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

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

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<tr>
<th>Initiation stage</th>
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<th>Wrist monitoring</th>
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<td>11</td>
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**Engineering starting point (CTXT, PPL)**
- University spin-off from signal processing engineering
- Engineers with safety alarm device history

**Encouragement from elderly care (ID, INT)**
- Informal contacts with elderly care highly positive
- Informal contacts with elderly care highly positive

**Idea about viability (INT)**
- Encouragement from elderly care actors
- Own assessment, market studies

**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

**Explicit market or user research (ID)**
- None
- Two studies on European markets

**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.

**Changes in key technical components (TECH)**
- None
- Several

**Tight funding (CTXT)**
- Small research and development grants
- Founder’s own assets

**“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

**User side funding prior to pilots (CTXT, INT)**
- Some funds for living lab collaboration used in technical development
- None

**Target market (MKT)**
- Elderly care institutions

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Figure 1. Resemblances and differences in the key events in the initiation stage.
<table>
<thead>
<tr>
<th>Significant resemblance</th>
<th>Moderate resemblance</th>
<th>Moderate difference</th>
<th>Significant difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Realities faced in early use: leading to redesign</strong></td>
<td><strong>Floor monitoring</strong></td>
<td><strong>Wrist monitoring</strong></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Continued technology development during pilot use (TECH, OUT)</td>
<td>Yes, first in short pilot use, then with small number of paying (pilot) customers.</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unneeded technical sophistication reduced (TECH, OUT)</td>
<td>Proactive alarms unattainable reliably and not needed: visiting residents regularly</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unexpected uses (ID)</td>
<td>Floor plans used for retrospective assessment of incidents</td>
<td>Activity curve appropriate for determining the shape of the resident in retrospective assessment</td>
</tr>
<tr>
<td>25</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unexpected variability (ID)</td>
<td>Falls had greater variety than technically prepared for: inaccurate algorithms</td>
<td>Fluctuations in the condition of the elderly greater than prepared for: inaccurate algorithms</td>
</tr>
<tr>
<td>26</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elderly in much weaker condition and needing more assistance than expected by developers, nurses the primary users. (ID)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unexpected integrating to nursing work needed (ID, TECH, OUT)</td>
<td>Alarm reception, routing, handling, prioritization and responsibilities significant and complex, Interface and working principles redesigned.</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unexpected integration to other equipment (ID, TECH, OUT)</td>
<td>Redesigned to fit in with extant software, nurse call, PC's, cell phones, fire alarms, flooring, wiring etc</td>
<td>Redesigned to fit in with extant software, PC's, cell phones, fire alarms and alarm centre software's</td>
</tr>
<tr>
<td>29</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Need to invest in own network and software (TECH, OUT)</td>
<td>Integration to city networks too much safety risk</td>
<td>Extant safety phone software could not handle new alarms</td>
</tr>
<tr>
<td>30</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unexpected contextual problems (TECH, ID)</td>
<td>E.g. no holes allowed for wires in walls due to fire safety</td>
<td>E.g. receiver unit signals interfered with by elevators or thick walls</td>
</tr>
<tr>
<td>31</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unexpected user behaviours (PPL, TECH)</td>
<td>E.g. nurses leaving laundry piles on the floor</td>
<td>E.g. Insulating the monitoring unit with cotton, wearing in shower</td>
</tr>
<tr>
<td>32</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Installation and repair costs higher and hamper internationalization (TECH, MKT)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Early developer-user collaboration</th>
<th>Floor monitoring</th>
<th>Wrist monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td>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)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>×</td>
</tr>
<tr>
<td>Collaboration agreement and plan (INT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td>Local / Generic tension (TECH, INT, MKT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td>×</td>
</tr>
<tr>
<td>Pilot costs and work shared (CTXT, INT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>×</td>
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</tr>
<tr>
<td>New design aim: getting the technology to work reliably (TECH, OUT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td>Initial user interface very difficult to use (TECH, OUT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td></td>
<td>×</td>
</tr>
<tr>
<td>False alarms and missed accidents frustrate nurses and elderly, particularly during nights and during treatment tasks. (TECH, OUT, PPL)</td>
<td></td>
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<tr>
<td>30</td>
<td></td>
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</tr>
<tr>
<td>Developers perceived as arrogant in the face of user problems and risks from the technology (INT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td>Elderly care actors react (INT, OUT)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td></td>
<td>×</td>
</tr>
<tr>
<td>Mediating personnel quit (INT, OUT)</td>
<td></td>
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</tr>
</tbody>
</table>

