into a proactive nursing tool.

Since the original focus of the project, the project staff had a background in nursing, not co-design. Nevertheless, they managed to create a methodology for co-development, reminiscent of "official" co-design methods (e.g. focus groups and design ethnography).[9] An important difference compared to typical living lab projects was that there was no need to transfer the sticky information (see subchapter 2.1) about the users and context of use to the project staff since they were elderly care professionals themselves. The methodology of the project emerged from the particular needs of the project and the methods were flexibly changed and updated as the needs of the project evolved. The project continued for several years and therefore there was a good opportunity for profound and long-lasting collaborative learning between the stakeholders.

Thus, the smart floor case is an excellent example of a living lab project as it features 1) a design collaboration between the public sector, companies and academia, 2) it is a sustained project, 3) the project runs over a long period of time, 4) the project is set in a real-life context and 5) the end-users are actively engaged in the development activities of new technologies and services.

[9] A similar phenomenon was observed in the co-development of a diabetes treatment database studied by Hyysalo and Lehenkari (2003).

4. Theoretical Framework

This chapter introduces the theoretical background of the research. I began my journey by turning to one of the key traditions on detailed studies of innovation – the SST approach – which offered tools and concepts to describe the role of users and user-developer interaction in socio-technical change. Three decades of SST research on the process studies of innovation has demonstrated that innovations are not a linear and orderly processes but are rather long and winding journeys, where the best possible courses of action might be hard to perceive (Williams and Edge, 1996; Van de Ven, Polley, Garud et al., 1999; Höyssä and Hyysalo, 2009). Due to this uncertainty and contingency, learning between users and developers plays a crucial role in successful innovation (Williams, Stewart and Slack, 2005; Russell and Williams, 2002).

4.1 Social Shaping of Technology

The theoretical framework of this thesis is based on the research field of STS, research on SST (MacKenzie and Wajcman, 1985; Williams and Edge, 1996; Bijker and Law, 1992) and particularly the branches of SST that focus more carefully on users and uses, which are both the social learning in technological innovation (SLTI) framework (Williams, Stewart and Slack, 2005; Sørensen and Williams, 2002) and the biographies of artefacts and practices (BoAP) framework (Hyysalo, 2010; Hyysalo, Pollock and Williams, forthcoming; Pollock and Williams, 2008).

STS is a multidisciplinary field of research that, according to Sismondo (2008), looks at how science and technology are constructed. Research on SST, one of the most influential subfields of STS, departs from the notion that technologies "might have been otherwise" (Bijker and Law, 1994) and continues to problematize the "black box" of technology by drawing attention to the process through which an artefact has reached its form and contents (Williams and Edge, 1996).

The field of SST grew from critique of technological determinism:

> [SST] studies show that technology does not develop according to an inner technical logic but is instead a social product, patterned by the conditions of its creation and use. Every stage in the generation and implementation of new technologies involves a set of choices between different technical options. Alongside narrowly "technical" considerations, a range of "social" factors affect which options are selected – thus influencing the content of technologies, and their social implications. (Williams and Edge, 1996: 866)

According to Sørensen (2002: 21) SST studies typically explore the negotiations between different groups and actors in order to make visible the choices between the different technical options potentially available during design and implementation. The negotiability inherent in the design of artefacts and the direction of larger innovation programmes is accentuated: the design process is seen as a "garden of forking paths", where "[d]ifferent routes are available, potentially leading to different technological outcomes" (Williams and Edge, 1996: 866). The mission is to indicate, problematize and open up these decisions for investigation. SST research seeks to demonstrate how organizational, political, economic and cultural factors influence technology design and to investigate what kinds of social and political choices were made in the course of the innovation process (Williams and Edge, 1996; Oudshoorn and Pinch, 2003; MacKenzie and Wajkman, 1985). SST research offers a complex understanding of technological change which highlights the influence and interaction of a range of different players (Williams, Stewart and Slack, 2005).

Early SST Research

The first wave of SST studies emerged throughout the 1980s, and the most influential strands were the social construction of technology frameworks (Pinch and Bijker, 1987; Bijker, Hughes and Pinch, 1987; Bijker and Law, 1994) and actor-network theory (ANT) (Latour, 1987; Law, 1991; Callon, 1986; Akrich and Latour, 1992). Whilst the early SST studies privileged sites of design and development as the locus of their analysis, later SST research became interested in the processes of social shaping that take place during the implementation and consumption of new technologies (Sørensen, 2002). Early studies typically concentrated on demonstrating how "technologies embody and reflect dominant social interests in their form and features" and often analysed how "class, gender, military or bureaucratic interests" directed the technological development and its impacts on the surrounding society (Russell and Williams, 2002: 40–41).

In the late 1980s, Pinch and Bijker (1987) studied the **interpretative flexibility** around technological artefacts through a historical study of the bicycle in order to explain why some variants of an artefact die and some survive. They created the **social construction of technological systems** (SCOT) approach, which aimed at a multidirectional description of technological development. At the heart of their theory was the charting of **relevant social groups** around an artefact, which can be organized or un-organized groups of individuals who attach the same set of meanings to the technology. The application of the SCOT approach brought out the conflicts (technical, moral, social etc.) present on the development path and demonstrated how various solutions are in fact possible. Pinch and Bijker also described the process of **stabilization**, which means that the debate around an artefact reaches **closure** and one dominant meaning and form become prevalent (Pinch and Bijker, 1987; Bijker, 1987).

Prior to SCOT, another influential strand of SST emerged in the field of science studies from where it was also extended to explain the dynamics of technological change. ANT is a material-semiotic approach to studying questions related to power and controversy in the making of technologies or scientific facts. ANT sees technologies existing as part of a (more or less stable) actor network that consist of **human** and **non-human** elements. A central claim of ANT is that non-human elements (e.g. technologies or bacteria) also have the ability to act, and thus material elements should be analyzed in the same terms as human actors (the principle of **generalized symmetry**). By "following the actors" (Latour, 1987) the researcher gets to see the network of connections that make up the specific technological system.

Callon (1986) describes the process of **translation** through which an actor seeks to stabilize a certain version of the actor network. First comes the **problematization** phase during which the actor seeks to define the situation or the "problem" in such terms that the definer becomes an **obligatory passage point** in the resolution of the problem, in other words the programme of investigation. Problematization is followed by **intressement**, a series of processes through which the actor seeks to "lock" other actors to the roles proposed to them in the programme. Next comes **enrolment**, a set of strategies through which the actor seeks to define and interrelate the roles allocated to others. The final phase is **mobilization**, which refers to a set of methods used by the actor to ensure that the spokesmen for different collectivities were able to represent those collectivities (Callon, 1986).

In her influential work **The De-Scription of Technical Objects** Akrich (1992) followed the tradition of ANT and described how assumptions about the potential user were translated into the form of technical artifacts. She argued that technical objects embody the innovator's attempts to predetermine the relationship between the object, the actors around it and their surroundings. This included predicting the way different actors interact and deciding what should by delegated to machines and what to human actors.

> Designers [...] define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they assume that morality, technology, science, and economy will evolve in particular ways. A large part of the work of innovators is that of "**inscribing**" this vision of (or prediction about) the world in the technical content of the new object. I will call the end product of this work a "script" or a "scenario". (Akrich, 1992: 208)

However, ANT and Akrich emphasize that there is no guarantee that the actors will play the part ascribed to them or that the users will **de-scribe** the objects in the way anticipated by the designer. Yet, in order to function technical objects must succeed in stabilizing the network of actors around them and integrate into the social fabric. And when objects are stabilized, they become "black boxes" and the sociotechnical facts that the objects produce become "facts pure and simple" (Akrich, 1992: 221).

Around the mid-2000s the focus of SST researchers extended to the neglected area of the implementation and use of technology. Research in this area had been advanced in the field of cultural, media and consumption studies, and from these grounds some researchers extended their analysis to include the role of users in shaping technology during phases of appropriation and use. These approaches – described as "SST mark 2" by their proponents (Russell and Williams, 2002) – are introduced in the following subchapters.

4.2 Social Learning in Technological Innovation

SLTI research examines the processes of collaborative learning and negotiation between developers, users and other parties in development/design and implementation/use of technology. The social learning perspective seeks to describe how society learns about technical offerings and how designers and developers learn about users and uses (Williams, Stewart and Slack, 2005; Sørensen and Williams, 2002; Stewart and Hyysalo, 2008).

The SLTI framework grew from research on SST (MacKenzie and Wajcman, 1985; Williams and Edge, 1996). The concept of social learning focuses on users' efforts in adapting novel technologies to local contexts through technical configuration and the creation of uses, practices and meanings around the technology: "[t]he interpretation of an innovation is of great importance to its eventual success or failure" (Williams, Stewart and Slack, 2005: 54). Considerations related to identity and the moral acceptability of technology are important dimensions in social learning.

By drawing from concepts of innofusion (innovation in technology diffusion; Fleck, 1988), domestication (Berker, Hartmann, Punie, et al., 2006; Silverstone and Hirsch, 1992; Lie and Sørensen, 1996) and appropriation (Du Gay, Hall, Janes, et al., 1997) the SLTI framework highlights the appropriation phase (implementation and use) as an important arena of innovation. For Sørensen (1996) social learning refers to the...

> combined act of discovery and analysis, of understanding and giving meaning, and of tinkering and the development of routines. In order to make an artefact work, it has to be placed, spatially, temporally, and conceptually. It has to be fitted into the existing, heterogeneous network of machines, systems, routines, and culture. (Sørensen, 1996: 6)

Social learning refers to the cyclic and iterative relationship between user representation, design and appropriation. It is not a "one-off act, but is part of an iterative series of activities" (Williams, Stewart and Slack, 2005: 110). Representations of and hypotheses about users and use are materialized in the design and configuration phase and these materializations are further tested in the implementation phase, during domestication and innofusion, which again generate new representations, hypotheses, materializations and designs (Williams, Stewart and Slack, 2005).

The concept of **innofusion** reminds us that innovation does not stop when the product leaves the research and development laboratory but continues in the struggles of the users to integrate the technology into their everyday life. Innofusion refers to the "processes of technological design, trial and exploration, in which user needs and requirements are discovered and incorporated in the course of the struggle to get the technology to work in useful ways, at the point of application" (Fleck, 1988). Innofusion has its roots in the concepts of "learning by doing" (Arrow, 1962) and "learning by using"(Rosenberg, 1982), which describe the phenomenon of users finding more efficient and productive ways to use technology over time. Fleck (1994) has introduced the concept of "learning by trying", which highlights the creative struggles users have to go through in order to get the technology to work in the implementation phase. Fleck (1988) emphasized the importance of linkages between users and suppliers that enable the suppliers to utilize users' innovative activities during implementation in the design of their future technological offerings.

Another important facet of the social learning framework is the concept of **domestication**, the roots of which are in cultural and consumption studies (Berker, Hartmann and Punie, 2006; Silverstone and Hirsch, 1992; Silverstone and Haddon, 1996). During a process of domestication "wild" and unstable technologies are "tamed" into useful tools through co-production of social and technical elements (Sørensen, 2006). In technology studies the concept refers to the work users go through in "fitting [technologies] into the pre-existing heterogeneous network of machines, systems, routines and culture" (Sørensen, 1996). Domestication studies look at technologies in different settings in order to analyze how people produce meaning, identities and patterns of use in relation to technologies (Sørensen, 2006). The focus is on...

> [t]he construction of a set of practices related to an artefact. This could mean routines in using the artefact, but also the establishment and development of institutions to support and regulate this use. [2] The construction of the meaning of the artefact, including the role the artefact eventually could play in relation to the production of identities of the actors involved. [3] Cognitive processes related to the learning of practice as well as meaning. (Sørensen, 2006: 47, citing Sørensen, Aune and Hatling, 2000)

The term **design fallacy** refers to an understanding that technologies are largely fixed in their properties. From this it follows that the solution to meeting user needs is to build ever more knowledge about particular users and contexts into technology design. However, this has not proven to produce strikingly different or better solutions. Instead, the SLTI approach suggests an evolutionary understanding of system design and development that recognises that innovation is not restricted to the prior design phase but that it continues as technologies are implemented and used (Stewart and Williams, 2005).

Williams, Stewart and Slack (2005: 49) write that social learning should not be understood as the term is used in the fields of education or in social psychology, that is to say, as a narrowly cognitive process. Instead the term should seek to guide understanding of the "processes of socio-technical change, as also a process of negotiation and interaction between different players and thus subject to conflicts, and differences of power and interest."

Research on social learning in technological innovation, socio-cultural psychology and activity theory eventually gave birth to the BoAP approach, which is a ambitious methodological framework for studying socio-technical change in multiple settings over long periods of time (see subchapter 3.3).

Technologies-in-Practice

Orlikowski's (2000) work on technological structures is not part of the SLTI framework or even STS, but it offers a nuanced understanding of interaction between users and technologies in an organizational context and of technologies' roles in organizational change. Orlikowski draws from organizational research and Giddens' (1984) theory of structuration, where structure refers to a set of rules and resources instantiated in recurrent social practice.

Orlikowski (2000) argues that technology use is situational and emergent: technologies do not embody structures (in the sense of e.g. Akrich's concept of script), but instead structures are instantiated in social practice. She calls for enacted structures of technology use: technologies-in-practice. The term focuses on the use of a technology instead of the artefactual character of technology and refers to

> a specific structure routinely enacted as we use the specific machine, technique, appliance, device, or gadget in recurrent ways in our everyday situated activities. Some properties provided by the artefact do not exist for us as part of our technology-in-practice, while other properties are rich in detailed possibilities. (Orlikowski, 2000: 408)

Orlikowski thus emphasizes users' creativity in diverting from the intentions and inscriptions of designers, although she notes that the recurrent use of technology is not infinitely malleable.

> When people use a technology, they draw on the properties comprising the technological artifact—those provided by its constituent materiality, those inscribed by the designers, and those added on by users through previous interactions [...] People also draw on their skills, power, knowledge, assumptions, and expectations about the technology and its use, influenced typically by training, communication, and previous experiences (Orlikowski and Gash 1994). These include the meanings and attachments—emotional and intellectual—that users associate with particular technologies and their uses, shaped by their experiences with various technologies and their participation in a range of social and political communities. Users also draw on

> their knowledge of and experiences with the institutional contexts in which they live and work, and the social and cultural conventions associated with participating in such contexts. In this way, people's use of technology becomes structured by these experiences, knowledge, meanings, habits, power relations, norms, and the technological artifacts at hand. Such structuring enacts a specific set of rules and resources in practice that then serves to structure future use as people continue to interact with the technology in their recurrent practices. (Orlikowski, 2000: 410)

4.3 The Biographies of Artefacts and Practices

As previously stated in subchapter 4.1, early STS is know for the so-called "laboratory studies" of science and technology. These were typically rich ethnographies of particular settings with a mission of demonstrating an issue, such as how "the user" is constructed by the technology and the actions of the designers.[10] "Laboratory studies" were criticized for an overly politicized and deficient view of designer–user relations, partly because the research designs excluded moments of implementation and use (Hyysalo, 2004; Stewart and Williams, 2005). In addition, the scope of these studies was usually a couple of months in one setting, which limits the reach of acquirable insights (Hyysalo, Pollock, and Williams, forthcoming).

The studies that Russell and Williams (2002) call SST mark II, in other words SLTI studies, had already pointed out that innovation continues in implementation and use, and that the phases of design and implementation/use should be studied in tandem in order to avoid the "snapshot" view of innovation. "Snapshot" studies describe an organization before and after the implementation of the particular solution in order to demonstrate the impacts of a new technological system. Another popular research type is implementation studies, which are often methodologically more sound but are retrospective accounts and of short duration. The type of data used, and the temporal and spatial framing of the study shape

[10] Exemplified by Woolgar's (1991) "Configuring the user" paper

the research findings and the overall picture of technology development, and they possibly overemphasize the “effects” of the technological system (Pollock and Williams, 2008; Williams, Stewart and Slack, 2005).

The BoAP approach grew from these grounds as a critical reaction to widespread ways to temporally and societally frame studies on technology and work organization that were often aligned with the interests of technology supply. The proponents of BoAP argue that socio-technical change happens over several years, in multiple intertwining settings, in multiple interlinked situations and that it is shaped by an ecology of actors, and that this should be taken into consideration in research design when studying innovation processes (Hyysalo, Pollock, and Williams, forthcoming).

The approach evolved from two strands of research, from the 1990s onwards: the seminal work was done in Edinburgh in the field of software applications in manufacturing and the service sector (e.g. Pollock and Williams, 2008) and in Helsinki around health technologies (e.g. Hasu, 2001; Hyysalo, 2000, 2010; Hyysalo and Lehenkari, 2002; Hyppönen, 2004).

BoAP studies typically utilize different kinds of data available (documents, interviews, field observations, digital traces) on the phenomenon in combination with the “strategic ethnography” of key sites and historiographic methods. The scope of the research is extended temporally but also the wide range of actors that contribute to innovation is emphasized: their relationships, interaction and practices and how they evolve over time. Special attention is paid to intermediary actors and their contribution in getting systems to work in local settings (Hyysalo, Pollock and Williams, forthcoming; Pollock, Williams and Procter, 2003).

Hyysalo (2010: 35) and Hyysalo, Pollock and Williams (forthcoming) summarize the key facets of BoAP studies:

> 1. They should have sufficient spatial and temporal **reach** to understand the dynamics of the innovation studied. Studies must encompass multiple loci and points of time where the sociotechnical change takes place.
>
> 2. BoAP studies acknowledge and analyze the **ecologies of interconnected actors** and their practices which shape the technology. It is also fruitful to identify and look into the **interstices** between focal actors, that is to say, the moments and sites where actors interlink and affect each other and the evolving technology.

3. The phenomenon should be studied on **multiple scales**, both temporal and spatial, in order to understand the dynamics of the innovation studied. Bird's-eye accounts of socio-technical change should be completed with actors' real-time "frog's-eye" accounts, which are typically missing from broad historical reconstructions.

4. Different temporalities and spans of change are considered **multiple enacted contexts** rather than ontologically different layers. Events are seen as simultaneously constituting and being constituted by broader patterns.

5. The **materiality** of technology – its content and form – is given great attention. BoAP studies look at how technology evolves, but interest in materiality is extended to the production systems, tools and infrastructures where designers and users operate. The **shaping and shape of technology** in the process should be investigated.

6. BoAP studies should produce **balanced** and empirically accurate accounts of the different actors' contributions to innovation.

7. **The dynamics of sociotechnical change** should be captured both empirically and theoretically by following detailed understandings of change in different settings and moments.

BoAP research has come to highlight the innovation diffusion phase as an equally important moment in the lifecycle of an organizational technology as that of the initial design. As the number of client organizations is rapidly growing, the product needs to become generic and in order to cater for increasingly large number of users. Pollock, Williams and Procter (2003: 318) call this phase generification and they describe it as "the supplier strategy of taking a technology that has worked in one place and attempting to make it work elsewhere, and, in principle, 'everywhere'."

4.4 Innovation Intermediaries and Living Labs

In order to understand mediation processes in living labs and to describe the large variety of intermediation work taken place in the project under study, I have turned to research on innovation intermediaries. Previous research has highlighted the central role of intermediary actors in the user-side activities and processes of social learning.

Howells (2006: 720) describes an innovation intermediary as "[a]n organization or body [or an individual] that acts as an agent or broker in any aspect of the innovation process between two or more parties". The concept has its roots in several disparate fields of research: literature on technology transfer and diffusion, and research on innovation management activities and firms. In addition, research on innovation systems and service organizations like knowledge-intensive business services has highlighted the significance of intermediary actors in the innovation process (Howells, 2006).

Intermediary functions (Howells, 2006)

1. Foresight and diagnostics
2. Scanning and information processing
3. Knowledge processing and (re)combination
4. Gatekeeping and brokering
5. Testing and validation
6. Accreditation
7. Validation and regulation resources; organizational development
8. Protecting the results
9. Commercialization
10. Evaluation of outcomes

Bridging activities (Bessant & Rush, 1995)

1. Articulation of needs; selection of options
2. Identification of needs; selection training
3. Creation of business cases
4. Communications; development
5. Education; links to external info
6. Project management; managing external resources; organizational development

Previous research has focused on supply-side intermediaries and middle-ground agencies, whereas actors working at the user end of the continuum and with the processes of social learning have remained more in the shadows (Stewart and Hyysalo, 2008).

> The highly visible supply-side intermediaries [...] and the easily identifiable middle ground agencies [...] tend to overshadow the often more informal yet just as crucial intermediaries at the user end of the supply-use relation. Intermediate users, local experts and "tailors" facilitate, configure and broker systems, usages and knowledge about systems and their deployments, helping users to domesticate them and suppliers to respond to actual, realised uses. (Stewart and Hyysalo, 2008: 319)

Stewart and Hyysalo (2008: 297) define user-side innovation intermediaries as organizations or individuals that "attempt to configure the users, the context, the technology and the 'content', but they do not, and cannot, define and control use or the technology". Hyysalo has further clarified the definition by stating that:

> [innovation intermediaries] are [...] actors who seek to influence users and developers, but do not have final say over how the technology is eventually used (this is what users and managers at user organizations do) nor do they hold decision-making power, or necessary skills, to alter the form of the technology at the developer end. (Hakkarainen and Hyysalo, 2016: 46)

Stewart and Hyysalo (2008) have recognized three intermediary activities with respect to social learning: configuring, facilitating, and brokering. **Facilitating** means

> providing opportunities to others, by educating, gathering and distributing resources, influencing regulations and setting local rules. Facilitation involves "creating spaces" of various types: social (communities, networks), knowledge (skills and know-how resources), cultural (positive images), physical (a place or equipment), economic (providing funds), and regulatory (creating rules to guide activities and reduce uncertainty). (Stewart and Hyysalo, 2008)

Configuring refers to "material and symbolic alteration of technology, adjusting its form and content (often in minor ways), as well as how it is interpreted and used" (Hakkarainen and Hyysalo, 2016: 47). Configuring can also mean configuring the identity of the users, and it includes "setting rules and regulations on use and usage, prioritising uses, the goals and form of projects, and the goals and expectations of other members of a network" (Stewart and Hyysalo, 2008).

Brokering stands for the "establishing, nurturing, adjusting, and altering of connections between different actors", which is "often selective and occasionally self-serving to the position of the intermediary actor itself" (Hakkarainen and Hyysalo, 2016: 47).

Living lab organisations have been previously analyzed as innovation intermediaries by Almirall and Wareham (2011), Baltes and Gard (2010), and Katzy, Turgut, Holzmann et al. (2013). Almirall and Wareham (2011) define living labs as

> open innovation intermediaries that seek to mediate between users, research, public and private organisations, advance our concept of technology transfer by incorporating not only the user based experimentation, but also by engaging firms and public organisations in a process of learning and the creation of pre-commercial demand. (Almirall and Wareham, 2011)

Previous research on interaction dynamics between living lab participants has addressed themes and questions related to communities of practice and boundary objects (Johansson and Snis, 2011), living lab actors' roles and role patterns (Nyström, Leminen, Westerlund et al., 2014; Heikkinen, Mainela, Still et al., 2007), living lab networks' modes of coordination and participation (Leminen, 2013), the functions and roles of public open innovation intermediaries (Bakici, Almirall and Wareham, 2013), the strategic capabilities of living labs (Katzy, Turgut, Holzmann et al., 2013), paradoxical tensions in living labs (Leminen, DeFillippi and Westerlund, 2015), complexity in the stakeholder interactions (Pade-Khene, Luton, Jordaan et al., 2013) and the possibilities of social and cognitive translation between stakeholders (Svensson and Ebbesson, 2010). By building on work by Heikkinen, Mainela, Still et al. (2007) Nyström, Leminen, Westerlund et al. (2014) have also explored the roles of intermediary actors in a living lab context.

Previously identified actor roles
(Heikkinen, Mainela, Still et al., 2007)

1. **Webber:** Acts as the initiator; decides on potential actors
2. **Instigator:** Influences actors' decision-making processes
3. **Gatekeeper:** Possesses resources
4. **Advocate:** Background role; distributes information externally
5. **Producer:** Contributes to the development process
6. **Planner:** Participates in development processes; input in the form of intangible resources
7. **Accessory provider:** Self-motivated to promote its products, services, and expertise

Newly identified roles (specific to living labs)
(Nyström, Leminen, Westerlund et al., 2014)

8. **Coordinator:** Coordinates a group of participants
9. **Builder:** Establishes and promotes the emergence of close relationships between various participants in the living lab
10. **Messenger:** Forwards and disseminates information in the living lab network
11. **Facilitator:** Offers resources for the use of the network
12. **Orchestrator:** Guides and supports the network's activities and continuation; tries to establish trust in the network to boost collaboration to further the living lab's goals
13. **Integrator:** Integrates heterogeneous knowledge, development ideas, technologies, or outputs of different living lab actors into a functional entity
14. **Informant:** Brings users' knowledge, understanding, and opinions to the living lab
15. **Tester:** Tests innovation in (customers') real-life environments (e.g., hospitals, student restaurants, and classrooms)
16. **Contributor:** Collaborates intensively with the other actors in the network to develop new products, services, processes, or technologies
17. **Co-creator:** The user co-designs a service, product, or process together with the company's R&D team and the other living lab actors

The listings of intermediary functions and activities – like those of Howells (2006) and Bessant and Rush (1995) – do not describe on a more detailed level how intermediaries act and what kinds of engagements make up their work in innovation. Stewart and Hyysalo (2008) have tried to further research in this field by analyzing the user-end intermediary activities related to social learning. However, there is still research to be done in examining how intermediaries – identified as central actors in living labs and innovation more generally – perform their activities and how the profiles of their activities change in the course of innovation processes and with respect to living lab inclusive innovation in particular.

In the next chapter I will go through the methodological details of my study and describe how the further analysis has been carried out for each of the four articles.

5. Doing the Research

The methodological choices of this dissertation have been influenced by theoretical and empirical literature in the field of science and technology studies (STS) and more specifically research on social shaping of technology (SST) (Williams and Edge, 1996), research on social learning in technological innovation (SLTI) (Williams, Stewart and Slack, 2005) and the biographies of artefacts and practices (BoAP) framework (Hyysalo, 2010; Pollock and Williams, 2008; Hyysalo, Pollock and Williams, forthcoming). All these approaches take a critical attitude towards linear and deterministic accounts of technical change, where the diffusion of innovations is seen in simplistic term. Instead, the appropriation phase is an important site of innovation (Hyysalo, 2010; Pollock and Williams, 2008; Williams, Stewart and Slack, 2005).

The BoAP framework (see subchapter 4.3) developed the theoretical insights and research practices of social learning studies into a more programmatic and ambitious form, which in practice meant that innovation studies should have spatial and temporal reach and phases of design and implementation/use should be studied in multiple contexts as well as the ecology of actors that shape the innovation. Also the materiality of technology should be given careful attention.

My research approach has also been influenced by ANT (Latour 1987; Callon and Law, 1982) in that I have sought to identify and "follow" the central actors of the innovation project and to recognise their interests in the evolving artefact and the way that these interests are in conflict with each other. I have also analyzed and described the simultaneous evolution of the artefact and the (actor) network around it (see Latour, 1987).

This theoretical background (which has been described in more detail in the previous chapter) has several implications for the research design of this study. First of all, the innovation process is studied qualitatively and longitudinally in order to produce an in-depth, detailed and rich picture of the phenomenon that captures contextual factors and multiple voices and perspectives. This type of research design is typical in the field of STS, where the technological "black box" is opened up and the negotiations and politics around the form of the artefact are made visible.

The research process was divided in two phases: in the first phase, in 2010, the project biography was reconstructed retrospectively. The second phase (summer 2011 to spring 2014) consisted of five follow-up interviews, which were conducted after the market launch of the product (see figure 4).

The starting point of my study was an interest in user-developer collaboration in a living lab project and how the interaction plays out in a real-life project. Living lab environments had been gaining popularity rapidly and the promoters of the concept typically depicted the multi-party collaboration as unproblematic. From these grounds, the objective of my research became to explore and describe collaboration in a living lab project and its evolution in detail and from multiple perspectives.

5.1 Research Process

My research began by familiarizing myself with the larger innovation undertaking and its sub-projects that were ongoing in the nursing home, which was listed as a living lab on the Helsinki Living Lab[11] website at the time. In subchapter 3.4 I described how I selected the smart floor as the focal innovation of my study. The case was considered a good representation of a living lab collaboration mainly due to two characterising qualities that have been emphasized in the living lab literature: 1) the scale and nature of user participation and 2) the extent that the system was redesigned based on the collaboration.

I paid a visit to the nursing home in spring 2010, when the

[11] Helsinki Living Lab website: http://www.helsinkilivinglab.fi/ (accessed: 21.11.2016)

innovation undertaking was just coming to an end. I was initially welcomed to the "field" by the project secretary. I discussed the living lab activities taking place in the nursing home with the coordinators and project workers of the different sub-projects as well as with people working in the management of the innovation project. The smart floor project was selected as the object of my research from among three more substantial projects and one lighter innovation project. In the smart floor project the collaboration with the end-users was the most in depth and the artefact had transformed the most due to user collaboration.

After making the decision about the object of my study, I began to identify and interview the project participants. The grassroots level project workers were generally exited to talk about their work and had a positive attitude towards my curiosity, whereas the project and the nursing home management both expressed some initial reservations. The managers' suspicions were understandable as a research project represents an intrusion into the life of the institution and its members with no perceptible immediate or long-term pay off (Flick, 2014: 160):

> Research unsettles the institution with three implications: that the limitations of its own activities are to be disclosed; that the ulterior motives of the "research" are and remain unclear for the institution; and, finally, that there are no sound reasons for refusing research requests. (Flick, 2014: 160)

Yet after I applied and was granted a research permit by the city's Department of Social Services and Health Care, I was able to start interviewing project participants freely (see subchapter 1.2). However, putting together a consistent picture of the events based on retrospective interviews turned out to be difficult. I asked my key informant, a smart floor project worker, if I could get access to some of the documents that had been produced during the project. She consulted the innovation project management, and I was given access to over 90 meeting memos and other document material (see subchapter 5.3), which proved to be an extremely valuable and fruitful data set for my study, combined with the interviews.

As stated previously, I applied and was granted a research permit by the city's Department of Social Services and Health Care. As the living lab units of the nursing home had already been subjected to several types of research and development activities due to the living lab, the relatives of the residents suffering from dementia had been asked to give consent for these activities. The project and nursing home management did not consider it necessary for me to ask for consent anew for the few visits that I made to the units to interview the care workers and to observe the use of the smart floor. I have anonymized the individuals as well as organizations that took part in my study to minimize the potential disadvantages and damage caused by their participation. It should also be noted that I have acted as an outside researcher of the case, that is to say, I did not participate in the execution of the project nor did I have a consulting role either in the project or after it.

5.2 Research Questions

As previously stated, the starting point of my study was an interest in the collaboration that takes place in living lab environments as they had been rapidly gaining popularity in recent years. Based on previous research it was justifiable to assume that the realities of multi-party collaboration were not as rosy and unambiguous as living lab promoters would like you to believe. Based on the background and literature presented in chapter 4, I formulated the overall research questions that guided my study from the beginning:

How did the collaboration between developers, users and other relevant actor groups evolve during and after the living lab project? How did this collaboration shape the emerging technology?

When I entered the field, gathered more information about the case and got myself acquainted with the relevant literature, I was able to operationalize the overall research questions into more detailed and specific sub-questions. These questions guided the data gathering and later data analysis, which resulted in the reconstruction of the smart floor's biography and the "master narrative" (see Kohtala, 2016: 49 and Hyysalo, 2004: 56–57).

The first group of questions stem especially from the literature on SST (see chapter 4.1):

1. Who participated in the development of the smart floor? What were the roles of different stakeholder groups in the development? What kind of interests did they have in the project and the smart floor? How did these interests conflict with each other?

The second group of questions was based on the SLTI framework (see subchapter 4.2) and work by Hyysalo (2004, 2010):

2. How did social learning between developers, users and other relevant actors take place in the development of the smart floor? What kinds of tools and methods were used? What was learned? What advanced this learning and what hindered it?

The third group of questions was motivated especially by the living lab literature and research gaps in the field (see chapter 3):

3. What was the value of the living lab approach? What were the benefits and burdens of the collaboration for different participant groups? How did the smart floor evolve during and after the living lab project?

The four articles further elaborate the primary questions by focusing more deeply on certain themes and aspects of the living lab approach. The first article is based on the above mentioned research questions. The second article focuses on the role of one stakeholder group in the project and after it. The third article seeks to distil the value of the living lab approach by comparing two cases. The fourth article makes a cross-case comparison across several cases of user-driven innovation (UDI).

The research questions of the four articles are:

Article 1.
What learning took place between project participants during and after the living lab project?

Article 2.
What intermediation work took place during and after the living lab project?

Article 3.
What is the added value of the living lab approach?

Article 4.
What user-driven innovation practices can be identified in Finnish companies? How do these practices change over time?

5.3 Data Sources

My research strategy with respect to data was to gather and to combine different types of data around the phenomenon. It is typical for BoAP studies to draw upon a wide variety of available data sources (Hyysalo, Pollock and Williams, forthcoming). Since the living lab project was ending at the time when I began my study, ethnographic investigation and observation of the collaboration meetings were out of question. I had began to interview different participants of the project when I was provided with access to the meeting memos and other documentary material that had been produced during the project.

Next I will describe the different types of data that have been analyzed to create the "master narrative" (see Kohtala, 2016: 49; Hyysalo, 2004: 56–57) of the smart floor innovation path.

Documents

The document data of the study consisted of 151 documents generated during the living lab project. The majority of the document data (90 out of 151) were meeting memos, which recorded almost all official meetings held with different assemblies during the project. In addition to meeting memos the document data consisted of project reports, project plans, marketing material, journal articles, and different kinds of forms and Excel sheets that were used to collect and transfer information between project stakeholders.

A typical meeting memo included details of the meeting (time and location), a list of the attendees, a list of the addressed issues with headlines and descriptions, and – at the end – a list of the persons to whom the memo was to be distributed. The meeting memos were typically one to three pages long and they were in most cases written by a project worker.

The primary function of the memos was to inform the project management and other relevant parties unable to attend the meeting about the status quo and next steps of the project as well as the system development. The memos included information on the topics that were discussed: what was the state of the system; what kinds of changes had been made to the system since the last meeting; what kinds of changes the engineers were planning to do in the near future; what kinds of development ideas, wishes or demands the project workers or users had for the system; how the implementation was progressing; what the next steps of the project were more generally; and what decisions had been made (see subchapter 1.3 for more details).

Considering that the project participants often had differing interests in the project as well as the technology, the memos probably played a role in clarifying misunderstandings and preventing disputes. They included quite directly written descriptions about problems that had arisen in the project and disagreements between the project participants.

The meeting memos that documented the feedback meetings between the project workers and the care workers probably also reflected the fact that project workers sought to influence the sceptical care workers' opinions on the project and the system. The project and the system were described in more positive terms in them than in the other memo types.

Interviews

The interview data of the study consisted of twenty-one semi-structured interviews conducted face to face that varied in length. Sixteen individual semi-structured interviews were conducted at the end of the innovation project in 2010 with the members of different project participant groups. Five semi-structured follow-up interviews were conducted between June 2011 and May 2014 with a customer care specialist (a former living lab project worker and a key informant in this study) and a sales manager of the developer company.

Semi-structured interviews are based on a set of mostly open-ended questions and they leave room for the interviewee's perspective, and additional topics and issues that the interviewee sees as important (Flick, 2014). Through the interviews I sought to recognize different participants' interests in and perspectives on the project and the evolving artefact. I also wanted to figure out how they saw their position as part of the living lab network.

The interviewees were selected by gradual selection or "snowballing" (Flick, 2009: 120), in practice this meant asking each interviewee to name people that I should talk to in order to get as full a picture of the project as possible. I made the decision to only interview people who continued to work in the project, the company or the university (with the exception of the previous CEO of the smart floor company), and this probably affected the picture about the events to some extent, especially since the first part of the project was characterized by tensions between the participant groups and several key participants resigned at that point. Had the number of people interviewed been larger, new perspectives and interpretations about the events could possibly have been brought forth. Nevertheless, this limitation was counterbalanced by the rich meeting memo data.

The length of the interviews varied from short chats to in-depth interviews that lasted over an hour, depending on the role and responsibility of the interviewees in the project, their ability to describe and to recollect their actions, their attitudes towards my study and the interview situation. The care workers were interviewed in the nursing home units, some during their care duties.

In 2010 interviewed the smart floor project co-ordinator twice and the two care workers simultaneously, which means that fifteen different people were interviewed altogether at that time. The majority of the interviews were recorded and transcribed. When an interview was not recorded, notes were taken actively.

The interviewed people of the first round (in other words, excluding the follow-up interviews) included (in chronological order): the planner of the larger innovation undertaking (interviewed twice), the smart floor project co-ordinator (interviewed twice), two project co-ordinators of the other sub-projects, the manager of one of the living lab units (long-term care), the manager of the nursing home, the software developer of the developer company, the head of the innovation undertaking, a researcher from the university of technology, two care workers from one of the living lab units (long-term care; interviewed simultaneously), two care workers from one of the living lab units (short-term care; interviewed alongside work duties), an IT specialist from the municipal bureau of social services and the previous CEO and sales manager of the developer company.

In the interviews conducted in 2010 I asked each of the interviewees how they had participated in the project and asked them to explain how the development process had proceeded. In addition I asked what the objectives of the project were and how these objectives changed during the project. Lastly we discussed about what they thought that, in retrospect, should have been done differently. The questions for the care workers were slightly different as their participation was not voluntary. I asked the care workers how they had participated in the development of the smart floor, and how the smart floor had changed their work and everyday life of the residents. In addition we discussed about the attitude of the care workers in general towards the smart floor and the living lab project.

In addition to the interviews conducted in 2010, five semi-structured follow-up interviews were conducted with a customer care specialist and a sales manager of the developer company between June 2011 and May 2014. The customer care specialist was a former smart floor project co-ordinator and key informant in my study, who was hired by the developer company after the project. During the first four follow-up interviews I interviewed the sales manager and customer care specialist together in the company premises. The last follow-up interview was conducted with the customer care specialist alone as by this time both of these informants had quit working for the developer company.

The majority of the follow-up interviews were recorded and the most important sections of the recordings were transcribed. In addition, notes were taken throughout the interviews. The length of the follow-up interviews varied between one and two hours. In the interviews conducted after the market launch of the smart floor, the focus was on changes in the product, the evolution of the company's business model, the relationship between the company and customer organizations, and the future plans of the company.

Hyysalo, Pollock and Williams (forthcoming) remind us that innovation research interviews

> may be shaped by the interests and self-justification of actors involved. Thus interviews with technology developers may be coloured by their (often enthusiastic) visions, goals and optimism and conflate potential with achievement. Users, whose perspectives are constrained

> by particular locales, conversely may be well versed in current practices but may lack the breadth of experience or skills needed to develop a clear picture of unfolding developments or anticipate futures. (Hyysalo, Pollock and Williams, forthcoming)

Table 2. The interviews

Date	Interviewee/s	Lenght of the recording	
25.01.2010	Planner of the innovation project	not recorded	Notes were taken during the interview
20.04.2010	Smart floor project coordinator	1:04:37	Transcribed
28.04.2010	Project coordinator (of another sub-project)	1:10:31	
29.04.2010	Project worker (of another sub-project)	0:07:15	
30.04.2010	Planner of the innovation project	1:00:39	
05.05.2010	Smart floor project coordinator	1:21:56	
05.05.2010	Manager of long-term care unit	0:49:04	
06.05.2010	Manager of the nursing home	0:23:05	
10.05.2010	Sofware developer of the developer company	0:25:59	
18.05.2010	Head of the innovation project	0:54:08	
18.05.2010	Laboratory engineer from technical university	2:04:59	
19.05.2010	Two care workers (long-term care unit)	0:45:36	
19.05.2010	Care worker (short-term care unit)	not recorded	Notes were taken during the interview
19.05.2010	Night-time care worker (short-term care unit)	not recorded	
27.05.2010	IT expert of the city department of social and health care	0:35:03	Transcribed
09.09.2010	Former CEO and sales manager of the developer company	0:32:43	

07.06.2011	Sales manager and customer care specialist	not recorded	Notes were taken during the interview
20.01.2012	Sales manager and customer care specialist	1:58:09	Notes were taken during the interviews and completed after-wards with the help of the recordings. Relevant sections of the interviews were transcribed.
17.10.2012	Sales manager and customer care specialist	1:50:04	
28.02.2013	Sales manager and customer care specialist	1:03:11	
23.05.2014	Customer care specialist	0:38:34	

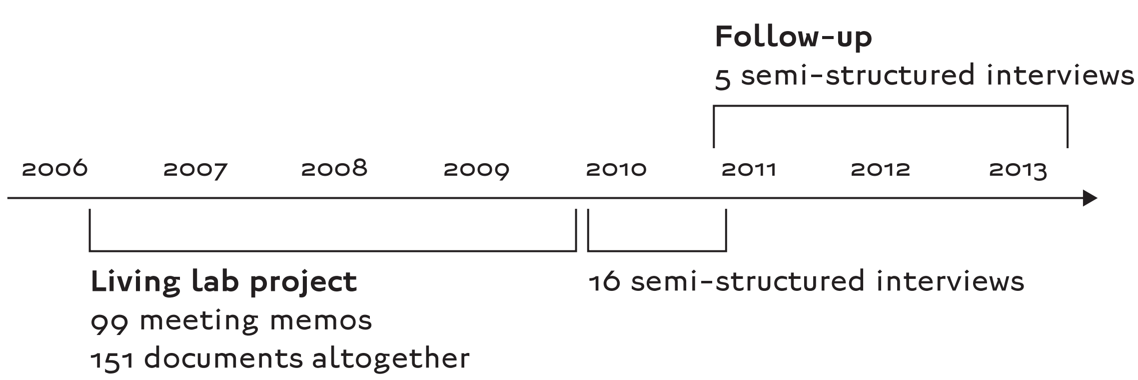
The smart floor project coordinator and the customer care specialist are the same person.

5.4 Construction of the Biography and Further Analysis

As I was studying an innovation process that lasted for several years, my research design combined both retrospective and longitudinal elements: the living lab project description was constructed retrospectively, as the project was ending, but through the follow-up interviews I continued my study longitudinally. By combining these two types of approaches I was able to cover altogether approximately eight years of the biography of the smart floor artefact.

I followed the principles of the SLTI and BoAP approaches to the greatest extent possible within the limits of the resources available: I thus sought to describe the phases of design, implementation, use and generification in the biography of the smart floor. The purpose of the first round of data gathering and analysis was to trace, follow and describe the evolution of the material make up of the technology as well as the relationships and practices of the key stakeholder groups. In addition I have focused on the learning between users, developers and individual user-side intermediaries (the project workers / the customer care specialist).

Figure 4. The data of the study



When I felt that I had acquired a sufficient data set for the construction of a “master narrative” of the living lab project, I began its construction by creating a timeline of the most relevant events based on the information in the meeting memos. The meeting memos were ordered chronologically, carefully read through twice and coded manually as were the transcribed interviews. Based on the memos I was able to reconstruct the backbone of the smart floor biography (e.g. key events, the evolution of the artefact, project participants, the methods of co-design that were used).

I coded the segments of text from the meeting memos and transcribed interviews into the following categories related to my research questions: who participated in the project, how the participant network evolved during the project, the interests and goals of different stakeholder groups, the kinds of tensions and conflicts present in the collaboration, the kinds of tools and methods used to transfer knowledge between different stakeholder groups, how the artefact evolved during the project and how the collaboration shaped the evolving artefact. The categories were not imposed a priori upon the data, although theoretical literature, especially in the field of STS, inevitably guided my understanding of the phenomenon and observations that I made from the data.

The picture that was formed based on the meeting memos was critically evaluated against the information gathered through the interviews. The interviews revealed the importance of certain key events and themes to the participants, especially with respect to tensions and conflicts. The interviews also played a key role in shedding light on the developer’s perspective as the meeting memos were written by the project workers and mostly reflected user-side interpretations and concerns.

As a result of the analysis, the biography of the living lab project was written out in Finnish (see Hakkarainen, 2013) and the key informants were given an opportunity to read and comment on it. The result of this biographical analysis can thus be seen as a “master narrative” with respect to the articles of the dissertation.

Triangulation

The study seeks to demonstrate how the technology, relationships around it and practices of different stakeholder groups evolved during and after the four-year living lab project.

Data and method triangulation (Denzin, 1979) has been widely used in BoAP studies and innovation studies more generally as different data types and sites of data collection frame the phenomenon differently. Flick (2014: 184) defines triangulation as taking "different perspectives on an issue under study or – more generally speaking – answering research questions." These perspectives can be founded on several methods, several types of data and/or several theoretical approaches which are compatible with each other.

Combining different methods and data is common in the study of innovation processes, which are slowly maturing social processes that continue over several years and which are polyphonic and contradictory by nature (Miettinen, 1993). The biography of an innovation is a construction that has been shaped by the kind of data used, theories that have informed the questions asked and the way the data has been analyzed, as well as by the temporal, personal and material resources available to the researcher.

> The reliability of analysts' interpretation is improved through two mechanisms. First, through studying different actors across several interlinked sites and comparing juxtaposed accounts, otherwise taken-for-granted features and local framing effects can be unpicked and balanced accounts of interaction created. Moreover, second, the extended scope of study tends to level out particular actor concerns or "displays put on for the ethnographer" when one enters the site over a sustained period. (Hyysalo, Pollock, and Williams, forthcoming)

From these grounds and by following the tradition of historical case studies in STS (see subchapter 3.1), the biography of the smart floor has been reconstructed by using methods of historiographic research and data triangulation (Denzin, 1989; Flick, 2016: 182–192).

When studying and reconstructing historical events, we should utilize and combine different kinds of data in order to minimize distortion (Elton, 2002). Miettinen (1993) recommends the historical approach in the study of innovation as it makes the different interests and motives of stakeholders visible and helps in understanding how local practices resist change; it also helps in creating hypotheses about the future. A problem with the retrospective approach is that the current situation influences the assessment of past events and the events of the past are only partially reconstructed (Flick, 2014: 126). This limitation can be lessened by the triangulation of data and methods.

Next I will describe how the research was carried out in the individual articles.

Methods and Analysis by Article

In articles 2–4 a second level of analysis was performed. This means that the smart floor master narrative was reanalyzed by focusing on the actions of a particular stakeholder group (article 2), by comparing two cases (article 3) or by performing a cross-case comparison where the smart floor was one of many cases (article 4). Next I will go through the methodological choices and further analysis made in each of the articles, as elaborated in them.

Article 1. How Do We Keep the Living Laboratory Alive?

The first article (Hakkarainen, 2013) provides an overview of the results of my licentiate thesis and focuses on user involvement, learning and interaction between participants.

The research questions of the study were: What kind of learning took place between participants? What were the challenges in achieving this learning? How were these challenges overcome? The data and analysis of the paper are described in the current and previous subchapters.

Article 2. The Evolution of Intermediary Activities

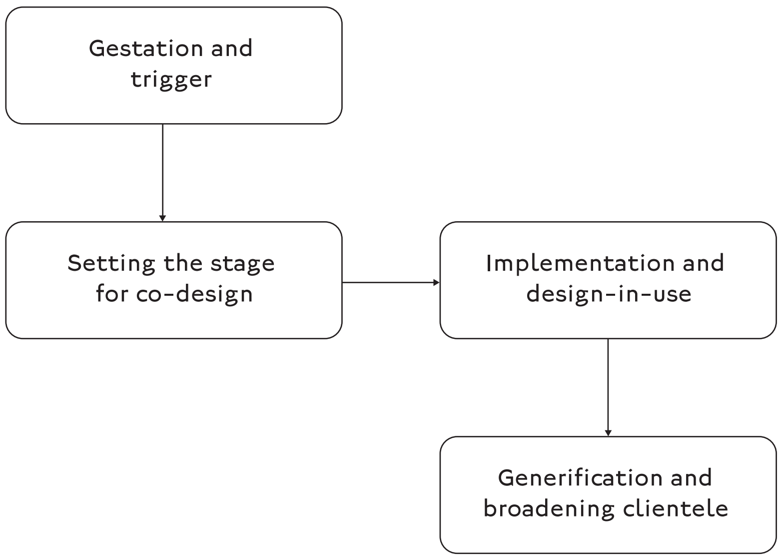
The second article (Hakkarainen and Hyysalo, 2016) concentrates on the role, tasks and activities of individual user-side innovation intermediaries, in this case the project workers in the living lab project. The developer company hired the key project worker, so the analysis is extended to the time after the market launch of the product.

The data covers almost eight years of the biography of the smart floor. The article continues analysis that began in my licentiate thesis (Hakkarainen, 2013) and continued in my first two articles (see Hakkarainen and Hyysalo, 2013; Hyysalo and Hakkarainen, 2014). The data of the study consists of the data set described previously. The unit of analysis were the work tasks of the living lab project workers.

> By task, we mean an organized set of actions that can be either a one-time effort or a repeated pattern in the practices of the mediating personnel – in any case, a set of actions that formed a mutually recognized whole by both the mediating personnel and their colleagues (Hakkarainen and Hyysalo, 2016: 49, citing Strauss, 1993).

The tasks were coded from a detailed project description (in other words the “master narrative”) and from follow-up interview notes. The smart floor innovation process was divided in four phases based on process dynamics observed in my licentiate study (Hakkarainen, 2013) and findings from previous empirical research on innovation processes by Van de Ven, Polley, Garud et al. (1999) and Pollock and Williams (2008) (see figure 5).

Figure 5. The phases of the innovation process



Altogether 31 tasks were identified and reorganized under 13 different higher-level activities and ordered chronologically. The results were organized in a matrix that shows how the activities and tasks were spread in the different phases of the innovation process and evolved over time (see table 3). In the final step of the analysis, the tasks were divided according to facilitating, configuring and brokering (Stewart and Hyysalo, 2008) in order to see if there were changes in the broader-level orientation of the intermediaries in the course of the innovation project.

Table 3. The evolution of intermediary tasks and activities in different phases

Activity	Task	1	2	3
Techinical tinkering	Diagnosing and fixing bugs with the engineers	C	C	C
	Taking part in the installation and testing	C		C
	Documentation of technical problems and false alarms with the users		C/F	
Co-designing	Defining preliminary user requirements with the users	C		
	Formulating project plan and choosing methods of collaboration	C/B	C/B	
	Documenting the co-desing process	F	F	
	Collecting, filtering and transfering end-users' ideas to the developers		B	B
	Coming up with development ideas and evaluating them with the users		C/F	C/F
User research	Studying the users, their work and context of use	F	F	
	Observing use and spotting usability problems		F	F
Advocating	Communicating the user perspective to the developers	B	B	B
	Pressuring the developers to realize users' wishes	B	B	
Developing work practices	Developing new work practices which the system supports		C	C
User training	Creating and carrying out a training program for the users		F	F
	Assessing the need for user training			F
Carryiong out implementation	Making and carrying out an implementation plan		C	
	Supporting users during the implementation phase		F	
	Monitoring the use of the system			C/F
Developing uses	Discovering optimal ways to use the system with the users		C/F	
	Defining codes of conduct for problematic situations with the users		C	
	Encouraging the users to actively discover new ways to utilize the system		F	
Studying effectiveness	Planning and carrying out studies to assess the effectiveness of the system		F/B	
	Documenting the benefits of the system with the users		F/B	
	Evaluating how the system affects the residents with the users		F/B	
Negotiating	Recognising and mediating interests of different stakeholder groups		B	
	Pushing the end-users and mid-managers to use the system		B	B
	Building trust with the users		B	B
Networking	Negotiating finance and partners for the R&D activities			B
Marketing and sales	Demonstrating the system to potential customers		B	B
	Taking part in sales negotiations			B
Customer service	Receiving and resolving customer concerns		B	B

1 = Setting the stage for co-design; 2 = Implementation and design-in-use; 3 = After the Living Lab project; C = Configuration; F = Facilitation; B = Brokering

Article 3. What Difference Does a Living Lab Make?

The third article (Hyysalo and Hakkarainen, 2014) is a comparison between two biographies of health technology innovations (see Hyysalo, 2004 and Hakkarainen, 2013). The floor monitoring innovation – the smart floor – was developed in a living lab setting whereas the other innovation – a wrist monitoring system – was not. Through this comparison the study seeks to distil the benefits and added value of the living lab approach. The key events and interactions in the biographic narratives were coded and compared against each other (see table 6, parts 1–5). In the coding phase, the principles of the innovation journey event mapping technique of Van de Ven, Polley, Garud et al. (1999) were loosely followed. Key ideas, key outcomes, changes in people or technology, key interactions between designers and users, and issues about markets and the contexts of the two innovations were mapped and then compared. Both authors read the detailed case descriptions and then sought to identify the factors to be compared. After the initial mappings, 69 key points for comparison were identified. These could be consolidated into 52 points of comparison that were directly relevant for understanding the role of the living lab for designer–user relations. Data-based discussion between the authors was then used to evaluate the degree of difference or resemblance of each event.

Table 4. Resemblances and differences between floor monitoring and wrist monitoring cases (parts 1–5)

1. The initiation stage

Item	Note	Floor Monitoring	Wrist Monitoring	Assessment
1. The starting point, based in engineering (context, people)		A university spin-off from signal processing engineering	Founding engineers with safety alarm device history	Significant resemblance
2. There is encouragement for innovation from elderly care actors (ideas, interaction)		Informal contacts with elderly care is highly positive	Informal contacts with elderly care is highly positive	Significant resemblance
3. The viability of the idea (interaction)		There is encouragement from elderly care actors	The developers' assessment; market studies	Significant difference
4. The developers' implicit idea of users (interaction)		A fall detector for readily awaiting care personnel	An alarm for readily awaiting caregivers about the movements of the elderly and attacks of illness	Significant resemblance
5. Explicit market or user research done before pilot use (ideas)	The WM developers did not alter their design in any way before version 2.0	None	Two studies on European markets	Moderate difference
6. Early energy is targeted to technical development (basic mechanics, electronics, and algorithms (technology)	WM development took considerably longer	Floor monitoring and its interface: a year-long pre-living lab; 3 more years in a living lab to reach the stable version 2.0	Proactive and fast response alarms and interfaces: 6 years pre-launch; 3 more years after launch to reach the stable version 2.0	Moderate resemblance
7. Changes in key technical components (technology)		None	Several	Moderate difference
8. Tight funding (context)		Small research and development grants	The founder's own assets	Moderate resemblance
9. The developers thought they had created a "ready" product in the lab (ideas)	The customer relationship is in place	Sales agreements with a few institutions prior to the Living Lab; the Living Lab agreement was originally to develop applications for a ready product	Sold to a few users and institutions prior to pilots	Moderate difference
10. There is user-side funding prior to pilots (context, interaction)		Some funds for the Living Lab collaboration are used in technical development	None	Significant difference
11. Target market (market)	In the case of wrist monitoring, private home use dominated the early version but institutional use dominated later	Elderly care institutions	Elderly care institutions	Moderate resemblance

Item	Floor Monitoring	Wrist Monitoring	Assessment
12. There is continued technology development during pilot use (technology, outcome)	In the Living Lab, where the original aim of the user collaboration was to test technology and to develop care practices, but technology development became a priority	First during short pilot use, then with a small number of paying (pilot) customers	Significant difference
13. Unneeded technical sophistication is reduced (technology, outcome)	Nurses simply visit the room, no need for remote viewing	Proactive alarms are not reliably attainable and not needed; visiting residents regularly	Significant resemblance
14. Unexpected uses (ideas)	User interface floor plan functionality is used for retrospective assessment of incidents instead of remote viewing	An activity curve is appropriated for determining the shape of the resident and for retrospective assessment	Significant resemblance
15. Unexpected variety in users' conditions and behaviours (ideas)	Falls had greater variety than was technically prepared for: inaccurate algorithms	Fluctuations in the condition of the elderly were greater than prepared for: inaccurate algorithms	Significant resemblance
16. The elderly were in a much weaker condition and in need of more assistance than expected by the developers; nurses are the primary users (ideas)			Significant resemblance
17. Unexpected integration to nursing work is needed (ideas, technology, outcome)	Alarm reception, routing, handling, prioritization and responsibilities were significant and complex and led to redesign of the interface and working principles of the systems		Significant resemblance
18. Unexpected integration with other equipment (ideas, technology, outcome)	Redesigned to fit in with extant software, nurse call system, PCs, cell phones, fire alarms, flooring, wiring etc.	Redesigned to fit in with extant software, PCs, cell phones, fire alarms and the alarm centre's software	Significant resemblance
19. The need to invest in a network and software (technology, outcome)	The integration of a Linux-based system to city networks is too big a safety risk	Extant safety phone software could not handle the new alarms	Significant resemblance
20. Unexpected contextual problems (technology, ideas)	For example, no holes were allowed for wires in walls due to fire safety	For example, receiver unit signals were interfered with by elevators or thick walls	Significant resemblance
21. Unexpected user behaviours (people, technology)	For example, false alarms due to nurses leaving laundry piles on the floor	For example, insulating the wrist monitoring unit with cotton by wearing it on top of a sleeve or wearing the wrist device in the shower	Significant resemblance
22. Installation and repair costs are higher than expected and hamper internationalization (technology, market)			Significant resemblance

3. Early developer-user collaboration

Note	Item	Floor Monitoring	Wrist Monitoring	Comparison
	23. Both users and developers expected the product to be more or less ready at the deployment and expected the work to focus on the development of new care practices (technology)			Significant resemblance
	24. Collaboration agreement and plan (interaction)	The Living Lab collaboration agreement and loose project plan	A vague agreement about testing and piloting taking place	Significant difference
	25. Local/generic tension (technology, interaction, market): The users wanted local and quick tailoring whereas the developers wanted to create generic and profitable product			Significant resemblance
	26. Pilot costs and work effort are shared (context, interaction)	Funding and workforce are available from the elderly care side	Purchases from elder care Workforce time used	Moderate difference
WM struggled longer than expected to achieve reliability	27. Pilot use leads to a new design aim: getting the technology to work reliably (technology, outcome)	Achieving reliability dragged on for 2 years, blended with other aims; users' efforts are key inachieving it	Achieving reliability dragged on for 6 years, blended with other aims; users' efforts are key inachieving it	Moderate resemblance
	28. The initial user interface is very difficult to use (technology, outcome)			Significant resemblance
	29. False alarms and missed accidents frustrate nurses and the elderly, particularly at night-time and during treatment tasks (technology, outcome, people)			Significant resemblance
	30. The developers are perceived as arrogant in the face of user problems and the risks posed by the technology (interaction)			Significant resemblance
The FM company was forced to take users' requests seriously sooner	31. Elderly care actors' reactions to the dissatisfaction with the system and the developer company (interaction, outcome)	Wishes turn to requests, heavy pressure and refusal to proceed with wider implementation	Wishes are expressed; some pressure; patience is required; some collaborations end	Significant resemblance
n FM, users bear the pressure too	32. Mediating personnel quit (interaction, outcome)	Many of the user-side project workers quit as well as the company CEO	Five company employees who are responsible for mediating the developers quit during five-year period	Moderate resemblance

Note	Floor Monitoring	Wrist Monitoring	Assessment
	33. Version 2.0 fits nursing work and the context better and allows more tailoring to individual users (technology, outcome)		
WM version 2.0 takes longer to emerge	Version 2.0, a year after first implementation	Version 2.0, four years after first implementation	Significant resemblance
In the FM case the Living Lab project workers were care professionals by education	34. No formal or neutral outside facilitator for collaboration: no resources; it is not perceived as needed by any party (interaction)		Significant resemblance
	35. A user-side innovation intermediary emerges (interaction)		
The key person resides on a different side; in the WM case the collaboration works best when both sides have motivated and experienced persons	The Living Lab project hired a new user-side project coordinator who finds a way to successfully mediate between the users and the company	The company hires a new product manager who integrates the installation, training, troubleshooting and refining of design requests	Moderate resemblance
	36. A well-functioning form of collaboration develops (interaction)		
	There is active problem and idea seeking; observations and problem sheets; regular meetings		Significant resemblance
	37. The use of the system is made mandatory by a management decision (interaction)		
FM is more strictly mandated	Non-use is declared mistreatment by the care workers	The price of the wrist device is included in all rents	Moderate resemblance
	38. Giving feedback about the system is made mandatory for the care workers (interaction)		
	Giving feedback is made mandatory for the care workers	Giving feedback is not made mandatory for the care workers	Significant difference
	39. Panopticon issues: monitoring renders elderly and care personnel's doings more visible		
	Management endorses the technology; users adapt it (technology, people)		Significant resemblance
	40. Night panopticon's key benefit: no need to check residents by opening doors (technology, outcome, ideas)		Significant resemblance
	41. Users ideate the new key value points (technology, ideas)		
	Anticipation of falls and just-in-time care is initiated by users	The activity curve is creatively appropriated and developed into a diagnostic and proactive tool	Moderate resemblance
	42. The importance of reliability is agreed and emphasized by both parties (technology, interaction)		Significant resemblance
	43. Both technologies end up with similar end benefits despite different early aims (ideas, market, outcome)		
	Detection, anticipation and help with falls and worsening conditions; support for the night shift; allowing a natural day rhythm for the residents		Moderate resemblance

Floor Monitoring	Wrist Monitoring	Resemblance
44. The rapid gaining of a customer base of a few hundred installations (market, outcome)		Significant resemblance
45. Most sales are in new eldercare institutions due to the floor monitoring system's installation under the flooring and public sector purchase logic (technology, market)		Moderate resemblance
46. Profitable operation is a challenge; there are further development needs (market, technology, outcome)		Significant resemblance
47. The required funding leads to ownership changes (context, outcome)		Significant resemblance
48. There is further redesign and further configurabilityof the product (technology, outcome)		Significant resemblance
49. There are unexpected contextual technical differences in other settings (technology, ideas)		
For example, the higher humidity of cement in new buildings interferes with the algorithms	For example, differences in how alarms are routed and receiver unit coverage	Significant resemblance
50. Higher than expected local configurability is needed (technology, ideas)		Moderate resemblance
51. There is to and fro between localization and a generic offering (technology, market, outcome)		
Localization is decided upon and then the decision is reversed, several times		Significant resemblance
52. New product versions are made (technology, market, outcome)		
There are new ways of installing floor monitoring; new generations of wrist monitoring; and the product is segmented into institutional and home versions		Significant resemblance

Article 4. Diversity and Change of User-Driven Innovation Modes in Companies

The fourth article (Hyysalo, Repo, Timonen et al., 2016) is based on analysis of 58 case descriptions of user-driven innovations (UDIs) in Finnish companies. The analysis seeks to grasp the diversity of UDI practices and their evolution over time on a more general level. We identified five main modes of UDI (see table 7) and categorized the case descriptions to see whether and how they feature diversity and change in their dominant mode of developer–user configurations over time.