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,

<table>
<thead>
<tr>
<th>Maturing of collaboration and concept</th>
<th>Floor monitoring</th>
<th>Wrist monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>33</td>
<td>2.0 version fits nursing work and context better and allows more tailoring (TECH, OUT)</td>
<td>2.0 version a year after first implementation</td>
</tr>
<tr>
<td>34</td>
<td>No formal or neutral outside facilitator for collaboration: no resources, not perceived needed by any party (INT)</td>
<td>User side innovation intermediary emerges (INT)</td>
</tr>
<tr>
<td>35</td>
<td>New user side project manager mediates between other users and company limitations.</td>
<td>New company product manager integrates installation, training, troubleshooting and refining of design requests.</td>
</tr>
<tr>
<td>36</td>
<td>Well functioning form of collaboration develops (INT)</td>
<td>Active problem and idea seeking, observations and problem sheets, regular meetings.</td>
</tr>
<tr>
<td>37</td>
<td>Mandatory use by management decision (INT)</td>
<td>Non-use declared as mistreatment</td>
</tr>
<tr>
<td></td>
<td>Price of wrist device included in all rents</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Feedback made mandatory for nurses (INT)</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Panopticon issues: monitoring renders elderly and nurses work more visible. Management endorses, users adapt. (TECH, PPL)</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Night panopticon key benefit: no need to check residents by opening doors (TECH, OUT, ID)</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Users ideate the new key value points (TECH, ID)</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Anticipation of falls and just-in-time care initiated by users.</td>
<td>&quot;Activity curve&quot; creatively appropriated and developed into a diagnostic and proactive tool.</td>
</tr>
<tr>
<td>43</td>
<td>High importance of reliability agreed and emphasized by both parties (TECH, INT)</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Similar end-benefits despite different early aims (ID, MKT, OUT)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Detection, anticipation and help with falls and worsening condition, support for night shift, allowing natural day rhythm for residents.</td>
<td></td>
</tr>
</tbody>
</table>

Figure 4. Resemblances and differences in the key events in the stage of matured collaboration.
<table>
<thead>
<tr>
<th>Extending from pilots</th>
<th>Floor monitoring</th>
<th>Wrist monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>Rapid gaining of a customer base of few hundred installations (MKT, OUT)</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Most sales in new rest homes: flooring, public sector purchase logic (TECH, MKT)</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Profitable operation a challenge, further development needs (MKT, TECH, OUT)</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Required funding leads to ownership changes (CTXT, OUT)</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Further redesign and further configurability to the product (TECH, OUT)</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Unexpected contextual technical differences in other settings (TECH, ID)</td>
<td>e.g. Higher humidity of cement in new buildings interferes with the algorithms</td>
</tr>
<tr>
<td>50</td>
<td>Mandatory use by management decision (INT)</td>
<td>Non-use declared as mistreatment</td>
</tr>
<tr>
<td>51</td>
<td>Higher than expected local configurability needed (TECH, ID)</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>To and fro between localization and generic offering (TECH, MKT, OUT)</td>
<td>Localization decided and undecided several times</td>
</tr>
<tr>
<td>53</td>
<td>New product versions made (TECH, MKT, OUT)</td>
<td>The installation floor, new generations of vivago, segmentation of product to institutional and home versions</td>
</tr>
</tbody>
</table>

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 aid 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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References