We employed a two-phase research strategy: first a case-by-case analysis and then a comparison across case descriptions. Our original dataset consisted of 80 qualitative case descriptions of innovation processes, which were examined project by project, focusing on what kind of interaction between developers and users took place in different stages of the innovation process.

In the data gathering phase, we allowed the case companies themselves to describe how and where a product development process started, what events took place, what kind of collaborations were part of the process and how the process ended, without presuming or imposing a model or stages by which this should have happened. This approach allowed for detailed accounting of non-technical product development – such as service concepts, business models, and new products comprising of the features of existing products. The data collection intensity and methods varied among the cases. At the maximal end of intensity, case companies and their user sites were observed over several years, combining tens of interviews with ethnographic observation and analysis of documents; the smart floor project provides good representation of these deeper cases. At minimum, we started off from a publicly available project and product descriptions and then carried out narrative interviews with company representatives.

In the interviews, a chronological frame for actions occurring during product development was construed, as well as documentation of whether any engagement with users took place and, if so, how it took place. The resulting descriptions represented the chain of what took place from the beginning of the innovation process to the end and commercialization.

In the analysis phase, the first four authors assessed the user drivenness of 80 case descriptions of UDI in Finland. The authors had researched and written the large majority of the cases. Next the assessments were compared and 58 cases were selected as passing the criteria for representing UDI in companies by all four authors.

Next we classified the type of UDI evident at each stage in terms of the five modes (see table 7). This was done to analyze both variety among cases and possible changes in the dominant mode of UDI within each case. The four authors independently coded each of the 58 cases according to five modes representing UDI. Each coding began from the starting point of the identified UDI process and further codes were added if such major changes were observed in the developer-user configurations over time that the dominant configuration between developers and users had clearly changed. After each of the four authors had independently coded all cases, we set up a number of meetings to compare the codings, which were mostly uniform. In six instances coding by one of the authors differed from that of the others and so we revisited the original case description and carried out extended discussions with the author who had written or become familiar with the original case description. In two cases a majority vote of 3:1 was used to determine the coding between two alternative ways to mark a transition; in all others instances agreement was reached after revisiting the data.

Table 5. Modes of UDI used in the analyses of the fourth article

Mode	Rationale	How generated	How stored and accumulated	How used	Examples in research
User Inspiration for Design	Designers have user benefits as core of their work	Intuition, own experience, and/or encounters with users, secondary sources	Typically, no systematic storing or accumulation apart from product features	As background knowledge to ideate and refine design solutions	Using field observation to tune designers, (lighter forms of) emphatic design
Studies on Use	Gathering knowledge about markets and uses of already established concepts beyond mere market research	A study, research or field experiment on users of an already ideated product	Typically, as a report and in a user requirements template	In setting user requirements, pruning the interface and usability, adding new features, altering some parts of the concept	Concept studies, consumer research, usability studies
User Centred Design	Creating deep understanding of users and their context to ideate and design products	In depth studies on users; Ethnography, interviews, interactive prototyping, etc.	Typically, models of users and contexts, requirement, wireframes, mock-up prototypes	As a source for product ideas and a backdrop to assess viability of concepts	User centred design
User Innovation	Users invent products for themselves	Ideating and building a prototype	As a prototype, in users head, sometimes as requirements	As a starting point for further development	Innovation by users
Design Collaboration	Deep interaction between developers and users helps ideate, refine and test products	In a series of meetings and visits and digital interchanges between parties	As requirement, prototypes, listings, recordings etc.	To ideate, refine and test product	Participatory design, co-design

6. A Summary of the Papers

This chapter presents a summary of the papers. The original research papers are appended at the end of the introductory section.

Article 1. How Do We Keep the Living Laboratory Alive? Learning and Conflicts in Living Lab Collaboration

Living lab environments engage private companies, citizens, researchers and public organizations in mutually beneficial learning. They are experimentation platforms situated in a real-life context. Living labs turn users from passive research subjects to active co-creators of value and allow the simultaneous maturing of an artefact, use practices and the context into which the solution will be integrated. Based on a longitudinal case study of the four-year living lab project carried out in a public nursing home in Finland, the article describes how the relationship between users and developers evolved during the project. The outcome of the collaboration – the smart floor – was the precautionary floor monitoring system, which was a significant evolution from its starting point, the reactive "safety floor". The article describes two major challenges that the project faced: power issues between the project stakeholders and end-user reluctance to participate in the development of the smart floor. The project workers played a crucial role in mediating the conflicts and instilling fruitful collaboration between parties. The study suggests that learning between living lab stakeholders does not take place automatically but requires significant investments from all parties involved. The study draws from science and technology studies, especially the social shaping of technology approach and its further development, the social learning in technological innovation framework.

Article 2.
The Evolution of Intermediary Activities: Broadening the Concept of Facilitation in Living Labs

Living labs can be analysed as innovation intermediaries which bring different stakeholders together. They aim to extend co-design activities from ideation and concept design to design-in-use. Different organisational cultures, professional identities, interests and goals are at play in living lab projects, which is why individual intermediary actors play a crucial role in facilitating learning between stakeholders as well as managing tensions and conflicts of interests. The current living lab literature recognizes the importance of intermediation in living labs but does not shed light on their work a practical level.

The article is based on a longitudinal qualitative study of a four-year living lab project, which was described in the summary of article 1. The article describes the work tasks and broader activities of the project workers who act as user-side innovation intermediaries in the studied living lab project and analyses how these intermediation tasks are distributed across different phases of the innovation process. The smart floor developer company hired the key intermediary after the living lab project, and follow-up interviews were continued in order to cover the time after the market launch, during which the company clientele grew rapidly. Thus, the study covers eight years of the biography of the smart floor.

The study identified altogether 31 different intermediary tasks (e.g. diagnosing and fixing bugs, observing use, documenting the benefits of the system with the users), which were categorized under thirteen higher-level activities (e.g. technical tinkering, user research, studying effectiveness). The tasks were ordered chronologically and divided into the different phases of the innovation process (gestation and trigger; setting the stage for co-design; implementation and design-in-use; and generification and broadening the clientele). The theoretical framework created by Stewart and Hyysalo (2008) was applied to further categorize the tasks into facilitation, configuration and brokering activities.

The study shows how the nature of intermediation work in a living lab consists of a much larger variety of tasks and activities that those traditionally understood as part of "facilitation". In the course of a successful project, the content and form of intermediary work evolves. For this reason it is pivotal for the intermediary actors to be able to identify the needs of the project and to adjust their role and actions to changing circumstances. The article is based on research on social shaping of technology, social learning on technological innovation and innovation intermediaries.

Article 3. What Difference Does a Living Lab Make? Comparing Two Health Technology Innovation Projects

Living labs are open-ended, sustained and complex coproduction arrangements, and their popularity has increased rapidly in recent years. Yet there are very few detailed empirical assessments of the merits of living labs. This is understandable since the previously mentioned characteristics make it very difficult to assess their effects as exploratory projects tend to be affected by tens or even hundreds of significant events and decisions.

This paper presents the findings from a rare opportunity to compare two unusually similar health care innovation projects with one crucial difference: one relied on a living lab and the other did not. The two projects – wrist monitoring for elderly care and a floor monitoring system for elderly care – used similar basic technology, had a technology-driven start-up history, originated in the same city, were targeted at the same users and use contexts, and had both struggled similarly to succeed but are both still up and running.

Both cases were studied using biography of technologies and practices approach, which means executing an in-depth longitudinal case study focusing on the evolution of the technology, as well as on the practices of its developers, users and other relevant stakeholders. The cases were studied by combining different research materials: semi-structured interviews, documents and, in the case of the wrist monitoring study, field observations.

Our hypothesis was that due to the living lab approach the development paths would be strikingly different. Yet this proved not to be the case. Strong similarities appeared when the projects moved from technical development to first deployment at the user site. This led to major redesigns through high levels of frustration and conflicts of interest between the developers and users. In both cases the users were the ones who ideated the new key value points.

The reason for the resemblance seemed to be that the wrist monitoring company had to establish real-world partnering arrangements similar to those of living labs. In both cases interaction and learning between developers and users was paramount for achieving a successful product. As a positive finding regarding the hopes raised by living labs, the floor monitoring living lab project resulted in a stable working product much quicker than did the wrist monitoring project. "Living lab type" long-term co-development in real-life settings appears to be something that health care technology developers may have to engage in anyway, and it thus it makes sense to do so from the onset.

Article 4.
Diversity and Change of User-Driven Innovation Modes in Companies

User-driven innovation (UDI) has gained increasing attention in academic and policy discussions as well as in the innovation practice of companies throughout the 2000s. Yet the definition of UDI has remained somewhat blurry and debated. In addition there is little research on how companies across industries apply UDI and work with users in practice on a more permanent basis. The paper presents findings from a cross-sectional analysis of 58 Finnish cases of UDI. The aim of the study is to understand how different patterns of UDI are distributed over the cases, what kinds of engagements take place between users and developers in companies, and how these engagements evolve over time. The study draws from literature on social shaping of technology and social learning in technological innovation.

Based on the analysis, five main modes of UDI (user inspiration for design; studies on use; UCD; user innovation; design collaboration) are presented and five change sequences (light UDI trials; from intensive to less intensive user relations; user innovation used alone; deepening or sustained collaboration; integrated UDI) that companies can experience after initial experimentation with UDI are identified.

In almost half of the examined cases, the dominant mode of UDI changes at least once and in some cases up to three times. Understanding this diversity of UDI practices and the dynamics of change in UDI modes has implications for innovation management and policy as it highlights the importance of extended management and the support of UDI efforts. For living lab research, the cross-case comparison indicates that the kinds of shifts in the collaboration patterns between developers and users identified in the first three articles are more prevalent features in UDI.

7. Cross-Cutting Contributions

It is crucial for a health technology company to establish well-functioning relationships with end-users (see Miettinen, Hyysalo, Lehenkari et al., 2003). A living lab arrangement is one way to do this. Despite the general fuzziness and ambiguity around the concept, around 400 living lab initiatives have seen the light of day worldwide since the turn of the millennium. Due to the lack of detailed and longitudinal studies of innovations involving living labs, the picture of the realities, dynamics, demands and potential of collaboration in living labs has remained insufficient.

This dissertation has demonstrated that an ambitious living lab collaboration that that takes place in real-life context and where users are considered partners in product development instead of research subjects is a demanding task for all parties involved. It has been well documented that these kinds of design collaborations do not emerge without high levels of frustration as well as time, energy and resources (e.g. Schuler and Namioka, 1993; Bødker, Kensing and Simonsen, 2004). The living lab arrangement is nevertheless justifiable when companies are designing for safety-critical, heavily regulated institutional contexts like those of health care or elderly care, or when designing for users from whom they are separated by a large social distance (Johnson, 2013), that is to say, for users whose characteristics and everyday realities are far away from those of the designers. In fact, it seems that when these characteristics apply, companies have no choice but to build living lab style collaboration arrangements with the end-users in order to succeed (Hyysalo and Hakkarainen, 2014).

Although it is important to note that in the case of consumer products or less complex workplace technologies, lighter forms and methods of collaborative innovation (e.g. user studies, selected human-centred or participatory design methods, user-inspired design) might be sufficient (Hyysalo, Repo, Timonen et al. 2016).

For public sector actors, the living lab offers a possibility to develop new work practices around a prototype and to give direct feedback and ideas to the developer company, which the company can utilize to make the product more valuable for the user. The information about both realized ways to use the system (as opposed to developers' visions and expectations before use) and users' considerations related to the meanings given to the system and its role with respect to their identities are essential in regard to not only product development but also to marketing.

The dissertation contributes to the current theoretical understanding of living lab activities by providing in-depth knowledge of interaction dynamics and their evolution in a living lab project and after it. More specifically the study focuses on processes of learning, tensions between stakeholders, the role of innovation intermediaries in facilitating learning and the patterns of learning found in a living lab project with respect to user-driven innovation (UDI) activities more generally.

Next I will summarize the most important contributions of the dissertation, formulated into design principles for individuals and organizations that are considering entering an intensive living lab collaboration.

7.1 A living lab is not a panacea for information transfer and learning

The study clearly demonstrated that multi-stakeholder learning in a living lab project did not occur automatically. Yet this learning seemed to be crucial for the success of the innovation.

The metaphor of "quadruple helix", often used in living lab literature and marketing, conveys an image of effortless collaboration between users, companies and academia. Based on this study, this is not what practitioners should be prepared for nor something researchers should take for granted, at least not in the case of the design collaboration characterized by living lab "ideals": users as partners, intensive co-design, open-ended exploration and a long time frame.

Perhaps not surprisingly, the realization of multi-stakeholder collaboration is difficult, but what is surprising is that this is not clearly stated in the living lab literature. A large part of living lab research papers describe how collaboration should look like or reduce the description of collaboration dynamics to simplified listings of the project phases and co-design methods used. Additionally depictions of living lab projects and the approach on a more general level have been characterized by authors' overly optimistic and partisan attitudes, which also may have led to downplaying the requirements of the approach. As a result it looks like intensive co-design has become more of an ideal than a realized mode of operation in the living lab field (Følstad, 2008a; Schuurman, 2015).

In the smart floor project, the realization the living lab collaboration required over 90 face-to-face meetings among different assemblies of project stakeholders and the active day-to-day presence of the project workers in the living lab units, especially during the design-in-use phase. Tensions and conflicts between project participants made the collaboration particularly demanding, although these are well documented by participatory design research and a "natural" part of intensive co-design. Project workers' roles as individual user-side innovation intermediaries and the tensions that the project faced are described in more detail in the next sections.

The project workers played a crucial role in the information transfer. They were care professionals by education and not familiar with formal co-design methods. The case showed that a living lab can be executed without this kind of expertise, although it could have helped. On one hand, project workers' position as "members" of the user community had major benefits in gaining the trust of the care workers (see e.g. Hartswood, Procter, Rouncefield et al., 2000; Ogonowski, Ley, Hess et al., 2013), on the other hand knowledge about co-design and facilitation might have eased the conflict between users and developers at the beginning of the project.

It is noteworthy, that in the smart floor case part of the potential of the living lab was lost because the project participants were not prepared for the scale of redesign that the system ended up going through from the onset. The developers assumed that they had created a "ready" product in the lab, but it turned out to be something far from ready when brought in contact with real life. From this starting point the living lab got off to a rocky start, but eventually fruitful ways of collaboration were negotiated and the design-in-use got going.

7.2 Tensions are a natural part of intense design collaboration

The project was divided in two phases: in the first phase the system was tested on two pilot rooms, major bugs were fixed and the rules of the collaboration were outlined. In the second phase the system was implemented and the design-in-use activities were extended to three full units. Both project phases were characterised by struggles between the project stakeholders: power plays between the developers and project workers in the first phase, and user reluctance to use the system and to participate in the co-design activities in the design-in-use phase.

Innovation brings together multiple stakeholder groups with different organizational cultures, professional identities, values, priorities, interests, schedules and goals. Thus controversies are a likely and possibly even desirable (see Björgvinsson, Ehn and Hillgren, 2012; Buur and Larsen, 2010) part of innovation. The living lab approach brings together diverse stakeholders, working on equal ground for an extended period of time. These characteristics can be expected to increase the likelihood of tensions and conflicts – both between stakeholder groups and also within them. At the same time, a living lab is meant to facilitate these conflicts and lead to more satisfactory outcomes for all parties.

In the beginning of the collaboration the care professionals and the engineers had difficulties in reaching a common understanding about the maturity of the prototype and reaching an agreement of the rules of the collaboration. The developers struggled to grasp how demanding it is to integrate an incomplete prototype into a high-dependability context like a nursing home and to put it into use. The project workers and nursing home staff felt that the engineers did not take reliability issues seriously enough, which made the engineers appear indifferent. These facors led to frictions and power plays.

In the second phase of the project, the implementation was extended into three units. At this point, some of the care workers began to boycott the system and the general attitude towards the project among the care workers was negative. Learning to use a complex technological system alongside normal care duties, let alone participating in its development, was unpleasant and laborious task for many. At the end of the day, they were care professionals, not machinists. The care workers were also disappointed that public money is invested in technology development projects when elderly care has to get on with diminishing finances.

Due to this dissatisfaction, the care workers were given a chance to transfer to a non-living lab unit. But if they chose to stay, the use of the system and participation in the co-design activities was obligatory. One care worker seized the opportunity to transfer.

The commitment of the mid-management and project workers daily presence on the units proved crucial for pushing the project through. The project staff played a pivotal role in finally turning divergent interests into complementary ones by building trust between different stakeholder groups including the management and the employees of the user organization.

Questions related to users' motivation for participating in living lab projects have been discussed in several research papers as there seems to be a tendency for users to drop out of living lab projects for numerous reasons (see e.g. Ogonowski, Ley, Hess et al., 2013). Yet the nature of the challenges is quite different when participation is an obligatory part of the work duties in an institutional setting when compared to individual users who participate voluntarily in an everyday-life consumption setting. Conflicts that arise from this kind of configuration are less discussed, yet in the analysis of eight living labs set up in Danish care homes, Kanstrup (2016) reports very similar tensions arising from the dissatisfaction of care workers.

In order to ease and prevent frictions, the living lab participants could chart their priorities, terms and restrictions at the onset of the collaboration. All parties could articulate what issues are difficult to compromise, what they could be flexible about, and how they see the schedule and the maturity of the system. Regular meetings, face-to-face collaboration, active communication with the end-users and capable intermediary actors are essential in handling conflicts.

7.3 Living lab catalyzed learning between users and developers

Living lab research has been persistently criticized for not presenting an empirical assessment of the benefits of the approach (e.g. Schuurman, 2015). To address this question we executed a comparison between two similar and similarly studied monitoring technology innovations for elderly care: the smart floor and the wrist monitoring system. The cases had one crucial difference: the smart floor was co-designed in a four-year living lab project whereas the wrist monitoring system was not.

The comparison revealed that the learning paths between developers and users were surprisingly similar in both cases: the success of the innovations demanded extensive redesign in the pilot phase, motivated by user feedback and information about the realized uses. In practice this meant information about how the care workers ended up utilizing the functionalities of the system, which functionalities they found most valuable and how the systems were integrated with the work processes in the nursing home units. In both cases the envisioned use (by the designers) and the realized use (by the end-users) differed significantly and the key value points of the system eventually came from the users.

Both the smart floor and the wrist monitoring system required an extended learning period for developers and users, and consciously built collaboration arrangements. Also effective boundary spanners and investments in conflict resolution were observed in both cases. Additionally, the amount of work required to get the monitoring technology to work reliably in a real-life context was much higher than expected by the developer company or by the public sector actors in both cases.

The most important difference between the cases was the speed with which the necessary learning challenges were faced and solved. Based on the comparison it looks like the living lab sped up this process. The wrist monitoring company, which did not use the living lab approach, had to build living lab-like collaboration arrangements with the users after the market launch of the product. In spite of marketing studies and prior user research carried out in the concept design phase, the company had to acquire a profound understanding of the everyday realities and procedures of the elderly care institutions. This was not possible before the system was implemented and put to use. As a result, the wrist care system went through very similar alterations to those of the smart floor during the living lab project. But without the formal living lab arrangement, the process took longer and caused strain in the early customer relationships.

The rationale for living labs, particularly in the health care sector, thus finds empirical support in the analysis of this dissertation, as does the capability of living labs to deliver positive outcomes in a collaboration – as long as we remember that the results are not automatic and require the efforts identified by the study.

7.4 The living lab collaboration guided the company in refocusing

The extended four-year design collaboration with the users offered multiple benefits for the developer company: most importantly it managed to refocus the smart floor's value promise before the market launch. During the living lab project many of the developers' original implicit ideas of users' behaviour, needs and the context of use proved to be mistaken. The operating idea of the smart floor evolved from a simple fall alarm to a precautionary nursing tool. The final version of the smart floor – a technology that informs care workers of situations where there is a risk of falling down as well as actualized falls, instead of only alerting them about actualized falls – had much more value for the users than the original prototype developed in the university laboratory.

The developer company gained a better understanding of which system functionalities were the most valuable for the users and in which situations. For example the system was most useful during the night-time: since the smart floor would sound an alert for the nurse if someone woke up, the night nurse was able to stop the routine checks that bothered residents' sleep. Users utilized the affordances of the prototype in unexpected ways, and these uses were supported in the next iterations of the system. The floor plan functionality of the user interface did not prove to be useful for the care workers in the way anticipated by the developers, but it allowed the care workers to study the information about residents' movements retrospectively after an accident in order to prevent new ones.

The system faced several contextual challenges that were difficult to predict before the implementation in a real-life context. These began with installation, which was severely complicated by the fire regulations. Getting the system to work reliably in the nursing home took considerably more time than anticipated by the engineers as well as the users: the falls of elderly people had for example a larger variety than expected by the developers, which required laborious changes to the algorithm. A significant effort by all parties was made to fix a myriad of technical problems and bugs. The care workers documented carefully all the mistakes the system made during their daily duties (false alarms, the lack of an alarm, double messages etc.) by filling in a form in which they provided details about the situation where the problem occurred.

The care workers also documented situations in which the system turned out to be useful. Also more formal effectiveness research was carried out, and the results were later utilized in the marketing of the system. Mappings of the benefits of the system provided the company, as well as the public sector actors, with important information about the value of monitoring technology in a nursing home context.

7.5 Skilful and active intermediation is a crucial part of a living lab collaboration

A growing number of studies highlight the importance of mediating actors in keeping the living lab network together and supporting the users in their struggle to integrate an unfinished prototype into their everyday life (e.g. Kanstrup, 2016), but to my knowledge, detailed empirical assessments of intermediary work in living labs are still missing. Nyström, Leminen, Westerlund et al. (2014) identified the actor roles specific to living labs, but such abstract role listings have a limited capacity to cater for living lab practitioners. This qualitative longitudinal case study of a living lab collaboration suggests that the significance of intermediaries and intermediary work in living labs is a more important and multifaceted phenomenon than was previously understood. Mere "facilitation" is not enough to describe their share in the equation.

The intermediation work in this living lab case consisted of thirteen higher-level activities, which included 31 different tasks. These tasks changed in different phases of the project. Project workers were responsible for configuring technology and use practices, and brokering contacts and interactions between different actors, as well as facilitating work, learning and collaboration.

The innovation project management made a particular strategic choice in the planning phase with regard to the recruitment of the project personnel: all the project workers hired to manage the living lab activities had a background in nursing. This choice had clear advantages: for example, the intermediaries did not need to learn the elderly care work practices and working culture from scratch and their background helped them to gain the trust of not only the care workers but also the developers. On the other hand, at the beginning of the collaboration the absence of a "neutral" middleman, that is to say, for example a service design consultant, possibly exacerbated the conflict between developers and the user organization.

Although the use of formal co-design methods might have made the collaboration more pleasant and efficient at times, the case demonstrated that management of a living lab project is possible even without this kind of expertise. With respect to information transfer, information about the work processes and user context remained mostly tacit and embodied as, because of the project workers' background, there was no need to write it out. Maybe partly because of this, the developer company decided to hire the key project worker when the project finished. A user-side innovation intermediary was obviously a critical link between the users and the company.

Characteristics that proved especially valuable for the intermediary actors, in other words the project workers, were sensitivity towards the needs and concerns of different stakeholder groups as well as the needs of the project; the ability to actively and independently adjust their role to changing circumstances; methodological creativity with respect to co-design practices; the ability to build trust with and between different stakeholder groups; negotiation skills; and the ability to convince different stakeholder groups of each other's good intentions. The head of the innovation undertaking admitted that it took some time to figure out what kind of persons were apt for the job, and the right employees were found after the resignation of the first project workers.

The original objectives of the project were technology testing and the development of new care practices, but as demanding design-in-use activities became a priority, the requirements for the intermediaries changed.

Table 6. The intermediary tasks and activities in different phases of the living lab project and after it

Setting the stage for co-design

Activity	Task
Technical tinkering	Diagnosing and fixing bugs with the engineers (C) Taking part in the installation and testing (C)
Co-designing	Defining preliminary user requirements with the users (C) Defining preliminary user requirements with the users (C) Formulating project plan and choosing methods of collaboration (C/B)
User research	Studying the users, their work and context of use (B)
Advocating	Communicating the user perspective to the developers (B) Pressuring the developers to realize users' wishes B)

Implementation and design-in-use

Activity	Task
Techinical tinkering	Diagnosing and fixing bugs with the engineers (C) Documentation of technical problems and false alarms with the users (C/F)
Co-designing	Formulating project plan and choosing methods of collaboration (C/B) Documenting the co-desing process (F) Collecting, filtering and transfering end-users' ideas to the developers (B) Coming up with development ideas and evaluating them with the users (C/F)
User research	Studying the users, their work and context of use (F) Observing use and spotting usability problems (F)
Advocating	Communicating the user perspective to the developers (B) Pressuring the developers to realize users' wishes (B)
Developing work practices	Developing new work practices which the system supports (C)
User training	Creating and carrying out a training program for the users (F)
Carryiong out implementation	Making and carrying out an implementation plan (C) Supporting users during the implementation phase (F)
Developing uses	Discovering optimal ways to use the system with the users (C/F) Defining codes of conduct for problematic situations with the users (C) Encouraging the users to actively discover new ways to utilize the system (F)
Studying effectiveness	Planning and carrying out studies to assess the effectiveness of the system (F/B) Documenting the benefits of the system with the users (F/B) Evaluating how the system affects the residents with the users (F/B)
Negotiating	Recognising and mediating interests of different stakeholder groups (B) Pushing the end-users and mid-managers to use the system (B) Building trust with the users (B)
Marketing and sales	Demonstrating the system to potential customers (B)
Customer service	Receiving and resolving customer concerns (B)

After the living lab project

Activity	Task
Techinical tinkering	Diagnosing and fixing bugs with the engineers (C) Taking part in the installation and testing (C)
Co-designing	Collecting, filtering and transfering end-users' ideas to the developers (B) Coming up with development ideas and evaluating them with the users (C/F)
User research	Observing use and spotting usability problems (F)
Advocating	Communicating the user perspective to the developers (B)
Developing work practices	Developing new work practices which the system supports (C)
User training	Creating and carrying out a training program for the users (F) Assessing the need for user training (F) Monitoring the use of the system (C/F)
Negotiating	Pushing the end-users and mid-managers to use the system (B) Building trust with the users (B)
Networking	Negotiating finance and partners for the R&D activities (B)
Marketing and sales	Demonstrating the system to potential customers (B) Taking part in sales negotiations (B)
Customer service	Receiving and resolving customer concerns (B)

C = Configuration; F = Facilitation; B = Brokering

7.6 User-developer learning after the market launch

The mode of UDI in the smart floor case changed from the initial phase of developer-centred work into an intensive four-year design collaboration with the users in a living lab environment. After the market launch, when the customer base expanded, the company adopted a lighter, company-controlled mode of user engagement. A clear change in user-developer relations happened when the initial product was "ready" and the company began to target larger markets and more diverse user groups. In our analysis of 58 cases of UDI in Finnish companies, the smart floor case represented a pattern of learning that can be characterised as either a **shift to a lighter UDI mode** or **withdrawal from UDI** upon commercialisation and market launch. In these types of cases, after market launch of the product intensive design collaboration with users either changed to "arm's-length" relationships or it was discontinued altogether. Pollock and Williams (2008) call this development path "generification", during which particular user inputs are converted into generic products for a more diverse user base. These cases can begin with any of the more intensive user involvement modes (design collaboration; user innovation; UCD) and feature several alternative change sequences.

The cross-case comparison demonstrated how diversity and change are evidently part of UDI practices in companies and how different modes of UDI have different implications for companies. For example, UCD and studies on use seem to produce results that the companies do not seek to complement with other modes of UDI. The analysis indicates that companies navigate and improvise their modes of engagement with users amidst other development priorities rather than being advocates of this or that UDI mode. The maturing of user engagements does not take place automatically and when it does, it does not necessarily follow clearly defined steps. Finally it seems like there are factors hindering the commercialization of user innovations and possible discrepancies between these solutions and the preferences of the rest of the market.

With respect to making generalizations from the living lab collaboration, it is important to bear in mind that among the studied UDI cases, even the largest number of cases in our sample can be only characterized as **light UDI trials**. These projects relied on studies on users or user-inspired design, or a combination of these two, which in practice could mean non-mainstream market research or design-empathy dominated trials. This type of UDI might contribute new design features but does not fundamentally question or change the product or service offering. This is a rather different mode of working than a living lab collaboration, which is intense from the outset. Another significant group of cases can be described as **deepening collaboration** or **in-depth collaboration** as they are characterized by a move towards deeper collaboration. In these cases UDI becomes an integrated part of the company's operations. Change paths in this group can be shifts from user innovation to design collaboration or from UCD to design collaboration, or they can stay as a continuing design collaboration. A small number of cases remained in the **user innovation** mode, which suggests that user innovation might be insufficient for companies in the creation of commercial market offerings, unless they have a specific niche market in mind. The final group of only two cases represent cases where UDI and in-depth collaboration with the users has become an **integrated part of the company repertoire**. Both cases include established companies where in-depth UDI projects and collaborative projects with academia have become legitimate ways of working.

The cross-case analysis demonstrated that companies creatively find and change ways of collaborating with users and that living lab-style intensive design collaboration is not needed or even recommended in all situations. In the case of consumer products, lighter modes of UDI might be enough, but, as the previous research (Miettinen, Hyysalo, Lehenkari et al., 2003) points out, intensive learning between developers and users seems to be a prerequisite for success in the field of health and social care innovations.

7.7 Generalizing from the findings

When making generalizations based on the findings of this dissertation there are several facets and circumstances to keep in mind: first of all, as previously stated, living labs come in a great variety of shapes and sizes and thus the findings of this work mostly apply to cases which Schuurman (2015) describes as the "European" living labs, that is to say to labs where the scale is relatively small and the emphasis is on co-design rather than testing. More than that, it is wise to acknowledge that when the users form a (professional) community the challenges are very different in nature compared to situation where the users are individual consumers. Thus similar process characteristics might be found in other innovation projects where workplace technologies are developed. Further consideration should be paid to the characteristics of health and social care institutions: they are hierarchical, safety critical, highly regulated contexts dominated by female employees. The management's decision to make participation in the living lab activities non-voluntary for the users[12] would be difficult to imagine if the living lab project had taken place in a different type of organization, as would be the specific reaction from the users: they boycotted the system. Complex elderly care technologies also evoke (often justified) criticism, scepticism and moral considerations on an individual level and also a societal level, which certainly influenced the depth of the care workers' dissatisfaction. Highly similar challenges and reactions were observed in eight Danish care home living labs (Kanstrup, 2016), although in the Danish case the lack of capable intermediary actors hindered the realization of user-developer learning.

Another factor that should be kept in mind is the enabler-driven (Leminen, Westerlund and Nyström, 2012) character of the case described in this study, which in practice meant that public sector actors, in other words the user side of the project, applied for the funding and because of this had at least as good a negotiation position as those of the developer company or the academy side in the collaboration. Thus the findings related to power games between participants are generalizable to cases where living lab participants collaborate from (close to) equal grounds.

Additionally, it should be noted one more time that the demanding living lab project was justified as the smart floor was a novel technological system, but in case of more incremental development projects, less laborious co-design or user research methods might be more fruitful.

As a result, it is safe to say that intense living lab collaboration is not recommended in all situations and all innovation projects. But in cases where developers struggle to grasp and evaluate what is relevant information about the users, their practices and context of use, intense design collaboration offers clear benefits.

[12] The care workers were given the possibility to transfer to a non-living lab unit, but if they chose to stay, participation was obligatory. One care worker used this option.

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Original Research Papers

Technology Innovation Management Review December 2013

How Do We Keep the Living Laboratory Alive? Learning and Conflicts in Living Lab Collaboration

Louna Hakkarainen and Sampsa Hyysalo

> *To understand the dynamics of interactive learning or knowledge creation, we need to study interaction between people: what was learned, how, by whom, and at what level of work and organization.*
>
> Reijo Miettinen (2002; tinyurl.com/ls3rgg5)
> Professor of Adult Education

Living lab environments are often promoted as a way to engage private companies, citizens, researchers, and public organizations in mutually beneficial learning. Based on an in-depth case study of a four-year living lab collaboration in gerontechnology, we agree that successful living lab development hinges on learning between the parties, yet its emergence cannot be presumed or taken for granted. Diverse competences and interests of participating actors often make technology development projects complicated and volatile. The study describes two specific challenges faced in a living lab project: i) power issues between the actors and ii) end-user reluctance to participate in the development of new technology. Despite the hardships, we suggest that the living lab environment worked as a catalyst for learning between users and developers. Nevertheless, realizing the benefits of this learning may be more challenging than is usually expected. Learning for interaction is needed before effective learning in interaction is possible.

Introduction

A living lab turns users from observed subjects to active co-creators of value, ideas, and innovative concepts – it is not only a testbed (McPhee et al., 2012; timreview.ca/article/601). It gives an opportunity to embed complex product ideas and prototypes within an environment that closely resembles the context of the product in real-life (Pierson and Lievens, 2005; tinyurl.com/9t9sylo). This opportunity, in turn, can stimulate interactions, create institutional support for innovation, and reduce innovation failures (Pierson and Lievens, 2005; tinyurl.com/9t9sylo).

Previous research further suggests that a living lab methodology helps in developing more context-specific insights on development and acceptance processes, and the interaction between them especially. Living lab experiments inform us about requirements of the embedding of technology in society, and they illustrate the potential societal impacts of innovation (Ballon et al., 2005; tinyurl.com/8hox58r). Almirall and Wareham (2008; tinyurl.com/8vwtjw2) posit that living labs offer governance and structure to user contributions; help the sensing of user insights; provide solutions to the filtering problem; create societal involvement; and can be used to promote user entrepreneurship. The living lab is seen to institutionalize the meeting place for all organizations involved, and integrate and synthesize the human, social, economic, and technological processes of innovation (Niitamo, Kulkki, Eriksson, and Hribernik, 2006; *Proceedings of the 12th International Conference on Concurrent Enterprising*). A human-centric innovation may emerge through the process, where technology is created and challenged in interaction with human, social, and institutional elements (Niitamo et al., 2006).

In terms of innovation research and innovation management, the research on living labs appears to be at the point where an interesting new phenomenon is charted from multiple directions, for instance, by comparing projects and experiences across living labs in dif-

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ferent countries and sectors (e.g., Leminen et al., 2012; timreview.ca/article/602), by analyzing living labs as innovation intermediaries (e.g., Katzy et al., 2012; tinyurl.com/lvroe2d), by situating living labs in the field of user-driven innovation methodologies (e.g., Ballon et al., 2005: tinyurl.com/8hox58r; Almirall et al., 2012: timreview.ca/article/603), by examining issues related to intellectual property rights (e.g., Pitkänen and Lehto, 2012; tinyurl.com/qjne78j), and by presenting specific cases of living lab development (e.g., Bendavid and Cassivi, 2012: tinyurl.com/kuup5rb; Bourgault, 2012: tinyurl.com/mz4aegx). A type of research that is hitherto missing in the living lab domain is an in-depth longitudinal case analysis examining some key facet, such as user–developer interaction. Such studies have become commonplace in innovation research over the past three decades (Van de Ven, 1999: tinyurl.com/n5h6xv2; Russell and Williams, 2001: tinyurl.com/nxeh3sv; Garud and Gehman, 2012: tinyurl.com/k97f6tu) and have thrown significant new light on how innovation processes play out.

The present article provides a rare overview of the results of such an in-depth longitudinal case study (Hakkarainen, 2013; tinyurl.com/l8dqpsr) of some of the key aspects of living labs: user involvement, learning, and interaction between participants (Katzy et al., 2012; tinyurl.com/lvroe2d). We follow these aspects during a four-year living lab collaboration that took place in a Finnish nursing home, and ask:

1. What learning occurred between participants?

2. What were the challenges in achieving this learning?

3. How were these challenges overcome?

Our research draws from one of the key traditions in the detailed studies of innovation, the social shaping of technology approach (Williams and Edge, 1996: tinyurl.com/kh2oncz; MacKenzie and Wajkman, 1984: tinyurl.com/mhbbatg), and its further development, the social learning in technological innovation approach (Williams et al., 2005: tinyurl.com/ma479bl; Stewart and Hyysalo, 2008: tinyurl.com/lox4bvp; Hyysalo, 2010: tinyurl.com/qz3ebln). Alongside other detailed longitudinal approaches to innovation, the three decades of social shaping of technology research have come to emphasize that innovations are typically long and winding journeys rather than orderly projects (Williams and Edge, 1996: tinyurl.com/kh2oncz; Van de Ven, 1999: tinyurl.com/n5h6xv2). They are characterized by high contingency and uncertainty; indeed, there may be a “fog” over the best possible courses of action (Russell and Williams, 2001: tinyurl.com/nxeh3sv; Höyssä and Hyysalo, 2009; tinyurl.com/kn59mhk). Learning, particularly related to uses and user contexts, has been found to be crucial to these processes and whatever success they may have (Williams et al., 2005: tinyurl.com/ma479bl; Hyysalo, 2009: tinyurl.com/mcwgdd8), because innovation is typically an affair between multiple stakeholder groups that have different cultures, priorities, and interests towards the project (Williams and Edge, 1996; tinyurl.com/kh2oncz). Different perceptions over the appropriate form and function of new technology tend to lead to tensions and conflicts between stakeholders (Miettinen, 1998: tinyurl.com/mre2ezj; Johnson et al., 2013: tinyurl.com/lzr5y39; Latour, 1996: tinyurl.com/mgk2ot3).

Particularly in health technology innovation, learning between developers and users has been found to be of crucial importance (Hasu, 2001: tinyurl.com/pvwp3kc; Hyppönen, 2007: tinyurl.com/od997pt; Hyysalo, 2000: tinyurl.com/kyw6pma; Hyysalo, 2010: tinyurl.com/qz3ebln). The parties typically have limited capacity to absorb information from other stakeholders due to lack of time and often required extensive background understanding. Many times, the parties find it difficult to even judge which information is relevant for them (Hyysalo, 2010; tinyurl.com/qz3ebln). It is further unclear who should invest in the learning and creation of working arrangements for interaction. In all of this, the shape of technology, uncertainties about its material realization, and the types of knowledge related to it, do matter. The net outcome is that the required learning tends to become a complex issue to master and grapple with; indeed, it is a multi-level game between stakeholders (Stewart and Hyysalo, 2008; tinyurl.com/mssxkf3).

With regard to innovation management, the longitudinal studies on innovation have come to view the orderly, controlled, and linear management models better suited for incremental new-product development projects. When initiating new product types or product categories, measures such as stage gate models act more as legitimizing devices than effective tools for management (Van de Ven, 1999: tinyurl.com/n5h6xv2; Jolivet et al., 2008: tinyurl.com/lfctg7g). In dealing with high uncertainty, periodical direction assessment and re-setting appear better suited for working towards the eventually desirable and attainable shape of technology, its business case, and social implications (Duret et al., 1999: tinyurl.com/ll4wqcx; Jolivet et al., 2008: tinyurl.com/lfctg7g).

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Our living lab research continues this line of studies of the mechanisms of learning and interaction between developers and users in real-life settings. We now proceed by first introducing the development project and the main difficulties in executing such intensive long-term collaboration. Thereafter, we present how the participants overcame these challenges and what were the most important benefits of the living lab methodology. Finally we distill a set of key messages to companies and other actors who are involved or interested in living lab collaboration, especially in the field of healthcare.

Research Approach, Methods, and Data

The data and analysis methods of our study are reported at length by Hakkarainen (2013; tinyurl.com/l8dqpsr). In short, the main bodies of data are 90 meeting memos and 16 semi-structured interviews. The project personnel, who were hired to organize the collaboration and who acted as user-side innovation intermediaries, documented nearly all the meetings held with different participant groups over the course of the four-year collaboration project. We used historiographic document analysis to track down processes of learning, tensions, and conflicts between the participants, as well as the temporality of the innovation process. The length of one memo was typically one to two A4 pages. In addition to memos, the data included project reports, plans, and marketing material. Altogether, the data included 151 different documents related to the development and use of the "smart floor" (described below). The historiographic document analysis was carried out by following the principles of source criticism and was triangulated with the analysis of the interviews in order to gain understanding of the events and to capture the multiple perspectives to the innovation process. The interviews varied from recorded and transcribed interviews of over one hour, to more informal half-hour chats during a normal workday. Open coding was used to categorize both the document and interview data on different research themes, events, methods etc. Our research covers the smart floor innovation project prior to and after living lab collaboration, as well as the intertwined phases of design and use of the system during the project.

Outline of the Collaboration Project

The origins of the smart floor system are in the Helsinki University of Technology (now Aalto University: aalto.fi), where the motion-tracking technique behind it was discovered in the early 1990s. Years later, a group of researchers and students created the first version of the floor monitoring system, and a startup company was founded around the concept in 2005. The idea for the gerontechnological device originally came from the user side: an innovation-oriented nursing home manager became aware of the discovery and encouraged the engineers to advance the technique into a floor-monitoring system for elderly care.

The system consists of: i) a sensor foil, which is installed under the flooring material; ii) the user interface on a computer situated in the office; and iii) cell phones, which the nurses carry with them during their work shifts. The movements of the residents generate alerts, which the nurses receive through the cell phones. The system can inform the nurses about, for example, a situation where a frail elderly person is getting out of bed, entering or leaving the room, entering the toilet or occupying the toilet for an unusually long time. The alarms are tailored individually to each person.

The system reached its final form during a four-year living lab undertaking, which took place in four units of a large public nursing home from 2005 to 2009. Participants in the collaboration were the startup company, researchers from the university, project personnel – who acted as user-side innovation intermediaries (Stewart and Hyysalo, 2008; tinyurl.com/lox4bvp) – management and care personnel of the nursing home, IT experts from the municipal bureau of social services and health care, and indirectly the residents of the nursing home. The funding for the project came from a municipal innovation fund and was mostly used to hire project workers at the elderly care site.

From the perspective of elderly care actors, the goal of collaboration was to develop new technology and simultaneously discover ways to utilize it. The implementation started at the end of 2007 in a pilot unit where the smart floor was installed in two rooms. Later, the system was put to use in three other units, each with around 20 residents, where the sensor foil was installed in all the rooms and public spaces. An overview of the project timeline is provided in Box 1.

The project was realized without formal co-design methods. Information exchanges took place in regular meetings, where the project workers met the end users and the developers (i.e., the nurses and the engineers), separately. User concerns were learned through weekly

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to monthly feedback meetings with the nurses discussing how the system had been utilized, what its benefits were, how it changed the care work, and how it had affected the elderly people. This feedback was complemented by observing the daily use, which the project workers valued as the most important way to collect information for the improvement of the system. Their background as care workers helped them to make sense of the daily work. But, before events got to this point, the project had to navigate a number of serious potholes, as described in the following section.

Box 1. Project timeline

1990s	Motion-tracking technique is discovered at the Helsinki School of Technology
2005	Smart floor receives an award in a business idea competition; spin-off company is founded
2006	Sensor foil is installed in the nursing home building; user collaboration begins
2007	August: User interface version 1.0
	November: Use of the system begins in the pilot room
2008	April: Implementation is extended to three full units
	May: User interface version 1.1
	June: New alarms are added to the system
	September: User interface version 2.0
2009	April: User interface version 2.2; new alarms are added to the system
	May: Startup company merges with an established electronics company
	Fall: Living lab project ends and the smart floor is launched
2013	Smart floor is installed in over 2000 rooms in residential care facilities, mainly in Finland

Birth of the Smart Floor through Conflicts and Power Plays

At the onset of the project, the engineers and the care professionals had strongly differing understandings of the maturity of the system and each other's roles. The company was in a hurry to launch their product, but from the user perspective, the smart floor was not even ready for the test implementation. The client – as represented by nursing home staff and project workers – was frustrated with the functioning of the system and severity of its bugs, and saw the engineers as arrogant and indifferent to the welfare of the residents, whereas the company saw the users' requests as unreasonable and unrealistically scheduled. The goal of the company was to create a generic product instead of a tailored system; accordingly, the engineers were skeptical about the client's demands. A struggle for power over the project ensued. The key issues revolved around how quickly and accurately the developers had to answer to the wishes and demands of the care professionals, and who finally decided what functionalities would be developed into the system. The events culminated in the nursing home management and project workers refusing to proceed with the implementation unless their suggestions and demands were met. At the end of 2007, the conflict culminated in the resignation of several members of the living lab project, bringing the whole project to the verge of collapse.

Nevertheless, when the rollout of the system began at the beginning of 2008, the developers, project workers, and management of the nursing home found common ground for carrying forward the project. The hiring of a new project coordinator seemed to be essential for the new consensus. At this point, the innovation project manager wanted to find an independent and innovative negotiator, someone who would be able to change perspectives when needed, instead of just being a passionate advocate of the user side. They were looking for a person who could convince all the stakeholder groups of each other's good intentions and react quickly to changing circumstances, in other words, a genuine innovation intermediary. Nevertheless, this person had to be practical enough to push through the demanding implementation phase.

Pushing forward with the rollout of the system required the developers, project workers, and nursing home management to ally against the care personnel, many of whom were reluctant to use the system or participate

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in its improvement. Because of heavy and demanding work, the nursing staff was unwilling to study new things alongside their normal workload or to change their work routines. The nurses saw themselves as caregivers, not machinists, and were generally reserved about complex gerontechnological devices (tinyurl.com/k5z7k2c). Broader societal dissatisfaction with the financing of elderly care services also loomed in the background. Many care workers boycotted the smart floor, for instance by not carrying the cell phone with them during their shift, and continuing to work as they used to. In these circumstances, the commitment of the nursing home management to the implementation proved to be crucial. The use of the system and attendance at the feedback meetings was made obligatory for the nursing staff, yet they were given a chance to transfer to another unit. The manager of the innovation project was a former manager of the nursing home, which seemed also to play a role in building the commitment of the department managers to the living lab project and overcoming the resistance of the nursing home staff.

During the implementation, the strict discipline was counterbalanced by the devotion of the newly hired project staff, who were also care professionals by education. They spent time in the living lab units every day and helped the nurses in the implementation of the system, occasionally also in normal care duties. The distress of the nurses was discussed in the weekly feedback meetings, where the care personnel had an opportunity to speak out, comment on the system, and express new development ideas.

Unfortunately, the disgruntled care personnel were not very keen on generating development ideas. The responsibility to develop the system further was left on the shoulders of the project workers, especially the new project coordinator. As noted, the project workers observed use, identified problems and solutions with the engineers, and thought about ways to utilize different functionalities and properties of the system with the care personnel. Another important theme of discussion with the nurses was the question of how the system should be used in order to produce optimal results: for example, how to determine the right mix of alarms for each resident, how the system affects elderly people in the long term, and what should be done when a nurse receives overlapping alarms. The project workers and the care personnel also thought about the challenges the living lab project created, for example what should be done when the system does not work the way it is supposed to.

Hence, as unfortunate the tensions and conflicts were, they did "hammer in" each stakeholder group's realities and priorities to the others, thereby leading to deeper and more appreciative collaboration. Learning sensible ways to organize and time collaboration as well as learning to listen and respond to other party's concerns had to be achieved before mutually beneficial collaboration was achieved.

Fruits of the Living Lab Collaboration

Despite the challenges, the benefits of living lab collaboration for the innovation project appear formidable. Before the user collaboration, the operating idea of the system was limited to detecting instances when elderly residents accidentally fell in the nursing home environment. During the living lab project, the system evolved from a simple "fall down alarm" to a precautionary nursing tool, which instead of simply alarming the falls actually aimed to prevent them. Fall-down detection alone had relatively low value, because falls were detected fairly quickly in a nursing home environment anyway. The living lab collaboration, thus, helped the company to change the focus as well as the value promise of the system before the market launch. The fall-down alarm evolved to a smart floor.

During the living lab project, several new alarms were added to the system. Moreover, unexpected uses emerged and were conveyed to the company. For instance, in case of a fall, the nurses used recorded data about the movements of the residents to diagnose potential risk factors in order to prevent new falls. Improving the quality of care, such as reducing the use of movement-restriction devices (e.g., bedside rails), was an important motivation for the municipal actors to start collaboration with the company and the university of technology in the first place. During the collaboration, the system evolved to reach that goal. The nurses also kept track of all the false alarms sent by the system, which enabled the company to fix a large element of the technical bugs before the large-scale marketing of the system began.

In summary, the living lab collaboration helped the company to redirect the focus of its product to a more valuable opportunity, gain new product features and value-added uses, and helped in weeding out bugs in the system. Equally important, the company gained a profound understanding of the use contexts and real-life benefits of their product, which included how the smart floor changes care work, what efficient implementation and use of the system require from the end users as well as from the company, and how the system affects the residents in the long run. During the collaboration, the company reached an in-depth understanding of the benefits, functioning, effects, implementation, risks, and possibilities of their product as well as the realities of the elderly care field in general. This knowledge helped the company to market their product and to support the implementation process in new client organizations.

Key Messages Emerging from the Case

Successful learning between developers and users can lead to a crucial yield with regard to the innovation process, but it is not an automatic feature of living lab collaboration per se. It requires often painstaking and conflict-ridden effort to establish such learning, even though the living lab setting and the commitment of parties to this collaborative mode of development may act as facilitating conditions. The case shows that, in high-dependability environments such as health and social care, particular attention should be paid to the following facets of living lab collaboration:

First, participants should chart different priorities and restrictions at the onset of collaboration: what issues the parties will be most concerned about, what issues are likely to be difficult to compromise, and what the conditions are in both work practice and in the technology that the parties can be flexible about.

Second, the participants should be prepared to handle conflicts, hire competent intermediary actors, and establish adequate governance structures in both organizations before the beginning of the collaboration. The needs of the project should be reviewed in the course of the collaboration, which might be difficult in the case of a rigid project plan. Regular meetings, face-to-face communication, and adequate ways to agree on scheduling are further issues that facilitate learning and help to build trust between the participants. We also recommend seeking adequate collaboration tools – in cases, just memos and lists can do the job, but at other times prototypes, mock-ups, and digital collaboration platforms may be needed.

Third, it is crucial to find adequate innovation intermediaries who can mediate between both developer and user contexts: relying solely on general process facilitation is unlikely to be sufficient. In the smart floor case, the intermediaries had to continuously adjust to unexpected situations and play several different roles. This task required creativity, negotiation skills, independence, interest in developing technology as well as elderly care practices, and the capacity to build trust between the parties. This flexibility was made possible by a loose project plan and by the project workers' sufficient understanding of the user context through their own background in care work.

Conclusion

Most researchers see collaborative learning among stakeholders in real-life environments as the core rationale for setting up living labs. The current case analysis lends support to this view. Users, indeed, became co-creators of value, ideas, and innovative concepts (McPhee et al., 2012; timreview.ca/article/601). A complex product was successfully embedded in a demanding context (Ballon et al., 2005: tinyurl.com/8hox58r; Pierson and Lievens, 2005: tinyurl.com/9t9sylo), and in doing so, interactions and institutional support were fostered and a governance structure for user and developer contributions was created (Almirall and Wareham, 2008; tinyurl.com/8vwtjw2). Insights on development and acceptance processes, the value proposition of innovation, and on deployment processes were formed (Pierson and Lievens, 2005; tinyurl.com/9t9sylo). We dare to state, that without the living lab, the current success case would likely have been another innovation failure.

The case study, however, also shows how laborious and volatile such long-term and intensive collaborative undertaking can be. Before there was effective learning *in* interaction, there had to be learning *for* that interaction (Hyysalo, 2009: tinyurl.com/mcwgdd8; 2010: tinyurl.com/qz3ebln). The early phases were characterized by the stakeholders' inability to understand and cater for each other's key concerns. The company staff underestimated the weaknesses of their prototype, did not take reliability issues seriously enough, and did not appreciate how superficial was their understanding of the elderly care context. The care personnel, in turn, were unwilling to learn to use and to work with a complex, incomplete system in addition to their demanding care duties.

The case provides further suggestions about what types of actions may turn the divergent interests and competences in to complementary ones. The active role of innovation intermediaries appears to be central, as does their deep-seated knowledge with regard to user practices. This central role helped them to seek innovation relevant information from daily use and to understand user concerns. Their frequent face-to-face communication with both parties and (by then) the genuine oppor-

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tunity to make a difference helped to build trust and overcome resistance. Further research on innovation intermediaries in living lab undertakings is needed in order to better support and enhance the learning processes in living labs. The nursing home management who forced system use and the company that continued its commitment to the collaboration also played key role in the success. The deepest knowledge transfer to the company came through hiring the key project intermediary (i.e., the project coordinator) upon completion of the project. The learning in collaboration succeeded without formal co-design methods or arrangements; it largely relied on the intermediaries' first-hand acquaintance of elderly care contexts. Knowledge of such means or having developer-side intermediaries to distill findings also could have been helpful.

To date, in-depth longitudinal analyses of living lab collaboration have been rare. The current case overview gives a glimpse of their merits in describing the micro-processes of living lab development, and how to come to better grips with them (Katzy et al., 2012; tinyurl.com/lvroe2d). Such research-based descriptions of practical living lab collaboration and change over time are needed to give managers, facilitators, and workers of living labs a better sense of the processes at stake. In terms of further research, such analyses can provide grounds for comparison between living lab development with projects conducted without living labs, and how this might vary in different sectors and in different kind of living labs.

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The Evolution of Intermediary Activities: Broadening the Concept of Facilitation in Living Labs

Louna Hakkarainen and Sampsa Hyysalo

> *It is hardly possible to overrate the value… of placing human beings in contact with persons dissimilar to themselves, and with modes of thought and action unlike those with which they are familiar. … Such communication has always been… one of the primary sources of progress.*
>
> John Stuart Mill (1806–1873)
> In *Principles of Political Economy*

Innovation intermediaries play an important role in open innovation endeavours. In living lab projects, where different professional identities and organizational cultures are at play, intermediary actors facilitate learning between stakeholders and manage tensions and conflicts of interest. The current living lab literature recognizes the importance and multifacetedness of these actors, but does not shed light on the work they do at a more practical level. Our study seeks to capture the variety and evolution of work tasks of user-side innovation intermediaries during and after a four-year technology project in a living lab. The study explores how these mediating actors tackle the everyday challenges of a living lab project. This article is grounded on a longitudinal qualitative case study of a innovation process for a floor monitoring system for elderly care – the "smart floor".

Introduction

Living labs are real-life experimentation environments in which new products and services are given shape through collaborative efforts of users and developers. They aim to extend co-design and open innovation activities from mere concept design and ideation to design-in-use, which is often requisite for co-realizing the true value points of new technologies and services (Botero & Hyysalo, 2013; Hartswood et al., 2002; Hillgren et al., 2011; Hyysalo, 2010; Leminen et al., 2015; Voss et al., 2009).

The success of such real-life collaboration, which aims to promote learning between different stakeholders, hinges on how the co-design process has been orchestrated, facilitated, and managed. In discussions about living labs notions such as "quadruple helix" and "public–private–people partnerships" flag the issue prominently. However, research on collaboration dynamics in living labs remains nascent, and it seems that often the complex knowledge exchange tends to be taken for granted, overlooked, or simplified beyond what, for instance, the kind of guidance practitioners would benefit from the most.

This article on intermediation work in a living lab project is based on a longitudinal qualitative study of a four-year (2005–2009) living lab project that took place in four units of a large public nursing home in Finland. The data allows us to describe and analyze how the user-side innovation intermediaries facilitated learning between developers and users during a long-term co-design project. We focus on the intermediation work done by three living lab project workers, whose educational background was in nursing and elderly care. After the four-year living lab project, the developer company hired the key project worker as a customer care specialist. This made it possible to extend the scope of our research to a total of eight years and to include the after-market launch period, when the locally tailored product was "generified" to serve a widening clientele (Hyysalo, 2010; Pollock & Williams, 2008).

In order to address the variety of intermediation work in the case, we have turned to research on innovation intermediaries. Innovation intermediaries have been central in social learning processes in technological innovation (Stewart & Hyysalo, 2008; Williams et al., 2005). In innovation studies, these mediating actors have been studied for some time. Howells (2006) describes an innovation intermediary as "[a]n organization or body [or an individual] that acts an agent or broker in any aspect of the innovation process between two or more parties".

For a long time, research around the topic focused on supply-side actors, such as industry associations and knowledge-intensive business services, but lately, work has been done to highlight the significance of innovation intermediaries in the user-side activities and processes of social learning: "The highly visible supply-side intermediaries […] and the easily identifiable middle-ground agencies […] tend to overshadow the often more informal yet just as crucial intermediaries at the user-end of the supply-use relation. Intermediate users, local experts and 'tailors' facilitate, configure and broker systems, usages and knowledge about systems and their deployments, helping users to domesticate them and suppliers to respond to actual, realised uses." (Stewart & Hyysalo, 2008). Our present study focuses on the role of public sector user-side innovation intermediaries in a collaborative innovation process.

Theoretical Framework

Our understanding of living labs relies on findings from science and technology studies – especially around social learning (Hyysalo, 2009; Williams et al., 2005) and domestication of technology (Berger et al., 2006; Silverstone et al., 1992; Sørensen, 1996).

The social learning in technological innovation approach (Williams et al., 2005) grew out of research on the social shaping of innovation (MacKenzie & Wajcman, 1999; Williams & Edge, 1996). The concept of social learning places particular emphasis on the activity of the users during the appropriation of new technology and highlights the importance of simultaneously studying processes of design, implementation, and use. Social learning refers especially to two simultaneous, complementary, and intertwined processes: innofusion (Fleck, 1988) and domestication of technology (Sørensen, 1996). Innofusion (innovation that takes place during diffusion) refers to "processes of technological design, trial and exploration, in which user needs and requirements are discovered and incorporated in the course of the struggle to get the technology to work in useful ways, at the point of application" (Fleck, 1988). The concept of domestication has its origins in cultural consumption studies, and it refers to the work users go through in "fitting [technologies] into the pre-existing heterogeneous network of machines, systems, routines and culture" (Sørensen, 1996).

From these perspectives, we see living labs as a co-design infrastructures in which users' creativity around technology use and their efforts to fit technology to cultural, organizational, and material contexts become resources for product development. However, the potential of this kind of collaboration does not realize automatically, which is why we focus on the crucial work done by innovation intermediaries in living lab networks.

Innovation intermediaries
Stewart and Hyysalo (2008) define user-side innovation intermediaries as organizations or individuals that "attempt to configure the users, the context, the technology and the 'content', *but they do not, and cannot define and control use or the technology*". They are thus actors who seek to influence users and developers, but do not have final say over how the technology is eventually used (this is what users and managers at user organizations do) nor do they hold decision-making power, or necessary skills, to alter the form of the technology at the developer end.

In their seminal studies, Howells (2006) and Bessant and Rush (1995) have listed functions and bridging activities of innovation intermediaries (Box 1). Shortcomings of these kinds of listings are that they leave aside the common types of engagements that these actors are involved in during their "bridging activities".

Stewart and Hyysalo (2008) have attempted to move from a mere ordered list of functions to an analytically ordered set of concepts that describe how intermediaries act and what are the different facets of their work in innovation. They have recognized three user-side innovation intermediary roles with respect to social learning: facilitating, configuring, and brokering.

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Box 1. Functions and activities of innovation intermediaries

Intermediary functions (Howells, 2006)

1. Foresight and diagnostics
2. Scanning and information processing
3. Knowledge processing and (re)combination
4. Gatekeeping and brokering
5. Testing and validation
6. Accreditation
7. Validation and regulation resources; organizational development
8. Protecting the results
9. Commercialization
10. Evaluation of outcomes

Bridging activities (Bessant & Rush, 1995)

1. Articulation of needs; selection of options
2. Identification of needs; selection training
3. Creation of business cases
4. Communications; development
5. Education; links to external info
6. Project management; managing external resources; organizational development

Facilitating means providing opportunities to other *people,* by educating, gathering and distributing resources, influencing regulations, developing the local rules, and creating "spaces" for others to act. Configuring means material and symbolic alteration of *technology,* adjusting its form and content (often in minor ways), as well as how it is interpreted and used. Brokering refers to the establishing, nurturing, adjusting, and altering of *connections* between different actors. This work on connections is not just neutral bridging, but is often selective and occasionally self-serving to the position of the intermediary actor itself.

Intermediation work in living labs

In recent years, living labs also have been analyzed as innovation intermediaries (e.g., Almirall & Wareham, 2011; Baltes & Gard, 2010; Katzy et al., 2013). Almirall and Wareham (2011) define living labs as "[…] open innovation intermediaries that seek to mediate between users, research, public and private organisations, advance our concept of technology transfer by incorporating not only the user based experimentation, but also by engaging firms and public organisations in a process of learning and the creation of pre-commercial demand."

Some attempts have been made to shed light on the interaction dynamics inside living labs on a more detailed level. Such research has focused on communities of practice and boundary objects (Johansson & Snis, 2011), living lab actors' roles and role patterns (Nyström et al., 2014; Box 2), living lab networks' modes of coordination and participation (Leminen, 2013), functions and roles of public open innovation intermediaries (Bakici et al., 2013), strategic capabilities of living labs (Katzy et al., 2013), paradoxical tensions in living labs (Leminen et al., 2015), complexity in the stakeholder interactions (Pade-Khene et al., 2013), and possibilities of social and cognitive translation between stakeholders (Svensson & Ebbesson, 2010). Part of this work has been attempts to also identify the roles of intermediary actors in living labs (Heikkinen et al., 2007; Nyström et al., 2014; see Box 2).

Although helpful in gaining a sense of what functions actors perform in collaborative innovation, empirically derived listings and classifications bear close similarity to previous empirically derived listings of innovation intermediaries such as those of Howells (2006) or Bessant and Rush (1995) (see Box 1).

Gregor (2002) has characterized such listings as "naming theory", the most rudimentary form of theory within a research domain, a stepping stone on which more analytically ordered typologies and gradually more explanatory theory building can take place. One of the steps needed to move beyond naming and answering simple "what" questions is to conduct empirical studies that expose the situatedness and context-specific aspects of the innovation process and can shed light on "how" questions. This is important also for gaining practical sense of what works (Gregor, 2002; Woolrych et al., 2011)

Thus, with regard to actor roles in living labs, further work is called for, particularly in two respects. First, there is a need to empirically gain better specificity in what kinds of engagements the roles relate to. The current lists of actor roles by Nyström and colleagues (2014) have been derived from multiple projects and multiple different actors and beg for further clarification, as do the contents of the different roles. Furthermore, only some of the roles are present in different projects and, at that, different *phases* of projects. Existing analysis of processes of intermediation in or by living labs address the systemic or organizational level, but fail to describe in detail how individuals tackle the challenges posed by everyday life in living labs.

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Box 2. Identified actor roles

Previously identified actor roles (Heikkinen et al., 2007)

1. Webber: Acts as the initiator; decides on potential actors
2. Instigator: Influences actors' decision-making processes
3. Gatekeeper: Possesses resources
4. Advocate: Background role; distributes information externally
5. Producer: Contributes to the development process
6. Planner: Participates in development processes; input in the form of intangible resources
7. Accessory provider: Self-motivated to promote its products, services, and expertise

Newly identified roles (specific to living labs) (Nyström et al., 2014)

8. Coordinator: Coordinates a group of participants
9. Builder: Establishes and promotes the emergence of close relationships between various participants in the living lab
10. Messenger: Forwards and disseminates information in the living lab network
11. Facilitator: Offers resources for the use of the network
12. Orchestrator: Guides and supports the network's activities and continuation; tries to establish trust in the network to boost collaboration to further the living lab's goals
13. Integrator: Integrates heterogeneous knowledge, development ideas, technologies, or outputs of different living lab actors into a functional entity
14. Informant: Brings users' knowledge, understanding, and opinions to the living lab
15. Tester: Tests innovation in (customers') real-life environments (e.g., hospitals, student restaurants, and classrooms)
16. Contributor: Collaborates intensively with the other actors in the network to develop new products, services, processes, or technologies
17. Co-creator: The user co-designs a service, product, or process together with the company's R&D team and the other living lab actors.

Second, although the more detailed empirical examination of roles and their prevalence in actual living lab projects is in order, the research on actor roles in living labs would also benefit from seeking to move beyond mere naming towards better understanding of the interrelations of different roles, as was done with innovation intermediaries previously (Stewart & Hyysalo, 2008). Our focus on living lab facilitators happens to reside within the broader notion of innovation intermediary, and hence we shall examine whether our previously developed typology of configuring, brokering, and facilitating would be fit for further organizing the findings in the present article.

Research Approach

Our work enriches the previous research by focusing on the innovation intermediaries' work on the level of tasks and activities. We map the evolution of the intermediation work during and after the living lab project, covering almost eight years' time on the biography of the maturing artefact.

The study continues an analysis started in licentiate study by Hakkarainen (2013) and continued during the follow-up phase of study (Hakkarainen & Hyysalo, 2013; Hyysalo & Hakkarainen, 2014). The living lab project workers documented nearly all the collaboration meetings held with different assemblies over the course of the four-year project. In addition to memos, the data included project reports, plans, and marketing material – altogether 151 different documents related to the development and use of the "smart floor", which we describe later in the article. The overall number of qualitative in-depth interviews is 21: 16 during the living lab project and five after it. Four of the latter interviews were conducted with the developer company's sales manager and customer care specialist (who was previously a living lab project worker), and one was conducted with the customer care specialist alone. The last interview was conducted after the both interviewees had quit working for the company.

The units of analysis are *intermediary activities and tasks* of the living lab project personnel. By task, we mean an organized set of actions that can be either a one-time effort or a repeated pattern in the practices of the mediating personnel – in any case, a set of actions that formed a mutually recognized whole by both the mediating personnel and their colleagues (Strauss, 1993).

The coded tasks were ordered chronologically and reorganized under higher-level activities. The result of the analysis were 31 different tasks, which were categorized under 13 activities. The results were organized in a matrix (see Table 4) that shows how the activities and tasks evolved over time in different phases of the innovation process.

The smart floor innovation process has been divided in four phases (Figure 1). The division is based on empirical work done by Van de Ven and colleagues (1999) on innovation journeys and by Pollock and Williams (2008) on biographies of artefacts as well as process dynamics observed in the study by Hakkarainen (2013). Each transition represents significant changes in the innovation network as well as in the smart floor artefact.

In the final step of the analysis, we structured the tasks according to facilitating, configuring, and brokering (Stewart & Hyysalo, 2008) to see if there are changes in the broader-level orientation of the intermediaries in the course of the innovation project.

Case Study: A Smart Floor System

The origins of smart floor system are in the Helsinki University of Technology (now Aalto University), where the motion-tracking technique behind it was discovered in the early 1990s. Years later, a group of researchers and students created the first version of the smart floor – a simple floor monitoring system – and a company was founded around it in 2005. The idea for creating a gerontechnological device originally came from the user side: a well networked, innovation-oriented nursing home manager became aware of the discovery and encouraged the engineers to advance the technique into a system for elderly care.

The technology was next developed in an enabler-driven living lab (Leminen et al., 2012), which was established in 2006 as part of Helsinki Living Lab, an early member of the European Network of Living Labs. The lab focused on a large public nursing home. The public-sector actors were the initiators of the collaboration and were also responsible for applying funding and hiring of the project personnel that acted as innovation intermediaries. The nursing home manager later became the head of the innovation undertaking, wherein the smart floor was one of the four sub-projects. The main stakeholders of the project are presented in the Figure 2. The number of project workers varied between two and three fulltime workers in different stages of the project.

The smart floor system – the outcome of the collaboration – consists of a sensor foil, which is installed under the flooring material; a user interface, which is accessed on a computer situated in the office; and cell phones, which the nurses carry with them during their work shifts. The movements of the residents generate alerts, which the nurses receive through the cell phones. The system can inform the nurses about, for example, a situation where a frail elderly person is getting out of bed, entering or leaving the room, entering the toilet, or occupying the toilet for an unusually long time. The alarms are tailored individually to each person.

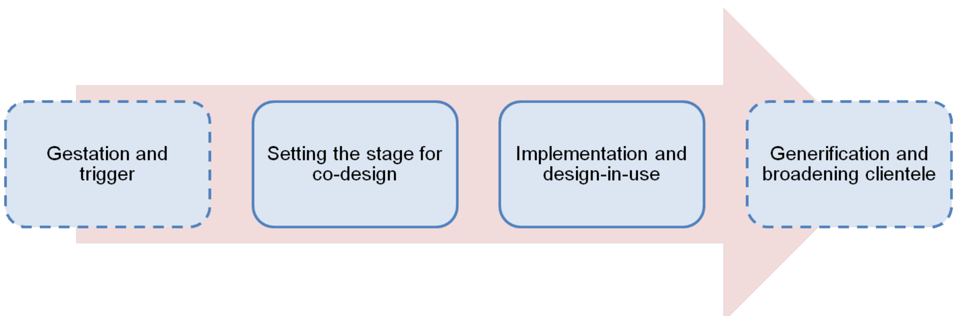

Figure 1. Phases of the smart floor innovation process

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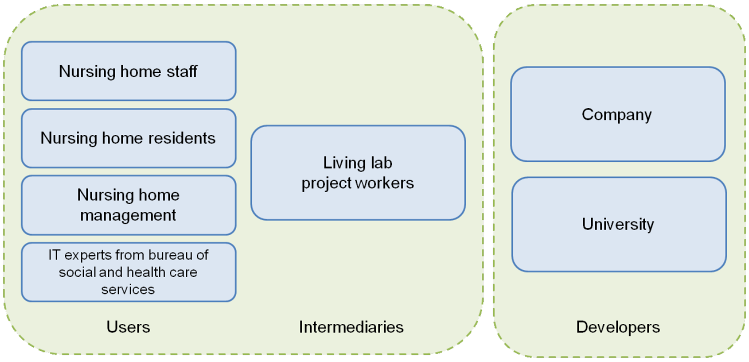

Figure 2. Stakeholders in the smart floor living lab

Setting the stage for co-design

Technology development was not the purpose of the collaboration project from the beginning. The initial plan was to explore ways to efficiently utilize the smart floor technology in the everyday life of the nursing home. However, due to the immaturity of the product, the focus of the collaboration changed to technology development.

The project workers had background in care work and, during the first months of the project, they participated in regular care duties in the units. This meant that the project workers had a profound understanding of the users, their work practices, and the context of use. However, they were not familiar with formal co-design or participatory design methods.

The collaboration started officially with a workshop in which the intermediaries, developers, and care workers defined the first user requirements for the system. After this, the information exchanges took place mostly in regular meetings. The project workers could organize the collaboration as they saw best, and the goals and methods were reassessed regularly and adjusted to the needs of the project.

The project was formally divided in two sub-projects: the main purpose of the first part was to test the smart floor in two rooms and to develop it further, especially by fixing technical bugs and getting rid of false alarms, so that the second part, a larger-scale implementation, was possible. The project workers had significant responsibility in diagnosing and weeding out technical problems.

From the beginning, the engineers and the nursing home staff and management – project workers included – had strongly differing understandings about the maturity of the product and each other's roles in the collaboration. The company was in a hurry to launch their product, but from the users' perspective, the smart floor was not even ready for the test implementation. The client – as represented by nursing home staff and project workers – was frustrated with the functioning of the system and severity of its bugs; they saw the engineers as arrogant and indifferent to the welfare of the residents and nursing home staff. The developers, for their part, saw the users' requests as unreasonable and unrealistically scheduled. The goal of the company was to create a generic product instead of a tailored system, and they were sceptical about the representativeness of the client's demands.

Finally, the nursing home management and project workers refused to proceed with the implementation unless their demands were met. At the end of 2007, two out of three members of the living lab project staff – including the project manager and project co-ordinator – resigned, as did technology company's CEO, bringing the whole undertaking to the verge of collapse.

A summary of intermediary activities and tasks in the first phase is presented in Table 1.

Implementation and design-in-use

Changes in staff eased the tensions, and the collaboration continued, after the developers, two project workers (one newly hired), and management of the nursing home found common ground prior to the implementa-

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Table 1. Intermediary activities and tasks in the stage-setting phase

Activity	Task	
Technical tinkering	Diagnosing and fixing bugs with the engineers	C
	Taking part in the installation and testing	C
Co-designing	Defining preliminary user requirements with the users	C
	Formulating project plan and choosing methods of collaboration	C/B
	Documenting the co-design process	F
User research	Studying the users, their work, and context of use	F
Advocating	Communicating the user perspective to the developers	B
	Pressuring the developers to realize users' wishes	B

C = Configuration; F = Facilitation; B = Brokering

tion phase. At the end of 2007, the smart floor was installed in two rooms as a pilot and then rolled out to three other units (each with around 20 residents), where the sensor foil was installed in all the rooms and public spaces.

The hiring of a new project worker was pivotal for the new consensus. At this point, the project management had better understanding of the requirements of the intermediary position. This time, they were looking for an independent and innovative negotiator, someone who would be technology-oriented and able to change perspectives when needed. In a delicate situation, the project workers needed to convince different stakeholders of each other's good intentions, recognize shared interests, and react quickly to changing circumstances. Nevertheless, they had to be practical enough to push through the demanding implementation phase and support the care workers by taking part in the regular care duties.

The implementation phase invoked a new kind of division between the living lab project stakeholders: many of the end-users – the nursing home staff – reacted negatively to the smart floor. The nursing staff was unwilling to study new things alongside their normal workload or to change their work routines. Their job was demanding enough on its own. In addition, the nurses saw themselves as caregivers, not machinists, and were generally reserved about complex gerontechnological devices. Many care workers boycotted the project and the system, for example, by not carrying cell phones with them during their shift and continuing to work as they used to. Pushing forward with the rollout of the system required developers, project workers, and nursing home management to ally themselves against the care personnel, among who many were reluctant to put the system to use let alone participate in its improvement and to make the use of the system. Attendance at the feedback meetings was made obligatory for the nurses.

During the implementation, the strict discipline was counterbalanced by the devotion of the project workers, who were also care professionals by education. They spent time in the living lab units on a daily basis and helped the nurses in the implementation of the system, even occasionally assisting them with normal care duties. The weekly (later monthly) feedback meetings provided the care personnel an opportunity to speak out, comment on the system, and express new development ideas. The project workers and the nurses discussed how the system had been utilized, what its benefits were, and how it affected the care practices and the elderly people. This feedback was complemented by observing the smart floor's daily use, which the project workers valued as the most important way to collect information for the improvement of the system. Their background as care workers helped them to make sense of the daily work in the units, which was needed because the burden of developing the system further was placed on their shoulders. The project workers ob-

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served use, identified problems and solutions with the engineers, and thought of ways to utilize different functionalities and properties of the system with the care personnel. Another important area was how the system should be used in order to produce optimal results: for example, how to determine the right mix of alarms for each resident, how the system affects elderly people in the long term, and what should be done when a nurse receives overlapping alarms. They also had to think about the challenges that the living lab project created, for example, what practical actions to take when the system does not work the way it is supposed to.

In addition, the project workers were active in planning, organizing, and executing effectiveness research of the impact of the smart floor on, for example, resident safety and nursing work. The work was done primarily for the client (the City of Helsinki), but the results were highly valuable for the company as well. Later in the project, the project workers were also active in showcasing the system and the project to numerous potential customers from all over the world.

A summary of intermediary activities and tasks in the design-in-use phase is presented in Table 2.

After the living lab project: Generification and broadening the clientele

In the course of the living lab project, the startup company had merged with an established electronics company. When the living lab project was coming to an end, the company hired, as a customer care specialist, the key project worker – the one that had started in the middle of the project and who managed to turn the confrontation into fruitful cooperation.

After the market launch of the product, the clientele of the company grew, and new contextual problems arose, for example, in new buildings where the concrete was more humid and disrupted the normal functioning of the system. There were also minor differences in work practices at different institutions, which required some changes to the system.

From the onset, the company adopted a tailoring strategy, which meant that the system was customized to each customer organization's needs. After a while, this strategy was found to be unviable, and a more generic product was needed. Hence, the company sought to repackage its offering as a more standard product and servicing, where the customer care services, that previously were offered freely, were billed separately.

The customer care specialist organized user training and took care of the customer concerns, but she also continued to participate in the R&D activities by collecting user feedback, ideating improvements in the system, and networking with potential partners. She acted as a link between the customers and the company, and for this reason she had a very realistic understanding of the customers' reactions, concerns, and preferences. Her technical know-how, which had accumulated during the living lab project, allowed her to participate actively in the technical installation, testing, and problem solving in new client organizations. She also had credibility and the ability to consult management of the client organizations in renewing their care practices in order to get the biggest benefit out of the system.

Committing the client organizations to the use of the system remained as one of the biggest challenges for the company. The use of a complex system such as the smart floor can easily degenerate in new client organizations, because the end users and mid-level managers are usually not the ones making the purchasing decision.

The customer care specialist also participated in the marketing and sales negotiations. Because of a shared professional identity, she was able to ally herself with the client organization and even make some critical comments if the sales manager's pitch was too direct.

In 2013, the company was sold once more and the sales manager was laid off. At this point, the customer care specialist also decided to resign, because she was expected to assume the sales manager's responsibilities in addition to her existing responsibilities. By the start of 2016, the smart floor had become a stable product in the market and it has been installed in over 2000 apartments, mostly in northern Europe.

A summary of intermediary activities and tasks in the design-in-use phase is presented in Table 3.

Evolution of Intermediary Activities

The mapping of the responsibilities of the project personnel shows how intermediary activities and tasks are spread out through the course of the innovation process, and how they continue and change along with the project (see Table 4). Above all, it reveals the diversity of responsibilities undertaken by the intermediary actors.

The most intensive engagement took place at the implementation and design-in-use phase, during which the

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Table 2. Intermediary activities and tasks in the design-in-use phase

Activity	Task	
Technical tinkering	Diagnosing and fixing bugs with the engineers	C
	Documenting technical problems and false alarms with the users	C/F
Co-designing	Formulating project plan and choosing methods of collaboration	C/B
	Documenting the co-design process	F
	Collecting, filtering, and transferring end users' ideas to the developers	B
	Coming up with development ideas and evaluating them with the users	C/F
User research	Studying the users, their work, and context of use	F
	Observing use and spotting usability problems	F
Advocating	Communicating the user perspective to the developers	B
	Pressuring the developers to realize users' wishes	B
Developing work practices	Developing new work practices which the system supports	C
User training	Creating and carrying out a training program for the users	F
Implementing	Making and carrying out an implementation plan	C
	Supporting users during the implementation phase	F
Developing uses	Discovering optimal ways to use the system with the users	C/F
	Defining codes of conduct for problematic situations with the users	C
	Encouraging the users to actively discover new ways to utilize the system	F
Studying effectiveness	Planning and carrying out studies to assess the effectiveness of the system	F/B
	Documenting the benefits of the system with the users	F/B
	Evaluating how the system affects the residents with the users	F/B
Negotiating	Recognizing and mediating interests of different stakeholder groups	B
	Pushing the end users and mid-level managers to use the system	B
	Building trust with the users	B
Marketing and sales	Demonstrating the system to potential customers	B
Customer service	Receiving and resolving customer concerns	B

C = Configuration; F = Facilitation; B = Brokering

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Table 3. Intermediary activities and tasks after the living lab phase

Activity	Task	
Technical tinkering	Diagnosing and fixing bugs with the engineers	C
	Taking part in the installation and testing	C
Co-designing	Collecting, filtering and transferring end users' ideas to the developers	B
	Coming up with development ideas and evaluating them with the users	C/F
User research	Observing use and spotting usability problems	F
Advocating	Communicating the user perspective to the developers	B
Developing work practices	Developing new work practices which the system supports	C
User training	Creating and carrying out a training program for the users	F
	Assessing the need for user training	F
	Monitoring the use of the system	C/F
Negotiating	Pushing the end users and mid-level managers to use the system	B
	Building trust with the users	B
Networking	Negotiating finance and partners for the R&D activities	B
Marketing and sales	Demonstrating the system to potential customers	B
	Taking part in sales negotiations	B
Customer service	Receiving and resolving customer concerns	B

C = Configuration; F = Facilitation; B = Brokering

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Table 4. Evolution of intermediary tasks and activities

Activity	Task	I	II	III
Technical tinkering	Diagnosing and fixing bugs with the engineers	C	C	C
	Taking part in the installation and testing	C		C
	Documenting technical problems and false alarms with the users		C/F	
Co-designing	Defining preliminary user requirements with the users	C		
	Formulating project plan and choosing methods of collaboration	C/B	C/B	
	Documenting the co-design process	F	F	
	Collecting, filtering and transferring end users' ideas to the developers		B	B
	Coming up with development ideas and evaluating them with the users		C/F	C/F
User research	Studying the users, their work, and context of use	F	F	
	Observing use and spotting usability problems		F	F
Advocating	Communicating the user perspective to the developers	B	B	B
	Pressuring the developers to realize users' wishes	B	B	
Developing work practices	Developing new work practices which the system supports		C	C
User training	Creating and carrying out a training program for the users		F	F
	Assessing the need for user training			F
Carrying out implementation	Making and carrying out an implementation plan		C	
	Supporting users during the implementation phase		F	
	Monitoring the use of the system			C/F
Developing uses	Discovering optimal ways to use the system with the users		C/F	
	Defining codes of conduct for problematic situations with the users		C	
	Encouraging the users to actively discover new ways to utilize the system		F	
Studying effectiveness	Planning and carrying out studies to assess the effectiveness of the system		F/B	
	Documenting the benefits of the system with the users		F/B	
	Evaluating how the system affects the residents with the users		F/B	
Negotiating	Recognizing and mediating interests of different stakeholder groups		B	
	Pushing the end users and mid-level managers to use the system		B	B
	Building trust with the users		B	B
Networking	Negotiating finance and partners for the R&D activities			B
Marketing and sales	Demonstrating the system to potential customers		B	B
	Taking part in sales negotiations			B
Customer service	Receiving and resolving customer concerns		B	B

I = Setting the stage for co-design; II = Implementation and design-in-use; III = After the living lab project
C = Configuration; F = Facilitation; B = Brokering

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largest number of tasks were performed. The case history underscores, however, that despite fewer tasks in other phases, they are equally crucial for success: effective collaboration in the design-in-use phase requires great effort, and achieving the goal of a profitable, widely applicable technology after the living lab phase was equally crucial for the innovation projects' success.

With respect to our analysis considering facilitation, configuring, and brokering, we can see three patterns emerging: i) all three engagements are quite evenly distributed in the first part of the living lab project; ii) the design-in-use phase is dominated by facilitation and brokering; and iii) brokering played the most important role after the project.

The three types of engagement do indeed appear to characterize the tasks of living lab intermediaries – none of these more abstracted roles appear redundant or absent. They underscore how the common way to denote such people as living lab "facilitators" seems to be a misleading way to characterize what such people do as innovation intermediaries: this role comprises only one third of their engagements and is strongest only in the design-in-use phase of collaborative innovation in living lab. Without a longitudinal perspective that reaches beyond the design-in-use phase, the illusion of the centrality of facilitation would prevail in our data as well.

Conclusions

Our study shows that the nature of intermediation in living lab projects cannot be reduced to facilitation. Intermediation work in a living lab project consists of a range of tasks, including configuring of technology and use practices, brokering contacts and interactions between different actors, as well as facilitating their work, learning, and interactions. Furthermore, the content and form of intermediary work evolves in the course of successful living lab project. Altogether, we recognized the intermediaries participating in 13 different intermediary activities and 31 tasks. Engagements that are typically thought of as "facilitating" comprise only a third of what these mediating personnel need to handle and comprise the most common form of engagement only in the phase after implementation, when design-in-use efforts are most active.

Previous research has approached the topic of intermediation in living labs mostly through cross-case comparisons of multiple organizations participating in multiple projects and networks (e.g., Heikkinen et al., 2007; Nyström et al., 2012). Because of this approach, the granularity of the findings has remained coarse and has resulted in "naming theory" of identifying lists of "actor roles". Following Gregor's (2002) framework for theory development, this is the most rudimentary form of theory in a given area that merely answers "what" questions. In the present article, we have shown how moving to longitudinal in-depth case studies of particular projects conducted in living labs helps to reveal process descriptions and answer "how" questions: both how living lab projects are shaped over time and how actor roles play out. This approach offers a richer understanding of the tasks and actions of particular actors as well as how they evolve over the course of an innovation project, allowing us to further connect living lab actor roles to wider theoretical development within innovation studies on innovation intermediaries (Bessant & Rush, 1995; Howells, 2006; Stewart & Hyysalo, 2008), as well as in-depth process studies on innovation (e.g., Hyysalo, 2010; Van de Ven et al., 1999; Williams & Edge, 1996; Williams et al., 2005).

Considering the pivotal role that the intermediary actors play in open innovation processes, such as those using living labs, we are surprised how under-researched the topic is to date. Recent living lab research has actively focused on the network composition and different methods that are used in living labs, but we want to highlight the importance of focusing, in detail, on the active engagements between different stakeholder groups and between people and technology.

The complexity of the intermediary work also reveals important practical insights for living labs: in a real-life context with multiple stakeholders, the direction of the innovation and challenges the project has to face are very difficult to predict. Thus, the capability of intermediaries to adjust their role and actions to changing circumstances is essential. This view holds implications for the recruitment of employees to living lab projects and for the management of living lab activities. Intermediaries hired in a living lab project need to engage in technical configuration and substance issues of the user domain, and not only in the brokering and facilitating tasks. Our study also lends support to the findings by Nyström and colleagues (2014) regarding the need for role ambidexterity, temporality, and multiplicity – an actor's capability to flexibly change, create, adjust, and adapt to roles with respect to the evolving network structure as well the ability to hold multiple roles at the same time.

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What difference does a living lab make? Comparing two health technology innovation projects

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Living laboratories are increasingly common and promising arrangements in collaborative design. Their strength lies in being real life, open ended, sustained and complex coproduction arrangements, but these characteristics also make it hard to research what difference a living lab collaboration would make – after all the project within a living lab should be quite different to one conducted without it. This paper reports on a rare opportunity to compare two unusually similar innovation projects, one of which relied on a living lab and the other that did not. Contrary to what one might have predicted, the living lab collaboration did not make the development paths very different, and the key challenges regarding design collaboration remained closely similar. Extensive redesign in pilot use, an extended learning period between developers and users, consciously built collaboration arrangements, effective boundary spanners and investment in conflict resolution were equally paramount to success in both cases. The living laboratory did make meeting these challenges quicker, and lessened the strain that redesigns caused to customer relations.

Keywords: living lab; collaborative design; case study comparison; health technology; innovation

Introduction

The field of collaborative design has grown to feature a wide range of approaches by which designers and users can collaborate in the creation of new technologies and services. Further, it has become salient that in more demanding contexts any one-time measure is unlikely to be sufficient. Most codesign approaches rely on some form of iterative development, but many now argue that design collaboration needs to continue also after the initial launch. The full potential of an innovation and its eventual best shape becomes visible only after being explored in its real-life settings by both users and designers (Voss et al. 2009; Hess and Pipek 2012; Simonsen and Hertzum 2012; Botero and Hyysalo 2013).

This is where many see promise in real-life exploratory settings such as living laboratories. Defined as ‘a real-life test and experimentation environment where users and producers co-create innovations’ (ENoLL [European Network of Living Labs] website 2014), living labs are seen as an opportunity to give shape to new technology in real-life contexts and turn end users to active coproducers (Ballon, Pierson, and Delaere 2005; Hillgren, Seravalli, and Emilson 2011; Manzini and Rizzo 2011); embed complex product ideas and prototypes in everyday life; and to enrich the description and the evolution of

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behaviour, motives, attitudes and knowledge of the persons involved (Pierson and Lievens 2005). Living labs have been further endorsed as offering a governance and structure to user involvement and user contributions, helping sense user insights, providing solutions to the user input filtering problem, creating societal involvement and promoting user entrepreneurship (Almirall and Wareham 2008). By now, over 340 living labs worldwide are listed by ENoLL website (2014).

Yet, to our knowledge, there is little detailed empirical assessment of the merits of living labs as settings for collaboration in innovation projects. As is typical to the early years of a research area, most of the over 200 key research papers we have identified on living labs focus on what *can* or *potentially could* be done in them and how it *should* happen. The papers that seek to assess living labs or practices therein combine practitioner reflection and conceptual comparisons with other collaborative design settings and means, or have compared differences between various living labs (e.g. Mulder and Stappers 2009; Almirall, Lee, and Wareham 2012; Leminen, Westerlund, and Nyström 2012).

The lack of empirical assessments is likely owed to it being considerably more difficult to undertake such assessment than it may first appear. Unlike relatively simple and short codesign *techniques,* such as card sorting or collaborative walkthroughs (Bødker, Kensing, and Simonsen 2004), the effects of living labs are hard to assess in experimental set-ups or through comparing project experiences. This is because a living lab is *an open ended, sustained and complex coproduction arrangement* that brings together technology providers, users, researchers and other social actors such as cities. By definition, living labs are not just test beds; they turn users to active co-creators and explorers of emerging ideas, scenarios and innovative concepts (Manzini and Rizzo 2011; Leminen, Westerlund, and Nyström 2012). Research on innovation processes has shown how such exploratory projects tend to be affected by tens or even hundreds of significant events and decisions made by partisan actors as well as external stakeholders (Van de Ven et al. 1999). The resulting project trajectories are highly particular, and it is rare that one can sensibly compare high contingency processes with regard to the relative merits of this or that complex arrangement (Russell and Williams 2002; Garud and Gehman 2012).

In the course of running a 15-year research programme of longitudinal studies on designer–user collaboration in innovation projects, however, we gained access to two health care information and communication technology (ICT) projects that appear to provide grounds for sensible comparison of the merits of a living lab. These two projects – wrist monitoring and floor monitoring system for elderly care – used roughly similar basic technology, had a technology-driven start-up history, originated in the same city, were targeted at the same users and use contexts, had struggled similarly to succeed but are both up and running, although without as yet making it very big. One project evolved within the ENoLL listed Helsinki living lab, the other did not.

The wrist monitoring system refers to a device worn on the wrist, which collects data about elderly user's physical activity. In addition to regular nurse call feature, the system is able to automatically call for help when the user is unconscious. The floor monitoring system is based on a sensor network that is installed under the flooring material and it is used primarily in elderly care institutions. The system allows the monitoring of user's motion and position on the floor, and it can inform nurses, e.g. when an elderly person is fallen down, getting out of bed or spending unusually long time in the toilet. The alarms are received through cell phones in both technologies.

The floor monitoring innovation that evolved in a living lab matches, as an emblematic case, how living lab collaboration has been envisioned: it evolved in a living lab that is formally listed among ENoLL living labs, and we selected it from among several projects therein because it exemplified the most in-depth co-creation between developers, users and third parties in a real-life context to develop both the new technology and its applications. Indeed, upon starting to follow this project, our hypothesis was that its development path would be strikingly different than that of the wrist monitoring project we had studied before. The two paths continued, however, to resemble each other, and particularly the challenges they faced in collaborative design appeared roughly similar.

Assessing the merits of living lab for health technology innovation projects

In-depth case studies have become the state of the art for researching innovation projects, which tend to be *complex* and *contingent*; their outcomes are a result of many events, decisions and responses to the particularities of the then current situation. A given event in collaboration tends to be part of the configuration of other events that together have effects on the next steps. Some events may become negated later; for instance, the results emerging from user collaboration may be disregarded amidst other concerns. Thus, tens of interviews, rich document materials and observations are typically needed to form a mesh of observational units that covers the analysis units sufficiently (Van de Ven et al. 1999; Russell and Williams 2002; Höyssä and Hyysalo 2009; Garud and Gehman 2012).

Both of our cases were studied using the biography of technologies and practices approach (Pollock and Williams 2008; Hyysalo 2010; Johnson et al. 2014; Pollock & Hyysalo, 2014). The approach means deploying long-term investigation into the biography of an innovation by following the development of technology as well as the practices of both developers and users related to it, as well as the influences of other stakeholders insofar as they are relevant. With regard to the development project, the changes in the material make up, visions of its future states and the business models are charted as a changing nexus throughout its development. The organisation of the design activities, collaborative network, knowledge base, company organisation and size are mapped and linked to the biography of the project. Regarding user practices, the development paths of key user-organisations are investigated both prior to and after implementation. The evolution of use of the technology is then enquired for an extended period of time, in both studies reported here, encompassing from earliest ideas to more than one version of the technology being deployed. Other stakeholders' are investigated insofar as they play a major role, but are not given as much attention than developers and users, which form the key parties in the coproductive arrangement.

Longitudinal follow-up research has been realised by combining different research materials. The main data types were semi-structured interviews, documents and field observations. In both projects discussed in this paper, interviews were utilised to reconstruct the course of the innovation project prior to our entry as well as to make periodical updates on events and actor perspectives. In both cases, we also had access to rich documentary material both prior to and after our entry. Field observations were substantial in the wrist monitoring case, but remained as supportive data in the floor monitoring case. In both cases, the authors have been impartial outside researchers.

In the document analysis, we followed the principles of historiographic source criticism (Tosh 1991). Open coding of content was used to sort interviews. In the wrist monitoring study, we used ATLAS.ti, which led to 758 entries in 132 categories. In the floor monitoring case, the interviews were coded manually (Glaser and Strauss 1967). The source criticism of documents and the initial interview analyses were complemented by data triangulation and across-method triangulation (Denzin 1989). Interview data, such as informants' accounts of the development process, and document sets, such as the series of

Data type/case	Floor monitoring	Wrist monitoring
Semi-structured Interviews	16	95
Internal documents (memos, plans, project descriptions, correspondence, etc.)	90 meeting memos and plans, reports, etc. Approx. 150 documents altogether	Approx. 400 pages
Field observation	Several site visits	120 site visits between 1999 and 2007

business plans, were compared and cross-validated to complement one another. The case analyses and methods are reported in detail in prior articles and book length reports: on wrist monitoring – Hyysalo 2003, 2006, 2010; on floor monitoring – Hakkarainen 2013; Hakkarainen and Hyysalo 2013.

The above research provides us with fair confidence on the processes of design collaboration *within* both cases. Because of the same research approach and similarities in the project contexts, it also became sensible to seek further comparison (Russell and Williams 2002; Hyysalo 2010). This additional comparative analysis was conducted for the study presented here. It rests on coding and comparing key events and interactions following Van de Ven et al.'s (1999) event mapping technique of the innovation journey. Key ideas, key outcomes, changes in people or technology, key interactions between designers and users, and issues about markets and in the contexts of the two innovations were mapped and then compared. Both authors read the detailed case descriptions and then sought to identify the events to be compared. After the initial mappings, 69 key points for comparison were found. These could be consolidated into 52 points of comparison that were directly relevant for understanding the role of the living lab for designer–user relations and are examined in Figures 1–5. Data-based discussion between the authors was then used to evaluate the degree of difference or resemblance of each event.

In the following we first recount the floor monitoring project in five project stages, followed by the wrist monitoring case. In doing so we provide, in brackets, numbers related to events we compare for resemblance/difference in Figures 1–5. As an example, a marking (1, 3, 11) would point to three comparison events in Figure 1.

Case overviews: floor monitoring and wrist monitoring

Floor monitoring case

Initiation stage

The first innovation project, which we call 'floor monitoring', has its roots at Helsinki School of Technology, where a motion tracking technique was discovered in the late 1990s. The suggestion to advance the techniques from intelligent environment demonstrations (Kymäläinen 2015) into a gerontechnological device came from a manager of a large public nursing home (2). Because of this impetus, a group of researchers and students began to develop a system for detecting residents' falls in a nursing home environment (1, 3, 11). The students won a business idea competition with their concept in 2005, and set up a company around it with the prize money.

The nursing home manager was disappointed in the quality of elderly care technologies on the market and wanted to bring living lab activities to the nursing home in order to achieve better, more reliable and more ethical care technologies. She developed the nursing home into a living lab with the help of a municipal innovation fund and partnered with technology companies, one of which was the floor monitoring start-up. The nursing home living lab was established in 2006 as part of Helsinki Living Lab, an early and active living lab in the ENoLL. Within the nursing home living lab, four innovation projects were started, all of which aimed at developing new care arrangements and improving treatments along with technical testing and further technological development. These projects were a telecare remote rehabilitation service, a novel music service for elders, a safety monitoring carpet and the safety floor project examined in this paper. Out of the four projects, the safety floor project saw the most extensive collaboration between developers and users as well as the greatest technological development and expansion in the business case during the living lab. The safety floor thus represents a project done within the ENoLL living lab context formally, and within it it forms an emblematic case sample (Gobo 2004; Flick 2008).

The first version of the 'safety floor' was developed prior to the living lab based on the designers' implicit assumptions about the users and the context of use; the system would inform the nurses when a resident had fallen down, so that they could come to pick them up (4). The developers drew on their previous experience from surveillance technologies, and no formal market or user studies were carried out (5). The early effort was targeted at technical development and the system seemed to work well in the university laboratory where it had been thoroughly tested (6, 7, 8). The product had already been sold to a couple of institutions. The living lab development started in 2006 and the municipal innovation fund allowed the care actors to hire project workers to support the implementation in the user site and to organise collaboration (9). Whilst the start-up company mostly had only technical expertise, the health care side had expertise in the development and assessment of care practices.

Realities faced in early use: leading to redesign

The safety floor experienced real-life problems soon after the living lab collaboration started in 2006. In the university laboratory test, subjects had been lying on the floor, whereas in reality the elderly persons rarely ended up in that position as they grabbed the back of a chair or bedside rail when falling down (15). Also, the nurses behaved in unexpected ways; they, for example, placed dirty laundry piles on the floor, which the system identified as a person (21). In turn, the technology meant a new kind of monitoring of nurses work, for instance, placing laundry on the floor was against the nursing home's hygiene regulations (39). In general, the residents were in weaker shape and the care work was more laborious than the engineers had expected (16).

In creating the first version of the system, the developers had invested large amounts of time in creating unneeded technical features based on their assumptions about the nurses' work (13). One example of this was a floor plan function in the user interface. Based on their previous experience with surveillance technologies, the engineers assumed that it would be useful to monitor movements of the residents from the computer screen (13). In reality, the nurses neither had the time to sit in the office nor were they interested in the movements of the residents. If the nurses wanted to find out what was going on in the rooms, they would pay a visit. In spite of this, the users were active in coming up with unexpected ways to use the technology. When a resident fell down in her room, the nurses would use the data recorded by the floor plan function to analyse events that had led to the accident so as to prevent future falls from happening (14). In general nurses did not need a fall detector, but rather something else (14).

When the floor monitoring system was put to use in three units, it was possible to assess how the system affected daily care practices, which had to be redesigned together with the system. In addition, the system had to be integrated to the units' existing equipment (17, 18) and the nursing home building, e.g. fire safety regulations had to be taken into consideration in the installation phase. Moreover, IT officials from the municipal social and health care office had demands for the components, especially with regard to information security. In all, the installation and repair turned out to be more demanding and costly than anticipated in, for instance, the internationalisation plans (19, 20,22).

Early developer–user collaboration

The original goal of the project was to discover sensible ways to utilise the system in the nursing home. Several project workers were hired by the user site to organise the collaboration and implementation of the safety floor. The project plan was loose and the project workers could, to a large extent, work as they saw best (24). Pilot costs were thus shared between the public and private partners; the project workers in charge of the pilot were hired by the nursing home, and the technical development was financed by the company (26).

From the user perspective, the initial system was at best a prototype, whereas the company saw their product as more or less ready and was in a hurry to get to the market (8). Developing the system further and quickly getting it to work reliably became the new objective of the project (10, 23, 12, 27), albeit tension remained between the nursing home's wish to have a tailored system and the company's wish to have a generic and profitable product (25). The care professionals were also displeased with the initial interface (28).

False alarms, technical bugs and integration problems began to frustrate the nurses and project workers, who went as far as to exclaim that the safety floor was a raw prototype, not a product (29). The developers were perceived as arrogant with respect to the problems, which made the collaboration even more complicated (30). Eventually, the project workers' wishes turned into demands, and the user side refused to continue with the implementation until their requirements were met (31). The situation finally became so inflamed that the project coordinator, one project worker and the CEO of the company quit over a period of six months (32).

Maturing of collaboration and concept

Version 2.0 of the user interface was launched a year after the beginning of the original implementation (6). The care professionals were pleased, since their ideas and concerns had now been taken into consideration (33). A new kind of project coordinator was looked for: a negotiator rather than an advocate, someone capable of mediating between the participants, albeit one having a nursing background rather than being a neutral outside facilitator (34, 35). After the staff changes, the functioning form of collaboration started to develop and the new project coordinator started to actively observe problems and to seek new development ideas (36).

The reason for project workers becoming responsible in ideation and problem spotting by observing use lie in many nurses' reluctance to do so. Some went as far as boycotting the system by 'accidentally' forgetting to carry the phone with them during the work shifts. The nursing home management decided to make the use of the system and participation in the feedback meetings obligatory; not using the system was declared to be a mistreatment (37, 38).

When use became more widespread, the company got to more profoundly understand the system's impact on work processes and its key benefits. The night shift seemed to be the biggest beneficiary: the nurse on-call did not have to go around checking the residents all night as had previously been the case, because she was informed if someone got up during the night (40). The sleeping elderly were not disturbed by the checks, bedside rails were not needed and they no longer needed to communicate to the nurses that they wanted to get up. Floor monitoring allowed the nurses to help the residents when they put their feet on the ground and an alarm was sent. A new kind of care and work practices started to take shape, and it was because of the care professionals that the system had evolved from a fall detection system to a fall prevention system, which allowed more flexible 'just-in-time' care rather than rigid routines and support for the night shift, and its reliability had been worked on by both parties (41, 42, 43).

Extending from pilots

During the project the start-up company merged with an established electronics company (47), and after the project the merged company started to gain new customers (44). The firm hired the project coordinator; her new job was to train new users and act as a link between company and customers.

With new customers, new contextual challenges arose, which required some redesign. There were minor differences in the work practices of different institutions. Due to heavy installation costs, sales were limited to new rest homes (45), albeit newer buildings created new kinds of technical problems, e.g. the concrete had more humidity in the newer buildings, which initially messed up the algorithms of the system (49, 50).

The company adopted a tailoring strategy, and the system was fitted to each customer institutions' needs, which meant, e.g. integration to existing equipment (48). After a while, this was found to be unviable and a more generic product was needed (22, 51). Hence, the company sought to repackage its offering as a more standard product with servicing (46) and developed an installation floor version (52). By 2014 the floor had been introduced in over 2000 apartments and it was a stable product in the market.

Wrist monitoring case

Initiation stage

The second technology, we here call 'wrist monitoring', was equally a gerontechnology project that departed from new technical possibilities in monitoring elderly users. This concept took shape during the years 1992–1994 and a start-up company made up of engineers was founded to develop it. The idea arose from its inventor's experience with the engineering and marketing of safety phones and alarm-systems (1). The technology was designed to monitor users' physiological state from their wrist movement, temperature and electroconductivity sensing, and thereby to generate an automatic alarm in case of medical emergency. It included a manual alarm-button and a receiver unit. Alarms were relayed to a predetermined end, for example, to a nurse on call, an alarm centre or to relatives. This person then made the decision on the appropriate action, for instance, calling the user, her neighbours, maintenance or an ambulance.

After the project initiation, there were internal and external studies that assisted in defining the concept: technical feasibility and monitoring were studied within the technical research centre, European markets were investigated in two small marketing researches and the concept was 'test-marketed' in interviews with the inventor's elderly relatives. All of these indicated demand for this kind of technology (2, 3, 5). During the years 1995–1997, the prime concern for product development was finding the right sensors, ways of measurement and adequate algorithms for quick detection of illness attacks and for proactive measures. Further insight about users was generated in a design and usability study that was conducted during 1995–1996. This had hardly any immediate effects, even though it warned against some of the core assumptions made about the use of the device (4). The designers had already proceeded far with the design, and believed in it, albeit a technical setback made them lose a year (6, 7). The product was launched and first pilots started in early 1998 (6). The product developers regarded the device to be a success in technical terms and an achievement in terms of getting to market launch with just the personal assets of the company founder (8, 9, 10).

Realities faced in early use: leading to redesign

The first pilot uses revealed an unexpected number of false alarms that had to be worked on, along with other technical bugs. To work flawlessly, the device required specific procedures in wearing, removing and storing the device; cancelling false alarms, cleaning, et cetera. These instructions grew from 7 to 25 pages during the two first years of use. Even though some users were happy with the device, many had problems (11, 12, 20, 21). In institutions, much of the reliability of the device was on the shoulders of nurses. The system required them to be readily awaiting for and reacting to the information provided by the system; yet this was a poor fit with their work practices and existing instrumentations, whilst their care rounds also gave them a fair understanding of the elderly residents' condition (13, 17, 18).

Between 1998 and 1999, the company made numerous adjustments and new developments, ranging from adjusting the algorithms and reducing features, to user-training (14). The product was expanded to include diagnostic software for alarms, which was soon complemented with online graphical monitoring, following a suggestion from the users (13). Use of wrist monitoring in rest homes was augmented by developing an integrated system with a number of receiver units and wrist devices, in part due to difficulties in integrating the wrist monitoring devices to extant infrastructure and device stock both in rest homes and in alarm centres that received home sector emergency calls (17, 18, 19). During this period, experience from usage led to a questioning of many of the previous assumptions, such as who the users and clients were, how they worked the technology, how the technology fit the infrastructure and how the condition of the elderly could be monitored, given they were in fluctuating health and more frail than was assumed in the initial algorithms and instrumentation (15, 16, 18, 19). In the midst of struggling to fix and improve the technology, the company sold about 1000 devices and won both domestic and international innovation awards, received positive press coverage and attracted new investments.

Early developer–user collaboration

The pilots were set so as to only verify the technical feasibility and benefits derived from a technology along with fixing small remaining bugs. The developers and elderly care actors both expected a readily functioning technology (23). There were few preparations in place for handling the piloting phase such as what to do with continued technical problems (24). After the first pilot study, the sites were now paying-customers and both parties resented allotting time and money to techical bug fixing. The developers wanted to concentrate on marketing, internationalisation of business and development of the next product version, even though they became forced to create different versions and additions to the product in order to close deals with institutions (25). Elderly care actors ended up spending time on complaints and working around the early system that had frustrating interfaces and generated false alarms, albeit they did not formally provide resourcing or funding for the pilots (26, 28, 29). The company's first approach to the situation was to seek to train the elderly care staff to operate the technology better, but gradually they realised they needed to start fitting the technology to nursing work and increase its reliability to soothe the rising pressure from pilot sites. There were also a growing number of redesign wishes (30, 31) and the position of the mediating personnel between R&D and customers was difficult to bear: over a period of five years, five people quit this position regardless of how the position was defined (e.g. as product manager, marketing manager and customer manager (32)).

Maturing of collaboration and concept

During the years 1999–2002 the company built, tested and iterated the second version of the product (33). Attention was paid to the appeal and usability of both the wrist device and the monitoring software. Partnerships were developed with several user-organisations and they began to be used explicitly for testing and gaining ideas for improving the design (36). Strategies were changed with regard to how the technology was presented in marketing, user-training and in dealing with the medical community. Reliability was emphasised along the user-identified key value points in diagnosing and monitoring of elderly patients and restructuring care work particularly in the night shift. A key value point emerged from users finding care-work use for the 'activity curve' illustration, which the designers had originally created as a gimmick for a fair to visualise what their device monitored (39, 40, 41, 42, 43).

User-organisations, in turn, began to charge rent for the device irrespective of whether it was in use (37, 38). Inside the company, all installations, user-training and feedback to R&D were placed under a single person who had extensive experience with safety phone systems in elderly care (34, 35). The change in strategy in relating to users enabled the company to improve all aspects of the product system, particularly its control-software, which was a key feature for users to recover from false alarms, and overcome difficulties in fitting work practices into different rest homes and alarm centres (22).

Extending from pilots

The 2.0 version increased company sales to several thousands of units (44). In 2003, the nature of the user partnerships changed, as the company sought to build locally configurable but generic product packages to improve economic viability. As part of this, slowness and complex steps in public sector purchacing cycles became evident, along with difficulties of selling equipment beyond new nursing homes under construction (45, 46, 48, 49, 50). The company had to seek repeated rounds of further funding (47). The company still sought and received information from the key user sites, but ceased to alter the existing design, and channeled the improvements into the next release 3.0 (/2.0), which they launched in 2007 (50, 51, 52). At this point, there was was a stable and profitable product in the market.

Comparing the key project items in developer–user interaction

The comparative mapping of key events clarifies the resemblances between the two projects (Figures 1–5). As abbreviations we use OUT for outcome, TECH for technology, INT for interaction, CTXT for contextual event, MKT for market, PPL for people, ID for ideas.

Of the 11 comparison items in the initiation stage (Figure 1), three bear a strong resemblance and four a moderate resemblance, mostly resulting from the engineering starting point of both projects. Two of the three differences result from the fact that floor monitoring gained the idea of viability from elderly care actors, whilst wrist monitoring relied on the developers' own assessment, verified by market studies. With floor monitoring the user side also ended funding of the initial development, which gave them more say over the project in the ensuing stages.

Initiation stage

	Significant resemblance	Moderate resemblance	Moderate difference	Significant difference	Key event	*Floor monitoring*	*Wrist monitoring*	
1	×				**Engineering starting point (CTXT, PPL)**	University spin-off from signal processing engineering	Engineers with safety alarm device history	
2	×				**Encouragement from elderly care (ID, INT)**	Informal contacts with elderly care highly positive	Informal contacts with elderly care highly positiive	
3				×	**Idea about viability (INT)**	Encouragement from elderly care actors	Own assessment, market studies	
4	×				**Implicit idea of users (INT)**	Alarm for readily awaiting health personnel about falls	Alarm for readily awaiting caregivers about movements and illness attacks of the elderly	
5			×		**Explicit market or user research (ID)**	None	Two studies on European markets	WM developers did not alter their design in any way before 2.0 version.
6		×			**Early energy targeted to technical development (TECH)**	Basic mechanic, electronic, and algorithms: floor monitoring and its interface, a year pre living lab, 3 more years in living lab to stable 2.0 version.	Basic electronics, mechanics and algorithms: Proactive and fast response alarms and interfaces, 6 years prelaunch 3 more years after launch to stable 2.0 version.	WM development took considerably longer
7			×		**Changes in key technical components (TECH)**	None	Several	Customer relation in place
8		×			**Tight funding (CTXT)**	Small research and development grants	Founder's own assets	Developer time the greatest expended resource
9		×			**"Ready" product from the R&D (ID)**	Sales agreement with few institutes prior to pilots, Living lab agreement to develop applications	Sold to a few users and institutes prior to pilots	
10				×	**User side funding prior to pilots (CTXT, INT)**	Some funds for living lab collaboration used in technical development	None	
11		×			**Target market (MKT)**	Elderly care institutions		WM home use dominated early design but institution use dominated since

Figure 1. Resemblances and differences in the key events in the initiation stage.

Realities faced in early use: leading to redesign

#	Significant resemblance	Moderate resemblance	Moderate difference	Significant difference	*Floor monitoring*	*Wrist monitoring*
12				X	**Continued technology development during pilot use (TECH, OUT)**	
					Yes, in living lab. The aim was to develop care practices.	Yes, first in short pilot use, then with small number of paying (pilot) customers.
13	X				**Unneeded technical sophistication reduced (TECH, OUT)**	
					Nurses simply visit the room, no need for remote viewing	Proactive alarms unattainable reliably and not needed: visiting residents regularly
14	X				**Unexpected uses (ID)**	
					Floor plans used for retrospective assessment of incidents	Activity curve appropriated for determining the shape of the resident and in retrospective assessment
15	X				**Unexpected variability (ID)**	
					Falls had greater variety than technically prepared for: inaccurate algorithms	Fluctuations in the condition of the elderly greater than prepared for: inaccurate algorithms
16	X				**Elderly in much weaker condition and needing more assistance than expected by developers, nurses the primary users. (ID)**	
17	X				**Unexpected integrating to nursing work needed (ID, TECH, OUT)**	
					Alarm reception, routing, handling, priorization and responsibilities significant and complex, Interface and working principles redesigned.	
18	X				**Unexpected integration to other equipment (ID, TECH, OUT)**	
					Redesigned to fit in with extant software, nurse call, PC's, cell phones, fire alarms, flooring, wiring etc	Redesigned to fit in with extant software, PC's, cell phones, fire alarms and alarm centre software's
19	X				**Need to invest in own network and software (TECH, OUT)**	
					Integration to city networks too much safety risk	Extant safety phone software could not handle new alarms
20	X				**Unexpected contextual problems (TECH, ID)**	
					E.g. no holes allowed for wires in walls due to fire safety	E.g. receiver unit signals interfered with up by elevators or thick walls
21	X				**Unexpected user behaviours (PPL, TECH)**	
					E.g. nurses leaving laundry piles on the floor	E.g. Insulating the monitoring unit with cotton, wearing in shower
22	X				**Installation and repair costs higher and hamper internationalization (TECH, MKT)**	

Figure 2. Resemblances and differences in the key events in the redesign stage.

Strong similarities become evident when the projects move from technical development to first deployment at the user site (Figure 2). In both cases, this led to major redesigns and many early assumptions about use and system features becoming questioned. In 10 data items, the only difference was that the floor monitoring project evolved within the living lab, whilst for wrist monitoring the pilot sites were also paying-customers. The extent of continued development in use was an equal surprise in both projects.

The earliest designer–user collaboration happened in pilots in both cases. Here the differences induced by the living lab are visible through the collaboration arrangement and plan as well as in sharing costs (Figure 3). The strain caused by the redesigns and

Early developer-user collaboration	Significant resemblance	Moderate resemblance	Moderate difference	Significant difference	*Floor monitoring*	*Wrist monitoring*	
23	X				**Both users and developers expected the product to be more or less ready at the deployment and the work to focus on development of new care practices. (TECH)**		
24				X	**Collaboration agreement and plan (INT)** Collaboration agreement, and loose project plan to facilitate collaboration	Vague agreement about testing and piloting taking place	
25	X				**Local / Generic tension (TECH, INT, MKT)** Users: Local and quick tailoring vs. developers: generic and profitable product		
26			X		**Pilot costs and work shared (CTXT, INT)** Funding and workforce available from elder care side.	Purchases from elder care, workforce time used.	
27		X			**New design aim: getting the technology to work reliably (TECH, OUT)** Achieving reliability dragged on for 2 years, blended with other aims. Users key to achieving it.	Achieving reliability dragged on for 6 years, blended with other aims. Users key to achieving it.	WM dragged on longer.
28	X				**Initial user interface very difficult to use (TECH, OUT)**		
29	X				**False alarms and missed accidents frustrate nurses and elderly, particularly during nights and during treatment tasks. (TECH, OUT, PPL)**		
30	X				**Developers perceived as arrogant in the face of user problems and risks from the technology (INT)**		
31	X				**Elderly care actors react (INT, OUT)** Wishes turn to requests, heavy pressure, refuse wider implementation	Wishes expressed, some pressure, patience, some collaborations end.	FM company forced to take users seriously earlier
32		X			**Mediating personnel quit (INT, OUT)** Many of the user side project staff quit, company CEO	Company persons mediating dev. and use quit 5 times in 5 years	in FM users too bear the pressure

Figure 3. Resemblances and differences in the key events related to early collaboration.

reorientation of the project also affected the users in the living lab setting as user side mediating personnel quit, and not only staff within the company. However, in light of claims made in living lab literature, one would expect greater differences between the two projects already here.

The maturing of collaboration is where one would, at the latest, expect a decisive difference between the projects (Figure 4), but out of 11 events six bear close resemblance,

Maturing of collaboration and concept

	Significant resemblance	Moderate resemblance	Moderate difference	Significant difference	Event	*Floor monitoring*	*Wrist monitoring*	
33	X				**2.0 version fits nursing work and context better and allows more tailoring (TECH, OUT)**	2.0 version a year after first implementation	2.0 version four years after first implementation	WM 2.0 version longer to emerge.
34	X				**No formal or neutral outside facilitator for collaboration: no resources, not perceived needed by any party (INT)**			
35		X			**User side innovation intermediary emerges (INT)**	New user side project manager: mediates between other users and company limitations.	New company product manager: integrates installation, training, troubleshooting and refining of design requests.	The key person resides in different "side". In WM best collaboration when both sides have motivated and experienced
36	X				**Well functioning form of collaboration develops (INT)**	Active problem and idea seeking, observations and problem sheets, regular meetings.		
37		X			**Mandatory use by management decision (INT)**	Non-use declared as mistreatment	Price of wrist device included in all rents	FM more strictly mandated
38				X	**Feedback made mandatory for nurses (INT)**	Yes	No	
39	X				**Panopticon issues: monitoring renders elderly and nurses work more visible. Management endorses, users adapt. (TECH, PPL)**			
40	X				**Night panopticon key benefit: no need to check residents by opening doors (TECH, OUT, ID)**			
41		X			**Users ideate the new key value points (TECH, ID)**	Anticipation of falls and just-in-time care initiated by users.	"Activity curve" creatively appropriated and developed into a diagnostic and proactive tool.	
42	X				**High importance of reliability agreed and emphasized by both parties (TECH, INT)**			
43		X			**Similar end-benefits despite different early aims (ID, MKT, OUT)**	Detection, anticipation and help with falls and worsening condition, support for night shift, allowing natural day rhythm for residents.		

Figure 4. Resemblances and differences in the key events in the stage of matured collaboration.

Extending from pilots — *Floor monitoring* / *Wrist monitoring*

#	Significant resemblance	Moderate resemblance	Moderate difference	Significant difference	Floor monitoring	Wrist monitoring
44	X				**Rapid gaining of a customer base of few hundred installations (MKT, OUT)**	
45		X			**Most sales in new rest homes: flooring, public sector purchase logic (TECH, MKT)**	
46	X				**Profitable operation a challenge, further development needs (MKT, TECH, OUT)**	
47	X				**Required funding leads to ownership changes (CTXT, OUT)**	
48	X				**Further redesign and further configurability to the product (TECH, OUT)**	
49	X				**Unexpected contextual technical differences in other settings (TECH, ID)**	
					e.g. Higher humidity of cement in new buildings interferes with the algorithms	Price of wrist device included in all rents
50		X			**Mandatory use by management decision (INT)**	
					Non-use declared as mistreatment	e.g. Differences in how alarms are routed, receiver unit coverage
51	X				**Higher than expected local configurability needed (TECH, ID)**	
52	X				**To and fro between localization and generic offering (TECH, MKT, OUT)**	
					Localization decided and undecided several times	
53	X				**New product versions made (TECH, MKT, OUT)**	
					The installation floor, new generations of vivago, segmentation of product to institutional and home versions	

Figure 5. Resemblances and differences in the key events after the living lab / piloting phase of the project.

two a moderate resemblance and the only differing ones concern the issue of use and feedback becoming mandatory within the living lab. The explanation for resemblances appears to be that the wrist monitoring project had to, in effect, establish the similar kind of real-world partnering arrangements that the living lab development helped to build for floor monitoring. It is worth noting that in both cases it was users that ideated the new key value points for the project and that both projects ended up with somewhat similar benefits – more proactive care given by the nursing staff (not through automation as it was originally envisioned in both).

The road from the pilot stages bears close resemblance in both projects (Figure 5). In both, it became evident that the amount of customisation and partnering was unfeasible as a long-term business strategy, and they suffered funding shortages. In both cases, the company opted for a mix of occasional collaborations and more arm's length user relations. Also, in both, the company sought to have a generic product with a ready set of accumulated functionality that it then could just configure to each setting, and in both these configurationality needs were higher than expected after the pilot years.

When comparing the overall trajectories of these two projects, 63% of events have close resemblance, 19% feature some resemblance, 12% have moderate difference and 6% strong difference. Two things stand out as particularly salient as explanations for these high resemblances. First, the challenges in making monitoring technology work reliably in care homes were equally formidable as was the need to reiterate the working principles and value points of the technology. Second, the direction of events appears not to have been 'the living lab is not that different' but rather that the wrist monitoring, in fact, had to revert to establishing similar collaboration affording arrangements; in other words, collaboration that resembled the living lab was required to succeed.

Conclusions

Living lab advocates and research literature alike stress how these real-life environments for design collaboration offer a unique environment for exploratory collaboration between developers, users and third parties, seen as vital for improving the success of innovation (Niitamo et al. 2006; Almirall and Wareham 2008). Our study of two technology-driven health projects underscores that such collaboration, indeed, is vital for the success of these kinds of innovation projects. In both projects, it was hard for developers to grasp the health care context and to reiterate the concept and its material realisation sufficiently. Interaction and learning between developers and users was paramount for changes and for achieving a well-received product in the market. In neither project did collaboration emerge without high levels of frustration and conflicts of interests, purposeful efforts to build the collaboration arrangements and intermediary actors to champion it. These are all facets that research and practice on participatory design has stressed for a long time (e.g. Schuler and Namioka 1993; Bødker, Kensing, and Simonsen 2004). The literature would add that for both projects, more intensive collaboration at the very outset might have been beneficial.

The extended living lab collaboration appears to have speeded up the redesign process that both projects had to suffer. The living lab also spread some of the ensuing costs to users and mitigated the strain on early customer relations in the company. The eventual difference appears, however, to be of degree rather than kind in the shape of the innovation trajectory. As noted above, this is explained not so much by the failure of the living lab development, but by the necessity of the wrist monitoring case to move to a similar kind of collaboration arrangement in the course of the project. This interpretation finds support from the other similarly detailed case studies of Finnish health ICTs (diabetes software, brain imaging technology, e-grocery service for elderly, information infrastructure for elderly): both developer and user visions of the eventual working technology have been questioned, and only those projects where the visions and material form of the technology have been altered collaboratively have survived (Hasu 2001; Hyysalo and Lehenkari 2003; Hyppönen 2007; Hyysalo 2010; Botero and Hyysalo 2013). The case comparison can thus be taken to question the uniqueness of the effects of the living lab as a collaborative setting, but highlights the importance of *this kind* of collaborative setting and co-creation between developers and users.

To cap our analysis, through this comparison we argue that extensive collaboration between designers and users is paramount for the success of complex new health technology projects, but this can be achieved without a formal living lab arrangement, albeit such arrangement does appear to help in achieving it. The metaphor of the 'quadruple helix' is often used in living lab discussions, and conveys an image of a (genetic) formula for effortless and joyful multiparty collaboration. When the collaboration is examined in depth, as in the case here, the nature of collaboration is not effortless or automatic. A living lab, as such, appears to be no panacea for collaborative design efforts between designers and users. Rather, the question is whether the parties engaged in living lab collaboration are willing to go through all the work needed to create the specific and particular relationships by which the relevant information can be made visible and transferred to the other party. A living lab arrangement appears to offer a legitimate rationale for trying such engagement and the resources it requires. Perhaps creating a living lab may be best seen as shorthand for the collaboration processes, in which the partners in innovation processes have to partake in real-life settings in order to aide project success.

In terms of further research, the present study exemplifies the state-of-the-art *innovation process* research comparison on projects conducted in living labs. Living labs are *open ended, sustained and complex coproduction arrangements*, which typically affect even more *complex, multi-causally formed and long-term innovation journeys*. As Van de Ven et al. (1999), Garud and Gehman (2012) and Russell and Williams (2002) have shown, these characteristics limit the valid types of comparative research. Operating on variance epistemology and ontology is ill-suited for such complex process research and comparison. Less process-oriented and coarser-level comparisons can, however, be used to contextualise and generalise the findings from the present study (Gobo 2004). Our findings are most generalisable to innovative health care technologies, to projects in publicly hosted living labs (Leminen, Westerlund and Nyström 2012), to projects where co-creation is extensive (and not just testing) and to engineer-driven start-up technology companies. The further the distance from these primary contextual characteristics of these currently investigated projects, the lesser the likelihood that the patterns observed here would be found or play out similarly (Gobo 2004).

The findings indicate four recommendations for practitioners. First, at least in health technology innovation projects it is imperative to invest in creating a real-life collaboration setting with or without formal living lab. Second, even if living lab setting is used, targeted action needs to be taken to build up the collaboration and reconciling different interests of participants. Third, it is advisable to retain relatively open agreement on what the collaborative relationship may hold, but inform all parties realistically of the uncertainties and development needs both in technology and in user practices. Fourth, it is advisable to prepare for changes in collaboration as the innovation process evolves; the need for collaboration between developers and user will not disappear with ending of living lab collaboration, but the topics and forms will change when the product becomes sold to wide clientele.

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DIVERSITY AND CHANGE OF USER DRIVEN INNOVATION MODES IN COMPANIES

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User driven innovation (UDI) is a popular term in policy and corporate circles. However, it is not clear exactly what UDI means and how such practices are used across the spectrum of companies and over the innovation life cycle. The present study compares 58 UDI showcases in Finnish companies in order to analyse the diversity of UDI practices and their evolution over time. We identify five main modes of UDI and show how the ways of using UDI develop over time in individual companies. In almost half of the examined cases, the dominant mode of UDI changes at least once, and in some cases, up to three changes in dominant mode are observed. We then proceed to identify six qualitatively different ways in which companies' orientation to UDI evolves over time. The study has implications for innovation management and policy: It calls for greater attention to UDI diversity and particularly to the management and support of the continuity of UDI efforts.

Keywords: User driven innovation; case study; comparative study; companies; innovation management; innovation policy; user involvement; user innovation; participatory design; user centred design; marketing research.

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Introduction

User driven innovation (UDI) has gained increasing attention throughout the 2000s in innovation practice, research and policy alike. No longer seen as a fringe activity, users have been brought to the centre of attention in innovation projects as participants, informants, sources of designs and sources of inspiration. The gains sought from users include better transfer of user information to companies, more appealing products, utilising users' efforts and skills in product development, as well as gains through their involvement in marketing, delivery, business model development and greater likelihood of user acceptance.

Despite considerable bodies of academic research, and indeed also because of them, the definition of UDI has remained somewhat elusive and subject to debate. In some formulations UDI means new emphatic awareness of user identities and contexts that designers can bring to companies (FORA, 2009). Advocates of user centred design (UCD), however, tend to insist on more exhaustive and methodological engagement with users (Norman and Draper, 1986; Benyon *et al.*, 2005). Even more forcefully, many insist that the core of UDI is innovation by active users and user communities (von Hippel, 2005; van Abel *et al.*, 2011), or participatory innovation (Buur and Matthews, 2008; Bødker *et al.*, 2004). At the opposite end, UDI has been seen by policy makers as advanced early-stage customer research, rendering UDI arguably a more commonplace, yet also a more incremental addition to R&D practices (MEE, 2010; DAMVAD, 2009). Particularly in the UK UDI has been seen as a subset of open innovation (Piller and West, 2014), whilst this has not been the case for instance in Scandinavia.

Each camp holds good arguments as to why their view should define UDI and why others miss their mark. Further ambiguity in UDI results from the frequent blurring of normative, visionary, commercial and academic registers in addressing it. Views on how users *should* be engaged, how designers *could* create new concepts, and *what happens* in companies and other sites of innovation tend to overlap. This may be because companies fail to fully embrace UDI, or equally because UDI visions may be exaggerated. Additional uncertainty follows from the existence of hundreds of methods developed by consultants and academics, most of which have not been systematically tested for effectiveness.

Amidst all this rhetoric and development of tools, there is little research on how companies across industries work with UDI and how they integrate various forms of working with users in their innovation process on a more permanent basis. This is important because much of the policy, practitioner and academic discourse aims to get companies to experiment with some UDI methods with the (at least implicit) assumption that this experimentation would result in more permanent changes in the way companies manage innovation (MEE, 2010; Ehrvervs-og, 2010).

The present study aims to address this gap through an analysis of 58 Finnish cases of UDI. We examine empirically what kinds of engagement between users and developers takes place in projects seen as UDI in companies and how the engagement of users evolves in companies that experiment with some form of UDI.

Answering this question requires a different combination of breadth and depth than research to date has provided. Surveys of UDI practice are scarce, and do not explore in detail exactly how users were involved in the long term (e.g., Gales and Mansour-Cole, 1995; van de Vrande *et al.*, 2009; Carbonell *et al.*, 2009). Studies that examine within-case dynamics in more detail usually only focus on a handful of selected cases (e.g., Lettl *et al.*, 2006; Heiskanen *et al.*, 2010).

We aim to go beyond existing cross-sectional surveys of user engagement in innovation. In doing this, we draw on advances in the literature on social learning in technological innovation (SLTI), a further development in the social shaping of technology (SST) literature (Williams and Edge, 1996; Williams *et al.*, 2005). Rather than presuming that UDI in real-life projects is comprised of a fixed set of elements, such as methods, the approach examines how the product, its developers, users and third parties are constructed in the course of the development project (Russell and Williams, 2002; Johnson *et al.*, 2014). It further points to procedures and apparatuses through which knowledge about users is accumulated in various actions created by companies, their suppliers and clients and used in advancing and managing innovation (Russell and Williams, 2002; Williams *et al.*, 2005; Hyysalo, 2010).

Our current analysis seeks a new type of analysis within the social shaping of technology tradition. SST and other science and technology studies have excelled at detailed case analyses (Bijker *et al.*, 1987; Sørensen and Williams, 2002; Rohracher, 2005). The avoidance of fixed research templates and the reliance on maxims such as "follow the actors" (Latour, 1987) have been apt for analysing highly contingent innovation processes. Generalisations have come by way of characterising patterns in innovation processes captured by concepts (Russell and Williams, 2002), sometimes elaborated as process models, such as those of domestication and social learning (Sørensen and Williams, 2002; Williams *et al.*, 2005). Whilst valuable, the lack of comparative studies has arguably limited the uptake of SST results within quantitatively oriented fields of innovation research and policy-making. Drawing inspiration from van de Ven's and Poole's (2005) ideas for combing a variance epistemology with a process ontology, we conduct a cross-sectional analysis of 58 cases in order to identify how patterns of UDI are distributed over cases. We avoid further quantitative modelling in order to preserve the ecological validity of detailed process analyses (Garud and Gehman, 2012).

We contribute to research on UDI by empirically analysing how a variety of companies in different industries engage users in their innovation processes and, in particular, how these ways of engaging users develop and evolve over time. On the basis of this analysis, we identify six change sequences that companies can experience after initial experimentation with UDI. To the best of our knowledge such investigations have not been carried out before.

In the following sections, we examine different modes of conducting UDI and how the social shaping of technology approach helps to understand this. We then proceed to identify diversity and change in companies' ways of engaging users. We do this first by examining how the company UDI mode changes from one dominant mode to another, and second, by examining how the same orientation changes with regard to contents of the UDI processes, and linking these back to the social shaping of technology literature. In conclusion, we discuss the managerial and policy implications of the variations and transformations in UDI modes.

From Modes of User Driven Innovation to Analyses of Developer–User Relations

The term UDI is of relatively recent origin, surging to the fore in national and OECD policy programs after the turn of the millennium (see FORA, 2009 as an example). The surge, however, owes itself to a set of phenomena in innovation that has been known and has grown over decades.

Collaborative design as an approach to develop new workplace and later leisure products owes its academic roots to sociotechnical design in the 1950s and participatory design initiatives in the 1970s, which gained increasing impetus in more mainstream development practices towards the turn of the millennium (Greenbaum and Kyng, 1991; Voss *et al.*, 2009). It has found further expression in, for instance, real life development environments such as living labs (Hillgren *et al.*, 2011). Yet intense design collaborations (DCs) have taken place between interested developers and users, oblivious of academic endeavours (e.g., Lundvall, 1985; Williams *et al.*, 2005; Hyysalo, 2010). Collaborative design can thus be more neutrally described as design collaboration (DC) to include those DCs "in the wild" (Hyysalo and Lehenkari, 2002) that have taken place across decades but remained academically mostly undocumented.

User innovation (UI) is another well-known phenomenon, brought to gradual prominence by a series of studies since the 1970s, spearheaded by Eric von Hippel and the research community around him (von Hippel, 1976, 1988, 2005; Flowers *et al.*, 2009, 2010). In some special areas, such as scientific instruments, 80% of innovations have been reported to originate from users. It has been reported that

19–36% of users of some industrial products develop or significantly modify the products they use and 4–6% of consumers modify some products they use (for summaries see von Hippel, 2005; DeMonaco and von Hippel, 2013).

User centered design emerged in the early 1980s (Norman and Draper, 1986; Dix *et al.*, 2004) and has since grown and diversified into areas such as interaction design, user experience design and service design (Preece, 2002). Various UCD methods and techniques are used widely in software application design and industrial design. UCD's most distinctive legacy to UDI has come through the idea of ethnographic and other contextual studies on users as the basis for product and business development (Benyon *et al.*, 2005; Whalen and Szymanski, 2005). Particularly, the studies that focus on user value enhancement as part of product design were influential in the formulation of, for instance, Danish UDI policies (FORA, 2009).

UDI has also been seen to include variants of user studies that are more traditionally oriented toward design practice. These can be characterised as *user inspiration for design* (UIFD) where users are investigated more for inspiration than for grounding design (FORA, 2009; MEE, 2010). The academic versions of designer driven approaches include substantial investigations of user contexts and experiences (Mattelmäki, 2006; Sanders and Stappers, 2012), but most usages in industry rely on less documented and more intuitive engagement with users; the aim being to create products that would be usable and aesthetically pleasing for users. It is this latter meaning of UIFD that we employ in the current paper.

Finally, UDI has been seen to include advanced customer and market research methods such as data analytics, particularly in policy programs (cf. MEE, 2010). Drawing the boundary between UDI and deploying variants of marketing research in companies is difficult. Nonetheless, particularly for many small- and medium-sized enterprises (SMEs), more qualitatively-rich *studies on use* (SU) with prospective users can hold novelty value and reframe innovation efforts even when the companies develop their established offerings and we have included such more in-depth studies of use within UDI also in this paper.

In summary, UDI is not an academically or managerially unified field, let alone a unified concept. Yet the elements that can be found in most UDI formulations have discernible origins and are associated with academic research traditions.

However, these formulations may correspond more or less closely to what actually occurs in companies experimenting with ways of engaging users in their product development processes. Product and service development is commonly viewed as a sequential process in which tasks take place one after another. It is seen to take place in an organisational setting, either within an organisation or between organisations, but may also involve actors outside organisations, including co-creative user communities and individual users (Piller and West, 2014;

Prahalad and Ramaswamy, 2004; Chesbrough, 2003; Ulrich and Eppinger, 1995), also reflecting varying levels of openness and engagement (Vanhaverbeke, 2006; Earthy *et al.*, 2001). Such formalised processes may describe new product development in large companies with dedicated product development units. The linear progression is less likely in the case of more complex and innovative products (e.g., van de Ven *et al.*, 1999; Sørensen and Williams, 2002). Similarly, formalised process depictions are also questioned by the practices of SMEs and companies that lack dedicated product development units and rely as much on the entrepreneur's talent and networks as on formal planning processes (Mayer-Haug *et al.*, 2013), which both appear as recurring features in many of the Finnish UDI cases we examined. User engagement in product development did take place in the studied company cases, yet it was seldom strictly formally organized according to formal R&D processes. For instance, in the course of the innovation process users provided requirements, screened proposed solutions and contributed resources to product development in multiple ways, i.e., users engaged in a developer–user relationship. Our cases suggest that we need to view the organising (Czarniawska, 2008) of product development differently if we wish to understand how it relates to users, particularly when it is carried out in SMEs that operate in markets not usually associated with technical product development (Cox and Frenz, 2002).

To do this, we draw from the SLTI framework (Procter and Williams, 1996; Williams *et al.*, 2005; Stewart and Hyysalo, 2008), which is specifically focused on interrelations between developers and users. SLTI is a further development of the Social Shaping of Technology (SST) approach (Williams and Edge, 1996; Russell and Williams, 2002), which examines technological development not as a linear or deterministic process, but as one that involves social choice in the course of innovation. This choice is presented as a garden of forking paths where technical, social, economic and organisational considerations are weighted and acted on contingently by different actor groups. SLTI has been dubbed by its advocates as "social shaping of technology mark II" (Williams *et al.*, 2005). This is because it has sought to extend the analysis of innovation activities to the sites of use, where innovations are further developed after their first emergence. As a corollary to the emphasis on use activities in shaping technology, SLTI has taken the developer–user nexus as its key focal point and stressed the interrelations between how uses, technologies, services and systems are represented, how they are configured, and how they are appropriated in different sites and moments of innovation.

In this view, "user driven" innovation activities form one part of the innovation process, which are usually complemented by other sources of user and market representation. Moreover, the way in which users are represented can change along the course of the innovation process (Hyysalo, 2010). Finally, since innovation is not merely a process of learning, but also one of interaction and struggle

(Williams and Edge, 1996, Pollock and Hyysalo, 2014), companies may be reluctant to challenge their existing mode of operation even when faced with new and potentially valuable input from users (Heiskanen and Repo, 2007; Williams *et al.*, 2005).

Analysing User Driven Innovation Within Cases: The Example of Elderly Care Floor Monitoring

We employ a two-phase research strategy: First, a case-by-case analysis and then a comparison across case descriptions. Accordingly, we first examined the 58 qualitative case descriptions diachronically, project-by-project (rather than, for instance, surveying the companies about their espoused UDI strategies), focusing on what kind of interaction between developers and users took place in different stages of the innovation process. The SLTI approach provides a useful analytic point of departure for analysing real-life company practices, since it guides the analyst to trace in detail how the materiality of products and services emerges and what kinds of networks form around them in each case (Sørensen and Williams, 2002). We allowed the case companies themselves to describe how and where a product development process started, what events took place, what kind of collaborations were part of the process, and how the process ended, without presuming or imposing a model or stages by which this should have happened (cf. Stake, 1995). This approach also allowed for a detailed accounting for non-technical product development, such as service concepts, business models, and new products comprising of features of existing products.

The data collection intensity and methods varied among the 58 cases we compare in this article. At the maximal end of intensity, case companies and their user sites were observed over several years, combining tens of interviews with ethnographic observation and analysis of documents (Hyysalo, 2010). At a minimum, we started off from publicly available project and product descriptions and then carried out narrative interviews with company representatives. In the interviews, a chronological frame for actions occurring during product development was construed, as well as documentation of whether and how any engagement with users may have taken place. The resulting descriptions represent the chain of what took place from the beginning of the innovation process to the end and commercialisation (Gubrium and Holstein, 1998). Appendix A provides the list of cases and the abbreviated name we use for each case in the text.

To appreciate how SLTI informs case analyses, let us examine an extended vignette of one of the innovation process in our case sample: how a fall detector for elderly gradually evolved to a safety floor monitoring system for elderly care housing (from here on "elderly floor monitoring"), which has been reported at book length in Hakkarainen (2013) and in Hyysalo and Hakkarainen (2014).

Case Vignette 1: The analysed case of floor monitoring innovation has its roots at the Helsinki University of Technology, where a motion tracking technology was developed in the late 1990s. The suggestion to transfer the technology from intelligent environment demonstrations (Kymäläinen, 2015) into a gerontechnological device came from a manager of a large public nursing home. Because of this impetus, a group of researchers and students began to develop a system for detecting residents' falls in a nursing home environment. The students won a business idea competition with their concept in 2005, and set up a company around it with the prize money.

The first version of the "safety floor" was based on the designers' implicit assumptions about users and context of use: the system would inform nurses when a resident had fallen down, so that they could come to help them. The developers drew on their previous experience from surveillance technologies, and no formal market or user studies were carried out. Early efforts were targeted at technical development and the system was thoroughly tested in the university laboratory.

UDI entered into the innovation project in 2006, when the company joined a living lab led by the public nursing home that had suggested the transfer of the technology. The nursing home manager had become involved in the innovation activities because she had grown disappointed in the quality of elderly care technologies on the market. To change things, she wanted to bring living lab activities to the nursing home in order to achieve better, more reliable and more ethical care technologies. The living lab was supported by a municipal innovation fund and partnered with technology companies, one of which was the floor monitoring start-up.

Various alteration needs to floor monitoring surfaced shortly after joining the living lab. For instance, falling residents grabbed the backs of chairs and bedside rails and therefore rarely lay on the floor the way they had in the university laboratory tests. Also the nurses behaved in ways that developers did not expect, such as placing laundry piles on the floor, which the system identified as fallen persons. In turn, the technology monitored nurses' work in new ways and, for instance, made note of the aforementioned placing of laundry on the floor, which was against the nursing home's hygiene regulations. In general, residents were in a weaker physical condition and care work was more laborious than the engineers had expected. Furthermore, the system needed to be integrated with the units' existing equipment and the nursing home building, taking into account fire safety regulations and municipal social and health care office IT security levels.

It also turned out that the developers had invested large amounts of time in creating unneeded technical features based on their assumptions about the nurses' work. For example, the engineers assumed that it would be useful to monitor the movements of the residents from the computer screen. In reality, the nurses neither had the opportunity to do this nor were interested in the movements of the residents; they would pay visits to rooms when wanting to know what was going on. The nurses also invented new uses, most importantly analysed data logs to prevent accidents. In general, the nurses needed something else than a fall detector.

From the user perspective, the initial system was at best a prototype, whereas the company saw their product as more or less finished and was in a hurry to commercialise it. Developing the system further and quickly getting it to work reliably became the new objective of the project, albeit tension remained between the nursing home's wish to have a tailored system and the company's wish to have a generic and profitable product. False alarms, technical bugs, cumbersome interfaces and integration problems began to frustrate both nurses and project workers. Eventually, the project workers' wishes turned into demands, and the user side refused to continue with the implementation until their requirements were met. The situation finally became so agitated that the project coordinator, one project worker and the CEO of the company resigned within a period of six months.

Amid tensions, an updated version of the user interface was launched a year after the beginning of the original implementation. After the staff changes, a functional form of collaboration began to develop and the newly hired project coordinator started to actively observe problems and to seek new development ideas.

When use became more extensive, the company more profoundly understood the system's impact on work processes and its key benefits. The night shift seemed to be the biggest beneficiary: the nurse on-call did not have to go around checking on the residents all night as earlier, because the system informed her if someone got up during the night. The sleeping elderly were no longer disturbed by the checks, bedside rails could be removed, and residents no longer needed assistance to get up. Floor monitoring allowed the nurses to help residents when they put their feet on the ground and an alarm was sent. A new kind of care and new kinds of work practices began to take shape, and it was due to the care professionals that the system had evolved from being a fall detection system to becoming a fall prevention system, which allowed more flexible "just-in-time" care rather than rigid routines, and provided support for the night shift.

During the project the start-up company merged with an established electronics company, and started to gain new customers. The project coordinator was hired from the user site to the company to train new users and act as a link between company and customers, hence continuing UDI activities on the company side. Her role was now more limited, due to different development needs and budgeting, and the relationships with the customer organisations were much less intense than in the living lab phase. Continued UDI engagement was still needed as new customers provided new contextual challenges and differences in work practices, which led to requirements for redesigns. Due to high installation costs, sales focused on new rest homes, albeit newer buildings created new kinds of technical problems such as humid concrete, which required new algorithms for the system. After the living lab, the company initially adopted a tailoring strategy, and the system was fitted to each customers' needs and equipment. Eventually, this was found to be unviable, and a more generic product offering was developed, including a version that can be assembled on top of old flooring. By 2014, the monitoring floor has been installed in over 2000 apartments and has become a stable product in the market.

The nine year floor monitoring innovation process presents findings that are in many respects common in SLTI studies (Williams *et al.*, 2005; Hyysalo, 2010; Voss *et al.*, 2009). The innovation activities span across product launches, and there are different interests and actors shaping the innovation, which also affects its material and organisational form through the pursued technological paths and targeted value-points. The relationship between developers and users also undergoes changes from relatively sustained configurations to new ones. In the case on floor monitoring, there was first a year-long phase of developer-centred work, which then changed to three years of intense DC between developers and users in the living lab. This in turn changed into a lighter company controlled mode of user engagement with new customers as the innovation matured and the customer base expanded.

It is this phenomenon of diverse and changing developer–user configurations which we analyse in the following across multiple cases.

Comparing User Driven Innovation Across Multiple Cases

To date, SLTI studies have provided case-by-case evidence of UDI modes prevailing for some time and then changing in the course of the innovation project as we saw with elderly floor monitoring case vignette. This has given rise to criticism for making generalisations on limited empirical basis. To examine the generality of the phenomenon, we mapped 58 Finnish UDI cases to see whether and how these cases feature diversity and change in their dominant mode of developer–user configurations over time. Our research strategy was to examine each case description and highlight and then compare the changes in the developer–user configurations, the predominant sets of relations, as well as information and material exchanges between developers and users. While this suppresses the intricacy of social choices in the processes, it does allow us to compare the diversity evident in the initial UDI engagement and potential changes in the dominant mode of UDI.

Our procedure for achieving comparison was that four authors first assessed the user-drivenness of 80 examples selected to promote UDI in Finland (at www.udi.fi, in Finnish), of which the authors had researched and written the large majority. Then, the assessments were compared and 58 cases were selected as passing the criteria for representing user driven innovation in companies by all four authors. The discarded examples were either descriptions of innovation intermediaries or experimental setups (i.e., not product development projects as such), or did not qualify as research cases due to having been described too superficially.

In the second stage, we classified the type of UDI evident at each stage in terms of five modes of UDI. This was done to analyse both variety among cases and possible changes in the dominant mode of UDI within each case. The characterisation of different modes draws on the UDI research traditions explicated in the section "From modes of UDI to Analyses of Developer-user Relations" and on findings on empirical counterparts to those research traditions in company practices (Hyysalo, 2009b). The five modes have been operationalised as follows for the current analysis (Table 1).

Procedurally, this second stage was conducted as follows: four of the authors independently coded each of the 58 cases according to five modes representing UDI: (1) UIFD, (2) SU, (3) UCD, (4) UIs, and (5) DC. Each coding began from the starting point of the identified UDI process and further codes were added if such major changes were observed in the developer–user configurations over time that the dominant configuration between developers and users had clearly changed. After each of the four authors had independently coded all cases, we set up a number of meetings to compare the codings. The coding was mostly uniform. In six instances coding by one of the authors differed from others. Such differences were solved by revisiting the original case description and carrying out extended discussions with the author who had written or become familiar with the original case description. Still, in two cases a majority vote 3:1 was used to determine the coding between two alternative ways to mark a transition, in all others agreement was reached after revisiting the data. Case Vignette 2 provides an example of how the cases were coded with regard to UDI modes.

Case Vignette 2: Coding the case of the bathroom concept for assisted living:

A group of social and health care professionals working with elderly and disabled people had long been frustrated with the bathrooms of the residential care facilities. The bathrooms were so large that people often needed assistance to use them, simply for the sake of the room size.

Table 1. Modes of UDI used in the current analyses.

Mode	Rationale	How generated	How stored and accumulated	How used	Examples in research
UIFD	Designers have user benefits as core of their work	Intuition, own experience, and/or encounters with users, secondary sources	Typically, no systematic storing or accumulation apart from product features	As background knowledge to ideate and refine design solutions	Using field observation to tune designers, (lighter forms of) emphatic design
SU	Gathering knowledge about markets and users of already established concepts beyond mere market research	A study, research or field experiment on users of an already ideated product	Typically, as a report and in a user requirements template	In setting user requirements, pruning the interface and usability, adding new features, altering some parts of the concept	Concept studies, consumer research, usability studies
UCD	Creating deep understanding of users and their context to ideate and design products	In depth studies on users; Ethnography, interviews, interactive prototyping, etc.	Typically, models of users and contexts, requirement, wireframes, mock-up prototypes	As a source for product ideas and a backdrop to assess viability of concepts	UCD
UI	Users invent products for themselves	Ideating and building a prototype	As a prototype, in users head, sometimes as requirements	As a starting point for further development	Innovation by users
DC	Deep interaction between developers and users helps ideate, refine and test products	In a series of meetings and visits and digital interchanges between parties	As requirement, prototypes, listings, recordings etc.	To ideate, refine and test product	Participatory design, co-design

> The care professionals felt that they wasted their valuable working time in helping even relatively fit people with their toilet activities, for no other reason than that the design of the room did not support the independent mobility of the user. The root of the problem lay in the Finnish building code for public toilets for disabled people, which is intended for toilets situated in places such as shopping malls and department stores. Since a proper building code for residential care facilities does not exist, construction companies use this code intended for public spaces. In addition to the increased need for assistance, this also creates other problems, such as a lack of sufficient cabinet space and too few electrical wall plugs.

When a new public nursing home was being planned in Puotila, Helsinki, the care professionals together with architects decided to tackle the problem. While listing user requirements for the new bathroom, they group quickly grasped that suitable furniture did not exist in the market. This meant that they would have to start the planning of the ideal bathroom for elderly and disabled people from scratch. They settled on a mock-up bathroom from plywood, which could be used to try out the ideas (code 1: UI).

The plywood room was then tested by elderly residents, nursing home cleaners, physiotherapists, and an expert from the rheumatism association. Based on the feedback gained from the residents and the experts, the designer group determined optimal movement trajectories for the user from the perspective of ergonomics. The goal of the design was to support the independence of the frail or disabled user.

After the testing period, the care professionals and the architects started to look for a cooperative manufacturer for their design. They contacted a Finnish company that specialises in designing, selling and marketing bathroom solutions for special user groups. The company was so impressed by the new design that they decided use its insights to revise their entire existing collection of bathroom furniture. Based on the original design, the company later redeveloped new versions of the bathroom for other user groups, such as people with memory disorder and hospital patients (code 2: UIFD). Today, over 25,000 bathrooms of this line are installed in different care facilities in Finland, Japan, Norway, Sweden and Russia. The design has been awarded a prize by the Finnish Ergonomics Association.

Both the bathroom concept for assisted living and elderly floor monitoring cases exhibit a clear-cut change in the developer–user configuration at the point of moving from perfecting the initial product to targeting larger and more diverse user groups. In some of the other 58 cases, the changes were more overlapping as

Table 2. Overall characterisation of the data-set.

		Number of cases
Company size	Small company (< 50 staff)	33
	Medium sized company	12
	Large company	13
Clientele	B2B	20
	B2C	27
	B2B and B2C	11
Offering	Product	33
	Service	16
	Product and service	9
	System	9
New or improved offering	New offering to the company	49
	Improved offering	9
Not yet on the market		5
Data	Long-term data	10
	Limited to one project	48

one mode persisted, but others became increasingly used and gradually gained dominance. The most complex case was Habbo Hotel, which is a virtual world for youngsters. Altogether 26 different ways mediated the developer–user relations during the 10-year course of service development. Yet, even here the dominant mode of engagement was relatively easy to characterise in four major phases, because we had extensive documentation available on the developer–user relations therein (Johnson, 2013; Johnson *et al.*, 2010).

Appendix provides the basic features of all 58 UDI cases with respect to the size of the company involved, type of clientele, nature of its offering, and the novelty it represents, as well as whether we have long-term data on the case. The cases represent a variety of industrial sectors such as digital services, health technology, hospitality, ICTs, retailing, and sports equipment. Table 2 condenses this information into descriptive statistics.

Modes of and Changes in User Driven Innovation in Companies

Distribution of initial and final UDI modes and the number of changes in between

Let us begin comparisons by examining the initial distribution of dominant UDI mode in the cases (Table 3). The greatest number of cases (17) began as inspiration for design (UIFD). These cases targeted user benefits as the core of their offering, which turned designers to focus on users' desires, contexts and preferences. Yet formal user engagement or formal information gathering was not

Table 3. Distribution of cases according to UDI modes and transitions in modes.

Mode of UDI	As initial UDI mode (number of cases)	As final UDI mode (number of cases)
UIFD	17	22
SU	9	14
UCD	10	8
UI	15	3
DC	7	11

conducted. Similarly there were nine cases of SU targeted at refining an already established concept. UCD was dominant in ten cases, in which extensive and systematic investigation was conducted on users and their lives and contexts, the results serving as the impetus for developing new concepts. Fifteen cases began as UIs and seven with intensive DC between users and developers.

The distribution of UDI modes in the 58-case data-set is considerable both regarding the initial and the final mode and hence witness to the diversity in the meaning of UDI in companies. Truncating UDI to a single engagement mode such as UCD or UI, would leave out a significant number of user driven efforts undertaken in the companies.

We next take a look at the changes that companies' UDI went through during the process of innovation and which present an added element of diversity. The phenomenon of changes in the dominant UDI mode in company product development cases has not gained much attention in UDI literature. The exceptions are observations of lead users turning to user innovators and manufacturers or alternatively revealing their designs for companies to commercialise (von Hippel and DeMonaco, 2013), as well as the usability maturity models of the 1990s, and open innovation maturity models of 2010s where the company mode of user orientation was seen to deepen or lessen (Earthy *et al.*, 2001; Enkel *et al.*, 2011; Kuutti *et al.*, 1998).

In the 58-company cases analysed, we found a considerable number of changes in the dominant modes of UDI. Four cases went through three changes, six cases two changes and 11 cases one change in their dominant UDI mode. These changes were characterised by varying paths, lengths and contingencies. Five clusters of UDI change sequences emerged from this analysis (Table 4), which we discuss in the follow subsections.

Light UDI trials

The largest number of cases (22 in total) can aptly be characterised as *light UDI trials*, and include small or traditional trials with UDI, typically including some

Table 4. Company UDI change sequences by innovation process content.

UDI orientation	Description and focus	Changes	Cases
Light UDI trials: Companies seek compatible additions to their existing mode of operation	Trials in SU	None, i.e., remain in SU	Cell phone safety button, energy monitoring unit, smart news feed, user friendly apartments, transportation information display, online television recorder, GPS data collector, energy corporation user boards (8)
	Trials in UIFD	None, i.e., remain in UIFD	Electric plug, green labelling for offices, fabric store concept, dried berries, hardware store energy counselling, web security rating service, human centric wellness services, tea strainers, lightweight fireplace, energy efficient residential blocks (10)
	Trials combining UIFD and SU	UIFD–SU	LED lighting, online meeting organiser, speech-recognition service, additive-free meals (4)
Generification: A shift from more to less intensive user relations	Moving from initial user idea to serving a broader and more diverse customer base	UI–SU–UIFD	Nanocoating for skis, online swapping service, terrain golf game (3)
		UI–UIFD	Bathroom concept for assisted living, finance instrument for GSHP, baby clothing renting service, love locks, log carrying device (5)
	Moving from in-depth user collaboration or UCD to lighter engagement	DC–UCD–UIFD	Copper electricity harvesting (1)
		DC–UIFD	Elderly floor monitoring (1)
		UCD–SU	Interactive TV for seniors (1)
	UCD only	None, i.e., remain in UCD	Platform for distributed work, replumbing renovation concept, blood sugar monitoring system, playground for seniors, warehouse trucklifts, mobile tourist guide, insurance for teenagers (7)

Table 4. (*Continued*)

UDI orientation	Description and focus	Changes	Cases
	Swing to deeper collaboration and back after successful market launch	SU–DC–SU	Elderly wrist monitoring (1)
UI only	Innovations developed by users	None, i.e., remain in UI	Gluten-free pastry, dog leash, live video streaming system (3)
Deepening or in-depth collaboration	In depth user collaboration remains or becomes an integrated part of the company operation	UI–DC	Childbirth station, fishing equipment (Lindeman) (2)
		None, i.e., remain in DC	Dairy detergent and refill service, 3D skull X-ray, electronic health record, crowdsourcing platform for celiacs, park our playground (5)
		UCD–DC	Information system for kindergartens, elderly care software integration platform (2)
		UIFD–SU–UI–UCD	Social media platform for teenagers (1)
		UI–DC–UIFD–DC	Information system for diabetes patients, fishing equipment (Rapala) (2)
UDI becomes integrated in the company repertoire	Different UDI modes continue to be used in a large company	UIFD–SU–UIFD	Integrated elevator concept (1)
		UIFD–SU–UCD–UIFD	User friendly faucets (1)

non-mainstream market research (those remaining in SU) or small design empathy-dominated UDI trials in innovation projects (those remaining in user-inspiration for design, UIFD). The TVkaista online television recorder is an example of (the lighter end of) a light UDI trial (Example 1). As in the other cases, the trials contribute new design features, but do not fundamentally question or change the product or service offering of the company.

Example 1. The online television recorder as an example of a light UDI trial.

> TVkaista is an online recorder for programs from selected free television channels in Finland. Its recordings can be viewed on many different devices and also abroad. Initially, users could keep programs from the previous two weeks in a buffer and save selected programs in personal online storage for a longer period of time. When the service was redesigned in 2010, capacity emerged as an issue that required redesign. TVkaista used online surveying of its users' opinions about the features of the services, particularly to gain a better sense of balancing online storage and longer term storage. Based on the information gained, TVkaista renewed its concept by substituting the personal storage with a longer four-week buffer. Although the results and choices based on these results were of strategic importance to TVkaista, the user involvement method was light in its depth and did not question the role of TVkaista as product developer and service provider (*codes: SU, no changes*).

In light UDI trials, companies experiment with UDI, but do not integrate it into their product development process. From the SLTI perspective, the popularity of light trials is not surprising. Companies tend to have their extant ways of knowing the market in place and rather seek compatible additions to their mode of operation than seek to change the way their business is run (Williams *et al.*, 2005; Heiskanen and Repo, 2007).

Generification: A shift from more to less intensive user relations

In a large number of our cases that involved UDI modes requiring intensive relations with customers (such as UI or DC), we found that these intensive relations were not sustained after market launch, but turned to arms-length relations or were completely discontinued. Four different trajectories fall under our category of "generification", where particular user inputs were converted into generic commercial products (Pollock and Williams, 2008), hence rendering further user input redundant, or at least less important.

Within this category falls the second largest group of cases in which companies *shifted to a lighter UDI mode or withdrew from UDI* altogether at commercialisation and market launch. This can start off from any of the deep user involvement modes, and features several alternative change sequences. Before examining the sequences in closer detail, let us examine an example case starting from UI, namely how a UI developed nanocoating for cross-country skis (Example 2).

Example 2. Nano coating for skis, shifting to a lighter UDI mode.

> Many argues that cross-country skiing is enjoyable only when one's skis is in good condition. The coating of skis plays an important role here, as it requires skills to apply glide and kick wax to one's skis. Finnish innovator Matti Järvinen had years of skiing experience as well as extensive expertise in ski coatings. He trialled nanocoatings (*code*: UI), and as the coatings evolved he set out to investigate coatings that could make skiing more enjoyable for recreational, even occasional, skiers and children who have difficulties in servicing their skis. Järvinen prepared skis with various prototype coatings to be tested by regular skiers and asked for their feedback (*codes*: SU, first change). He wanted feedback from regular skiers rather than professionals, who are typically considered in the skiing industry. Once Järvinen's coating was finalised, he cooperated with ski manufacturing companies to prepare nanocoated skis for the market. In this phase, the manufacturers brought in their manufacturing expertise. Nanocoating is applied at the factory and the curve profile of nanoskis is lower than usual (*codes*: UIFD, second change). Within a few years, more than a half of the cross-country skis produced in Finland had nanocoatings.

Similar changes can be found in two cases starting off from DC, and one from UCD. Floor monitoring for the elderly described in case Vignette 1 is an example of the former.

The next subgroup emerges from a set of seven cases where "UCD only" engagement led to a product, after which further user input was deemed unnecessary. These appear to share the same background rationale of a successful product emerging and UDI being no longer needed — to our knowledge none of the cases continued UDI in the project or other projects in the company.

The case of elderly wrist monitor innovation is also included in this group, even though it features a more complex changes of first deepening DC and only then diminishing (SU–DC–SU) because the product was generified after the necessary functionality was in place (Hyysalo, 2010). In total, the set of successful generification cases then results in 19 company innovation processes.

User innovation only

Successful generification finds its counterpart in the UI *only* orientation found in three out of 13 cases that start as UI. The UI mode appears to be sufficient when users act as entrepreneurs (Shah and Tripsas, 2007; Haefliger *et al.*, 2010). Only one of these cases, gluten-free pastries (Example 3), resulted in commercialised products, whilst a new dog leash and live video streaming remained to be used only by their inventors.

Example 3. Gluten free pastry, UI only.

> The CEO of the bakery Vuohelan herkku was diagnosed with coeliac disease, which encouraged this part-time bakery entrepreneur to modify her product range to a selection of gluten free pastries (*code*: UI). According to the CEO, this made sense, because the Finnish market was lacking appealing gluten free bakery products. Therefore, she started to develop new recipes with an aim to beat the competitors' products on taste and consistency. Coeliac consumers found the Vuohelan herkku products quickly and liked them, which made the business grow in a decade from a one-person enterprise to an employer of approximately 40 people.

Our data include only few cases of such UI and the data are merely suggestive concerning this category of cases. However, it makes sense to argue that UI in and of itself appears insufficient for many companies in the creation of commercial market offerings, unless they have a very specific niche market in mind (as exemplified by the example above).

Deepening or sustained in-depth collaboration

A significant company strategy represented by 12 cases falls under *deepening or in-depth collaboration* in the course of innovation. This cluster of cases includes six business-to-business as well as six business-to-consumer cases, of which five consist of young firms and seven of established firms. Whilst the exact changes differed, they all ended in intense DC and their preceding modes feature a tendency to move towards deeper collaboration. In social shaping of technology terms, the UDI becomes part of the company's sociotechnical constitution, a pervasive part of how it operates in its development and marketing activities (Williams and Edge, 1996; Russell and Williams, 2002). Companies adhering to this strategy also rely on their designers' competences. Let us examine such a change sequence with multiple strategies through Rapala's fishing equipment case (Example 4).

Example 4. Fishing tackle, deepening and in-depth collaboration.

> Rapala originates in fisherman Lauri Rapala's innovations in fishing tackle and products that then followed in lure fishing (*code*: UI). The company focus is on amateur use of lures and Rapala enhances users' cultures of amateur fishing. However, the market is global and the company has to offer a variety of lures for different use environments. Rapala has collaborated with fishing guides and professional fishermen to keep renewing its lure development. The company also has a systematic process to collect and develop diverse ideas from fishermen (*code*: DC). It also uses its designers' expertise heavily in the process: No new tackle is rushed to market, but new products are crafted from years of experience. A wide range of technical tests are also conducted and all Rapala lures are designed and tested to swim perfectly right out of the box. Social media is used as an important arena for teaching fishing skills (*code*: UIFD). The amateur and professional users continue to play a role in Rapala's new lure development, playing key roles in many development projects, whilst others are more in-house dominated (*code*: DC).

The cases that feature deepening or in-depth collaboration include several different change paths. They may evolve from UI to DC, continue as extensive and sustained DC, involve a shift from UCD to DC, or entail several consecutive changes, as in the fishing tackle example described above. In the cases we analysed, there was no one driver explaining the deepening collaboration but rather it happened as a gradual response to opportunities the collaboration presented and the relative lack of factors impeding it.

UDI is integrated in the company *repertoire*

The final group relates to in-depth collaboration becoming part of the company *repertoire*. Both cases include established companies where in-depth UDI projects, sometimes collaborative projects with academia, have become a legitimate part of corporate *repertoire* albeit amidst other ways of working in their R&D. Such wider, sometimes complementary but occasionally also competing arrays of user relation methods are also commonly found in previous studies (Johnson *et al.*, 2014). Let us examine the Oras faucet case.

Example 5. Faucets, UDI as part of company *repertoire*.

At Oras, a faucet manufacturer for 80 years, the needs of customers and design have always been an integral part of product development. Oras has emphasised user oriented design throughout its lifespan. The creation of a new product starts by identifying a user need, which the company designers then build their designs on (*code*: UIFD). Oras also has a large *repertoire* of ways of working with users to probe markets and for creating usability that goes beyond the standard (*code*: SU). Whilst some of these studies, often academic collaborations, dig deep into people's everyday life as grounding for design (*code*: UCD), UIFD has remained the predominant mode of engagement in the company for making faucets easier, safer and more ecological than before.

Controlling the findings for data longevity

As noted, the studied set of 58 cases include both long-term and short-term cases, the former spanning over several product launches. The concept of dominant mode in user engagement allows us to juxtapose short-term and long-term cases. Two control questions emerge in terms of longevity: First, to what extent do changes occur in the short-term cases (i.e., within one product launch)? Second, do more changes in dominant mode occur in cases with long-term data than in cases with short-term data?

Let us first examine the 10 cases on which we have long-term data. Of these, four cases go through three changes in their dominant mode of user engagement — and account for all cases with three changes in our set of 58 cases. Two additional long-term cases go through two changes, representing one third of the cases with two changes. Another three go through one change. Only one stayed in the initial mode and represents DC, a mode that indicates in-depth information exchange between developers and users. UDI has not been abandoned in any of the long-term cases, but this could partly be an artefact of data gathering in that long-term follow-up does not tend to continue unless something interesting happens in the company.

We can also examine this relationship in cases that were only followed up until one product launch. There are four such cases with two changes in their dominant mode, i.e., two-thirds of two mode changes take place in the cases that only cover one project. From this, we can infer that some changes in dominant UDI mode take place even within cases that cover only short-term singular product launches, but the propensity to shift increases with time. With the caveat of the non-continuation of data collection, we can infer that the propensity of mode changes in the 58-case data-set would be subject to increase with the continuation of data gathering. Hence, the overall number of changes presented in the current analysis are likely to downplay the prevalence of changes in the dominant UDI mode in companies.

Discussion

Diversity is evident in the modes of UDI practiced in companies. Roughly half of the Finnish UDI showcases started out with a light mode of user involvement (UIFD or SU) and in half the company has taken user engagement to a level where it cannot remain as a simple add-on to their business as usual practices. Furthermore, about 40% of the Finnish UDI cases and 90% of cases with detailed long-term data featured a change in the dominant mode of UDI during the period analysed. These findings suggests that UDI is in indeed an umbrella term, but the modes of involving users within that umbrella are related to one another in company practice.

First, these findings point to the different implications of UDI modes for companies: For instance, how much control the company retains, how much it has to invest and how easy it is to commercialise the information gained. UCD and SU — two modes, in which users are studied to inform design — appear to produce outcomes that companies do not seek to complement with another UDI mode. A possible explanation is the strong control and ownership of the information produced through these two modes. Indeed, turning to UIs, which entails giving a way control is not — at least not yet, in this data-set — a strategy that companies would seek if they are already operating with another mode of UDI.

Second, that companies often used two or more modes is, we believe, an indication that what works for a company and its users in a situation need not work in another situation. Companies may not be advocates of this or that mode of UDI, let alone a particular method, *per se* (unlike many academics), but rather appear to navigate and improvise their modes of engagement with users amidst other priorities in their development activities (cf. Janssen and Dankbaar, 2010; Johnson *et al.*, 2010).

Third the findings help contextualise some recurring ideas found in different corners of the academic research related to UDI. Let us start with the idea of increasing maturity in user engagement, finding its clearest expression in usability maturity models (Earthy *et al.*, 2001; Kuutti *et al.*, 1998). We find seven cases where engagement with users led to further deepening and in-depth DC becoming the final mode of operation, together with the five cases remaining in that mode from the outset. This represents one-fifth of all cases, and within them there are five different change sequences. Maturing, hence, does not always take place nor does it appear to follow clearly defined steps — it does not appear as a uniform, directed process. Accordingly, further research is called for on how the maturation of UDI in companies actually takes place, and why it might not occur and what are most apt maturity levels in different contexts (Enkel *et al.*, 2011).

The other side of the maturity issue is that many companies see SU and UIFD as sufficient user engagement. It appears that policy makers' hopes for promoting user driven corporate cultures via light experimentation are hopeful at best, and hence, unlikely to achieve the kind of results that public funding programs seem to target.

Another common idea is that an innovating user would provide companies the user domain knowledge needed to innovate (von Hippel, 2005; Peine and Herrmann, 2012). Judged by 15 cases that start as UIs in our data-set, this rings true for domain knowledge needed to invent the product or service concept. However, when examined through to market entry, only one case with only an initial user innovator proved successful. In 12 other cases, another mode became dominant and in two others, the UI was not commercialised. These patterns may point to impediments and the disincentives that constrain innovating users (von Hippel and DeMonaco, 2013) but also to a discrepancy between lead user solutions (and lead users domain knowledge) and the solutions preferred by rest of the market and the related mainstream user domain information (von Hippel, 1988).

Implications for Management of and Policy for User Driven Innovation

Examining real life UDI cases lends support to the intuition that UDI is a multifaceted phenomenon. But not only that, it is one that changes its shape in the course of company practices. This implies a shift away from the currently popular short-term projects to introduce new methods or ways of working in the company, often championed by consultants or researchers. Instead, efforts should go into determining what would be the most apt UDI modes for the given company and its current and potential clientele, and into sustained interchange to refine these further. The move could be characterised as a shift from "tactical" engagement with UDI ("what could we do with UDI") to increasingly "strategic" engagement ("what would be the most apt way to benefit from UDI"). This would entail a shift in what is being targeted and given (corporate and/or public) support: Not seeking to refine any one of the modes as such, but to refine UDI practices within companies.

This does not, however, imply merely providing resources to companies and letting them sort issues out. Most companies do not have the competences to assess, refine and implement adequate UDI measures successfully on their own. In our interviews, the case companies found it easy to communicate their innovation processes and their engagements with users, but found it difficult to consider what other modes of engagement they might trial, or indeed, what might be the best suited candidates. Consultations that would open options and assess the aptness of different means for the company's information needs would be welcome.

The utilisation of DC and UCD tend to require slow learning processes within the company in order to become successfully incorporated in pre-existing corporate routines and practices (Hasu, 2001; Hyysalo, 2009a; Heiskanen *et al.*, 2010). The time span and new competences needed are in such cases considerable and should be reflected in support measures.

Thus in the light of our findings, recent UDI programs in European countries may not have paid sufficient attention to the longevity of UDI (Timonen and Repo, 2014; Repo *et al.*, 2013). For instance, in Denmark, the bulk of UDI support has gone to design consultants and researchers, resulting in many trials and new openings but few long-term development projects with industry (FORA, 2009; Elgaard Jensen, 2013). In Finland, funding was spent on academic research projects or handed directly to companies, neither of which seems to have been optimal in facilitating long-term strategic engagement with UDI. Dealing with the diversity in how UDI mode changes take place in companies, thus, presents a research and policy area that merits further attention.

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Appendix A

Table A.1 Characteristics of analyzed UDI cases.

Innovation project	Company/organisation	Sector	Small company < 50 staff	Medium sized company	Large company	B2B	B2C	Product	Service	Systematic offering	New offering to the company	Improved offering	Not on the market yet	Long term data
3D skull X-ray	Planmeca	Health technology		×		×		×	×	×	×			
Additives-free meals	Fazer Food Service	Hospitality			×		×		×			×		
Baby clothes renting service	Belbamboo	Clothing	×			×	×	×	×		×			
Bathroom concept for assisted living	Väinö Korpinen	Health technology		×		×	×	×			×			×
Blood sugar monitoring system	Modz	Health technology	×			×	×	×			×		×	
Cell Phone safety button	Mobile Care Safety	Safety technology/ICT	×				×	×			×			
Childbirth station	Relaxbirth	Health technology	×			×		×	×		×			
Copper electricity harvesting	Outotec	Mining and minerals			×	×		×	×			×		
Crowdsourcing platform for celiacs	Moilas Leipomo	Grocery	×				×	×				×		
Dairy detergent and refill service	Kill to Clean	Detergents		×		×		×	×		×			×
Integrated dual dog leash	(Company Commercia-lization halted)	Pet Products	×				×	×			×		×	
Berry health snacks	Biokia	Groceries	×				×	×			×			
Elderly care software integration platform	Wiktio	ICT	×			×		×	×	×	×			
Elderly floor monitoring	Smart Floor Technologies	Health tecnology	×			×		×	×	×	×			×
Elderly wrist monitoring	Vivago	Health technology	×			×	×	×		×	×			×
Electric plug installation system	Revolte	Construction	×			×		×			×			

Table A.1 (*Continued*)

Innovation project	Company/organisation	Sector	Small company < 50 staff	Medium sized company	Large company	B2B	B2C	Product	Service	Systematic offering	New offering to the company	Improved offering	Not on the market yet	Long term data
Electronic health record	Logica	ICT			×	×		×		×		×		
Energy corporation user boards	Fortum	Energy			×		×		×		×			
Energy efficient residential block	Sitra, SRV&VVO	Construction			×	×	×	×		×	×		×	
Energy monitoring unit	Enoro	Energy			×	×	×	×	×		×			
Fabric store concept	Eurokangas	Fabric retail		×			×	×				×		
Finance Instrument for heat pumps	Helmi säästöpankki	Finance			×		×		×		×			
Fishing nets	Lindeman	Fishing equipment	×			×	×	×			×			×
Fishing tackles	Rapala	Fishing equipment		×		×	×	×			×			×
Gluten free pastry	Vuohela bakery	Grocery	×				×	×				×		×
GPS data collector	Pajat Solutions	ICT/Mobile phone app	×			×		×			×			
Green labelling for offices	WWF	Non-governmental organisation		×		×			×		×			
Hardware store energy counseling	K-rauta	Hardware retail			×		×		×		×			
Human-centric wellness services	Create Amove	Wellness services	×				×		×		×			
Information system for diabetes patients	ProWellness	Information systems	×			×		×			×			×
Information system for kindergartens	WhileOnTheMove	Information systems	×			×		×			×			
Insurance for teenagers	Tapiola	Insurance			×		×		×		×			
Integrated elevator concept	Kone	Elevators			×	×		×	×	×	×			
Interactive TV for seniors	City of Espoo, Laurea and Videra	ICT/Elderly care		×		×	×		×		×		×	
LED lighting	MTG-Meltron	Lighting	×			×		×			×			
Lightweight fireplace	Nunnauuni	Fireplace	×				×	×			×			
Live video streaming system	Academica	ICT/Streaming	×			×	×		×		×			

(*Continued*)

Table A.1 (*Continued*)

Innovation project	Company/organisation	Sector	Small company < 50 staff	Medium sized company	Large company	B2B	B2C	Product	Service	Systematic offering	New offering to the company	Improved offering	Not on the market yet	Long term data
Log carrying device	Arvemet	Household appliances	×				×	×			×			
Love locks	Tukku Immonen	Household appliances	×				×	×			×			
Mobile tourist guide	see Finland	ICT/Tourism	×				×	×			×			
Nano coating for skis	Matti Järvinen sport	Sports Equipment	×			×		×			×			
Online meeting organiser	Dicole	Digital service	×			×			×		×			
Online swapping service	Netcycler	Digital service	×				×		×		×			
Online television recorder	TV Kaista	Digital media	×				×		×			×		
Parkour playground	Lappset	Playground equipment		×			×	×			×			
Platform for distributed work	Microtask	ICT	×			×			×		×			
Playground for seniors	Lappset	Playground equipment		×			×	×			×			
Replumbing renovation concept	Vahanen	Engineering			×	×			×	×		×		
Smart news feed	Leiid	Digital service	×				×	×			×			
Social media platform for teenagers	Sulake	Digital service/Social media		×			×		×	×	×			×
Speech recognition service	Suomen Puheentunnistus	Speech recognition	×			×		×			×			
Teastrainers	Paulilna Rundgren Handicrafts	Handicraft	×				×	×			×			
Terrain golf game	Solo-international	Sports equipment	×				×	×			×			
Transportation information display	Destia	Transportation			×		×	×			×			
User-friendly apartments	SRV	Construction			×		×	×				×		
User-friendly faucets	Oras	Sanitary fittings		×		×	×	×			×			×
Warehouse trucklifts	Roda	Industrial trucks		×		×		×			×			
Web security rating service	Web of Trust	Digital service	×				×		×		×			

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